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RHIZOME

Patterns of the use of technology by students in Higher Education

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PATTERNS OF THE USE OF TECHNOLOGY BY STUDENTS IN HIGHER EDUCATION

by

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DECLARATION

I, **Simon-Peter Kafui Aheto**, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

13th January, 2017

Signed **Date**

ABSTRACT

Rationale: Unavoidably, the 21st century is witnessing continuous discourse about students' technology uses in higher education. This thesis explores the underpinnings of students' technology usage in their rhizomatic (personal) learning networks in the higher educational environment through a lens of four sub-research questions and four research hypotheses.

Methodology: This research adopted a cross-sectional narrative and numeric study using the Frameworks for an Integrated Methodology (FraIM). The study was conducted in four universities comprising two universities in Ghana, one in South Africa and another in Belgium. Participants and respondents included students and lecturers. Data collection methods comprise focus group interviews, individual interviews, surveys (paper and web-based) and rhizomatic maps. The philosophical underpinning was inclined towards the critical realists' stance and hinged to Rhizome Theory and Actor Network Theory. Data were analysed through descriptive and multivariate analyses and learning analytics employing tools in social network analysis. Results were presented graphically via Rhizomatic Learning Network maps, charts, tables and narratives.

Findings: Students' personal learning networks exhibit traces of rhizomatic patterns which are related through human and non-human actors. Seven categories of actors – comprising 218 individual actors – were found in students' Rhizomatic Learning Networks. Out of 19 traceable digital devices used by students, this research established differences among the institutions in the four most widely used digital devices: *Laptop*, *Smartphone*, *Tablet* or *iPad,* and *E-Reader* pro rata. Students owned, in this sequence, *smartphones*, *laptops*, *tablets* or *iPads* and *e-readers*. This research also found statistically significant differences among all four institutions in terms of students' self-perceived importance of handheld mobile devices towards academic success, university wireless network experiences and satisfaction of Learning Management Systems in the universities. However, results indicated that students are not likely to skip classes when materials from course lectures are available online, implying an inclination towards a blended approach to learning despite a technologically-rich environment.

Implications and Value: With an underlying effect on curriculum design and implementation, this thesis, supporting rhizomatic approaches to learning, has tremendous potential to improve personal learning networks in higher education. It further contributes an understanding of emerging patterns in the personal learning networks of higher education students within a technology-rich environment. Again, integration of the two theories – FraIM, analytical tools and style of presentation – in understanding the problem through the lens of a critical realist is novel.

Key Recommendations: Further rhizoanalysis research into the detailed roles performed by individual technological actors in students' personal learning networks in the higher educational environment is required. Additionally, clear policies exhibiting willingness and enforcement strategies to integrate technology in all facets relating to learning should guide curriculum development within the universities.

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DEDICATION

To God, my parents, wife, two little daughters, Selaina Denise and Seli Johanna and the unborn

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GLOSSARY

Terms/Acronyms/Abbreviations		Definitions/Explanations
BEL	–	Pseudonym for the traditional university in Belgium used in this research
FraIM	–	Frameworks for an Integrated Methodology (Plowright, 2011) is the methodological choice for this research
GAC	–	Pseudonym for the traditional university in Ghana used in this research
GBR	–	Pseudonym for the University of Technology in Ghana used in this research
SAR	–	Pseudonym for the University of Technology in South Africa used in the research
Rhizoanalysis	–	Any analysis that involves the use of Rhizome Theory principles as a lens to arrive at its results
Rhizomatic Learning	–	A concept of learning in an open, dynamic and fluid system where a learner is connected to multiple entryways of learning resources within a personal learning network
Rhizomatic Learning Network	–	A map of interconnected actors or nodes that represents an abstract concept of learning in an open, dynamic and fluid learning environment
Wi-Fi	–	Wireless network technologies that enables connection to the Internet
Techno-connection	–	A state or feeling of always wanting to connect to technology in a learning space
Techademics	–	State of a student's preparedness to use technology for academic work

CHAPTER ONE

BACKGROUND TO THE STUDY

"The nature of society and education is rapidly being transformed by technology, the information era, and demographic shifts."

- Lewis J. Arthur (1983:9)

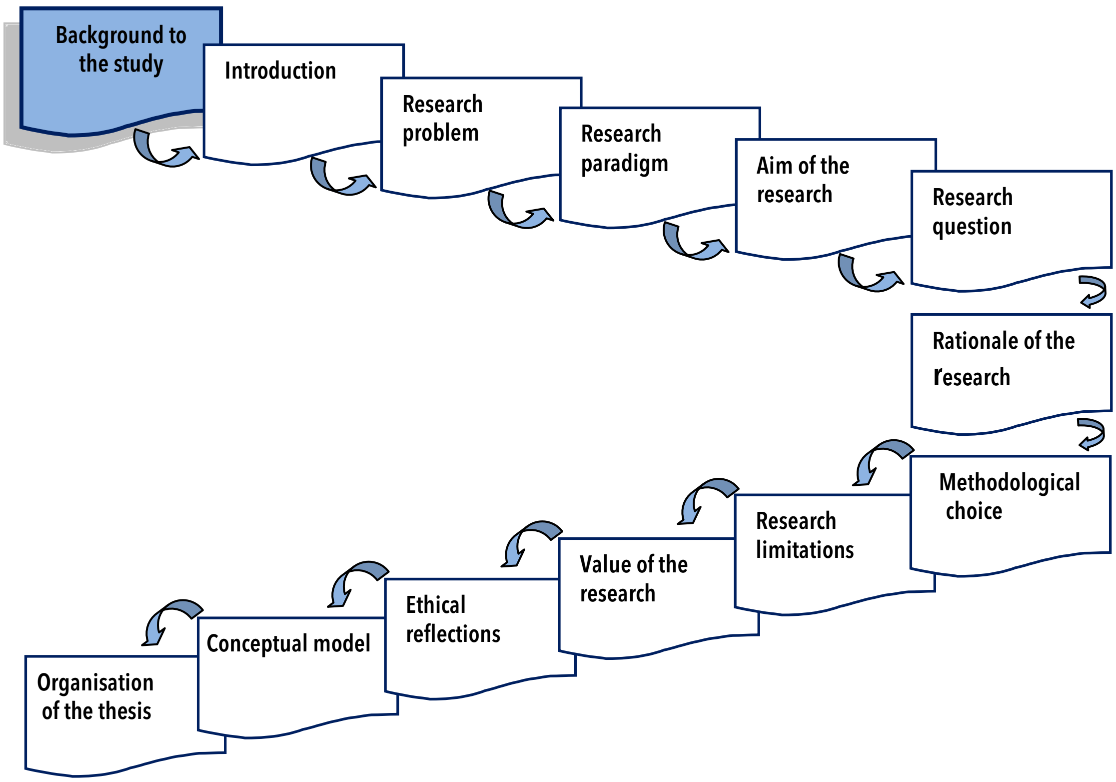


Figure 1.1: Map of Chapter One

1.0 Introduction

Back in 1983, Lewis Arthur opined that there are two ingredients relevant for 21st century education. One of them is the assistance to students to be more analytical with information. And the other is to *"encourage students to assume responsibility for their own learning–to become self-directed and lifelong learners"* (Lewis, 1983:10). Traces of Lewis' attributes are already evident in higher education where students take ownership of their learning (personalised learning) and become more analytical with issues. In this era, knowledge is also seen to be (de)constructed through negotiations and a sense of self-directedness based on its relevance to the student in a community (Cormier, 2008).

Furthermore, Target 9 of the Sustainable Development Goal 4 recognises technology as a cutting-edge tool for pedagogy in higher education. This recognition touts the urgent need for global action and student involvement in knowing how technological advances are affecting the ways in which students learn. However, Kinash, Brand and Matthew (2012) observe that students are rarely involved in curriculum decisions regarding how they learn, especially with the impact of new and constantly changing technologies. In higher education, students use various technologies to achieve their learning goals by self-directed learning or via their networks. Well-documented and ample evidence show that in higher education, emerging technologies play a significant role in students' learning environment (Kommers, 1992; Blignaut, 2002; Allison *et al.*, 2005; Prensky, 2005; Haag & Cummings, 2006; Prensky, 2006; Reeves, 2006; Cormier, 2008; Veletsianos, 2010; Warburton, 2010; Shelly, Gunter & Gunter, 2012; Ramorola, 2013; Boyd, 2014; Siemens, 2014; Towndrow & Fareed, 2014; and Kommers, 2016).

From the ideas of Lewis, Cormier and the earlier cited authorities, there is a practical challenge that stares us in the face. Current curriculum continues to follow the 'batch processing' of students fashioned for the industrial age. This discourages flexibility in considering how students can be involved and equipped with skills to create and co-create knowledge in the digital age.

Unfortunately, educators are not leveraging on the ubiquity of technology and information available to them, and are thereby hampering progress in student learning in higher education (Weller, 2011).

This thesis, therefore explores the underpinnings of students' technology use in their personal learning networks in a higher educational environment. The research was primarily conceived based on the Rhizome Theory with an idea of the biological rhizome plant as an "*open system*" whereby knowledge construction has multiple entry points (Cormier, 2008; Deleuze & Guattari, 1987:p.x). Hence, the term *rhizomatic* (from rhizome) in this thesis denotes an open, dynamic, generative and fluid system without a set of fixed structure(s) or centre. The use of the Actor Network Theory as a supporting theory also gives another perspective to the study to explain the kind of actors and interactions within students' personal learning networks.

The novelty in this research lies in the way rhizomatic maps, numeric and narrative methods are used to understand patterns of technological uses in students' personal learning networks in a higher educational learning environment. Pineda (2013) underscores the need for curriculum designers to make room for rhizomatic learning spaces since technology continues to expose students to myriad of learning opportunities and sources. Also, this research is in line with other researchers who found Rhizome Theory to be a useful lens for understanding patterns and personal learning networks via node connections and technology (Cormier, 2008; Bonnie, 2011; Guerin, 2013).

Some of the above issues that underpin patterns of students' technological uses can best be addressed by engaging with students themselves. Student engagement can be a retrospective reflection on their technological experiences in the organisation of their learning via multiple entryways (rhizomatic) (Cormier, 2008; Pineda, 2013). Students' technological experiences are broad and complex; however, with keyword searches, one is able to cede the most crucial themes such as social media, Learning Management Systems, Internet and wireless networks (Dahlstrom *et* *al.*, 2015). This substantive research also follows up on the work of Henderson, Kotz and Abyzov (2008) whose research recommended a further study on patterns of students' wireless network experiences. Findings in this research corroborate earlier studies by Barry, Murphy and Drew (2015) on the role of digital devices in achieving academic success. Again, the results from this research which indicate a significant amount of digital device ownership among students are consistent with Czerniewicz and Brown (2013) as well as Song and Lee (2012).

This research exclusively uses multiple entryways to explore students' patterns of technological uses in their personal learning networks. These multiple entryways include diverse perspectives from four different institutions found in three countries, namely South Africa, Ghana and Belgium. Data collection methods, the use and interpretation of rhizomatic maps and most importantly, students telling their own stories reflect multiple entryways focusing on the student. Once we understand what, why and how students use emerging technologies in their personal learning networks, appropriate curriculum designs will cater for individual differences and replace the outdated industrial age 'batch processing' of students currently followed.

This research is necessary because personal learning networks serve as effective tools for understanding students' learning preferences and pathways in the present complex technological milieu (Pineda, 2013). This research is also a response to Pineda's (2013) recommendation for further in-depth research on rhizomatic learning since this 'new' route in learning is motivated by technological connections.

1.1 Research problem

Reflecting as a practitioner in the field of Educational Technology and Information Technology, I realise that one of the greatest opportunities we have today as stakeholders is the proliferation and advancement of information, communication and technology in the industry. The resultant effect of information, communication and technologies in our educational delivery system is the change in learning patterns of our students (Dahlstrom & Jacqueline, 2014). Though technological advancement does not provide answers to everything, curriculum developers have failed to properly engage students in identifying how these emerging technologies are reshaping the way they learn. *"Teachers may, or may not, have considered what learners find useful or desirable, difficult or annoying when using these technologies for learning"* (Vesey, 2013:27). Especially in higher education, students' perspectives through engagement is key to the overall achievement of any sound and effective learning outcome (Katz & Aakhus 2002; Niemiec & Ryan 2009; Smyth, 2012). However, without involving them in the organisation of their own learning, the debate about fallen educational standards seems to reignite. According to Dr. Mike Boakye Yiadom, Research Fellow at the University of Cape Coast in Ghana, planning students' learning is a collective effort and so *"'much talked of' fallen standards of education [sic] can be revived if only students are given the chance to be part of the planners of the country's educational system."* Irrespective of these discussions that imply another generation of learning, Cuban (2003) suggests that most educators are yet to embrace instructional technologies. Thus, a rhizoanalysis of how students in higher education construct their personal learning networks in this era of technological advancement is much needed. The statement of the research problem is as follows:

> *The contributions made by students in curriculum planning and development are equally important inputs to achieving the learning outcomes of students (Niemiec & Ryan 2009; Smyth, 2012). Despite a continuous growth of students' personal learning networks founded on connections owing to emerging technologies in the 21st Century (Richardson & Mancabelli, 2012), higher education curriculum developers and educators have failed to engage students to discover the extent to which students' personal learning networks are underpinned by a rhizomatic model and anchored to a pervasive technological era which exposes students to multiple sources of formal and informal learning connections (Pineda, 2013; Dron & Anderson, 2016).*

1.2 Research paradigm

This research is aligned to a critical realist's perspective because knowledge is socially constructed and through reintroduction, it provides causal explanations of actual and empirical evidence. My ontological inclination also supports this critical realist's perspectives because I can "*focus on the reality of entities, generative mechanisms, deep structures, and causal powers*" (Vandenberghe, 2007) which have implications on technology use in students' personal learning networks. Again, critical realists' assumptions and features of realism correspondingly matchup with the theoretical lenses upon which this study is hinged: Rhizome Theory and Actor Network Theory. For example, I can determine what the intransitive reality is through reverse engineering, and the event in the Empirical that was caused by the mechanism in the Real which resulted in the effect in the Actual. Furthermore, I understand and interpret my results through socially constructed knowledge.

Epistemologically, reality is a social construction and is therefore subjective. There is no single reality in exploring students' personal learning networks which has been underpinned by technological affordances, but rather, there are multiple realities to understanding an individual's perspective on their personal learning networks. This position also influenced the use of multi-methods; and again, the research findings are subjective and dependent on the researcher and participants within the social contexts. Therefore, by implication, my contributions are driven by data, supported with literature and from my own professional practice, and the generalisability of findings in this research is limited to the population of the study. However, transferability of these research results to other contexts only depends on other multiple realities when a study has similar conditions, similar characteristics and similar subjects to this research.

1.3 Aim of the research

The aim driving this research is to explore the underpinnings of students' technology use in their personal learning networks in a higher educational environment.

1.4 Research question

The central question of this research is this: to what extent does technological influence on students' personal learning networks show traces of Rhizomatic Learning in higher education?

To effectively answer this primary question, the research question was further decomposed into four sub-research questions and four hypotheses which emanated from three contexts (see section 3.3.1) and preliminary literature review at the proposal stage.

1.4.1 Sub-research questions, context of formulation, objectives & methods

Table 1.1 shows the four sub-research questions, the context within which the questions were formulated, and their objectives and methods used in answering the questions for the study.

Table 1.1: Sub-research questions, context objectives and research methods

Sub-Research Question	Context	Objective	Method
1. What actors are in a rhizomatic learning network?	Theoretical	To identify actors in a rhizomatic learning network	Rhizomatic Map Analysis Interviews •Individual •Focus group
2. How are the emergent patterns in a rhizomatic learning network related?	Theoretical	To map out the network relationships in a rhizomatic learning network	
3. What digital devices are owned by students in higher education?	Theoretical and professional	To find the significance of digital device ownership towards the academic success of higher education students	Survey Interviews •Individual & •Focus group
4. To what extent are the devices used by students perceived to be a promoter of their academic success?	Theoretical and professional	To find out the about the perceived importance of the devices used by students towards their academic success	

Table 1.2 is a summary of the context within which all research hypotheses and their related research methods used in this research is reported.

1.4.2 Research hypotheses, context of formulation, objectives & methods

The four research hypotheses of this research, contexts, objectives and methods are presented in Table 1.2.

Table 1.2: Research hypotheses, context, objectives and research methods

Research Hypothesis	Context	Objective	Method
1. There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success	Theoretical, Professional and Organisational	To explore the difference in the self-perceived importance of handheld mobile devices for academic success among the four student cohorts	Survey and Focus Group interviews
2. There is no statistically significant difference among the four cohorts of students in terms of experiences with their university wireless networks		To explore the difference in students' experiences with their University Wireless Networks among the four student cohorts	
3. There is no statistically significant difference among the four cohorts of students in terms of their satisfaction level of Learning Management System in their institutions		To explore the difference in students' satisfaction level of Learning Management System in their institutions among the four student cohorts	
4. There is no statistically significant difference among the four cohorts of students in terms of their experiences with technology use in their institutions		To explore the difference in students' experiences with technology use in their institutions among the four student cohorts	

1.5 Rationale of the research

This research should be of interest from various perspectives because students' acquisition of knowledge now assumes a 'nomadic' identity due to technological undertones in the educational landscape. My rationale for this research is premised on two points: practical and academic rationales.

1.5.1 Practical rationale

The 21st century has seen dramatic proliferation and advancement of technological tools which increasingly permeate the fabric of our everyday activities, including the learning activities of students. Regardless of what universities provide (curriculum), much informal speculation suggests that much learning occurs outside the school setting due to a seemingly vast array of data and information available to the students in a semantic web. Such assumptions have consequential effects on the delivery of higher education. According to Wheeler (2012:2) "*a lot of what is learned (some claim up to 70 per cent) is informal and with a powerful enough network of connections to a personal learning network, there is no limit to what a student can achieve.*"

There appears to be a real practical challenge ahead of us (in terms of higher education) if we do not heed to Wheeler's assertions. Though technology can be a lever to improve learning outcomes, its role in society and the economy which affects student learning leaves much to be re-examined (Warschauer, 2011:10). Associating the beginning of the 21st century to a technology rich environment, Saadatmand and Kumpulainen (2012:267) opined that the pedagogies underlying learning in the beginning of this century are also evolving to meet the requirements of contemporary students. It appears that technological integration in learning is much slower than expected. Silvas (2011:00) argued that there is a real need for classroom technological enhancement to cater for students' individual differences and the need for "*developing 21st century skills of both analytical thinking and technology literacy*."

As an example, it has become obvious that there is reliance on social media by our current crop of students in building stronger learning networks, collaborations and social capital in a fast moving globalised village. Therefore, teaching, learning and curriculum must be competitively positioned to align new trends (CISCO, 2008:8). Admittedly, individual differences among students in higher education have become more pronounced due to the different ways in which students construct knowledge with the assistance of emerging technologies. These issues can be addressed when students who are the centre of learning are involved in mapping out the technologies they use in their personal learning networks to achieve learning tasks in higher education. Once patterns of technological use in student learning can be leveraged within a higher educational environment, students can apply appropriate technologies to their learning for maximum benefits. A number of practical societal challenges – ranging from unemployment, uninformed society and crimes – can also be averted and redirected to productive ventures for societal gains since education uplifts positive change, advancement and development.

1.5.2 Academic rationale

Fundamentally, this research was undertaken to contribute to the body of knowledge in the fields of Information Technology Education and Educational Technology, especially pertaining to student's personal learning and curriculum development in higher education. In my practical rationale, I described a picture of the learning situation where technology impacts pedagogy in higher education, but because of the incoherence in pattern mapping of students' technological use in their personal learning networks, there is urgent need for research to fill this gap.

In terms of patterns of technological use in learning and education in higher education, much emphasis has been placed on technological integration (Ramorola, 2013), social networking (Anderson, 2009; Kommers, 2016), policies (Blignaut *et al.*, 2010; Ramorola, 2013) and social media (Alsanie, 2015). But there has not been any integrated and holistic research that considers emerging patterns of students' technological uses in their personal learning networks in higher education. Furthermore, no research as of yet has been sighted to have included both the Rhizome Theory and Actor Network Theory to understand and map the emerging patterns of students' technological uses in their personal learning networks in higher education through both numeric and narrative methods. Grounded in the belief that there are multiple entryways to knowledge construction, this research also contributes an understanding to the kinds and uses of technologies by higher education students in their personal learning networks and to how curriculum developers and other educational stakeholders can leverage on the results and gaps identified. Methodological choice is covered in the upcoming section, concerning research design and related issues.

1.6 Methodological choice

1.6.1 Research design

This research is exploratory in nature with a design focusing on the numeric and narrative approaches. This methodological choice followed the Frameworks for an Integrated Methodology (FraIM) which also detests the use of 'technical' terms such as qualitative and quantitative due to the confusion it poses to readers (Plowright, 2011). An advantage of using this FraIM design is the complementary roles played by both narrative and numerical approaches in researching the research problem (Saunders, Lewis & Thornhill, 2012), as it made data triangulation possible, and in the research, narratives from the individual interviews and focus group interviews lead to further interpretations of certain outcomes from the numeric method and vice versa. Some challenges that must be addressed with this design include time consumption (Driscoll *et al.*, 2007), expense (Johnson & Onwuegbuzie, 2004) and skills to manage data. Handling these constraints required the dedication of plenty of time to this research. Again, I relied on open source software for my analyses, and when not available, I was fortunate to get free licenses for proprietary software from Cape Peninsula University of Technology for analytical software otherwise not affordable.

1.6.2 Data collection strategy and sampling techniques

Data was gathered through focus group interviews, individual interviews, a survey and a Rhizomatic map or rhizomatic learning network map. Ten focus group interviews were conducted with students in three institutions of higher education: namely, GAC and GBR in Ghana, and SAR in South Africa (Table 3.4). Focus group interviews were selected to enable a triangulation of findings from other data sources (Krueger, 1986; Byers & Wilcox, 1988).

Interviews involving three students from BEL in Belgium, one expert and 21 lecturers from GAC and GBR in Ghana and SAR in South Africa (Table 3.7), were conducted with the foremost aim of soliciting answers, experiences, and perspectives to the study of students' technology use in their personal learning networks in higher education (Yin, 2014). Again, the interviews were purposed to provide grounds for rich sources of data and triangulation through the adaptation of a 4-stage in-depth approach postulated by Kolb (2008): opening, questioning, probing and closing.

In total, 496 students responded to the questionnaire entitled Student Technology Survey (STS) adapted from EDUCAUSE Center for Analysis and Research. Data collected through the questionnaire were through paper-based (PBSQ) and web-based survey questionnaires (WBSQ) based on the preference of the students (Manfreda *et al.,* 2002). The aim of the survey was to extract data from students to allow for comparison of results among the institutions as a means of finding answers to two of the sub-research questions (2 and 3) and all the four hypotheses.

'Rhizomatic map' or 'rhizomatic learning network map' were coined for this research as a conceptual and relational mapping of connections (complex) in students' personal learning networks. The complex network maps from all four institutions were developed from students' individual personal learning networks which they personally drew. Rhizomatic learning network maps were the main tools employed in achieving the first two objectives of this research.

1.6.3 Research process

FraIM posits that research begins with research questions formulated within some contexts. My research was therefore guided by theoretical, professional and organisational contexts which underpinned the sub-research questions and research hypotheses. Sampling was at two levels: institutional and participant/respondent levels. Four institutions were purposely sampled as sites for the research due to certain attributes. Figure 1.2 presents an infographic map of the sites and locations of the four institutions selected.

Figure 1.2: Infographic map of sites and location of the research

Two traditional universities and two Universities of Technology were sampled purposely from three countries: South Africa, where I study as a doctoral candidate; Ghana, where I work; and Belgium, where I was a Visiting Scholar (*see Appendix G*). First, the institutions were sampled due to their proximity for data gathering and resources for the research. While the GAC in Ghana and BEL in Belgium represented traditional universities, GBR in Ghana and SAR in South Africa represented Universities of Technology. Second-level sampling also used snowballing and purposive sampling to identify participants. For instance, purposive sampling was used for initially identifying students or lecturers who then referred (snowballing) me to identify other potential students and lecturers for focus group interviews and individual interviews correspondingly. For his role as a chairman of Ghana's Educational Reform in 2007, one professor-interviewee was purposely sampled as an expert.

For the surveys, I was assisted by heads of departments who earmarked certain year groups and classes for data collection. Opportunities to speak with respondents allowed me to brief them on the rationale for the research and showcase the web link to the online survey for those who preferred an online mode of responding. Finally, after the focus group interviews, some participants were randomly selected to develop their personal learning networks which formed the rhizomatic learning network maps in this research.

1.6.4 Analysis and interpretation of data

After data gathering and organisation, data was screened, cleaned and coded for analyses. The analyses covered two data types – Numeric and Narrative – drawing on learning analytics, descriptive analysis, and multivariate analysis. Four different statistical tools aided my analyses. Gephi 0.9.1 beta version 3 was used for both numeric and narrative data analysis emerging from the Rhizomatic maps. For the rest of the numeric data, Statistical Product and Service Solutions (SPSS) version 18.0 were used for survey analysis and Excel for the charts. Finally, narrative data from interviews and focus groups were analysed using Atlas.ti version 7.5.11.

After presentation of results for each sub-research question and hypothesis, analyses from interviews and literature were used to support the discussions and emerging evidence from the data. Data from the Rhizomatic maps which answered the first two sub-research questions were analysed using learning analytics. Interpretations of the results were descriptive based on statistical and physical inspection of the maps. The last two sub-research questions were presented in figures and tables of frequencies and percentages and analysed descriptively. In analysing the four research hypotheses, a multivariate analysis which touched on factor analysis and reliability analysis through to ANOVA was employed, with results also presented in tables and figures. The succeeding two sections touch on the limitations and value of the research.

1.7 Limitations of the research

Findings from this research are only generalisable within the population of this research because of the sampling techniques employed. For instance, all four institutions where the study resided were purposely selected, and also recruitment of respondents for the surveys was not based on any probability sampling (Creswell, 2013; Yin, 2014). Yet again, in view of my epistemological stance, interpretation of reality is subjective based on my engagement with the participants, data and my professional experience. Practically, during the interviews, quite a bit of time was required to reach data saturation, resulting in huge loads of data coupled with other data sources such as rhizomatic maps and surveys. Moreover, working with data from all four institutions was occasionally overwhelming, requiring critical attention.

1.8 Value of the research

Generally, this research is not limited in value to only emerging and established Information/Educational Technologists and researchers, curriculum developers, higher education, the institutions and countries where studies were conducted, but relates to stakeholders in any higher education delivery system. This area, especially in learning analytics, is emerging, and for that reason needs critical investigation to inform educational reform policies. My research then adds value to current research in educational technology in a variety of ways, including the following:

1. Reappraisal of teaching and learning processes in higher education;
2. Awareness creation of the role played by technologies in students' Rhizomatic Learning Networks;
3. Literature and empirical data on the patterns of technological uses in learning by students in higher education;
4. Literature on the characteristics of the 21st century students in educational stakeholders;

5. Identification of the gaps that exist between so-called 'characteristics of 21st century students'; and
6. Informed basis for other studies into how the 21st century higher education student ought to be taught based on findings from a rhizomatic learning point of view.

Ethical reflections on the research, coming after this value of the research section, will address a number of ethical highlights of the research.

1.9 Ethical reflections of the research

One critical issue regarding research starts from its ethical foundations (Wellington & Szczerbinski, 2007). Throughout the research process, a number of ethical factors guided this study. The necessary approvals and permissions were sought. Data collection and analysis were conducted with strict adherence to the principles of informed consent and implied consent, voluntary participation, harmlessness, anonymity and confidentiality (see details on section 3.11).

1.10 Conceptual model

Based on the six principles of the Rhizome Theory and four elements earlier identified in the Actor Network Theory, a conceptual model (Miles & Huberman, 1994) is presented graphically in Figure 1.3. The interplay of elements from the two theories was integrated to inform understanding of the subject matter, thereby giving guidance to analysis and interpretation of results. In the analysis, the research sought to map the actors, relationships and differences in students' personal learning networks. Identifying the actors, relationships and differences assisted in exploring the extent of technological influence on students' personal learning networks with possible traces of Rhizomatic Learning.

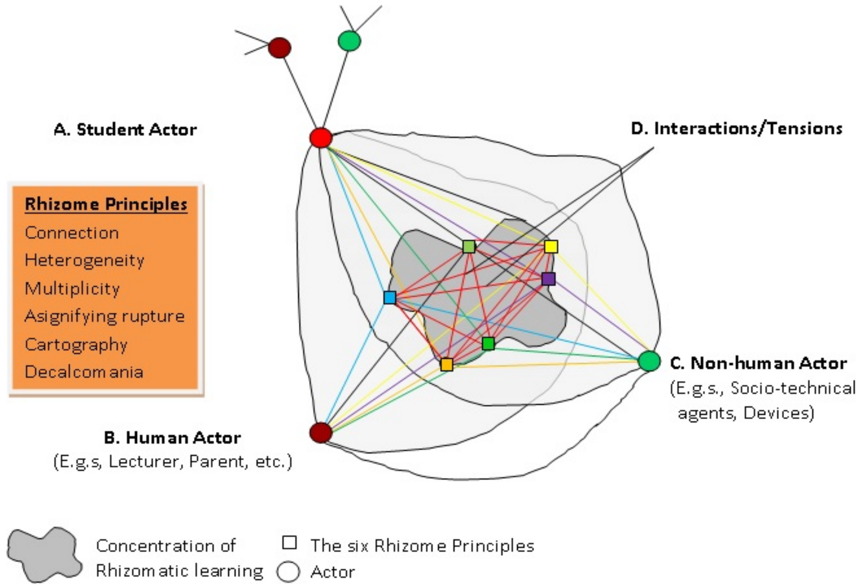


Figure 1.3: Conceptual model

The conceptual model depicts interplay among a student and two basic actors (human and non-human) of the student's personal learning networks. The model suggests that there is no single entry point or definite structure in the construction of knowledge for a student when interacting with the other actors. Elements of this conceptual model, based on the six combined principles of Rhizome Theory and Actor Network Theory, are explained below.

1. **Student Actor**: From the conceptual model in Figure 1.3, a student actor is the main actor around which all other personal learning activities of the student are centred. In this context, the student actor, representing a student in higher education, relates with two main actors categorised into human and non-human actors. In between these actors of the student's personal learning network evolve other networks of varied strengths, including actions of rhizomatic character. Basically, rhizome characteristics emerge within the context of interaction between the various actors.

2. **Human Actor:** As shown in the model, human actors form the group of humans found as part of the student's personal learning network. Biologically, the student actor belongs to the category of human actor, with examples including lecturers, classmates, parents and facilitators.
3. **Non-human Actor:** All inanimate and technical objects are represented in this class of actors. Any element that is not human within the context of students' personal learning networks is referred to as a 'non-human actor'. Various kinds of interactions, devices, technologies and characteristics are examples of this category.
4. **Network:** The network is the generative embodiment of all actors, processes, actants (objects or receivers of an actor's action) of the student's personal learning network. From the conceptual model, the ultimate network (personal learning network) is sustained by several other networks, usually enhanced through technology. Each of the four universities selected forms institutional learning networks feeding into the student's personal learning network.
5. **Interactions/Tensions:** The relationship or interface between the student actor and any other resources in a personal learning network shall be considered as 'interaction'. At its peak, it is understandable that 'tensions' will cause a burst and sometimes be the source of breakaways or weak connections between actors. Tensions also create cliques which may result in other splinter or study groups of students. This resonates strongly with the Rhizome's *Asignifying rupture* (see section 2.9.4) where students keep older ties from high school learning communities but indeed may rarely or sparingly contribute the communal work.
6. **Rhizome Theory principles** (see section 2.9*)***:** These six principles only describe characteristics of the kind of relationship that exists between actors at the centre of the student's personal learning network. For instance, *connection* suggests that a student interacts and is linked to learning resources within his personal learning network.

Cartography and *decalcomania,* which represent an open system such as a map, suggest the different learning paths and personal learning networks of each student. It again holds that these networks are uniquely created by the students themselves with or without technology by *connecting* with actors of their choice. *Heterogeneity* guides the exploration to discover the diversity of the student and other actors in terms of their interactions.

All actors do not communicate only with themselves or specific actors. They sometimes branch to construct knowledge from the usual actors. *Multiplicity* also helps understanding of the numerous entry pathways to knowledge. There is no single way to measure how knowledge is acquired. Basically, *Asignifying rupture* helps to analyse how physically active a relationship is between actors. An inactive relationship between the student and a particular technological platform does not mean death of that relationship. Usually, the characteristic favours actors who get passive or dormant by rechanneling their focus and more resources to other actors based on usefulness. This also does not imply total break away.

1.11 Organisation of the thesis

The rest of the research report has been organised into five chapters, as described in the ensuing paragraphs.

Doctoral Thesis Snapshot: The entire thesis has been captured in a large foldable sheet inserted between the end of Chapter One and the beginning of Chapter Two.

Chapter Two – Review of Related Literature: Chapter Two is part of the formalisation process that draws on current and previous studies presented under six main thematic areas. Through keyword searches, the key authors and related works emerged. The review of related literature not only allowed for contextualisation of the subject matter, but also to identify gaps and thus situate this study into existing literature (Booth *et al.*, 2012). The focus of the second part of this chapter was on **theoretical lenses** for the conduct of this research, as this research was founded on two theories: Rhizome Theory constituting the main theory, and Actor Network Theory.

Chapter Three – Research Philosophy and Methodological Choice: This chapter, aptly named, touched on my **research philosophy and methodological choice,** shedding light on and justifying the choice of critical realism and Frameworks for Integrated Methodologies (FraIM) which together formed the research philosophy and methodological choice of this research accordingly.

Chapter Four –Results and Discussions I -Sub-Research Questions: Under this chapter, analysis of results and discussions of findings emanating from the four sub-research questions are presented.

Chapter Five – Results and Discussions II - Research Hypotheses: Chapter Five presents analysis of results and discusses findings gathered from the four research hypotheses.

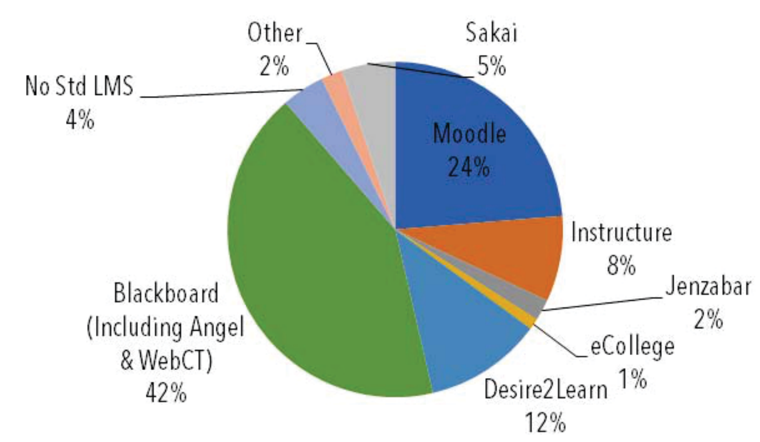
Chapter Six – Conclusion: This chapter was comprises of the summary, reflections and recommendations. The summary presents an overview of the research while the reflection portion itemises lessons learnt. Finally, the recommendations capture areas which must be given attention based on policies, practice and further research.

The next page is a snapshot that captures in a large paper format what this thesis is all about. This snapshot is organised into four parts presented in tables. The first part of this document briefly reports on the title, aim, research question and design. The rest of the first part is research philosophy and theoretical lenses that underpinned this research. The second and third parts are succinct exposition according to each objective and sub-research question/hypothesis, essential points from the literature review, methods used, results and recommendations. The last part presents a pictograph of the conceptual model and the outcomes from the research mapped unto the conceptual model which serves as my contribution of the study.

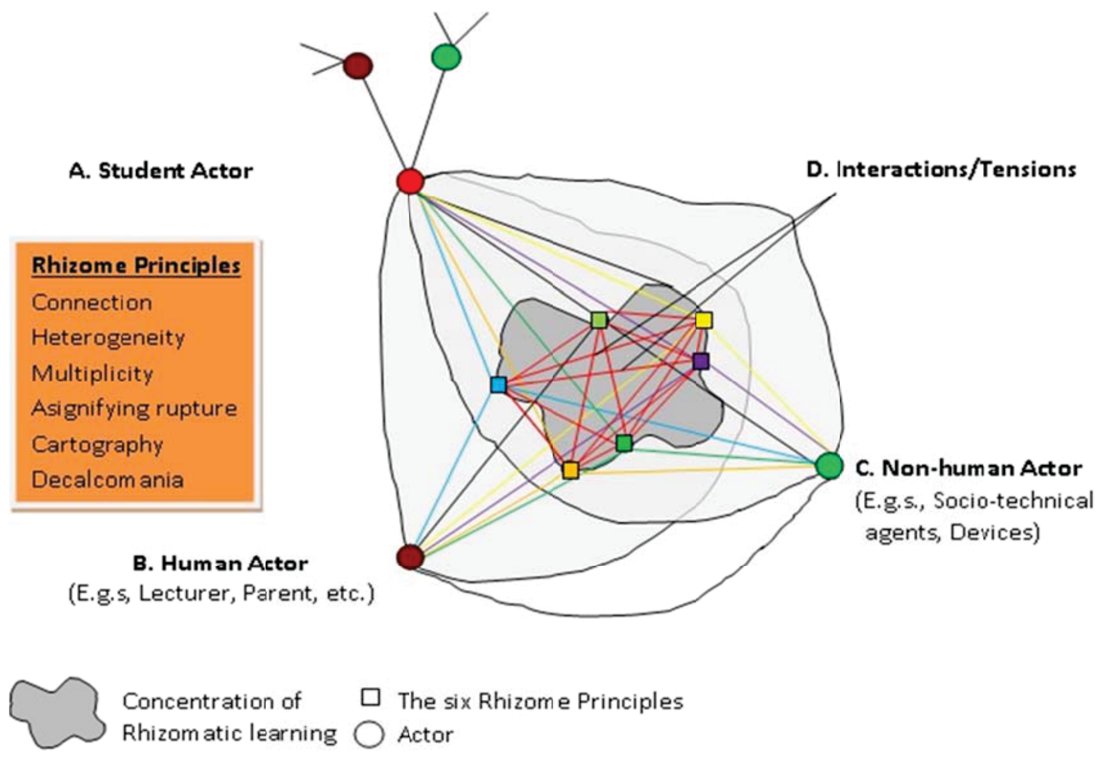
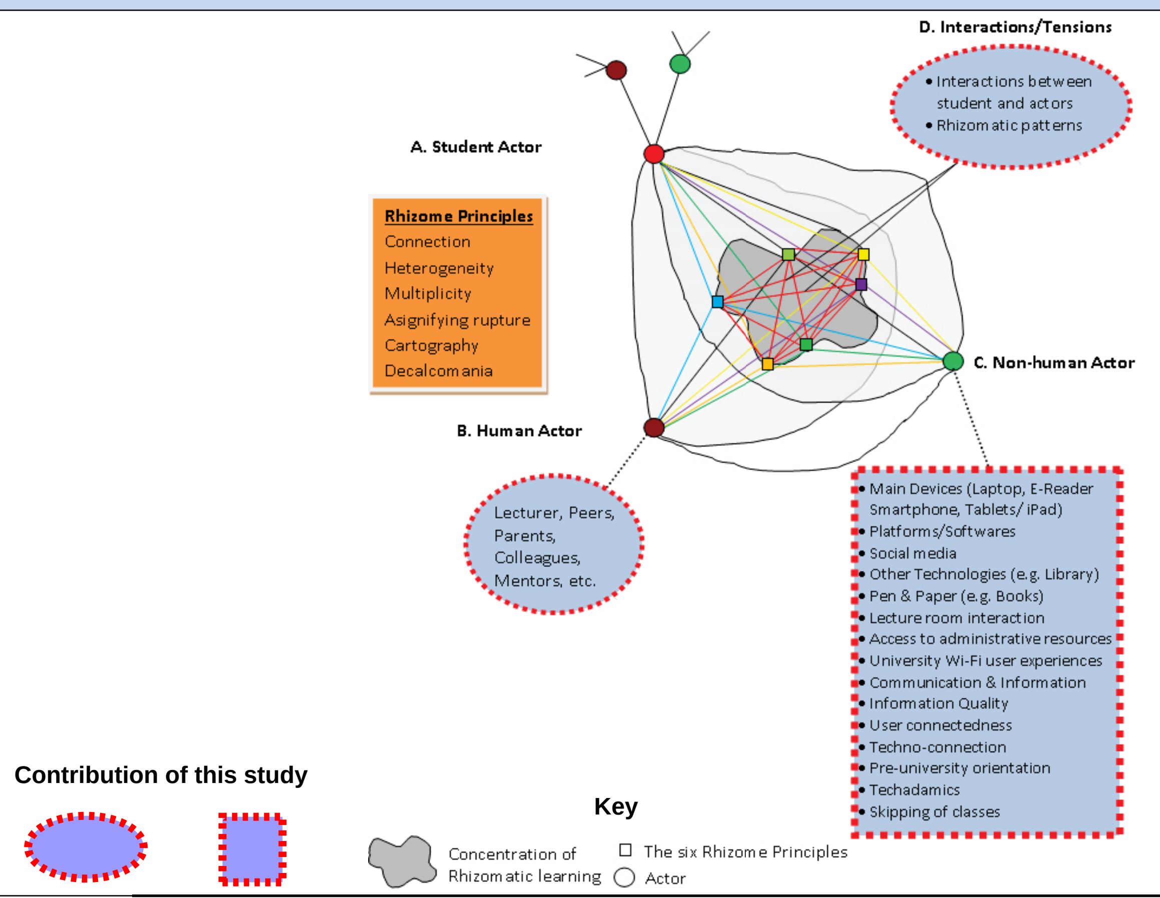
Doctoral Thesis Snapshot - Simon - Peter Kafui Aheto

Title:	**Patterns of the use of technology by students in Higher Education**
Aim:	The aim driving this research is to explore the underpinnings of students' technology use in their personal learning networks in a higher educational environment
Research Question:	To what extent does technological influence on students' personal learning networks show traces of rhizomatic learning in higher education?
Research Design:	Frameworks for an Integrated Methodology (FraIM) (Plowright, 2011) • narrative and numeric research
Philosophical underpinning:	
• Paradigm	Critical realism
• Ontology:	Knowledge of reality is socially constructed, subjective and intrinsic; hence, it cannot be known. Nonetheless, being unknown, there may be multiple realities only discoverable through many viewpoints by participants and respondents in this study
• Epistemology:	The complexities and multiple entryways associated with technology and its application in learning environments create the grounds for social conditioning which must be interpreted with an eye toward multiple realities. Rhizomatic Learning Network studies form the basis for exploring technological uses in students' personal learning networks
• Axiology:	This entails acknowledgement of research biases (especially for narrative studies). However, a way of dealing with this challenge is through reintroduction or insights from inferences. Therefore, the contributions to this study from students, lecturers and literature are highly valued as rich input toward the knowledge of the kind of relationships that exist in students' personal learning networks
Theoretical lenses:	1. Rhizome Theory 2. Actor Network Theory

Objective	Sub-Question	Literature Review (essential points)	Methods	Results	Recommendations
1. To identify actors in a rhizomatic learning network	What actors are in a rhizomatic learning network?	**Identification of actors in personal learning networks** • Learner (Drachsler *et al.*, 2008) • Relationships, interactions (Bauer, 2010;Van der Krogt, 1998:162) • Ideas, fields or communities, learning structures and learning processes (Siemens, 2004) • Community, curriculum (Cormier, 2008) • Connectors (Muñoz-Erickson & Cutts, 2016) • Connections and connectors (Warlick, 2009) • Social capital and connections (Couros, 2010) **Humans and non-humans** • Learner and RSS aggregator (*Neubauer et al.*, 2011) • Professors, devices, general knowledge, social media platforms, communication and other technologies (Pineda, 2013)	Rhizomatic map analysis Interviews •individual & •focus group	**<u>Actors:</u> 218** **<u>Categories:</u>** Humans and non-humans **Humans** Student, Peers/Colleagues, Lecturers, Mentors, Parents, Research Assistants **Non-Humans** Devices Platforms/Softwares Social media Other technologies Interactions	Further investigations into: 1. Lone (single) occurring actors per institution 2. Unique contributions of lone actors to success of students' personal learning networks
2. To map out the network relationships in a rhizomatic learning network	How are the emergent patterns in a rhizomatic learning network related?	**Actors' relationship in learning networks** create opportunity for learning choices (Nussbaum-Beach, 2013). **Key elements in a learning network**: *learning structures* and *learning processes* are strongly influenced by *learning actors* (Van der Krogt, 1998) **Personal learning network:** **Varied dimensions** showformal and informal learning connections (Harlan, 2009) **Types:** • Personally Maintained Synchronous Connections, Personally and Socially Maintained Semi-Synchronous Connections and Dynamic Maintained Asynchronous Connections (Warlick, 2009) • Rhizomatic Learning Network (Cormier, 2011; Aheto & Cronjé, 2014) • Learner operates as central actor connected to all other actors via actions and inactions in a learner's learning network. This learning network is founded on the principles of the rhizome theory (Cormier, 2011; Aheto & Cronjé, 2014) **Relationships in a Rhizomatic learning network:** • Actors are nodes that represent junctions, intersections or meeting points in the network (Callon, 1991, 1987; Callon, 1987, 1991; Law, 1992; Haythornthwaite, 1996; Latour, 1987, 2005) • Represents "*ideas, fields or communities*" that also influence *"learning communities"* (Siemens, 2004) • Describes the community as the curriculum (Cormier, 2008) • Learning networks promote active learning where students communicate and collaborate in knowledge creation in their learning networks (Bauer, 2010) • Learner-centeredness promotes individual differences (Drachsler *et al.,* 2008)	Rhizomatic map analysis Interviews •individual & •focus group	The learning networks exhibit traces of the biological rhizome plant. Rhizome principles as a lens explain the connections, characteristics, relationships, similarities and differences. **Connection and Heterogeneity:** Students are primary actors/nodes/ connectors who constitute their own learning networks of humans and non-humans. The networks are usually dynamic, fluid and varied and growth- dependent on the student. **Multiplicity:** Existence of multiple entryways in learning networks. For instance, Smartphones and laptops allow students to connect to various learning resources. Information can be accessed and verified from multiple sources **Asignifying rupture:** Students' passive involvement in a learning network does not signify a total breakaway; rather, a rechannelling of more attention to another learning resource or activity **Cartography and Decalcomania:** Students' experiences, learning networks, relationships and technologies are unique and diverse	The institutions must periodically generate rhizomatic learning network maps of students on their learning achievements
3. To find out which digital devices are owned by students in higher education	What digital devices are owned by students in higher education?	**Digital device ownership by students in higher education** • A review focused on handheld digital devices (EDUCAUSE, 2015) • Students' ownership and educational use of digital devices are due to *"convenience, connection and control"* (Oliver & Goerke, 2008:78); multifaceted perception by institutions and students in achieving various academic objectives (Barry *et al.*, 2015) • Institutional ban on digital device ownership and use because they are seen as disruptive (Amedeker, 2013; Doward, 2015; Veletsianos, 2010) • Institutional promotion of ownership and use of digital devices because they create better and stronger platforms for mobile learning and collaboration in higher education (Falloon, 2015; Mikie & Anido, 2006; Muyinda *et al.*, 2011; Ng'ambi, 2013) **Commonly owned digital devices owned by students:** • **Laptop** (Buchele & Owusu-Aning, 2007; Sharples *et al.* 2014) • **Smartphone/Cell phone** (Backer,2010; Czerniewicz & Brown, 2013;Paterson & Low, 2011; Sharples *et al.* 2014;Witecki & Nonnecke, 2015) • **Tablet/iPad** (Sharples *et al.* 2014; Song & Lee, 2012) • **E-Reader** (Boroughs, 2010; Song & Lee, 2012) • **Others:** iPod or MP3 player (Evans, 2008; Fernandez *et al.*, 2009; Lonn & Teasley, 2009a; O'Bannon *et al.*, 2011) • Amazon Kindle and Nook (Song & Lee, 2012)	Survey Interviews •individual & •focus group	**Main digital devices owned by students:** Laptop, Tablet/iPad, Smartphone, E-Reader **Others:** iPod or MP3 player, Amazon Kindle and Nook, Camera, Google Nexus 4,Memory card, Projector, Radio, Smart recorder, Voice recorder, Wacom Tablet	1. Ownership and use of digital devices should not be seen as the ultimate solution to all pedagogical challenges 2. Institutions should leverage on the devices owned (especially laptops and Smartphones)by students to support their personal learning
4. To find out about the perceived importance of the devices used by students towards their academic success.	To what extent are the devices used by students perceived to be a promoter of their academic success?	**Importance of devices used by students towards academic success** • Smartphones and *Facebook,* both in teaching and learning, promote students' self-motivation and autonomy and boost learning (Backer, 2010) • Derivation of motivation and creative uses of devices to solve educational problems (Bruner & Kumar, 2005) • Students who own tablets and E-readers access course materials on them (Cross, Sharples& Healing) • Gaming improves memory of students; Bluetooth and other handheld devices provide students with real-time access to the world (Bryan, 2006) • Enhanced students' capacities in coordination, negotiation, mobility, interactivity, and organisation of resources and communication (Falloon, 2015) • Ubiquitous learning (Evans, 2008); Development of intuition (Schneps, *et al.*, 2014) • PocketPCs are used in monitoring patients' encounters in medical education (Jackson, *et al.*, 2005) • Warschauer (2010) argues that students' exposure to a variety of digital resources means they are well- skilled in media content creation technologies. However, his argument did not relate the effects of the exposure on their personal learning networks **Challenges:** • Varied levels of students' skills in the use of digital devices for learning (Backer, 2010) • Despite the fact that handheld devices help to compress volumes of books and course materials, some faculties are unwilling to incorporate them into their teaching (Day-Black & Merrill, 2015) • Text management, smaller screens of devices (Falloon, 2015), downloads (Gupta & Koo, 2010), access to wireless networks (Motiwalla, 2015), isolation (Walmsley, 2014) and differences in access to library resources (Mcknight, 2011)	Survey Interviews •individual & •focus group	• Perceptions differ across institutions and devices • In order of importance:laptops, Smartphones, Tablets/iPads and E-readers are perceived promoters of students' academic success • Smartphones are useful but laptops are of academic importance to more than 75% of the students • Laptops are widely used for academic work because they integrate properties of other devices such as Tablets Smartphones and E-readers ✓ Other factors include sustainable battery power, large screen and storage and speed • E-readers are not widely used as compared to laptops and Smartphones as they have more limited functionalities	Full engagement of students in how to integrate handheld digital devices in the mainstream curriculum. This will enhance collaborations and real-time connections to students

Objective	Hypothesis	Literature Review (essential points)	Methods	Results	Recommendations
5. To explore the difference in self-perceived importance of handheld mobile devices for academic success among the four student cohorts	There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of academic success	*See details on last two reviews on items 3 & 4*	Survey Interviews • Individual & • Focus group	**Three factors** of self-perceived importance of handheld mobile devices for academic success: ✓ Lecture room engagement & interaction ✓ Access to administrative resources ✓ Communication & Information • **Differences** in students' perception due to: ✓ Faculty integration levels of handheld devices in curriculum ✓ Institutional policies ✓ Access to university portals ✓ Access to learning resources • Reliance of students on handheld mobile devices across the institutions • Reliance is because the devices make learning more ubiquitous and help students validate information from the Internet and negotiate learning, especially through virtual groups	Full engagement of students in how to integrate handheld digital devices in the mainstream curriculum. This will enhance collaborations and real-time connection to students
6. To explore the difference in students' experiences with their university wireless networks among the four student cohorts	There is no statistically significant difference among the four cohorts of students in terms of their experiences with their university wireless networks	**University Wireless Networks:** • Single most important provision to academic and research activities in higher education (Eduroam, 2016; McKenzie, 2001) • Abundant literature on the benefits, challenges and projects of universities wireless networks (Saha & Karpinski, 2016) • Future focus of students' wireless network experiences per connection of information among students and lecture theatres will include learning experiences and university resources (Castells, 2011). **Advantages to students:** • Relaxed fit, strategic deployment, low profile, simplicity, easy movement, flexibility, cleanliness, convenience and speed in terms of connectivity (McKenzie, 2001). Eduroam is in about 70 countries (Eduroam, 2016) • Massive investment in university wireless networks by 2020 (Anderson *et al.,* 2012). **Challenges:** • Cost (Galbus, 2001) • Privacy and security compromises, limited bandwidth, and reliance on battery (when mobile) (Pahlavan & Levesque, 2005) **Research Gaps:** • No follow-up research on Henderson *et al.'s* (2008) recommendations for further research into students' wireless network behaviour • No research focus on students' experiences with university wireless networks (Gupta & Koo, 2010) • In-class and out-class university wireless networks need coordination to support students and faculties (Oblinger *et al.,* 2005)	Survey Interviews • Individual & • Focus group	**A factor** of experiences with students' university wireless networks: ✓ University WiFi user experiences ✓ User connectedness • **Differences** in students' experiences due to: ✓ Institutional policies: all three institutions in Africa had some platforms or softwares blocked (*Facebook* and *Skype*) ✓ Access to bandwidth ✓ Corporate support of university wireless networks • Students and staff resort to personal wireless networks or dongles to access sites and platforms blocked by their institutions • Bandwidth excuses from authorities are unacceptable to students	1. The two institutions in Ghana should lead an implementation of an efficient inter-university wireless network system in Ghana such as Eduroam which exists in South Africa and Belgium. This move will make university wireless network systems more ubiquitous in supporting student learning. It will also curtail excuses related to bandwidth issues raised by authorities. 2. All three African universities in this research must review their policies that temporarily or permanently block certain sites (such as *Facebook* and *Skype*) on their university portals. Exploration into the educational values of those sites can be advantageous to students' personal learning networks in achieving their learning goals. Lessons from the Belgian institution can be useful to the African institutions
7. To explore the difference in students' satisfaction level of Learning Management System in their institutions among the four student cohorts	There is no statistically significant difference among the four cohorts of students in terms of their satisfaction level of Learning Management System in their institutions	**Learning Management Systems:** • Students' experiences, satisfaction and interests depend on the experiences staff take them through (Govender & Govender, 2014; Lonn & Teasley, 2009b) • Students experiences vary based on subject specifics, expertise of staff and institutional policies in promoting interaction via learning management systems (Murshitha& Wickramarachchi, 2016) • Correlation between students satisfaction and LMS use (Naveh *et al.,* 2010) • See commonly used learning management systems in Figure 2.7 according to Green (2015)  **Advantages to students:** • LMS can predict learning styles of students (Graf, *et al.,* 2009) • Prior access to topics by students for deliberations via LMS enhances effectual class engagement (Lonn & Teasley, 2000b) • Students' adoption of an LMS is hinged to interaction with lecturers and other students, experience and self- efficiency (Murshitha & Wickramarachchi, 2016) **Challenges:** • Improper needs assessment and training before adoption of LMS by institutions (Bower, 2008; Conole, 2013) • LMSs have created tensions in some institutions than their intent (Day *et al.*2000) **Research Gaps:** • Too much research focused on technological aspects of LMSs (McGill & Klobas, 2009) • Improper needs assessment and training before adoption of LMS by institutions (Bower, 2008; Conole, 2013)	Survey Interviews • Individual & • Focus group	**Two factors** of satisfaction level of students' learning management system in their institutions: ✓ Information quality ✓ User connectedness • **Differences** in students' satisfaction levels due to: ✓ Kinds of LMSs used by the institutions ✓ Institutional policies • Dissatisfaction in terms of LMS usage among the institutions in Africa • Student groups with challenges in accessing their LMSs keep one or two students as 'watch dogs' who are versed in using the LMS to monitor class assignments or announcements on the platforms • Belgium institution's LMS, Toledo, is proven to be very useful to students and staff • Toledo continues to be continuously modified to suit students and staff learning and teaching needs respectively	1. All the three African universities must conscientiously engage students and staff to make their learning management systems more user-friendly 2. Toledo in the Belgium University works because of the sense ownership by students and staff through customisation to suit their uses. The African universities can adopt lessons from LMS management at the Belgium institution
8. To explore the difference in students' experiences with technology use in their institutions among the four student cohorts	There is no statistically significant difference among the four cohorts of students in terms of their experiences with technology use in their institutions	**Students' experiences with technology in higher educational learning environments** **Learning Environment:** • Teacher and student perspectives that cover physical school environment or technologies adopted for students Personal Learning Environments (Bates, 2005) • Three spheres of learning: Peer culture, Interest powered and Academic orientation (Ito *et al.,* 2013:62) **Characteristics of the 'so called' 21st century student:** • Multitasking (Eton, 2011; Shelly *et al.,* 2012) • Play-oriented, Random access, Digital and graphic first (Shelly *et al.,* 2012) • Content knowledge, Information, Media & Technology, (Partnership for 21st Century Skills, 2007); Self-directedness (Guglielmino, 1978) • "*Bathed in bits*" Trilling & Fadel, 2009:29) • Heutagogy (Hase & Kenyon, 2007); Digital *"native speakers"* (Prensky, 2001) **Students' experiences:** • Motivating factor to learning depends on personal interest (Attwell, 2007) • Personal learning networks founded on social networks of humans (Veletsianos, 2010) • Use of technology or social media varies among users in private universities (Falahah & Rosemala, 2012) • Technology like social media is time wasting from learning (Alsanie, 2015) • Technologies such as social media set tone for "dialogue" and collaboration among students (Ramarola, 2013) • Exposure to social media contributes to social capital of student learning (Selwyn, 2009) • Social media poses both useful and problematic issues to learning (Kassens-Noor, 2012) Social media in learning is more of mediating tools; however, its infrastructure in higher education is not leveraged upon (Tess, 2013) • Need to maximise opportunities associated with social networksby streamlining social media usage in higher education (Kommers, 2016)	Survey Interviews • Individual & • Focus group	**Four factors** of experiences with technology use in their institutions: ✓ Techno-connection ✓ Pre-university orientation ✓ Techademics ✓ Skipping of classes • **Differences** in students' experiences with technology use in their institutions due to: ✓ Policies ✓ Technological infrastructure in the institutions ✓ Practices ✓ Prior exposure to before university education	1. Universities should engage in continuous research to explore how students can leverage on technology in their personal learning networks 2. Institutions and curriculum developers should have clear policies exhibiting willingness and implementation strategies to integrate technology in all areas of students' personal learning networks

Conceptual model and outcome of results of the research (patterns of students' technology use in higher education)

Conceptual model	Outcome of results
	

CHAPTER TWO

REVIEW OF RELATED LITERATURE

"A review creates a firm foundation for advancing knowledge. It also closes areas where a plethora of research exists, and uncovers areas where research is needed"

- Webster and Waston (2002:xiii)

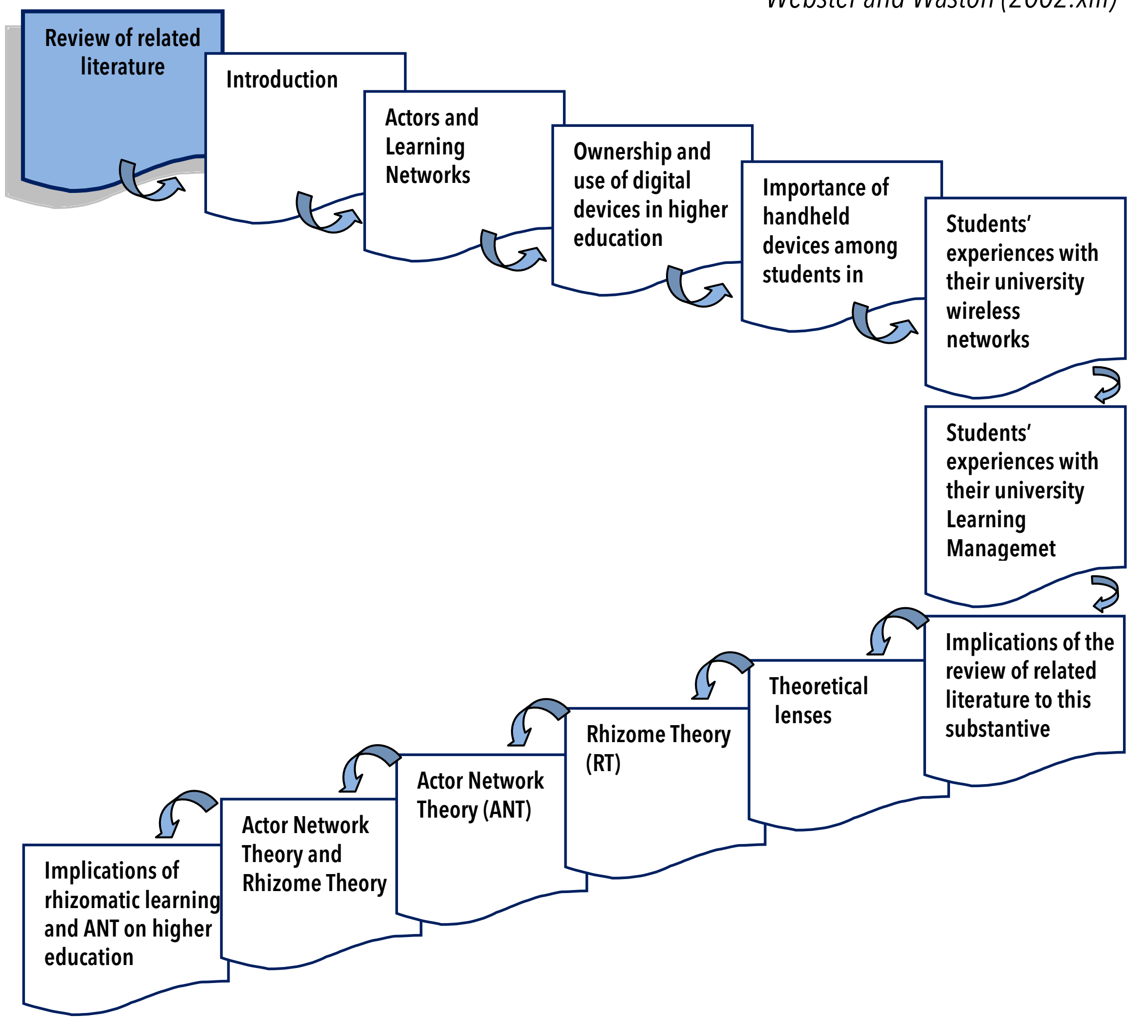


Figure 2.1: Map of Chapter Two

2.0 Introduction

This chapter is presented in two parts. The initial part deals with a review of what key authors related to this study have discovered their contributions and gaps identified. The second part discusses the two theories that underpin this research. Organisation of this chapter is based on themes derived from the objectives of the research after keyword searches. The identified keywords initially emerged from a preliminary literature review at the proposal stage. The keywords were entered into online databases (Google Scholar, Ebscohost, Sabinet, Cape Peninsula University of Technology and University of Cape Town libraries) for related literature. One criterion entailed the search for seminal works – articles or books – from keyword search results. Other relevant sources of literature also emerged from keywords set on Google Scholar updates.

The main issues pertaining to this study in higher education covered in this chapter are as follows:

- actors in students' personal learning networks;
- ownership and digital device uses;
- importance of handheld devices;
- students' experiences with their University Wireless Networks and Learning Management Systems;
- students' experiences with technology in a higher educational learning environment; and
- theoretical lenses
- Rhizome theory.

The differences, resonance and gaps identified from literature and the main issues above guided the formulation of the sub-research questions and hypotheses. In essence, each theme resulted in a research question or hypothesis which cumulatively addresses the aim of the research. This study aims at exploring the underpinnings of students' technology use in their personal learning networks in a higher education environment.

2.1 Actors and Learning Networks (LNs)

In this present 'knowledge economy', the world is virtually affected by the connection of nodes forming networks. For educational systems, there is high potential for students when it comes to Learning Networks due to the student-centeredness and elastic characteristics of Learning Networks setups (Drachsler *et al.,* 2008). It is too superficial to only focus on the student and object of learning (task to be achieved) without talking about the other linkages that serve as media and space for learning to take place. A Learning Networks includes actors that are the student, the object of learning, learning environment, verbal and non-verbal processes, learning experiences, and mediating tools such as books, people and technologies that work together towards achieving learning objectives (intended or unintended). The student and all other players, including the actions and inactions, operate as actors in a student's learning network.

To better appreciate a Learning Network, it is necessary to first understand the meaning of a 'network'. Van *der* Krogt (1998:162), in his seminal work, gave his perspective on a network:

> *"A network is made up of tactically operating actors. Actors operate tactically in a network, they act on the basis of their own capacities but at the same time anticipate the actions of others. The actions of actors can be explained on the basis of their positions and relationships in the network and on the basis of their 'individual' qualities."*

A network is illustrated in relation to actors and their relationships, relationships which may be tangible, intangible, simple or complex. Junctions, intersections or meeting points in a network are actors that form nodes (Callon, 1987, 1991; Law, 1992; Haythornthwaite, 1996; Latour, 1987, 2005). A network node may represent "*ideas, fields or communities*" that have an arena of influence in those *"learning communities"* (Siemens, 2004). Therefore, a network node can all the time be an actor, but an actor may not always be a node since actors either trigger relationship/action(s) between nodes or they serve as the action(s) or connectors or links or ties or bridges (Muñoz-Erickson & Cutts, 2016) themselves. It is usual to find some level of tensions in a network. Cohen and Barabási (2002) and Siemens (2005)vie that it is a natural phenomenon for nodes to contend for connections to stabilise their positions and relationships in a network. "*Networks are simply webs that grow through connections*" (Fenwick, 2011:119) of all kinds.

Networks may emerge through initiatives of individuals, groups and organisations. The concept of networks in our contemporary society leaves no faculty unattended, including our educational settings. In the 21st century, the subject of learning networks in higher education is crucial to study (Drachsler *et al*., 2008). According to Nussbaum-Beach (2013), networks afford people the opportunity to choose what they wish to learn. In the mid 90s, Harasim (1995) forecasted that "*learning networks have special relevance in the educational context [sic] as a result, raise expectations about learning and having better access to information*" (Harasim, 1995:70-73). Building on Harasim's assertions, Van der Krogt (1998) expounds that the key elements in a learning network consist of learning structures and learning processes strongly influenced by learning actors. Furthermore, to unearth the characteristics of learning networks, Van der Krogt (1998) proposed a matrix to describe four types of learning networks in terms of the elements in the learning network mentioned (Table2.1).

Table 2.1: Characteristics of Learning Networks

		LN1	LN2	LN3	LN4
		Loosely Coupled, Individualistic	**Vertical Mechanical**	**Horizontal, Organic**	**External, Innovative**
E1	**Actors**	Individuals	Officials, specialists	Groups	External actors
E2	**Processes**	Loosely connected activities; individual self-steering	Linear; planned	Organic; integrated	Externally initiated
E3	**Structure**				
$E3_1$	• Content	Unstructured collection of learning programmes	Job-oriented structured learning programmes	Problem-oriented open learning programmes	Profession-oriented thematic learning programme
$E3_2$	• Organisational Structure	Contractual relations; entrepreneurs	Formalised relations; students	Horizontal relations; group members	Professional relations; clients

Source: Van der Krogt (1998)

LN: Learning Network; E: Element

Table 2.1 brings to the fore key concepts in LN (Drachsler, Hummel & Koper, 2008) known as personal learning network (Couros, 2010) and rhizomatic learning network (Cormier, 2011; Aheto & Cronjé, 2014). In brief, personal learning networks are the organisation of an individual's own learning environment making use of resources available to his disposal (Bauer, 2010). A personal learning network may evolve from any of the Van der Krogt's four learning networks. Drachsler *et al*. (2008:26) assert in unequivocal words that *"personal learning networks are the do-it-yourself piece in the 21st century."* This is where personal or and rhizomatic learning network share features of organically evolving and dynamic learning network. The Learning Network is likened to the rhizome plant where student/actors are seen both as creators and contributors of knowledge that grows without any definitive structure. This may bud as a result of an individual, community or group action where learning takes place.

A rhizomatic learning network is a personal learning network that shows characteristics or patterns of the biologically occurring plant 'rhizome', as espoused by Deleuze and Guattari (1987). A closer look at Table 3.1 suggests that actors (E1) may occur as individuals, officials, specialists, groups or external actors. Again, there is a strong convergence between Van der Krogt's (1998) Loosely Coupled, individualistic (LN1),personal learning network and Rhizomatic Learning Network. The aspect of 'self' or 'individualism' echoes the point that a decision to take autonomy of one's learning per how and what is expected to be learnt lies in the bosom of the student. Van der Krogt (1998:166) further emphasises that Loosely Coupled, individualistic (LN1) students in such a category take ownership of and coordinate their own learning systems and can be strengthened through the three other learning networks in presented in Table 2.1. In support, Drachsler *et al*. (2008) describe Loosely Coupled, individualistic (LN1) as one occurring in diversity through filtering quality relationships and driving collaboration. Corroborating these later viewpoints, Bauer (2010) attests that such Learning Networks promote active learning environments for students to communicate and collaborate in knowledge creation in their learning networks.

The characteristics of content structure (**$E3_1$**) under *Loosely Coupled, individualistic* support heterogeneity and multiplicity of rhizomatic learning network where Cormier (2008) also describes the community as the curriculum. Moreover, **$E3_2$** well describes the rhizome principle of asignifying rupture (see Chapter Three on Rhizome Theory).

There are a number of identifiable learning networks (Van der Krogt, 1998). Learning networks include personal learning network (Couros, 2010), social learning network (Huang *et al.*, 2010), and the rhizomatic learning network (Cormier, 2011; Aheto & Cronjé, 2014). Upcoming review will focus on the first three identifiable learning networks (personal learning network) particularly within the context of Van der Krogt's (1998) Loosely Coupled, Individualistic (LN1) and Horizontal Organic (LN3) as it bears resemblance to characteristics of the biologically occurring rhizome plant.

2.1.1 Personal learning networks (PLNs)

Literature concerning the definitions of personal learning network is sketchy. A working definition of personal learning network is that it is an all encompassing nexus of events with the student at centre of interaction, with both human and non-human agents, within a space (physical or virtual) where knowledge, skills, attitudes and values are acquired through the senses. It must be noted that there are two interactions of personal learning networks: 1) between the student and actor(s); and 2) between other actors in a student's personal learning network about the student. Couros (2010:125) opines that personal learning network is the "*sum of all social capital and connections that results in the development and facilitation of a personal learning environment.*" Hitherto, focus has been placed more on Personal Learning Environments (PLE) than personal learning networks although peer networks have immensely influenced the construction of students' learning(Martindale & Dowdy, 2010). The notion of a personal learning network keeps the student not only at the centre but as the propeller of his own learning.

In a growing development, the concept of personal learning network (Couros, 2010) shares features with rhizomatic learning network (Pineda, 2013; Aheto & Cronjé, 2014) cutting across all characteristics of LN (Koper & Tattersall, 2004) as propounded by Van der Krogt (1998), especially LN1 and LN3 in Table 3.1. Like personal learning networks, rhizomatic learning networks have students at the centre of learning activities, getting them strongly involved as creators or contributors to knowledge. Hence, rhizomatic learning networks are metaphorical personal learning networks with traces of the characteristics of a rhizome plant, such as nodal *connections*, complexities due to *multiplicities*, and partial breakaways expressed as *asignifying ruptures*.

The idea that 'learning' in a personal learning network is customised and 'personal' can be supported by what Hase and Kenyon (2007) term as *heutagogy*. Heutagogy connotes a concept of non-linear, student-centred and self-determined learning which shares same attributes with personal learning network (Blaschke, 2012). These interrelated concepts shared between heutagogy and personal learning networks owes to the fact that the student is usually in control of his own learning. Colorado chemistry teachers Bergmann and Sams (2012), who originated the term *"flipped classroom"*, observed self-directedness as one of the characteristics of the students. Personal learning networks are also characterised by students' self-directedness: they cherry-pick the actors in their network. In the constitution of one's personal network, students are not limited when it comes to choosing other actors, as they may be human or non-human once serving a learning purpose. Self-directedness, learning ownership and personalisation which are linked to heutagogy are part of the characteristics the 21st century student identified in a previous sub-section (Eton, 2011).

It has been argued that heutagogy does not favour students of higher education to engage in deep approaches (Richardson, 2005) to learning. Sometimes this leads to students becoming fundamental with the most important learning objectives. However, this assertion contradicts Hase and Kenyon (2013) who believe that heutagogy offers other perspectives on how one conducts his or her learning but not an alternative to other kinds of learning.

Couros' (2006) pictorial representation of a personal learning network of a teacher (who acts as a student in the figure) provides a classical example of personal learning network, showing what students connect to in order to constitute their personal learning networks. One significant thing about Couros' personal learning network diagram is how interaction in the network is modelled. Communication is *only* possible between the personae and other actors in the network. The interaction portrayed in Figure 2.2 can be a bit problematic in the sense that a typical personal learning network will have multiple communication channels whereby other actors can also communicate about the personae without involving him. For example, if I am a *Facebook* and *Pinterest* user in my personal learning network, these two actors can interact with other databases or sites about me. This can be seen when birthday reminders or information on special events or other academics are brought to my knowledge. This is also one reason why social network is dominating a number of personal learning networks.

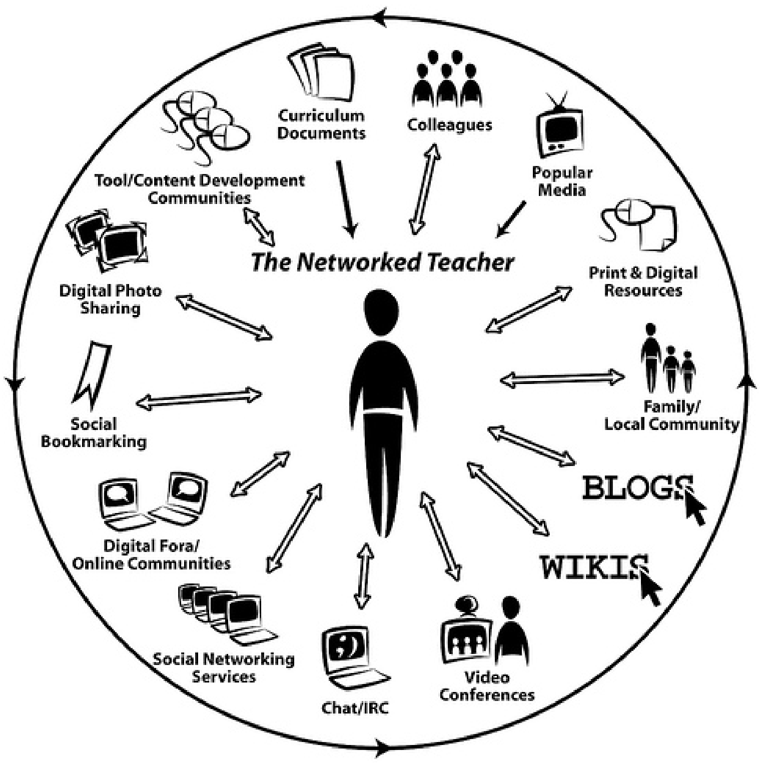


Figure 2.2: A personal learning network (adapted from The Networked Teacher from Couros, 2006:172)

Again, Figure 2.2 clearly demonstrates a direct relationship of actors with the student (principal actor) but fails to establish the indirect interactions about the student within the personal learning network of the same student.

Neubauer, Hug, Hamon and Stewart (2011) see personal learning network as experienced as a Rich Site Summary (RSS) aggregator occurring in a Digital Learning Ecology (DLE). Like an RSS aggregator, they argued to support the view that information is directed to a single place from multiple blogs with commonalities. Neubauer *et al.* (2011) demonstrated that personal learning networks are really used with Communities of Practice to organise resources for learning.

Likening a personal learning network to an aggregator agrees with Warlick (2009) who also believes that personal learning networks are not just for the benefit of the individual owning it. It also becomes a source of information to other personal learning networks, meaning the knowledge and resources of one's personal learning network can fit into other personal learning networks. Warlick presents this relationship diagrammatically in Figure 2.3.

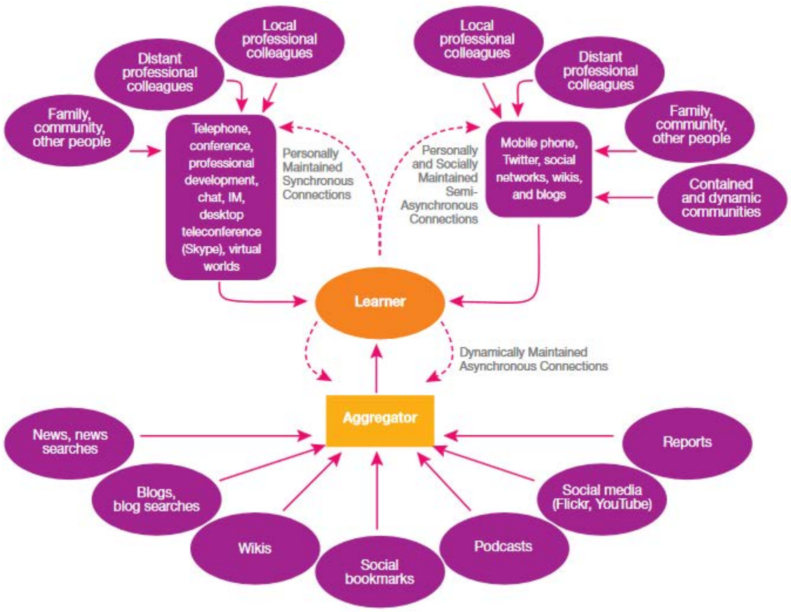


Figure 2.3: A student's personal learning network depicting relationships with other personal learning networks through an aggregator having the student as focus (adapted from Warlick, 2009:15)

For instance, the student traps information for his learning from multiple sources through an aggregator and then makes use of it, deciding whether or not to circulate it among his other networks. What is critical here is that the aggregator only has indirect contact to humans. From Warlick's diagram, some of the first line contacts with the aggregator could also generate their own data for the student just as the aggregator does. Indeed, social media sites like *Flickr* also sometimes behave like aggregators. The upper half of the diagram shows an integration of the tools, humans, groups and other factors under which the personal learning network are mediated. Again, Warlick's notion of a personal learning network diagram portrays an attempt to keep the complex relationships within and outside a personal learning network.

To deal with relationships and complexities of personal learning networks, Pineda (2013) defines a student's personal learning network from the perspective of shoots and stems of a rhizome. According to Pineda, shoots constitute a category with higher student tagging or main source of knowledge. Meanwhile the stems represent contributors to the learning (any representation of learning, for example, connections, and web and course materials). DLSU is the institution of the student. Figure 2.4 shows that the elements found in the personal learning network are made up of humans (real life), non-humans and generally socio-technological agents. Pineda simply presents a picture showing the interaction between a student and the resources at his disposal for learning construction.

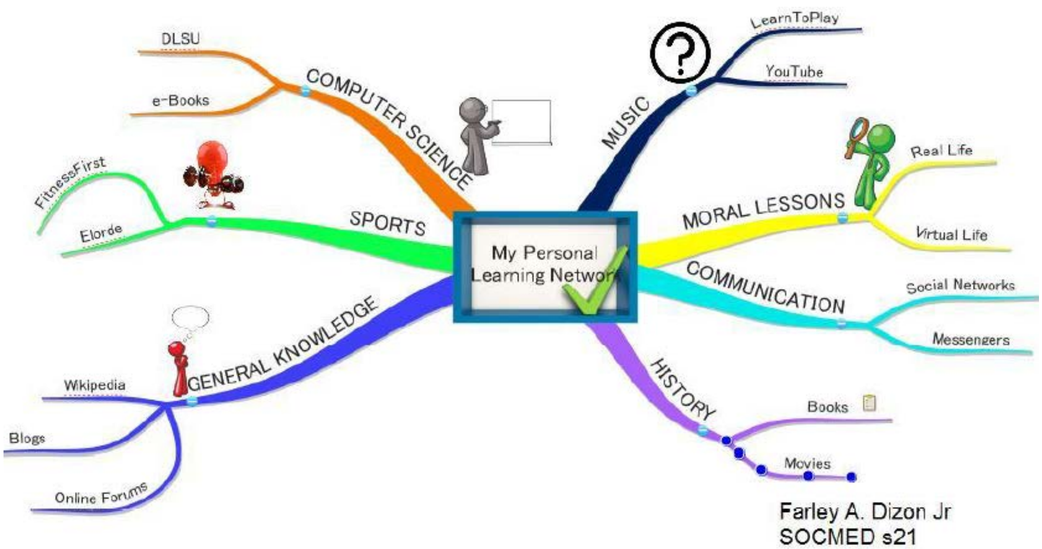


Figure 2.4: Personal learning network from the perspective of shoots and stems of a rhizome (adapted from Pineda, 2013)

Pineda's research reveals that students' personal learning networks show traces of activities occurring at home, school or online. These findings have implications for curriculum design and development in the choice of learning environments in higher education. A good impression about what constitutes the popular shoots and stems a personal learning network exhibiting characteristics of the rhizome is adapted from Pineda (2013)and presented in Figure 2.5.

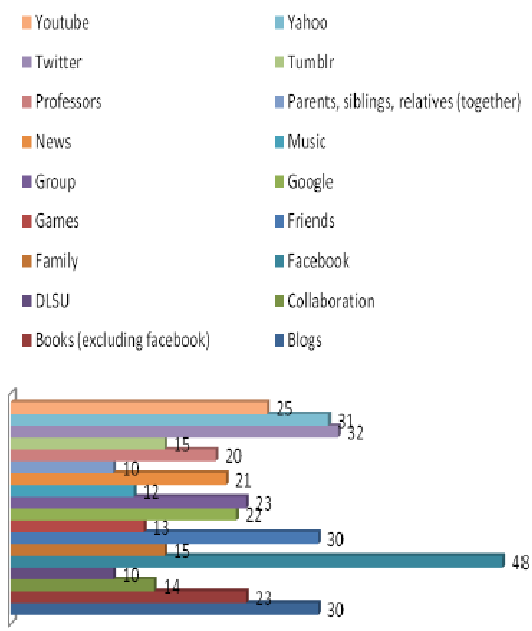


Figure 2.5: Illustration of some popular shoots and stems in a personal learning network(adapted from Pineda, 2013)

In a nutshell, the term *personal learning network* has varied dimensions (Harlan, 2009) which include both formal and informal learning connections. While the concept of personal learning networks has been approached from different angles, an underlying factor throughout the examples is a sense of complex connections of learning resources. Warlick (2009) was the only author who distinguished three types of connections found in a personal learning network: Personally Maintained Synchronous Connections, Personally and Socially Maintained Semi-Synchronous Connections and Dynamic Maintained Asynchronous Connections. Neubauer *et al.*

(2011) also examined personal learning networks within a Digital Learning Ecology (DLE) focusing on personal learning network as an RSS aggregator. Couros (2006) modelled the interaction with a personal learning network taking into account various resources. From a careful study of the literature, this research bears resemblance to earlier work by Pineda (2013); however, my research will not disintegrate the actors or resources of a personal learning network into the shoots and stems of a rhizomatic personal learning network as adopted by Pineda. Therefore, what remains unknown includes the emergent patterns among actors in students' Rhizomatic Learning Networks. Hence, actors and their emerging relationships will be identified through the two sub-research questions below:

- *What actors are in a rhizomatic learning network?*
- *How are the emergent patterns in a rhizomatic learning network related?*

In the next sub-section, students' ownership and use of digital devices are discussed.

2.2 Ownership and use of digital devices by higher education students

Ubiquity and ease of accessibility of digital contents are increasing causing a shift in device usage and ownership regimes among student populations. Teaching and learning is currently influenced by the presence of digital devices in and around the classroom. A number of researchers have documented the rise in digital device ownership and use among students in higher education (Dahlstrom, Grunwald & Vockley, 2011; Lalita, 2011; Cross *et al*., 2015; Witecki & Nonnecke, 2015; Mahenge & Sanga, 2016).

Depending on how it is managed, computers, microphones, still and motion capturing devices and portable gadgets like Smartphones make it more effective and efficient for learning to take place (Johnson *et al*., 2014).

Student ownership and educational use of digital devices have become phenomenal owing to *"convenience, connection and control"* (Oliver & Goerke, 2008:78). Digital devices are used by institutions and students in various ways to achieve academic objectives (Barry *et al.*, 2015). Commonly owned digital devices by students in higher education for their academic work include a Laptop and Smartphone or tablets (Sharples *et al.* 2014) and cell phones (Witecki & Nonnecke, 2015). Digital device ownership by students has influenced educational policies in so many ways, raising heated debate (Selwyn, 2010; Reform, 2013). While some institutions embrace digital device ownership and use within their institutions, others consider this disruptive and have therefore banned students and sometimes even lecturers from using their devices while at school (Amedeker, 2013; Doward, 2015). According to Muyinda *et al.* (2011), mobile device ownership creates better and stronger platforms for mobile learning in higher education. However, in Ghana, there is a policy ban on mobile phone usage by students in high schools (Amedeker, 2013) which somewhat contradicts the government's 'One Laptop per Child' project which seeks to distribute laptops to basic school children in the country (Buchele & Owusu-Aning, 2007). Banning the use of devices deemed to be teaching and learning materials may be attributed to the lack of knowledge and skills about the effective use of digital devices in schools. Veletsianos (2010) asserts that technology is classified as 'disruptive' only when its potential is not realised.

Most students and other stakeholders in education do not classify digital devices such as Smartphones as teaching and learning materials (Mikie & Anido, 2006; Ng'ambi, 2013); however, Falloon (2015) noted that digital devices in higher educational institutions are strong collaborative learning tools that improve pedagogical processes and resources. But digital devices differ in the way they are used by students. For instance, *iPads* were found to have varied performances and uses in a collaborative learning environment as compared to other digital or handheld devices, but Ibid further proposed future research to verify whether *iPads* triggered learning or not.

Elsewhere, digital media tools such as computers, *iPod* or *MP3players* have been used to broadcast study materials among university students through podcasting (Evans, 2008; Fernandez *et al.*, 2009; Lonn & Teasley, 2009a; O'Bannon *et al.*, 2011). In a pilot study involving Business and

Management students, Evans (2008) reported a 74% ownership of some sort of digital media player, with another 7% of students declaring their intent to acquire one within the next half a year.

A survey conducted in 1997 by Czerniewicz and Brown (2013) indicated a 98.5% cell phone ownership among university students across South Africa. Similar studies by Song and Lee (2012) explored ownership of mobile devices by international business students in the United States of America. Their study focused on three digital devices: *Smartphones, Tablet PCs* and *E-readers* such as *Amazon Kindle* and *Nook*. Their study revealed that 82% of the students owned Smartphones, followed by a significant percentage owning *Tablet PC.* However, ownership of E-readers was less important to students. The price of devices, data plans, lack of interest and operational knowledge of digital devices were reasons cited by students not owning digital devices. They also found that most of the students admitted to using their mobile phones for communication (emails, text messages) and social networking (Facebook, Twitter and blogs).

As opposed to banning handheld or digital devices in schools in countries such as Ghana and some schools in Japan (Ito, 2005) amid environments where digital device ownership keep spreading, Paterson and Low (2011:412), whose mixed study investigated the *"attitudes of students toward mobile library services for Smartphones"*, encouraged that the rapid spread of mobile device ownership and usage among schools and academic libraries is promising and therefore *"changing student behaviour"* must be accepted. One key finding was a remarkable 17% growth of students' Smartphone ownership within eight months, while 68% of the students intend to upgrade their mobile devices to Smartphones. Ito (2005) also noted different uses of mobile phone usage among students in Japan.

Recently, in their hypotheses testing, Mahenge and Sanga (2016) found statistical significant differences of Smartphone ownership ($p \leq 0.05$) and cell phone ownership ($p=0.917$) among three higher education institutions in Tanzania. However, further analysis revealed no statistical significant difference of laptop ownership ($p=0.097$) among those same three institutions. Despite the results pertaining to laptop ownership, Mahenge and Sanga's (2016) results did show that laptop ownership by students in those institutions ranged from 80% to about 98%.

High numbers in computer ownership against Smartphones or cell phones may vary based on individual or institutional value or use. In higher education institution, *"computers are valued to be more legitimate than cellular technologies"* (Czerniewicz & Brown, 2013:50). Discussions about legitimacy or consideration of one digital device over others by universities may be a product of institutional practices, ICT policies or institutional culture. In other words, the latter does not always suggest a direct relationship between ownership and increased numbers of digital devices among students due to usage. Empirical evidence is seen in the case of Dartmouth College in the United States of America where students are mandated to own a computer, and to facilitate this process, computers are sold in the institution's computer shop (Henderson *et al.*, 2008).

Oliver and Goerke (2008) reported similarities in device ownership and Internet access among undergraduate Engineering and Business students in three countries: Australia, Ethiopia and Malaysia. Although, they found 40% ownership of *MP3 players* among students, they also reported widespread mobile phone ownership and usage in Australia and Malaysia.

Clear evidence of dissatisfaction towards ownership, access and usage of digital devices by students in higher education institutions continues to gain roots, as usage is described as disruptive (Campbell, 2005), a complete waste of money, and an unnecessary luxury (Hawkridge, 1990). A topical debate has followed recent announcements by an Australian school, Sydney Grammar School, to prohibit laptop ownership by the school and students because it inhibited classroom interaction while also wasting money (Bita, 2016). The Sydney school can find support in recent research findings by Beland and Murphy (2015) that digital devices did not improve academic performance for low achieving students. However, the school neglected to take into account the positive impact of digital devices as expressed in research by numerous other researchers.

Results from Mahenge and Sanga (2016) do not appear to corroborate the findings of Czerniewicz and Brown (2013), Ito (2005) and Oliver and Goerke (2008) who noted a widespread ownership of Smartphones and mobile phones among university students across South Africa. However, all the research reports agree on the role of school influence of laptop ownership among students. Again Ito's (2005) results are consistent with Czerniewicz and Brown (2013) on the varied uses of devices by students. The review also noted variations of ownership, institutional ownership and usage policies, and understanding of the various devices.

The review observed increasing ownership levels and variations of digital device ownership by students, differences in institutional ownership and usage policies. Though a number of studies have been undertaken on device ownership and use, this present research addresses the seeming differences on device ownership and use at higher education institutions with the aid of empirical data from different geographical areas. Subsequently, these observations led to the formulation of a sub-research question and hypothesis:

- *What digital devices are owned by students in higher education?*
- *There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success.*

2.3 Importance of handheld devices among students in higher education

Mobile or cell phones, iPods, MP3 players, Smartphones, E-readers, tablets all fall under the classification of handheld devices. Studies have underlined the roles of handheld devices in higher education. Out of 12 students in an experimental research, Backer (2010) indicated that 11 of them agreed that incorporation of Smartphones and *Facebook* technologies into teaching and learning promoted student autonomy and motivation, in turn boosting their learning performances. Nonetheless, Backer (2010) noted some challenges in integrating handheld devices in education. One of them is that not all students had their hands-on innovative technology and therefore needed some effort to bring them to par with the well-skilled students.

In research by Cross *et al.*(2015), 50% of student using handheld devices said they used it at least once in a week for course-related content. A total of 103 students (72%) who also owned tablets and an E-reader confirmed accessing course-related materials from their handheld devices, at least once weekly.

In medical education, undergraduate students at the School of Medicine in Wayne State University used PocketPCs in monitoring the encounters by patients. According to the authors, the use of the handheld devices caused considerable amount of relief on hospital administrators (Jackson *et al.*, 2005). Warschauer *et al*. (2010) have contested that students exposed to a variety of digital resources (handheld devices included) are well-skilled in media content creation technologies. However, *ibid* did not focus their arguments on the underlining factors, such as guidance to the students, which also suggests that students get to build their personal learning networks through exploration.

Various uses of handheld devices in higher education have ranged from gaming (which is believed to improve the memory of student) (Bryan & Clegg, 2006) to light carriage of course materials and ubiquitous learning (Evans, 2008). Falloon (2015) identified six key areas where handheld devices become useful for collaboration in the learning landscape: coordination, negotiation, mobility, interactivity, organisation of resources and communication. Bluetooth and other handheld devices (N-Gage and iPod, for example) have also opened university lecture rooms to real-time access to the world (Bryan & Clegg, 2006). Furthermore, with little support, Schneps *et al*. (2014) argued that intuition of students can be strongly developed through the engagement of virtual simulations via handheld devices.

However, blockages such as unwillingness of faculty to incorporate handheld devices into their teaching delivery (Day-Black & Merrill, 2015) and the difficulty for clear enactment of educational policies on handheld devices (Blignaut *et al.*, 2010) have hindered mainstream integration of handheld devices in learning. Other complications associated with text management, smaller screens (Falloon, 2015), downloads (Gupta & Koo, 2010), access to wireless networks (Motiwalla, 2007), isolation (Walmsley, 2014) and differences in access to library resources (McKnight, 2011) have also been documented as hindrances to the use of handheld devices in learning.

Despite setbacks identified in the use and importance of handheld devices in higher education (Bruner & Kumar, 2005) held that students may derive inherent motivation as long as those devices can be used creatively to solve some educational problems. For instance, some E-readers allow students to concentrate more on their reading as compared to reading on a computer which distracts with the Internet, advertisements, emails and Internet calls (Boroughs, 2010). Furthermore, handheld devices have the capacity to contain a large number of books (even books with more than a thousand pages), assignments and other course materials without increasing the physical outlook or weight of the digital device. Day-Black and Merrill (2015)noted that course materials (textbook, for example) are becoming heavier each day, but handheld devices help compress this material into small and light digital format.

This review contributes to the understanding of the importance of handheld devices to students, despite some challenges, and situates this substantive research into the relevant literature (Booth, 2012). There is evidence in literature that suggests that handheld devices impact student learning with the potential to revolutionize higher education despite associated challenges (Boroughs, 2010).In this regard, this research empirically explores the level of importance of devices used by students by posing the question and hypothesis:

- *To what extent are the devices used by students perceived to be a promoter of their academic success?*
- *There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success.*

2.4 Students' experiences with their university wireless networks

University Wireless Networks present numerous opportunities to facilitate the conduct of teaching and learning in higher education environments (Vasiliou & Economides, 2007; Gupta & Koo, 2010). In the near future, students' wireless network experiences focusing on node connection of information among students and lecture theatres, lecturers, learning experiences, university resources and other stakeholders will be a matter of serious concerns in higher education (Castells, 2010). For most university students, a University Wireless Network is the currency of the day. According to Kim, Mims and Holmes (2006), universities around the world depend on the Internet and wireless networks to run university business and to promote academic and research activities, making the wireless network the single most important provision by any institution of higher learning (McKenzie, 2001; Eduroam, 2016).

University Wireless Networks not only allow students to connect to the Internet or university resources, but students get connected to each other (sometimes at remote locations), to lecturers, parents, devices, their learning and the world at large. Notwithstanding, Oblinger, Oblinger and Lippincott (2005) call for conscientious efforts to coordinate in-class and out-class wireless network to allow for maximum leverage by students and faculties. But Anderson *et al.* (2012) projects that even by 2020, universities will not change that much; rather, most universities will require full participation in lectures through personal attendance, though Internet and wireless networks will be ubiquitously available. However, more lecture room wireless network resources are estimated to be available for students' utilisation.

McKenzie (2001) identified nine advantages of wireless computers. These advantages could be extended to student user experiences with wireless networks in relation to the digital devices that get connected to these networks. The advantages are a relaxed fit, strategic deployment, low profile and simplicity. The remaining advantages are that wireless networks promote ease of movement, flexibility, cleanliness, convenience and speed in terms of connectivity. With wireless networks, students are not glued to computer laboratories for Internet or intranet access (Ramjee, 1997). The purpose of a university wide wireless network is to allow for convenience and flexibility, making connectivity more evenly distributed, less expensive, and most importantly, consistently reliable.

Apart from agreeing with McKenzie (2001), Oblinger and Oblinger (2005) and Henderson *et al.* (2008), on easy mobility of users within a network area, Pahlavan and Levesque (2005)placed more emphases on some major limitations presented by wireless networks. University wireless networks are sometimes prone to privacy and security compromises with internal or external imposters; limited bandwidth and reliance on battery (when mobile) were also cited as major challenges. Moreover, connecting a wireless device to a cable network was observed as a problem. In his thesis, Galbus (2001) identified cost of owning a wireless network and wireless mobile devices as relatively cheaper than cable networks. The cost component raised by Galbus is consistent with later studies by Oblinger and Oblinger (2005).

Henderson *et al.'s* (2008:2690) seventeen week research, situated at Dartmouth College in the United States of America, looked at changes characterised by wireless network system comprised of 7000 users and 550 access points. Their findings indicated a spectacular rise *"in peer-to-peer and streaming multimedia traffic"* over a two year interval. Regardless of an activated Voice over IP (VoIP) on wireless network system, students preferred cable network systems for VoIP. In their recommendations, Henderson *et al.* (2008) observed emerging patterns in students' wireless network behaviour, calling for further investigation into reasons why students used certain applications at Dartmouth College and not others.

Corporate institutions have lately extended support to universities to research and establish wireless networks. Sub-Saharan African countries such as Ghana, Nigeria, Senegal, South Africa and Uganda are benefitting from Google's grant initiative dubbed Google Apps Supporting Programs (GASP) to boost the use of Internet and Apps from Google. Recently in Kenya, the GASP project got

100 faculty and 2000 students hooked onto the wireless network to some 25 WiFi access points at Inoorero University (Mulupi, 2012).

Teaming up with Aruba Networks, University of Pretoria in South Africa acquired *"a 3600 mobility Controller on each of the smaller campuses and a resilient pair of 6000 mobility Controllers on its main Hatfield campus, where around three-quarters of its 50,000 students and 500 staff are based"* to solve earlier expensive bandwidth issues (Beeken, n.d.). Project manager, Dr. Wimpie Beeken, noted that the outdoor access points around the facilities fostered stronger interaction and engagement among students and faculty because students were seen hovering around. Yet again, other benefits of a university wireless network system include libraries that also give maximum advantages to digital device users such as tablets.

From the University of Pretoria's wireless project, Aruba (n.d.) identified some key benefits: massive "*student attendance and engagement, improved uptake and acceptance of Wi-Fi, leverage over combined in and outdoor-building Wi-Fi for cross-campus coverage, support for BYOD, time and cost savings*", as advantages over other higher educational institutions. Apart from university-led activities where students access university wireless networks for campus news, assignments, Learning Management Systems, collaboration and research, wireless resources at universities also create avenues for students to access personal emails and social networking sites if there are no limitations imposed by the institutions (Chen, 2012; Saha & Karpinski, 2016).

Ramjee's (1997) doctoral dissertation at the University of Massachusetts Amherst investigated mobility in wireless network connections and put forward algorithms to enhance effective and efficient connection among users. He contended that users of wireless networks must not experience fluctuations in their wireless networks due to mobility. His study supports reasons why wireless network interventions on campuses continue to spread across universities. One such intervention is Eduroam (education roaming) which is an international wireless or roaming service for research and educational purposes spread across over 70 countries (Eduroam, 2016). To buttress the constant search for access to Internet and wireless resources by students everywhere they go, Dr. Beeken observed that during occasions, about 50% of wireless users on campus who are connected Eduroam during occasions are visitors. This, in fact, lessens burden on universities wireless resources.

In conclusion, this substantive research recognised the gap in literature in addressing students' experiences with their university wireless networks. Going by Anderson *et al.'s* (2012) projections, by 2020 universities will have to invest more in lecture room wireless networks to promote learning opportunities, massive student-faculty interactions and engagement as experienced by Dr. Beeken in some faculties at the University of Pretoria. It must be noted that though students' access to university wireless networks promotes academic improvement, it does not automatically translate in academic quality since students are not obliged to use the resource only for academic work. Literature is not conclusive as to what students' experiences of university wireless networks are: though students access these networks in multiple realities and with multiple devices, there is a high possibility of usage which is unrelated to academic work. Generally, literature on the subject abounds, covering opportunities, benefits, challenges and limitations of university wireless networks. The review also noted a number of ongoing and recent university wireless network projects across the world, especially in Sub-Saharan Africa, supported by corporate bodies. To date, no follow-up research on Henderson *et al.*'s (2008) observed emerging patterns on students' wireless network behaviour has been cited. Based on this gap and recommendation, answers to students' experiences of university wireless networks is explored, first by establishing a relationship between their experiences with university wireless networks and later by delving into their perspectives viz-à-viz the topic. This gap is further addressed through testing of the hypothesis:

- *There is no statistically significant difference among the four cohorts of students in terms of experiences with their university wireless networks*

2.5 Students' experiences with their university Learning Management Systems

Learning Management Systems are web-based platforms that have become vital aspects of universities worldwide to promote teaching, learning and organisation of learning resources (Coate*et al.*, 2005; Lonn & Teasley, 2009b). Commonly recognised Learning Management Systems in higher education include Blackboard (Green, 2015; Kim & Do, 2016), Moodle (2016), Sakai (2016), Desire2Learn (2016) and Canvas by Instructure (2016). Others which are also used but not as popular among institutions are Docebo (2016), Edmondo (2016), Mzinga (2016) and Schoology (2016). In some institutions, Learning Management Systems have created tensions rather than their intended purpose (Day *et al.*, 2000). In a fast-moving technological economy, Learning Management Systems can be positioned to help university management, lecturers and students make pertinent decisions through enormous data and learning analytic tools that sit within the Learning Management System. Nonetheless, the value of Learning Management System is yet to be fully harnessed. Green (2015:1) opines this view through a rhetoric question on whether or not the worth of the Learning Management System is being valued:

> *"Is the* Learning Management System *just a platform that supports instruction or does the* Learning Management System*– or a specific* Learning Management System *platform – actually have a clear and discrete benefit on learning outcomes? Fully 15 years after many campuses first deployed a Learning Management System, we really don't have good data to provide a clear answer to this question."*

In the United States, Green's (2015) survey pointed out that a large number of Learning Management System subscribers go for Blackboard first, followed by Moodle. As indicated in Figure 2.6, other Learning Management Systems are also used in higher education; however, these are in the minority.

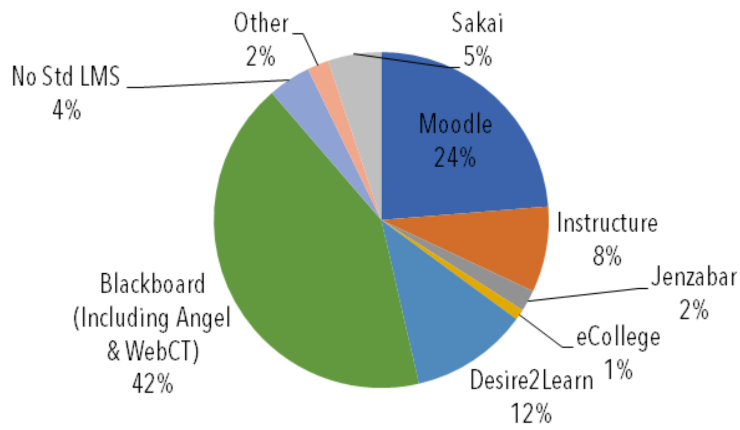


Figure 2.6: Popular Learning Management Systems used in higher education (adapted from Green, 2015)

Govender and Govender (2014) investigated key attitudes of faculty driving Learning Management System integration in teaching and learning to encourage usage among students in a university where a Learning Management System is in place. Using a mixed research approach, they collected data through online surveys within a university and found four constructs: performance expectancy, effort expectancy, social influence and facilitating conditions. Though their study revealed that faculty members found pedagogical uses for a Learning Management System, the majority expressed limited expertise in handling the Moodle platform. Invariably, findings from Govender and Govender (2014) evinced by default that the majority of students may either have poor perception about the Learning Management System or Moodle, especially if their institution is the first place using a Learning Management System. Obviously, lecturers will not likely advance beyond what they know.

Graf *et al.* (2009) focused on learning styles in Learning Management System. Data gathered through a learning style questionnaire and the learning behaviour of 127 students in an online course was compared. In the final analysis, the authors proposed a standalone tool, Determining Learning Styles (DeLeS), that can be plugged into a Learning Management System to assist lecturers easily recognise the learning styles of students for customised support. For future research, Graf *et al.* (2009:13)recommended the development of *"a concept for dynamic automatic student model."* This model is proposed to use data generated from the behaviour of students to better prescribe immediate learning styles for improved learning outcomes by means of a Learning Management System. The similarity between research conducted by Graf *et al.* (2009) and Govender and Govender (2014) is from the attempt to provide information about Learning Management Systems to faculty to improve learning outcomes.

McGill and Klobas (2009:496), acknowledging the widespread use of Learning Management Systems in higher education, sought to drift away from the highly focused research on technological aspects of Learning Management Systems. They suggested research to fill gaps by identifying the potentials of Learning Management Systems in promoting learning success. Using a technology-to-performance chain as a framework, these researchers established that unlike instructor norms having influence on learning through Learning Management Systems, *"facilitating conditions and common social norms"* did in fact affect learning via Learning Management Systems. This also means that the knowledge level of the lecturers or instructors becomes the 'prescribed' ceiling for operation of the Learning Management System for students as well. Again, general social perceptions about the application of technology improve learning cannot be warranted; hence a proper needs- assessment and training must be considered before adopting a Learning Management System under the assumption that 'technology solves every learning problem' (Bower, 2008; Conole, 2013). Literature thus far has revealed some key roles, derived benefits and attitudes of lecturers and instructors in the roll-out of Learning Management Systems in higher education (Graf *et al*., 2009; McGill & Klobas, 2009; Govender & Govender, 2014). Nonetheless, no studies have yet shown the direct effects of Learning Management Systems on student satisfaction.

On the flip side, previous and recent research has either made students their focal point in Learning Management System research or targeted both students and faculty (Lonn & Teasley, 2009b; Naveh*et al.*, 2010; Murshitha & Wickramarachchi, 2016). An examination of student satisfaction and use of a Learning Management System correlated with organisational variables (instructor status and course discipline) at an Israeli university (Naveh *et al.,* 2010). Analyses of this study indicated that students' use and satisfaction of Learning Management Systems were largely dependent on course discipline offered and teaching styles. Students more inclined towards skills in IT were mostly from the Engineering and Natural Sciences discipline. Some results showed that students were satisfied with their Learning Management Systems provided their courses were linked to the website; individual courses would have a website or learning materials were shared on the websites. For a more general perspective, the researchers recommended further investigation into the use and satisfaction of Learning Management Systems in more than just one university.

From an instructor and student standpoint, Lonn and Teasley (2009b) also explored perceived benefits of Learning Management Systems as an enhancement to conventional teaching and learning system. The study took into account attitudes of students and instructors in answering the research questions. When analysed, the two year survey data proved that Learning Management Systems enhanced class engagement when students have prior access to topics for deliberation. The latter analysis suggested that student engagement via Learning Management System must not be a one-show; rather, it goes through a cycle. Lonn and Teasley (2009b) recommended that more research be conducted to equip students and instructors with maximum pedagogical use of Learning Management Systems in higher education.

Murshitha and Wickramarachchi (2016) surveyed 50 extensive users of a Learning Management System, all undergraduate students, for their outlook on Learning Management System adoption in a blended learning environment. The results demonstrated that the key factors for student adoption of a Learning Management System are hinged on interaction with lecturers and other students, experience and self-efficiency.

In summary, a number of researchers regarding Learning Management Systems throw more light on faculty issues than students. This research is similar to work by Naveh *et al.* (2010). However, the objective on Learning Management Systems in this research focused explicitly on student satisfaction of Learning Management System use. Another limitation of their study was that they conducted research in only one university. Following their recommendation, the context of this current research is situated in four universities across three countries. Emerging patterns from findings of Lonn and Teasley (2009b), Naveh *et al.* (2010) and Murshitha and Wickramarachchi (2016) revealed that students are satisfied with Learning Management Systems when they are fully engaged with the system by also creating other outlets via links on the Learning Management System to websites they can frequent. Inconsistencies spotted in literature are thereby attended to in this research by testing a hypothesis on Learning Management System satisfaction among students as follows:

- *There is no statistically significant difference among the four cohorts of students in terms of their satisfaction level of Learning Management System in their institutions*

2.6 Students' experiences with technology in higher educational learning environment

2.6.1 Learning environment

Learning environment encapsulates all the spaces and practices within which learning can be influenced. The concept of learning environment can be viewed from the perspective of a either a student or a teacher (Bates, 2005). The Glossary of Educational Reform (2013) captures the Learning Environment as one that:

> *"refers to the diverse physical locations, contexts, and cultures in which students learn. Since students may learn in a wide variety of settings, such as outside-of-*

> *school locations and outdoor environments, the term is often used as a more accurate or preferred alternative to* classroom*, which has more limited and traditional connotations–a room with rows of desks and a chalkboard, for example. The term also encompasses the culture of a school or class–its presiding ethos and characteristics, including how individuals interact with and treat one another–as well as the ways in which teachers may organize an educational setting to facilitate learning [sic] And because the qualities and characteristics of a learning environment are determined by a wide variety of factors, school policies, governance structures, and other features may also be considered elements of a 'learning environment'."*

Bates (2005) contends that when dealing with the organisation of a learning environment, one must think about the context of the learning environment. In his view, the focus of a learning environment has predominantly been on the physical school environment or the technologies that are adopted for students' personal learning environments. He posits that student characteristics, teaching and learning goals, student support systems and other resources are also constituents of a learning environment. However, Bates focuses more on the students' learning environment from the viewpoint of a teacher. Figure 2.6 shows the elements of a learning environment from the perspective of a teacher. Though the choice of a teacher's perspective may have been influenced by their role in arranging the teaching environment, Bates did not include the framework that underpins what should be involved in organising a learning environment. These frameworks may come as policy documents, memos, laws and roadmaps formulated by teachers or schools. Apart from the policy aspect, to some extent, Bates' arguments are characteristic of a broader definition of what the Glossary of Educational Reform (2013) put forward above. But the Glossary of Educational Reform (2013) identified other 'soft' parts of a learning environment that were not considered by Bates. Their justification is that attributes such as *"school policies and governance structures"* define the boundaries, establishing the very existence of learning environments. Despite not considering a learning environment from the student's perspective in his publication, Bates (2005) admits that it is something worthwhile to look at because students continue to create their own personal learning environments.

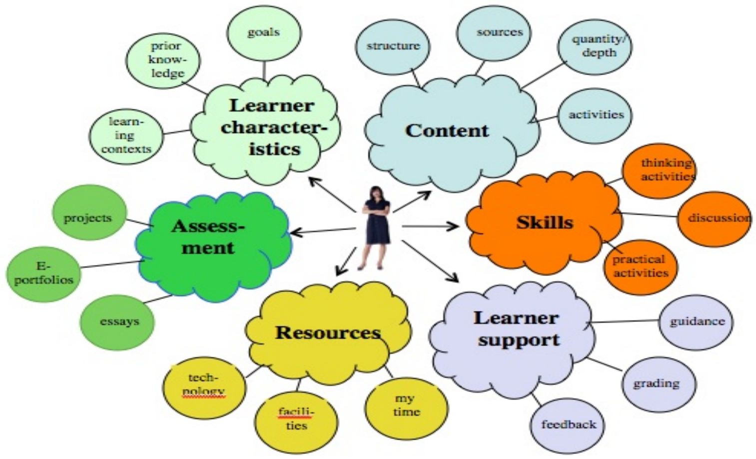


Figure 2.7:Learning environment from a teacher's perspective (adapted from Bates, 2005)

Other authors have also explored learning environments from different angles. Ito *et al.*(2013:62) talk about *"three spheres of learning"* that engender a connected learning environment: peer culture, interest power and academic orientation. Learning environments create a dynamic playing field for diverse learning experiences and connections to students (EDUCAUSE, 2013).

Student learning environments have become a mix of complex factors because humans are widely connected to the Internet by extraordinary pathways (Richardson & Mancabelli, 2012). One of these factors is the exposure of social media to students in higher education (Manca & Ranieri, 2013). Social media as a social capital to students also contributes significantly to school and personal learning experiences. While some have questioned the value of social media to learning (Selwyn, 2010), other researchers have suggested ways through which social networking sites can be of value to lecturers and students (Anderson, 2009; Ellison, Steinfield & Lampe, 2011; Ng'ambi, 2013).

Kassens-Noor (2012) explored the potential of Twitter in the learning landscape and found both useful and problematic areas using this social media. While it might be useful for some course content, it may be the reverse for other courses. However, the offer of a platform that is always active is advantageous to students in an environment informal enough for practice. Kassens-Noor's suggestion is that the tool of social media becomes an educational tool that extends outside the classroom boundaries.

Peer culture can be seen from a spot of direct and indirect influence from friends due to an association with learning networks and experiences from peers. Basically, the role played by peer culture in students' personal learning networks is when students negotiate to accept a platform or technology for use for the common good of the community, beneficial to all. These kinds of situations have an effect on the learning strategies of students within their personal learning network (Dabbagh & Kitsantas, 2012).

To corroborate with Ito (2012), Attwell (2007) posits that a motivating factor to learning can be based on personal interest. This is corroborated by the findings of Ito *et al.* (2013) on spheres of learning. Interest motivated learning or personal learning networks also answer the diversity in personal learning networks and are the reason why some graduates go back to school to pursue their dream courses no matter what the level. Interest in personal learning networks influences priorities assigned to actors in a network. The kind of peer culture and interests infused in a personal learning network determines one's academic orientation and thereby the importance of studies related to personal learning networks.

2.6.2 Characteristics of the '*so called*' 21stcentury students

Characteristics of 21stcentury students concern patterns of students' technology use in higher education. There is a re-demarcation of the boundaries of learning in higher education indebted to the nexus between education and today's fast paced technological advancements. The term '21st

century' has become a household word meaning *modern*, *technology*, *civility*, *new* and *up-to-speed*. The 21st century simply denotes another 100 years starting from 2001 to the year 2099. Even before the commencement of the 21st century, a number of educational analysts predicted the kind of educational landscape expected for the 100 year period (Lewis, 1983; Ross *et al*., 1992;Bates, 1995; Bennett & Lockyer, 1999; Duderstadt, 1999; Prensky, 2006). Most of these researchers grounded their arguments in the fast pace of technological advancement of the last decade of the 20th century. Only 17 years into this new century, for a student to excel in the 100 year period (21st century), a number of characteristics have again been identified as 'characteristics needed'. In the 21stcentury, students are expected to acquire the particular attributes of the 21st century student. These characteristics provide some basis for understanding the personal learning networks of students and the role played by technology in that space.

One is ascribed the name '21st century student' based on how he can integrate technology skills into activities related to his studentship. In her description, Eton (2011) illustrates that 21st century students are assertive, quite different from students in previous generations. She formalises her definition by associating the 21st century student with 21 characteristics:

1. *"Want to have a say in their education.*
2. *Often have higher levels of digital literacy than their parents or teachers.*
3. *Expect transparency in their parents, teachers and mentors.*
4. *Want you to tell them when you have messed up, apologize for it, and move on.*
5. *Don't care as much about having a job as they do about making a difference.*
6. *Demand the freedom to show their wild creativity. 21st century learners balk at rote learning and memorizing.*
7. *Want to connect with others in real time on their own terms.*
8. *Collaborate amazingly well.*
9. *Really can multi-task.*

10. *Appreciate a "trial and error" approach to learning new skills.*
11. *Learn by doing.*
12. *Have a 'can do' attitude.*
13. *Thrive in an atmosphere of controlled challenge.*
14. *Have multicultural awareness and appreciation.*
15. *Are open to change.*
16. *Are equal parts 'consumer' and 'creator'.*
17. *Increasingly aware of the world around them.*
18. *Know where to go to find information.*
19. *Are better educated than any generation before them.*
20. *Expect inter-disciplinarily.*
21. *Know that they are the future."*

Interestingly, students' involvement in curriculum design and development is usually minimal (Roeper, 1990). Here, Eton (2011) echoes from her first point a characteristic of student involvement in their own education or learning. Eton's characteristics on rote learning (point 6) and learning by doing (point 11) serve to emphasise each other. One who learns by practical means may not be enthused by rote learning. Real-time connection to students' learning environments can be related to the ubiquity of technology which also promotes collaboration.

EdTech Review (2009) appraises the characteristics of a 21st century student by identifying 10 characteristics of what the modern classroom should offer. The classroom must accommodate student-centeredness, active learning, adaptive learning, collaborative learning and mutual respect. Furthermore, the 21st century student prefers a learning space of computing devices and invitational environment, a place where students understand and follow the rules and procedures. The rest of the characteristics include student ownership of learning and performance-based assessment environments.

Shelly *et al*. (2012:16) describe students of today as "*media centric* [sic] *accommodating thousands of hours spent behind computer screens.*" *Ibid* maintain that nine characteristics of the 21st century student are as follows:

1. hyper communicators
2. multi-taskers
3. play oriented
4. random access
5. learning has to be relevant and fun
6. multisensory input
7. digital and graphic first
8. fantasy-based learning
9. twitch speed

According to *The Educational Technology and Mobile Learning* (2009), nine crucial characteristics of the 21st century student are student-centeredness, media-driven (this doesn't have to mean digital media), personalised, transfer-by-design, visibly relevant, data-rich, adaptable, interdependent and diverse.

In a similar plain, the characteristics of 21st century learning is captured by Partnership for 21st Century Skills (2007:1) under content knowledge, learning and innovation skills, information, media and technology, and life and career skills. In all, there are 12 core characteristics of the 21st century student distributed over the last three themes mentioned. Under learning and innovation, the characteristics identified include creativity and innovation, critical thinking and problem solving, communication and collaboration. Information literacy, media literacy and ICT literacy constituted characteristics of the student under information, media and technology.

The DPS (n.d.) in their seven categories of characteristics of the 21st century learner believe that such students build strong content knowledge, demonstrate independence and value evidence. While exhibiting all these characteristics, they use technology and digital media strategically and capably. The outcome of this later characteristics from having grown up "*bathed in bits*" since they were born (Trilling & Fadel 2009:29). Since students of today are connected into a network which includes search engines, validating evidence is relatively easy for them to do.

Digital characterisation of the 21st century student is the commonest phenomenon in the above literature. Digital characterisation is consistent with Prensky (2001:1) who corroborated that present day students are *"native speakers"* of digital communication. Often times, students of today are found operating a computer while listening to music with the cell phone in their hands for social media or other activities. Eton (2011) and the Durhan Public School concur with the assertion that the 21st century student engages in multitasking and in parallel sessions (Prensky, 2001:2). All the same, their stance on multitasking is in disagreement with the findings of Sana, Weston and Cepeda (2013:29). According to Sana *et al.,* students'

> *"Comprehension was impaired when they performed multiple tasks during learning, one being the primary task of attending to the lecture material and taking notes, and the other being the secondary task of completing unrelated online tasks."*

Their results further corroborate similar research (Wood *et al*., 2012); (Kraushaar, J. M., & Novak, 2010); (Barak *et al*., 2006). The argument put forward by Trilling and Fadel (2009) that communication and collaboration are necessary ingredients for career success align well with the stance of Eton (2011) and Partnership for 21st Century Skills (2011). On the other hand, Portrait of a 21st Century Student only resonated with Trilling and Fadel (2009) on communication, while *EdTechReview* (2014) agreed with Van Boxtel *et al*. (2000) and Heyman (2008) on collaboration.

Once more, the findings of Partnership for 21st Century Skills (2011) confirm earlier studies of Trilling and Fadel (2009) and others which revealed that this present day students maximise the use of technology to be widely connected in their learning networks as a way to improve their learning outcomes (Raines, 2002; Oblinger, 2003). Despite the advantages of collaboration as an attribute of a networked environment (Schrage 1990:48) for the 21st century student, this does not suggest that collaboration comes without any difficulty. Regardless of the multiple advantages of collaborative learning outweighing the difficulties that arise from its implementation (Bower & Richards, 2006), students are more likely to show traces of inherent uncertainties in their personal learning networks that go unnoticed in a real networked and collaborated settings (Waite *et al.*, 2004). This gap clearly reveals the necessity of empirically verifying collaboration as a characteristic of the self-directed student in a networked and connected environment.

Eton's position about 21st century students thriving in a controlled and challenged atmosphere may be supported by what Hase and Kenyon (2007) term as *heutagogy*. *Heutagogy* connotes a concept of self-teaching which draws on self-directedness (Guglielmino, 1978). Having identified some benchmarks of the characteristics of the 21st century student, the position of this research in literature can be formalised through exploration into how the 'so called' characteristics relate in students' personal learning networks. The next section also covers students' learning networks.

2.6.3 Social Media in higher education

Since 2004 when social media first began gaining ground, social media has become pervasive, due increasingly to ongoing creation and altering of content in real time (Kaplan & Haenlein, 2010). People do not have to be computer experts to understand and manage social networking sites. Veletsianos (2010) underscores the fact that personal learning networks are founded on social networks of humans. According to Veletsianos, educators must invoke proper understanding of social network and know what programme best works for what context. Social networking sites are popular and used by students in diverse ways. Examples include *Facebook, YouTube, Twitter*

Delicious and *Flickr*. Ersoy and Güneyli (2016) report how social media contributed to the personal education of impaired students in Turkey but observed that it did not contribute very much to discourse among the impaired students. However, they did not indicate why such discourse among impaired students was necessary if the social networks had in fact already promoted learning.

Social media use in education has received mixed reactions from researchers, experts and the public. Dabbagh and Kitsantas (2012:6) investigated the role of social media integration in the Personal Learning Environment and self-regulation of learning of students in the higher education context. The study finally proposed "a *framework for social media use to support both self-regulated learning in Personal Learning Environments*." Dabbagh and Kitsantas (2012) are of the view that learning paths created by students on social media are worth documenting to inform learning strategies and design. Boyd (2014) shares that social media affords teens the space to contribute to their community. But social media is not the space of only youngsters or students. In a survey, Moran, Seaman, Tinti-Kane (2011) revealed that teachers were not only aware of the existence of social media sites, but they also leverage on these sites for professional (in-class and out-class activities) and personal life. From a sample of 1,920 respondents, more than 90% of the faculty members surveyed were aware of *Facebook, Twitter, YouTube, Blogs* and *Myspace*. Furthermore, the records show that 80% had knowledge about *Wikis*, *LinkedIn* and *Flickr*. It is implied, therefore, that when there is an awareness of the positive impact of social media among teachers and policy makers, its integration in teaching and learning becomes somewhat a 'norm'. The study of Moran *et al*. (2011) showed that more than 60% of the respondents admitted to using social media in class. Out of this percentage, only 20% assigned students to make postings. Results from the 20% (assigned students to post) and 42% (assigned students to read/view) undermines research work that sees students as the creators of content (Cormier, 2008). Moreover, this indicates traces of traditional classrooms where teachers are seen as the all-knowing. The analysis is evident in the excerpt of Figure 2.8.

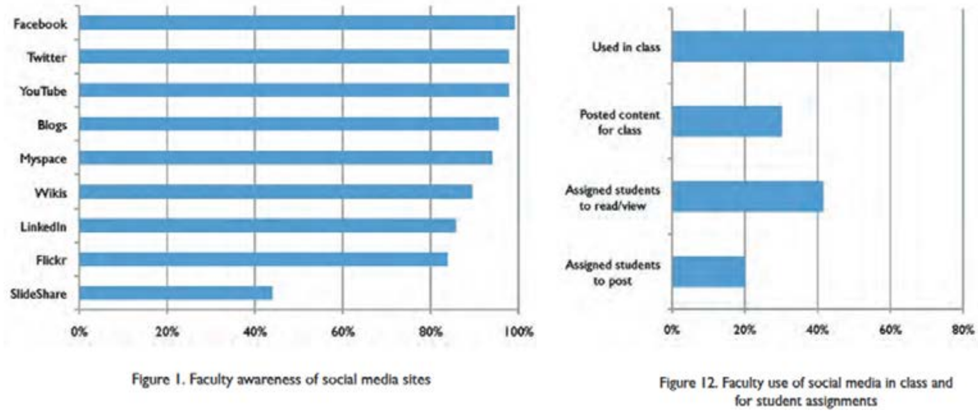


Figure 2.8: Faculty awareness and social media use for students' in-class and assignments

Holcomb *et al.* (2013) in a PEW report noted that people rely on social media for news. In their infograph to find out about crossover news use on social media, it was detected that a significant number of people who rely on *Facebook* (71%) for news items also do so for *Twitter*. The infograph, which has interesting pedagogical ramifications, suggest that students can be 'lured' to learning certain things based on a critical look of how the social media sites are interrelated. The findings of Holcomb *et al.* (2013) can be a good avenue for students and faculty of journalism, security, information and media studies. At the least, students in some of these fields will know when and where their hearers are popularly congregated.

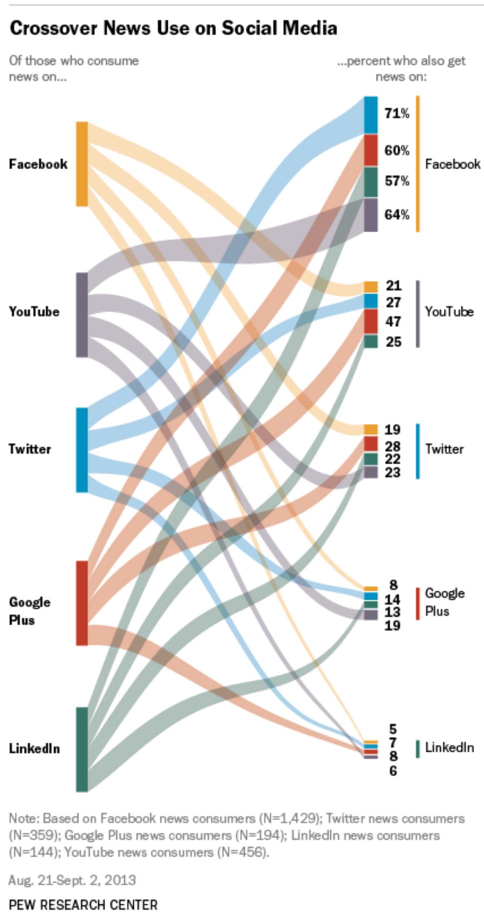


Figure 2.9: Crossover news use on social media (Source: PEW, 2013)

In a literature review by Tess (2013), he observed that most studies on the role of social media in higher education were either self-reported data or content analysis. His use of keywords such as *"social media", "higher education", "Facebook"* (Tess, 2013:A60) revealed that social media continues to grow into a mediating tool for teachers for student engagement. Unfortunately, Tess' study reported a dragging attitude of instructors in adapting social media as an integral part of the teaching and learning fabric, despite the existence of infrastructure in the universities.

Falahah and Rosmala (2012), in a survey with 300 respondents on social media use in three private universities with concentration on *Facebook, blogging, microblogging* and *instant messaging,* concluded that social media usage varied among users in private universities to include assignments and examinations. Falahah and Rosmala (2012) called for a policy to regulate social media use in the institution they studied. Apparently, workers using social media used work time and university resources for social media personal activities. The challenge here is that their account could not validate the exact uses of social media during those work hours. The policy part of their recommendation is consistent with Ramorola (2013) who also found the lack of policy on technology integration in senior secondary schools as a major challenge. It must also be noted that technologies such as social media set the tone for 'dialogue' among students and teachers (Ramorola, 2013:666). In line with earlier researchers, Issa, Isaias and Kommers (2016) underscored the need to maximise the opportunities associated with social networks (such as student-lecturer engagement) in higher education by minimising on the risk factors by streamlining social media usage in higher education.

Research conducted by Alsanie (2015) had interesting findings. Students said they did not use social media such as *Facebook* because of its time waste due to obsession. They again raised issues about vulnerability in protecting the privacy of users. Alsanie found that there is a negative relationship between students' use of social media and how they communicate with their families. But the results revealed that *WhatsApp* (93.4%) was widely used by the students, followed by 76.4% usage of *Twitter* and 36.8% of *Facebook*. Alsanie's conclusion suggests that students who use social media are prone to a life of solitude in reality at the expense of virtual reality.

Social networking sites are not limited to chats and casual activities. Students can use social media for class assignments, communication and for networking purposes. At the University of South Africa, Rooyan (2015) reported on the use of social media for online support to students in a second year module of an Accounting programme. The research recommended that most of the students were familiar with and had access to *WhatsApp, MXit* and *Facebook* on their mobile phones; therefore, this media could potentially enhance training of up-and-coming accountants for South Africa.

Research by Rambe and Chipunza (2013) revealed some merits of students use of WhatsApp in the university. Students who found themselves outside campus were still connected or privy to information via WhatsApp. However, they reported some related challenges with WhatsApp usage in Higher Education context. Among others, Rambe and Chipunza (2013:335) found Internet connectivity due to power outages as a hindrance in supporting "academic networking." Adhi's (2014) research also pointed to Internet connectivity issues in relation to WhatsApp. Other limitations of WhatsApp in education such as transfer of media and certain file formats like Portable Document Format (PDF) have been raised by Sonawane and Motwani (2014). Notwithstanding, Bere (2013) focuses more on how WhatsApp provides a platform for asynchronous communication which can be leveraged upon for educational gains.

In conclusion, students and teachers in higher education use social media to either promote personal or learning agendas. Literature suggests that various people, especially students who use social media in education, use this social media at different levels and in different courses. This review has demonstrated that though the infrastructure for social media exists in most universities, institutionalising its integration into teaching and learning is quite slow, primarily due to policy challenges. Nonetheless, students and teachers still use social media to achieve both personal and educational opportunities (Ersoy & Güneyli, 2016). There appear to be inconsistencies in literature. While Moran *et al*. (2011) report of teachers embracing social media to boost teaching and learning, Tess (2013) reports on the presence of social media infrastructure in higher education that is not leveraged upon, raising even more questions. Again, while some students perceive social media integration in learning as waste of time, elsewhere teachers and students see social media as effective pedagogical tool (Rooyan, 2015).

This research addresses the inconsistencies identified in literature in terms of students' technological experiences by compelling the finding of empirical answers to the following:

- *How are the emergent patterns in a rhizomatic learning network related?*
- *There is no statistically significant difference among the four cohorts of students in terms of their experiences with technology use in their institutions*

2.7 Implications of the review of related literature to this substantive research

The review admits that technology plays a role in redefining how learning occurs and is organised in higher education. Again, it is obvious that the concept of personal learning networks has been approached differently by various researchers (Harlan, 2009; Pineda, 2013). However, approaching the concept with a rhizomatic learning lens beyond listing actors, to the mapping of emergent patterns in a rhizomatic learning network, is yet to be realised. Another pattern gathered across literature indicates that curriculum developers in higher education have not conceived that students show traces of heutagogy (Hase & Kenyon, 2007). Heutagogy is an attribute of both Personal and Rhizomatic Learning Networks. From the above discussions, two key questions for addressing these gaps are:

- *What actors are in a rhizomatic learning network?*
- *How are the emergent patterns in a rhizomatic learning network related?*

In terms of ownership and digital device use among students in their personal learning networks, there appears to be a divide among scholars. Digital devices have not been accepted among some quarters, including educators as teaching and learning tools as many consider disruptive (Ng'ambi, 2013; Veletsianos, 2010). The implication is that consideration of the implementation of digital device ownership and use among students to advance learning in their networks may not be clear. As far as pedagogy is concerned, recent publications by Falloon (2015) and Mahenge and Sanga (2016)stress that digital device ownership and usage is very high among students. This research provides evidence as to the actual digital devices students own and the differences in importance in reference to their academic success. In response to this confusion, the following sub-research question and hypothesis were outlined:

- *What digital devices are owned by students in higher education?*
- *There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success.*

Handheld devices are not new in higher education. Though reports reveal challenges in the use of handheld devices in higher education (Backer, 2010; Blignaut *et al.*, 2010; Day-Black & Merrill, 2015; Falloon, 2015) there are key areas that support students' personal learning networks. First of all, literature tells about the widespread ownership of handheld devices among higher education students, many of which supports some learning (Lalita, 2011; Cross *et al*., 2015; Witecki & Nonnecke, 2015; Mahenge & Sanga, 2016). Some of the ways in which handheld devices assist students are through the organisation of resources and communication (Fallon, 2015), improvement of students' memory (Bryan and Clegg, 2006) and improved technological skills (Warschauer *et al*., 2010). Again, literature points to the differences in terms of clear policies in the use of digital devices in higher education (Blignaut *et al.*, 2010; Ramorola, 2013). What this implies is that integrating handheld devices into educational curriculum will streamline some of the challenges identified earlier on. However, further exploration needs to establish students' perception on how handheld devices contribute to their learning. This necessitated the following research question:

- *To what extent are the devices used by students perceived to be a promoter of their academic success?*
- *There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success.*

Literature predicts massive investment in university wireless networks by 2020 (Anderson *et al.*, 2012). This is already evident through the numerous private-public partnerships for rolling out wireless network projects in many universities (Aruba, n.d). Despite the indicators pointing to teaching and learning support via University Wireless Networks, researchers have not focused on the differences in terms of students' experiences with their university wireless networks (Gupta & Koo, 2010). Literature only reveals numerous researches on the benefits, challenges and projects of universities wireless networks (Saha & Karpinski, 2016). For this research, differences in university wireless network experiences imply a connection of actors to other actors who are all nodes but which promote interaction in students' personal learning networks. The wireless networks also interface between the student and other socio-technical aspects of personal learning networks so it is very important in this research to understand the differences. Major gaps dealing with understanding of students' experiences with university wireless networks and finding the differences remain a challenge. The hypothesis below, derived from the review, is to address the gaps:

- *There is no statistically significant difference among the four cohorts of students in terms of experiences with their university wireless networks*

Differences in the use of Learning Management Systems in higher education go beyond 'brand' names of the platform such as *Blackboard*, *Moodle* and *Jenzabar*. By way of implication, what was identified from the review ranged from interaction and expertise of students and staff, to students' perception of their institutional Learning Management System. This also means that students' interests in the use of any Learning Management Systems largely depended on the kind of experiences staff or lecturers take students through (Govender & Govender, 2014; Lonn & Teasley, 2009b). By extension, experiences are expected to vary at different levels based on subject specifics, expertise of staff and institutional policies that promote interaction through Learning Management Systems (Murshitha & Wickramarachchi, 2016). For instance, to address the shortfall of Naveh *et al.,* (2010) who studied only one institution, this research focused on four different institutions to form the basis of identifying institutional differences. Participants in this research across the institutions also vary in terms of the courses studied. The focus of this research is to address the inconsistencies resulting from the different kinds of institutions and participants studied, by analysing the hypothesis below:

- *There is no statistically significant difference among the four cohorts of students in terms of their satisfaction level of Learning Management System in their institutions*

Students' experiences with technology were reviewed based on their learning environment. One commonality that emerged across literature was the context and culture within which learning occurred (Bates, 2005; The Glossary of Educational Reform, 2013; Ito *et al.*, 2013). In this research, the context of The Glossary of Educational Reform (2014) is higher education, resonating with Ito *et al.* (2013) in terms of academic orientation of learning spheres. Furthermore, the culture includes all kinds of interactions within students' personal learning networks which can involve the student and all five pillars of Bates' (2005) learning environment in the relationships of student with actors: resources, student support system, assessment, content, skills and student characteristics. A student's personal learning network grows dynamic due to how all the pillars of Bates' (2005) learning environment interact with the student to achieve learning tasks. Once more, students' reliance on social media for reasons like learning collaboration describes the kind of peer culture (Ito *et al.*, 2013) and student characteristics (Bates, 2005) that curriculum designers must note. It was also found that personal interest drives learning. This is one characteristic of students involved in self-directed learning or heutagogy (Hase & Kenyon, 2013; Richardson, 2005) or social media. Another implication for this research is that students do not need special classes to become social media users; rather, this evolves from self-directed and personal learning networks. As part of student learning environments, the review established that students and teachers continually use social media to exploit personal and educational opportunities (Ersoy & Güneyli, 2016). But it remains unclear how students' technological experiences relate to their learning in their institutions; therefore, the motivation is to find answers to the underlisted research question and research hypothesis:

- *How are the emergent patterns in a rhizomatic learning network related?*
- *There is no statistically significant difference among the four cohorts of students in terms of their experiences with technology use in their institutions*

As earlier indicated in the review of literature, answers to each identified gap will emerge from the sub-research questions and hypotheses via empirical analysis. Furthermore, answers derived from additional empirical analysis from the aforementioned gaps collectively address the main research question which states the following:

- *To what extent does technological influence on students' personal learning networks show traces of Rhizomatic Learning in higher education?*

2.8 Theoretical lenses

The theoretical lenses section is the second part of this chapter. This research is underpinned by Rhizome Theory and Actor Network Theory. Six principles of the Rhizome Theory are used to understand patterns that emerge from students' personal learning networks in a technological learning environment. Actor Network Theory also offers guidance to the research in mapping the human and non-human actors that interact with the student within the personal learning networks.

2.9 Rhizome Theory

Knowledge can no longer be considered a lone-path or a one-size-fit-all concept despite its dynamic concept of many entry points without the limitation of where, when and how 'entry' is defined. This study adheres to Rhizome Theory (RT) the main theoretical lens of understanding. Fathers of Rhizome Theory (RT), French philosophical-psychoanalytical theorists Gilles Deleuze and Felix Guattari through their title, *A Thousand Plateaus, Capitalism and Schizophrenia* conceived the rhizome as an *"open system"* (Warburton, 2010:5; Deleuze & Guattari, 1987:p.x). Just like recent technological penetration in education, rhizomes oppose hierarchical patterns and by their nature, lack centre and end points; however, they grow to form stronger networked environments.

Eventhough Bonnie (2011) and Mackness *et al.* (2016) backlash on the use of RT as an educational theory, Bonnie admits that rhizomatic learning as a lens is intended to help one see differently and to also assist in "viewing the educational landscape." Rhizome Theory resonates with how students' personal learning networks get formed through the various diverse nodes owing to vehement technological advancements (Guerin, 2013). In distinguishing between the traditional and hierarchical treelike structure from the non-traditional and non-linear rhizomatic plants, Deleuze and Guattari (1987) noted the following:

> *"A rhizome as subterranean stem is absolutely different from roots and radicles. Bulbs and tubers are rhizomes. Plants with roots or radicles may be rhizomorphic in other respects altogether: the question is whether plant life in its specificity is not entirely rhizomatic. Even some animals are, in their pack form. Rats are rhizomes. Burrows are too, in all of their functions of shelter, supply, movement, evasion, and breakout. The rhizome itself assumes very diverse forms, from ramified surface extension in all directions to concretion into bulbs and tubers" (p.* 7-8).

To appreciate the 'genetic rhizome' as a metaphor, Deleuze and Guattari (1987:7) atomised the characteristics of a rhizome into six principles: *Connection* and *Heterogeneity, Multiplicity, Asignifying rupture, Cartography and Decalcomania*. In the 21st century, the 'genetic rhizome' and its theory can be used as a conduit to understand the patterns of seemingly complex personal learning networks of students in technology-rich learning environments. In spite of earlier research showing precedence in the application of Rhizome Theory to understand educational problems or used as a methodological concept for educational research (Guerin, 2013; Warburton, 2010;

Smagorinsky, Augustine & Gallas, 2006; Sermijn, Devlieger & Loots, 2008; Payne, 2010), its usage in "*teaching and learning*" has been called flawed and "*problematic*" by Mackness *et al*. (2016:78).

Rhizome Theory (RT) bears some resemblance with other educational theories, in part but not whole. Actor Network Theory (ANT) and Connectivism (Siemens & Downes, 2008) are other theories that make use of connections and agents or nodes similar to what is found in a rhizomatic network. Both Connectivism and Rhizome Theory, the embodiment of actors that get connected to knowledge sources, also get into the interpretation of patterns (Cormier, 2008; Siemens, 2006); however, in the Rhizome Theory, Rhizomatic Learning nodes also get multiplied through the connectedness to other sources that are not necessarily sources of knowledge but knowledge connecting tools. Section 2.11 is an exposé on how Rhizome Theory and Actor Network Theory resonates with this research, explaining its adaptation as the theoretical lenses for this study

2.9.1 Connection

In any personal learning network "*connection is far more critical*" (Wilson *et al.*, 2007:32). The term *connection* is as complex as the rhizome plant and also resonates with educational theories such as Connectivism. The 'genetic rhizome' "ceaselessly establishes connections between semiotic chains, organizations of power, and circumstances relative to the arts, sciences, and social struggles" (Deleuze & Guattari, 1987:7). The principle of connection echoes just how fast the 21st century learning gets complicated through networks. Cormier's point, when he describes the rhizome theory as a concept of community as a curriculum, is underpinned by a sense of connection. This assertion can be supported by Wheeler's (2012) discovery which states that *"we are better when we are connected and are working concertedly toward a shared goal."*

It is not new for higher education students to form study or social groups. What is becoming a novelty, though, is how these student communities create virtual learning and sharing environments (Russ, 2011) to support their personal learning networks. A recent example can be found in how students connectedness brought about a two week-standstill in fourteen universities in South Africa through the #FeesMustFall movement (Omar, 2015; Onishi, 2015). Students' active participation in decision making that impact on their learning is increasingly strengthened through hashtags. Some other examples include the #RhodesMustFall (Habib, 2016;Hussey, 2015) and #WitsFeesMustFall (Habib, 2016) movements in South Africa, #TakeBackHU (Svrluga, 2015) at the Howard University and similar campaigns.

Researchers have always tried to link students' personal learning networks to the Internet (Garrison & Kanuka, 2004; Wilson *et al.*, 2007). In their words, Garrison and Kanuka (2004:97) posit that *"Internet communication technology facilitates a simultaneous independent and collaborative learning experience."* Beaudoin (2002:148) also supports the idea that in distance education programmes, online learning promotes teacher-student interaction which further *"improves the quality of learning."* Regardless of the positive aspects of Internet in education, growing concerns about certain odds keep mounting. The use of wikis in education has been questioned over and over again. The "*accuracy and veracity on a wiki*" (Wheeler, Yeomans & Wheeler, 2008) has always been in doubt, despite the massive patronage of wikis in education.

Time for learning has been given over to the Internet due to too much exposure to the Internet in the forms of social networking and other distracting factors such as gambling, non-educational games, limited skills in searching for useful resources and blurred vision (Mutti & Zadnik, 1996). With mass connectivity, multitasking by students is also on the ascendancy. In a number of reports, researchers found negative effects of multitasking on students learning largely because of technology (Kirschner & Karpinski, 2010; Junco, 2012; Junco & Cotten, 2012). Song *et al.* (2013) recommend that media multitasking among students should be controlled because of its distractions to learning. In their research, Sana et al. (2013) detected that students':

"Comprehension was impaired when they performed multiple tasks during learning, one being the primary task of attending to the lecture material and taking notes, and the other being the secondary task of completing unrelated online tasks."

Due to the Internet's rapid spread, the world today is recognised as a very well-connected place by "human connections" and the Internet, with strong implications for both teaching and learning (Zuckerich of *Facebook*, 2015). Conversely, there are conflicting reports about the extent to which the Internet has connected the world; but this does not rule out the students' dependency on the Internet in their learning networks. Again, it buttresses the point that learning today is not all covered by technology and traditional methods of learning without the Internet are still common because the entire world is not yet covered with Internet. While *Internet live Stats* (2016)reported that two-fifths of the world's population is connected to Internet, Internet.org said that only one-third of the world's population is connected to the Internet (see Figure 3.2).

Figure 2.10: World's population connected to the Internet (Internet.org, 2015)

Due to the various and prominent activities of users on the Internet, there is a general assumption that the Internet covers the world such that everyone is connected to it. These discrepancies in statistics highlight the fact that the rhizome connection is not only about connecting to technology. It includes humans and other socio-technical factors. Assumptions and statistics about the Internet have implications on curriculum development. Nonetheless, the technological richness of a student's learning environment and how well the student can use technology will determine how technologically driven a personal learning network is. The connections in a student's personal learning network will be stronger, more complex and ceaseless in the technological age, if and only if, technology is what drives the learning.

To recap, at the very least, statistics on Internet coverage is indicative that despite an Internet-motivated connection, there are a number of communications built *outside* digital technologies which go undocumented. This phenomenon raises questions for curriculum developers since students, in their personal learning networks, connect with or without technology.

2.9.2 Heterogeneity

Heterogeneity can be explained with words like *diversity*, *array*, *mix*, *blend* or *collection*. The rhizome plant shows diversity in structure and behaviour: no two rhizomes have the same structure. Within a rhizome, the growth pattern of each node (actor) is unique. These unique characteristics stress the idea of students' technology use in their personal learning network environment. Students use a mix of technologies (software, hardware, platforms, social media and others) to achieve learning tasks. For instance, in a design class, students are free to use *Ms. paint*, *Corel Draw* or other tools to achieve the same learning task of producing an artefact. Cell phones owned by students are different from each other from brand, size, screen size, memory capacity, and keypad to storage capacity but they are used to attain the same learning objectives (Crowley & Spencer, 2011).

The heterogeneity of a personal learning network is an intimation of a dynamic learning network that is not only about people or books. It may include other learning practices and processes such as learning styles (Vermunt & Vermetten, 2004), learning environments (Wilson *et al.*, 2007), social networking (Kommers, 2016), learning materials (Sharples, 2000) and the creativity of the student. This is likened to the nature of the rhizome where entry points for knowledge are complex and diverse. Acquisition of knowledge cannot be a one-way route. The relationship between the student and his personal learning environment is always heterogeneous and different. One unique thing about the heterogeneity of personal learning networks is that they are never static, even for individuals. At one moment a student relies on a news channel for some information and at the other moment goes to Wikipedia or social media sites for confirmation. This sequence is never the same each time a student tries to confirm or triangulate. Sometimes the confirmation process begins with a phone call or *WhatsApp* text.

Another way to express heterogeneity in students' personal learning networks is the choice of project work that students elect (Valtonen *et al.*, 2012). Even for the same area or titles, students' present varied perspectives on the same question. Technology allows students to have multiple and heterogeneous sources of information which serve as reinforcement for students' ability for *"trial and error"* and multitasking. To the student, information in the 21st century can always be authenticated in real time so long as certain sources are seen as credible (Metzger, Flanagin & Zwarun, 2003). In a typical mathematics class, though students are taught with an approach or by a lecturer, students still approach mathematical problems with varied solutions that are less complicated for them (Jonassen, 2000).

Using a mobile device in a personal learning network can take many variations for students. While McGarr (2009) noted that some students use the mobile phone for recording lectures, in Japan Thornton and Houser (2005) observed students' creativity in the use of mobile devices to capture photographs. Nonetheless, mobile devices also favour music as a recorder and altering tool (Visagie & De Villiers, 2014). The same mobile device, such as a phone, can be used for scanning, group chats to solve assignments, streaming educational and non-educational videos and playing games. Heterogeneity runs correspondingly with Sayer's (1992) features (point 3) of critical realism:

> *"Knowledge develops neither wholly continuously, as the steady accumulation of facts within a stable conceptual framework, nor discontinuously, through simultaneous and universal changes in concepts."*

Sayer's statement suggests that in the 21st century, knowledge is heterogeneous and is no longer vested in the teacher (Lea, Stephenson & Troy, 2003). Concepts where teachers are seen as the primary repository of knowledge are challenged. Could it be that what students are taught is not really what they learn because they teach themselves (heutagogy) from multiple sources (via technology) amounting to deeper learning?

2.9.3 Multiplicity

Though knowledge can be conceived as a unit, there are multiple entry points in the conception of knowledge. Deleuze and Guattari (1987), who detest seeing knowledge as having finite measurements, contend there is no single reality when it comes to knowledge creation.

> "*A multiplicity has neither subject nor object, only determinations, magnitudes, and dimensions that cannot increase in number without the multiplicity changing in nature (the laws of combination therefore increase in number as the multiplicity grows). Puppet strings, as a rhizome or multiplicity, are tied not to the supposed will of an artist or puppeteer but to a multiplicity of nerve fibres, which form another puppet in other dimensions connected to the first: "Call the strings or rods that move the puppet the weave*" (Deleuze & Guattari, 1987:8).

The Rhizome Theory is conceptualised as flat and having imaginary lines of complex connections that are inter and intra woven without a *subject* or *object*. This means that equal values are assigned to all the actors in the rhizomatic network. In their description of the principle of multiplicity, Deleuze and Guattari (1987:6) noted that "*whenever a multiplicity is taken up in a structure, its growth is offset by a reduction in its laws of combination.*" According to Beetham (2013), technology in education has created multiplicity of worldview for students in their interaction with their teachers, methodological processes and learning experiences: called "*Rhizomatic Pedagogy.*"

A personal learning network is comprised of a multiplicity of actors talking to or about the student who owns that personal learning network. Platforms do talk to each other about the student. For example, when a student sets a filter on *Google scholar* or *Researchgate*, these platforms speak to other sources to search for 'relevant' and related materials for the student. The same principle works for tagging Folksonomy in the context of social media (Wheeler, 2012). In higher education, a student experiences multiplicity of experiences through the different lecture methods, social activities, friends and lecturers they encounter. Each of these experiences presents an opportunity for their personal learning networks.

Electronic devices used in personal learning networks of students exist in multiples. A typical student in higher education will be a user of the mobile phone, computer and certain computer/mobile applications. From the perspective of rhizome theory, there are no units of measurement, only multiplicities or varieties of measurement (Deleuze & Guattari, 1987). It is unfair for one assessment strategy be applied to grade a student. The divergent and multiple sources of knowledge open educators up to refuse to be rigid with fixed assessment styles. Educators are challenged to find innovative ways of assessing certain traditional methods of learning in certain fields such as essay writing, agriculture and mathematics (Bryan & Clegg, 2006).

2.9.4 Asignifying rupture

Tension in any network leads to possible breakages (Law, 1999). A breakage in a network does not signify a total disconnection as new communities are formed but linkages between the mother and splinter communities are still kept, even though weak. In a personal learning network, a student may decide to only play an inactive role on a *WhatsApp* or *Facebook* community rather than creating knowledge through postings. However, this "*inactive student*" may be a very active reader of posts of other group members. *Asignifying rupture* can also be described as a way of going into hibernation in order to focus more on other actors while nonetheless maintaining a relationship that is not dead.

In a typical community of a social network, students may decide to engage in a one-on-one conversation following a tense, heated argument on the community or group page. This does not in any way suggest that they are not part of the group. These lines can always be reactivated when they are mentioned in the conversation to react to certain things, as most of the time, inactive social media users respond to birthday wishes and other wishes.

There has been an increase in public outcry over certain observations in the educational landscape. One of them is the declining use of libraries and the other is the decline of students learning (Bita, 2016;Childs, Matthews & Walton *et al.*, 2013; Shelly *et al.*, 2012). These claims were earlier debunked by Walton (2006) whose research proved a renewed form in the use of libraries (spaces). The number of downloads of digital resources and access to digital databases exceed the number of physical books checked out from libraries in the past. Eton (2011) asserts that students of today have more information than generations before them. Students' declining use of physical books shows traces of *asignifying rupture*. More reading of books has been done by current students than past students due to how books have been reduced to digital and print media, making them handy for mobile devices (Crowdy & Spencer, 2011). Despite the debates over reading, the use of libraries, the use of books or the decline in learning, these activities still carry on in a stronger, robust learning environment that is even more personalised. Previously, one could hardly organise books for a personal library. In general students have branched away from the use of physical libraries to digital libraries where they can subscribe to books, literature and materials in real time. This is made possible by digital databases.

The rupture in the use of physical libraries suggests an increase in personal libraries. Indeed, there are many more personalised libraries, a fact which confirms student characteristics on student control and automacy (Callon, 1999). Students' physical use of the library will be the result of wanting a place to sit and study or to retrieve resources that cannot be found outside the library (Childs *et al.*, 2013).

2.9.5 Cartography and decalcomania

The principles of cartography and decalcomania hold that the rhizome plant is unique in its own nature, described as a "map and not a tracing" (Deleuze & Guattari, 1987:12). Students do not reinvent the wheel by forming some networks or learning paths as their counterparts. Each learning path and learning experience is created, constructed, unique and not amenable to structure. Long before present day technology in education, the principles of cartography and decalcomania were being applied in some spaces by educational theorists without direct reference. They have identified all students, irrespective of age or class, as possessing individual differences and abilities (Piaget, 1955, 1972; Skinner, 1953).

In the same vein, technology ownership and use in our classrooms today cannot be assumed to be one-size-fit-all activity. As with maps, there are multiple entryways, but not all these entryways are the same. A map forms a series of connections with other maps and other attributes. Similarly, in a rhizomatic learning environment, students construct chains of multiple connections for their learning networks with the aid of technology to achieve personal objectives. Notwithstanding, students are engaged in numerous negotiations, trials and errors in order to achieve learning tasks by becoming student-centric (Beetham, 2013; Eton, 2011). Beetham (2013:275) posits that *"increasingly, students expect to use their own digital networks, services and resources to support their studies, for this reason, curriculum designers will need to be flexible in response"* and take into consideration the growing multiple entryways for learning.

2.10 Actor Network Theory

Developed by Michael Callon in 1982, the Actor Network Theory is used to explore the socio-technical linkages and aspects of a network or community (Latour, 2005; Law, 2007). Actors, processes, actants (objects of actions from an actor), are the building blocks of the theory. This theory permits the study of both social and technical aspects of a network or community by assigning them equal values (Callon, 1999). Students' personal learning networks are integrated with other humans, processes and non-humans. According to Latour (1999:19) *"actors know what they do and we have to learn from them not only what they do, but how and why they do it."* From this premise of Latour, it can be deduced that information about a student's personal learning network is best known by himself. It again suggests that students can best ascribe the reasons why certain connections and interactions occur in their learning networks.

The Actor Network Theory also reveals the kind of tensions that exist among actors, tensions which affect the network in various ways such as breakaways, cliques or revisions of rules within the network. Actor Network Theory has also been applied by researchers to understand how social networks are negotiated (Domingo & Wiard, 2016; Mahapatra, 2016). The kind of negotiations identified in a personal learning network describes the kind of connections existing between nodes – weak, strong or casual. Given that the Actor Network Theory is applied in analysing technological and heterogeneous nature of networks (Elgali & Kalman, 2010) this theory is useful in the following ways:

1. to explore what the actors and interactions of students' personal learning networks are;
2. to explore the main similarities and differences among the personal learning networks of students

2.11 Rhizome Theory and Actor Network Theory

In his editorial, Latour (1999:15) agreed to Lynch's (1995:168) suggestions that due to the ANT's ontological perspective, Actant-Rhizome Ontology (ARO) would have been a more suitable name for this "*theory.*" Latour described the rhizome as "*series of transformations-translations-transductions which could not be captured by any of the traditional terms of social theory.*" In a later turnabout, he maintained that the term *rhizome,* implying "*transport without deformation, an instantaneous, unmediated access to every piece of information*", was in contradiction with the term *network* and what he referred to as *"double click information."*

Despite the discussions between Latour and Lynch, their point of convergence was in the fact that Actor Network Theory and Rhizome Theory conceive connections between animate and inanimate agents, whether weak or strong (Lynch, 1995). The agents are sometimes referred to as *actors* (usually animate) or *actants* (usually animate and inanimate agents). Though Actor Network Theory looks at the relationship between human and non-human actors (actants) which can also be the socio-technical agents of a network, Rhizome Theory does not draw specific lines between actors and actants or nodes(Law, 1992; Lynch, 1995; Latour, 1996; Callon, 1999; Siemens, 2005; Bell, 2010). The use of Rhizome Theory and Actor Network Theory can be corroborated by a similarity in powers. Both theories talk about power and control. In Actor Network Theory, actors are said to be *"endowed either with limitless power, or deprived of any room for manoeuvre at all"* (Callon, 1999). This later statement about Actor Network Theory by Callon can be shared to explain the Rhizome Theory principles of asignifying rupture and multiplicity

Two common junctions for the Rhizome Theory and Actor Network Theory are the concepts of *negotiation* and *multiplicity*. Latour (1999:225) construes strongly that *"humans and non-humans take on form by redistributing the competences and performances of the multitude of actors that they hold on to and that hold on to them."* In a rhizomatic map, the construction of knowledge is negotiated among the actors (humans and non-humans) who sometimes are involved in multiplication of the nodes or knowledge. A typical example is the use of an RSS feed aggregator in a personal or a rhizomatic learning network to collate distributed information from different sources for a student's learning network. In this case, non-human actors interact in multiple ways about a student. These are rights given up or filters set by students to strengthen their learning networks in a negotiated effort.

2.12 Implications of rhizomatic learning and actor network on higher education

From this, the term 'Rhizomatic learning' will be used to mean activities of a student and actors in his personal learning network that bears characteristics of the Rhizome Theory. There are enormous traces of rhizomatic characteristics that share relationship with the students' personal learning network(s). First and foremost, Rhizomatic learning has a number of implications on higher education, the main one being that advanced emerging technologies are altering traditional methods of teaching, learning and administration, creating complex networks of nodes of learning resources. However, the student takes ownership, becoming the centre of learning driving his own learning from multiple entryways. This chapter is summarised using Siemens' (2006) five-point properties of learning: 1) how learning occurs; 1) influencing factors; 3) role of memory; 4) how transfer occurs; and 5) types of learning best explained.

How learning occurs*:* Though complex learning occurs in a personalised fashion by students' customisation of resources and leveraging on available technologies to achieve learning goals. It does not matter what lecturers teach students as facts. Students always have the opportunity to verify those facts from web sources and other 'reliable' sources in their learning networks. Lecturers act as facilitators rather than 'experts' pouring knowledge into students. Simply put, students negotiate and construct their own knowledge, drawing from available resources (community or network) which include human and non-human agents (Latour, 2005; Cormier, 2008).

Influencing factors*:* Rhizomatic learning is influenced greatly by networks or community as the curriculum. It is also influenced by technology, open systems and the community (Deleuze & Guattari, 1987; Cormier, 2008). This implies that in designing and developing curriculum for higher education, it is imperative to involve the students (the most important stakeholder), as this will help to gather information on the kind of technologies and community that drive their (the students) learning or networks to which they belong.

Role of memory**:** The rhizome principles strive on networks which are comprised of nodes that interact with or without tensions to engender learning experiences (Guerin, 2013; Law, 1992; Siemens, 2004). The role of memory allows inferences from past and current experiences, existing connections, and previous and current contexts through concrete activities. The memory becomes 'smarter' based on 'learning by doing' and the transfer of experiences gathered from a personal learning network. For example, students who constantly use Microsoft Word to type their assignments will use less time navigating through other word processing applications. Again, basic operations (such as a web search) can easily be transferred from one device to another, like surfing the Internet from a laptop, mobile phone or a tablet; the principles are basically the same but what is learnt may be different.

***How transfer occurs*:** Primarily, learning is transferred from multiple entryways of existing connections or communities and growing networks (Cormier, 2008; Warlick, 2009; Pineda, 2013). This does not rule out the fact that some learning cannot be achieved outside students' learning networks. Learning is achieved through practical activities that are socially oriented but focus on the self. With the aid of modern and emerging technologies, knowledge acquisition can be programmed to filter interest areas, topics and fields (Barry *et al.*, 2015; Ng'ambi, 2013). A student is equipped with good, right and current information in a subject matter; if the appropriate filters are set, a student becomes learned in this particular field. Deliverers of higher education curriculum must pay more attention to sources where students harness information, and if possible, equip them with search and research skills right from the foundation of the courses. Some students will rely on Wikipedia as the universal truth; however, such students can make inferences within their network resources to validate their findings.

Types of learning best explained: Complex learning, multitasking, or personalised learning in fluid and diverse multiple entryways, learning is the construction of knowledge by the student and his or her community (network) in the curriculum (Cormier, 2008).

Finally, Rhizome Theory and the Actor Network Theory are used to understand patterns that emerge from students' personal learning networks. These two theories serve as a conduit to analyse the results in this research through the identification of the human and non-human actors and how they interact with the students in their personal learning networks.

CHAPTER THREE

Research Philosophy and Methodological Choice

"Every concept has components and is defined by them [sic]. There is no concept with only one component. Even the first concept of a philosophy has several components"
- Deleuze and Guattari (1994:15)

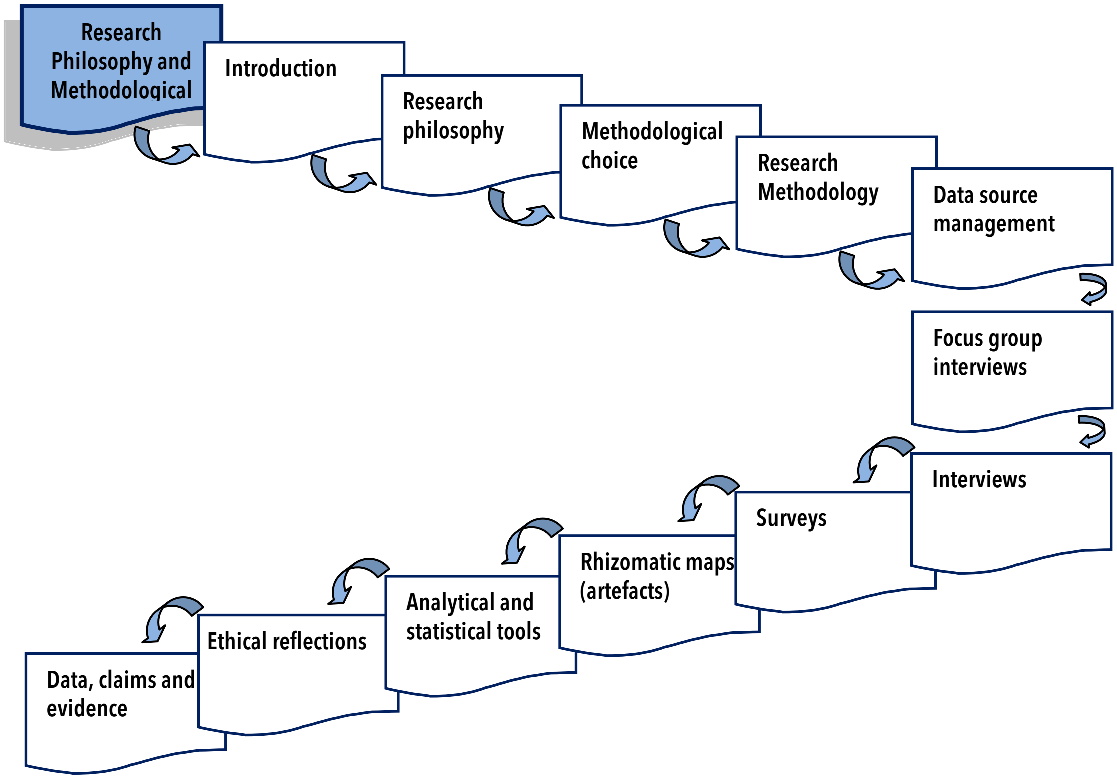


Figure 3.1: Map of Chapter Three

3.0 Introduction

This chapter draws attention to the philosophical underpinnings and the choice of research techniques and processes for this scientific research. The aim of the research is to explore the underpinnings of technology use in students' personal learning networks in higher educational environment. The chapter justifies the research alignment to critical realist philosophies because it allows this type of research to explore an understanding of students' personal learning networks via multiple entryways and realities. My choice of Ploywright's (2011) Extended Framework for Integrated Methodologies (FraIM) also provided sound foundation for the collection and analyses of numerical and narrative data to answer the research question. The research question was to find out the extent to which technological influence on students' personal learning networks show traces of Rhizomatic Learning in higher education.

3.1 Research philosophy

My understanding of research philosophy is an elucidation of the viewpoint of knowledge development of a belief, concept or theory against how knowledge about that same belief, concept or theory is seen and understood by the world (Bryman, 2012; Saunders *et al*., 2012; Deleuze & Guattari, 1994). Research philosophy is usually founded on abstract backgrounds. Creswell (2013:16) defines philosophy as *"the use of abstract ideas and beliefs that inform our research."* Philosophical debates have continued for years because there is no such a thing as one-philosophy-fits-all (Guba & Lincoln, 2005).

Philosophically, this research is aligned with the views and beliefs of critical realists (Bhaskar, 1997; Mingers, 2004; Smith, 2010). Dobson (2002) argues that *"a critical realist's position is that our knowledge of reality is a result of social conditioning and thus cannot be understood independently of social actors involved in the knowledge derivation process."* In this study, the interplay among actors in students' personal learning networks in a technologically-rich environment cannot be understood through a lens of single reality. Reality is subjective, intrinsic and cannot be known.

Even so, being unknown, multiple realities may exist but can only be revealed through many viewpoints by participants and respondents in this study.

The biological rhizome plant has no definitive structure and therefore it assumes multiple realities (Deleuze & Guattari, 1987; Cormier, 2008). Rhizome Theory and critical realism both present images of the real world, not the world itself; hence, this study is inclined towards exploratory research for in-depth results (Saunders, Lewis & Thornhill, 2014:136). The use of technology in learning has taken different dimensions. In the digital revolution age, students' personal learning network approaches have been characterised by no single approach to learning. A tabular representation of philosophical assumptions (critical realism) with its implications for practice is provided in Table 3.1.

Table 3.1:Philosophical assumptions with implications for practice (adapted from Creswell, 2013:21)

Assumption	Question	Characteristics	Implications for practice (examples)
Ontological	What is the nature of reality?	Reality is subjective, intrinsic and cannot be known. Nonetheless, being unknown, there may be multiple realities only discoverable through many viewpoints by participants and respondents in this study.	Emerging issues are analysed and reported thematically through multiple perspectives.
Epistemological	What counts as knowledge? How are knowledge claims justified? What is the relationship between the researcher and that being researched?	The knowledge of reality is multiple, based on an individual's perspective(s); Findings in this study are subjective and independent of the researcher and participants; Generalisations are permissible only within the population of the study; However, the permissibility of transferability is allowed when a study has similar conditions, similar characteristics and similar subjects to this study.	Researcher collaborates, spends time in field and engages with participants, and becomes an 'insider'. In this study, contributions are informed by data from participants and my professional practice.
Axiological	What is the role of values?	Researcher acknowledges that research biases can be present (especially for narrative studies). However, another way of exploring a phenomenon can come through insights from inferences.	Researcher openly discusses values that shape the choice of selection of research approaches through the use of numerical and narrative interpretations (which include my own interpretations and that of the participants). Again, researcher acknowledges that both numerical interpretations and arguments from the narratives complement each other.
Methodological	What is the process of research? What is the language of research?	Inductive reasoning, deductive inferences and retroduction (Danermark, 2002) are employed within the context of the study through varied multi-method approaches and an emerging design.	Researcher works with Rhizome Theory and Actor Network Theory as theoretical lenses to understand particulars (details) from data (narrative and numerical) before reporting. Describes in detail the context of the study, and continually revises questions from experiences in the field.

3.1.1 Ontological perspective

Ontology explains the viewpoint of the nature of reality or being in this research (Blaikie, 2009; Easton, 2010; Saunders *et al*., 2012). Mertens (1998) argues that in every research, a researcher's philosophical view of the world implies his or her research strategy. I have adopted the critical realist's ontology for this thesis because, *"it focuses on the reality of entities, generative mechanisms, deep structures, and causal powers"* (Vandenberghe, 2007) which has implications on technology use in students' personal learning networks. Moreover, the realists' assumptions and features of realism align correspondingly with my two theoretical foundations upon which this study is hinged: Rhizome Theory and Actor Network Theory.

1. ***Reality of entities***: Bhaskar (1975; 2013) articulates very well the independent existence of nature from what we actually see or think about nature. A typical example is when students rely heavily on Wikipedia for assignments but decide to look for references elsewhere to indirectly cite Wikipedia because Wikipedia is deemed to not be a peer reviewed or credible source by most academics. Again, the reality on the ground is that students will continue to use social media sites using their private Internet even when university authorities decide to block those sites during lecture hours. These examples have causal effects of the third principle of the Rhizome Theory: *Asignifying Rupture.*
2. ***Generative mechanisms***: As Winn and Lockwood (2013:221) noted, *Rhizomatic Pedagogy* has created multiplicity of the worldview for students in their interaction with the learning processes and experiences due to technology. The learning ecology is increasingly getting more complex (biological rhizome plant), outracing the curriculum in place. The community of students can best be described as the curriculum (Cormier, 2008). Based on how their knowledge is created (learning), the 21stcentury student (re)directs the curriculum in as many directions as possible.
3. ***Deep structures***: Since social systems are inherently part of student communities, the affordability of technology also impacts on their personal learning networks (Harding &

Engelbrecht, 2015). Increasingly, there is quest for students to get virtually connected into collaborative projects which indicates confidence to use technology in learning (Shelly *et al*., 2012; Boyd, 2014). These are the submerged and entangled roots of the rhizome that get messy and difficult to disintegrate. The infiltration of technology into the personal learning networks of students has not always yielded positive results, for example, the effects of Cyber security and ethical issues to learning. The same technology has been used as a tool for examination malpractice, software theft and a distraction from learning (Kizza, 2010). Despite the determines of technology integration in learning, the benefits outweigh the odds in terms of time, space and quick interaction for teaching and learning enhancement (Clark & Mayer, 2016).

4. ***Causal powers***: Bhaskar (2008:215) opines that as humans, we have become aware of our existence as *"causal agents"* affecting other *"causal agents"* in another world. In my view, the other world may include the non-human world. Non-human (socio-technical) actors in the personal learning networks of students have become so active they occasionally determine the pace of student's learning. According to (Elder-Vass, 2010):

"For critical realists…non-human objects are significant in sociological explanations because they have causal powers – just as human agents are significant in sociological explanations because they have causal powers" (269).

Further, Elder-Vass (2010:472) argues that causal power becomes the converging point for between Actor Network Theory and critical realism. Again, Rhizome Theory and critical realism intersect on the principle of open systems. Bhaskar refers to "open" as not being regular and that the world is possessive of causal powers and capabilities. Similarly, the Rhizome Theory espouses knowledge as an open system into which one can enter and return at any point (Deleuze & Guattari, 1987; Cormier, 2008; McAuley *et al.*, 2010). The power of technology cannot be underestimated, even for unacceptable or unintended learning outcomes.

For example, stakeholders have been very concerned about falling academic standards, blaming this on technology (McVeigh, 2002). Are curriculum developers taking a long time in leveraging on these technologies for stronger learning networks and achievement of desired learning outcomes?

3.1.2 Features of critical realism

Out of the eight main features of critical realism (CR) underlined in Sayer's 1992 book, Method in Social Science: A realist approach, three of Sayer's features of CR speak to my ontological position (Easton, 2010). The features of critical realism, according to Sayer (1992), are below:

1. *The world exists independently of our knowledge of it.*
2. *There is necessity in the world; objects–whether natural or social– necessarily have particular powers or ways of acting and particular susceptibilities.*
3. *Social phenomena such as actions, texts and institutions are concept dependent. We not only have to explain their production and material effects but to understand, read or interpret what they mean. Although they have to be interpreted by starting from the researcher's own frames of meaning, by and large they exist regardless of researchers' interpretation of them. ...the methods of social science and natural science have both differences and similarities (Sayer, 1992:5-6).*

From an epistemological position, this study uses both numerical and narrative methods to find answers to the research question. This dual approach is justified through critical realists' recognition of the world as a socially constructed one but, at the same time, they do not see it to be wholly so (Easton, 2010:122; Plowright, 2011). Based on the features stated above, there is no one way of arriving at answers because experiences and science have their own roles to play; nonetheless, each of them have the propensity to complement the other. Of course, some (inductive) interpretations from myself as researcher in this study are based on my personal and professional experiences and hence, inseparable from my research or the knowledge out there.

3.1.3 Precedent studies on critical realism

Critical realism has been used by researchers in varied ways (Kjærgaard & Sorensen, 2014; McEvoy & Richards, 2006; Maxwell & Mittapalli, 2010; Venkatesh, Brown & Sullivan, 2016; Zachariadis, Scott & Barett, 2013). My focus, however, will not be on the mounting debates about using critical realism for single approach studies or mixed study approaches. The focus will be on critical realism for studies that made use of the philosophy in both numeric and narrative ways and those that commented on critical realism and mixed research approach. Kjærgaard and Sorensen (2014:222) used critical realism as their epistemic approach to investigate the utilisation of *"web-tools and rhizome-like network collaboration"* in network learning. Their belief of a sense of reality resides at the echelon of transitive (partial reality and social orientation) and intransitive (real) levels which revealed that student success in learning was impacted from *"initial level of technological and network literacy"*– a reintroduction.

Zachariadis, Scott and Barett (2013) explored the importance of critical realism as a theoretical foundation for mixed-methods in Information Systems and argued for its widespread use in mixed study methods. Their study revealed that critical realism allows researchers to achieve the goal of a research that makes use of mixed methods and or different paradigms that initially seem incompatible. McEvoy and Richards (2006) posit that critical realism as a philosophy is sound for mixed study research because it offers a place for methodological triangulation. The focus of their research was on exploration in the primary care and community mental health fields.

Downward and Mearman (2007) also argued to support the reason that critical realism is vital to research that criss-crosses and has inter-disciplinary elements. Their support for critical realism as a philosophy to understand perspectives from more than one angle corroborates what McEvoy and Richards (2006) term *methodological triangulation*. Greene (2006:97) explicates reasons why critical realism is a '*strong*' contender of philosophical underpinnings that accommodate nuances of mixed methods. However, she also advised on the validation of knowledge under mixed methods and philosophies under critical realism and pragmatism.

Numerous studies have shown that critical realism is suitable for narrative and numeral studies such as this one, for exploration or in-depth understanding of a phenomenon. This research is similar to the studies of Kjærgaard and Sorensen (2014), whose studies applied critical realism as an epistemic lens to look examine socially constructed knowledge in order to explain an ontological mechanism.

3.1.4 Epistemological

I have a firm belief that multiple reality studies form a solid basis in exploring technological uses in students' personal learning networks, an epistemological position that aligns with the fathers of Rhizome Theory when they said that *"we do not have units (unites) of measure, only multiplicities or varieties of measurement"* (Deleuze & Guattari, 1987:8). The complexities associated with technology and its application in learning environments create the ground for social conditioning which must be interpreted with an eye of multiple realities. This research makes use of numerical and narrative perspectives as an embodiment of data from sources in Africa and Europe. The approach justifies a concept of multiple realities. Adoption and application of the Rhizome Theory and Actor Network Theory in this study echo the divergent and multiple viewpoints of understanding an exploratory study of such nature. Participants' views of the phenomena are treated objectively as their side of the story.

3.1.5 Axiological

The underpinnings of students' personal learning networks owing to technology is a social-cultural construct (Boyd, 2014). I acknowledge that research biases can be present (especially for narrative studies). However, a way of dealing with this challenge is through reintroduction or insights from inferences. Therefore, this study values the rich experiences of students and lecturers contributing to this study through their participation. Incorporation of technology into students' personal learning networks varies from person to person and therefore related experiences will vary as well. This study draws on the expertise of lecturers and student experiences viz-a-viz technology influence in the students' personal learning networks. Again, literature sources have also contributed to the world views of the underpinnings of students' personal learning networks in technological ubiquity(Harlan, 2009; Warlick, 2009; Pineda, 2013; Aheto & Cronjé, 2014).

3.2 Methodological choice

This section covers justification of the research design used. The section also deals with the reason why terms such as quantitative and qualitative and mixed methods are not used in this thesis.

3.2.1 Research design

For the research design, a numerical and narrative approach was chosen (Plowright, 2011) to explore the technological underpinnings of students' personal learning networks in four institutions. The position maintains a *"complete and emphatic rejection of the use of terms such as quantitative and qualitative methods in other that this research process will be articulated in a more useful and appropriate manner"* (Plowright, 2011:3). I prefer to use the terms *numeric* and *narrative* methods which support the Rhizome Theory and reject a treelike way of thinking or doing things (Deleuze & Guattari, 1987).

Without attempting to start a debate, but merely to emphasise my position on the use of the terms, *numerical* and *narrative*, I subscribe to Plowright's (2011:3) position:

> *"…it is not just the words that are significant here. It is the underlying concepts and meanings, expressed through those words that channel our thoughts, actions and understandings."*

The above statement reflects a motivation to express clear thoughts in my analyses and findings.

The research design shows the processes or structural positioning of this research. Creswell (2013:49) refers to *research design* as a *"plan for conducting research."* Gray (2014) also illustrates research design as a process describing the purpose of research through certain techniques such as data collection and analyses in a strategic plan. Yin's (2014) explanations of research design resonate with the principle of cartography which treats knowledge as a map but not a tracing. According to Yin (2014:240), research design is a map of logical linkages drawn between research questions and data collection and data analysis which translate into a kind of findings.

Rationale and justifications for using this chosen research design are provided in Table 3.2 below:

Table 3.2: Justification of using numerical and narrative research design (adapted from (Saunders *et al.*, 2012:169))

Rationale	Justification
Initiation	This design presents a premise for context within which the research is conducted. In this study, it is epistemologically acceptable to combine approaches. In addressing a research problem, multiple data sources may provide multiple aspects of reality to the same issue (convergent and divergent findings). Studying about the underpinnings of students' personal learning networks in a technology rich higher education environment require varied approaches to understanding of the research problem. Thus it requires the social and technological.
Facilitation	New insights and findings from one method may be discovered to enrich the other method (e.g. the interviews revealed certain patterns when I was analysing the rhizomatic maps and results from the survey).
Complementarity	Use of these two methods *"allows meanings and findings to be elaborated, enhanced, clarified, confirmed, illustrated or linked"* (Saunders *et al.*, 2012:169) f*or example, confidence in this table*).
Interpretation	Since the two methods have their own strengths and weaknesses, the narrative method may be used for in-depth interpretations of findings from a numeric method and vice versa.
Generalisability and transferability	This approach allows for the generalisability of findings within the population of this study. Findings from the narrative approach can be transferred to other contexts with similar conditions of this study(Creswell & Miller, 2000).
Diversity	Uses of numerical and narrative approach give room for multiple perspectives in addressing the research problem.

Rationale	Justification
Problem solving	Insufficient data from the numerical approach can be complemented with data from the narrative approach and vice versa.
Focus	*"One method may be used to focus on one attribute such as the macro details"* (e.g. numerical method for the interpretation of data from survey questionnaires), *"while the other method may be used to focus another attribute such as the micro details"* (e.g. narrative for the interpretation of rhizomatic maps) (Saunders *et al*., 2012:169).
Data triangulation	This technique allows for systematic checks on the validation or consistency of findings. Apart from descriptively interpreting patterns found in the rhizomatic maps, figures from inferential statistics on the rhizomatic maps can be generated for corroboration(Merriam, 2009; Patton, 2002). Analyses from the surveys can also be supported by interviews. Evidence from the findings can then be captured under two subheadings called Convergence of Evidence and Non-convergence of Evidence(Yin, 2014:121).
Confidence	For credible findings devoid of wrong judgement, numerical and narrative approaches were used. Describing patterns formed in the rhizomatic maps alone may not reflect the reality. Interpretation of statistical figures generated from Gephi software averted this weakness. For instance, determining attributes in a personal learning network such as the most *important* actor or the most *influential* actor may be difficult to trace by mere inspection of a rhizomatic map. These figures are objective, testable and generalisability validating subjective opinions of the rhizome map.

3.3 Research methodology

This research methodology section provides an underpinning for the concepts, theories and methods employed in the research in order to achieve the research objectives. A number of researchers have put forward various definitions of what research methodology is (Denzin & Lincoln, 1994; Babbie & Mouton, 2001; Punch, 2005; Plowright, 2011; Saunders *et al*., 2012; Punch, 2014). Methodology "*refers to the study of method(s), the overall analysis of how research unfolds*" (Punch, 2005:28).

In order to reflect my theoretical position and beliefs in multiple realities for finding answers to the research problem, data was collected from four sites (cases) on two different continents. Plowright's Extended Frameworks for an Integrated Methodology (FraIM) was specified as an appropriate methodology in guiding ethos of this research. Figure 4.2 shows the extended Frameworks for an Integrated Methodology adapted from Plowright (2011). FraIM was preferred because of its suitability for educational and social research values:

1. A better way of exploring and understanding current perspectives to issues under research (Ibid, p.181).
2. Observations of a research problem precede theorisation which then makes sense of the research problem through findings (Ibid, p.181).
3. It is a straightforward approach to diagram one's methodological choice.

Figure 4.2 on next page shows the view of the Extended FraIM adapted from Plowright (2011).

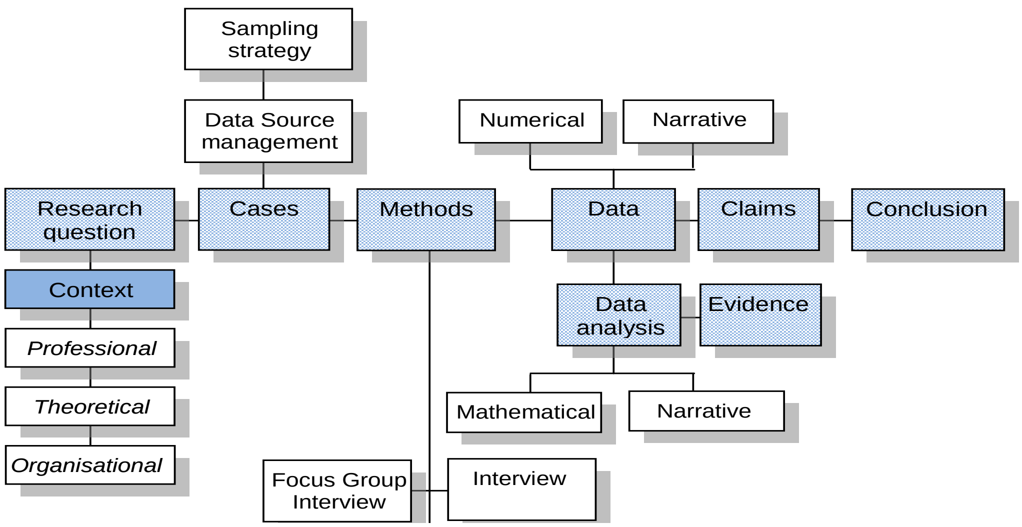


Figure 3.2:Extended FraIM (adapted from Plowright, 2011:9)

3.3.1 Research question and research hypotheses/context

The aim driving this research is to explore the underpinnings of technology use in students' personal learning networks in a higher educational environment. Formulation of the four research questions and four sub-research hypotheses (Table 4.4) were based on theoretical, professional and organisational contexts.

3.3.1.1 Theoretical context

Research question, sub-questions and hypotheses were developed from literature focusing on the statement of the problem (Plowright, 2011). Gaps revealed in a preliminary literature search of the pilot phase of this research also motivated the kind of questions necessary for the substantive research. Literature sources revealed a number of animate and inanimate (socio-technical) actors that played various unique roles in the personal learning networks of higher education students as a result of the growing presence of technology. The Rhizome Theory and Actor Network Theory were then acknowledged as the conceptual underpinnings of this research (Deleuze & Guattari, 1987; Latour, 1999).

3.3.1.2 Professional context

I have 14 years' experience as a trained teacher. My first teaching assignments saw me handle Mathematics, Science and Information, Communication and Technology in a Basic School in Ghana. In my practice, I realised the fast pace by which technology has affected teaching, learning and school administration. My observation led me to obtain a Master of Education in Information Technology at the University of Cape Coast in Ghana and later a Postgraduate Diploma in Educational Technology at the University of Cape Town, South Africa.

My current work as an Educational Technologist in a higher educational context in Ghana and my interaction with students and lecturers in higher education across continents gives me an advantage in knowing about the current state of technological impact on learning. Going forward, this research will add value to the call for reappraisal of teaching and learning processes in higher educational contexts against the backdrop of changes in technology and its undeniable impact on learning.

3.3.1.3 Organisational context

This research took place in four universities located in three countries in Belgium, Ghana and South Africa. The research is located within a higher educational and technology-rich environment. In Table 4.3, pseudonyms are used to represent the universities. Vogt *et al.* (2012:300) noted the difficulty associated with *"anonymity in the case of institutions"*; however, in the case of educational institutions, they advise that pseudonyms not only promote protection of institutions but of students alike.

My research did not seek to investigate the institutions themselves; nonetheless, Plowright explains that organisational context determines the questions to ask. All the research hypotheses aligned with the organisational context, as they sought to identify differences among the four cohorts of students (at each institution) and their self-perceived importance, experiences or satisfaction of a particular construct. Information about the four institutions (each site) concerning type and country/continent location is presented in Table 3.3.

Table 3.3: Information about the four institutions used in the study

University	Type of institution	Country	Continent
GAC	Traditional University	Ghana	Africa
GBR	University of Technology	Ghana	Africa
BEL	Traditional University	Belgium	Europe
SAR	University of Technology	South Africa	Africa

Note: Names of the universities are presented in pseudonyms

An overview of the locations of the four institutions (sites) is presented in an Infographic map in Figure 3.3.

Figure 3.3: Infographic map of sites and location of the research

Tables1.1 and 1.2 in Chapter One give a summary of the association between the sub-research questions, hypotheses and methods utilised to arrive at answers to the main research question.

3.4 Cases

Cases in this research represent *"sources of data"* (Hammersley, 1992; Plowright, 2011). Data source management and sampling strategy are the two elements of cases.

3.5 Data source management

Data was collected from multiple sources from the four universities:

i. focus group interviews;

ii. interviews (semi structured);

iii. survey; and

iv. rhizomatic map.

An overview of the data sources and their associated institutions, students and or lecturers who provided the data are availed in Table 3.4.

Table 3.4: Cross tabulation of the universities and their data sources

University	Data Sources				
	Students				Lecturers
	Focus Group Interview	Interview	Survey	Rhizomatic Maps	Interviews
GAC	√		√	√	√
GBR	√		√	√	√
BEL		√	√	√	
SAR	√		√	√	√

3.5.1 Sampling strategy

Selection of institution, respondents and participants are explained in details based on each data source. Detailed descriptions are given after the presentation of each data source.

3.5.2 Data collection

Data collected in this study were twofold: numerical and narrative. Where, when, why, and how data were collected are presented in earlier paragraphs in this chapter. Table 3.5 explains which data fell under numerical and narrative data types.

Table 3.5: Data types from the various data sources

Data Source/ Method	Numerical	Narrative
Focus group interview		√
Interview		√
Survey	√	
Rhizomatic map	√	√

3.5.3 Data analyses

Data from the various sources were analysed based on data type. In general, 5-step approach was employed in data analyses, following this sequence:

1. first level coding;
2. data capturing;
3. preliminary analyses;
4. data cleaning; and
5. running of data analysis

3.5.3.1 Numeric data, analytical and statistical tools

Numeric data was drawn from rhizomatic maps (see 3.10.1 for details) and the surveys (*see 3.10.2 for details)*. In brief, three main statistical tools were used to capture and analyse the numeric data:

i. Gephi for the Rhizomatic maps;
ii. Statistical Product and Service Solutions (SPSS) for surveys; and
iii. Excel for the chart demographics.

3.5.3.2 Narrative data, analytical and statistical tools

i. Atlas.ti for interviews and focus group interview; and
ii. Gephi for rhizome maps

3.6 Focus group interviews

Six main aspects driving the inclusion of focus group interview in this research are as follows:

1. combination with other data collection techniques is permissible (Kitzinger, 1995:300);
2. provision of checks in exploring participants' (students') concrete experiences about their technology use in their personal learning networks (triangulation) (Merton, 1987);

3. responses obtained on their recurrent experiences regarding technology use in their personal learning networks (Ibid);
4. snowballing in focus group interviews will incite a chain of in-depth reactions and additional comments about participants' personal learning networks (Hess, 1968; Easterby-Smith *et al.*, 2008);
5. stimulation of participants' excitement about sharing of information regarding use of technology in their personal learning networks (Hess, 1968); and
6. spontaneity provides naturalistic environment for more genuine responses because each participant is not obliged to answer all questions (Hess, 1968; Ghauri & Grønhaug, 2010).

A focus group interview (*see Appendix C*) is a data collection technique that allows a researcher to delve deeper into subject matter in a non-threatening and informal setting through conversation incorporating a small group of people. Beck, Trombetta and Share (1986) posit that a focus group is *"an informal discussion among selected individuals about specific topics relevant to the situation at hand"* (p73). The technique has also regarded one that reveals understanding into a phenomenon. Studies that are inclined towards interpretivism support focus group interviews in the sense that respondents in the group provide multiple perspectives on topic(s). According to Vaughn *et al.* (1996:4), the overall *"goal of focus group interviews is to creating a candid, normal conversation that addresses, in depth, the selected topic."* The arguments of Vaughn *et al.* support the technique as providing first hand information to a researcher in an open and naturalistic environment.

Using focus group interviews in this research supported triangulation of findings and thoroughly unravelled the complexities inherent in underpinnings of students personal learning networks owing to technology in a social-cultural construct (Krueger,1986; Byers & Wilcox,1988). By this, a number of my anticipated answers to the four sub-research questions and hypotheses were to be gathered through this technique.

3.6.1 Selection of participants for focus group

Students from three universities (GAC and GBR from Ghana and SAR from South Africa) were involved in the focus group interviews. In all, 10 focus group interviews were conducted. Each of the groups had a range of participants from five to seven. These group sizes are consistent with Kitzinger (1995:301) who suggests that an *"ideal group size"* for focus group should be *"between four and eight people."* Kitzinger further proposed that depending on the aims of a research, focus group techniques should consist of "*half a dozen to over fifty groups based on resource availability.*" Adhering to Kitzinger's proposal, this study consisted of 10 groups falling within acceptable range (Ibid: 300). Table 3.6 shows a distribution of participants for the focus group interviews.

Table 3.6: Distribution of participants for focus group interview

University	Number of focus groups	Number of participants				
		Group				
		1	2	3	4	5
GAC	4	5	5	6	5	
GBR	1	5				
SAR	5	5	7	7	5	6
Total	**10**	**56**				

The snowballing technique (Straits & Singleton, 2011) was used to identify participants, all current students, for the focus group discussions. After identifying one student (purposively) in or around a lecture room, I would then explain the intent of my research to the student to assess whether he or she could nominate people from either his class or personal learning network to join a focus group discussion (Gray, 2014). This inclined the individual groups towards homogeneity in order to take advantage of their *"shared experiences"* (Kitzinger, 1995:300). The objectives of my research questions are not for statistical generalisation but to seek enough in-depth data, as the use of a snowball sampling technique does not violate any rule (Merton & Kendall, 1946; Saunders *et al*., 2012).

Each focus group interview varied from 45 minutes to 1 hour (Gibbs, 1997). In GAC, two focus group interviews were each conducted on the 11th of January, 2015 (consisting of first year post-diploma degree Distance Education students) and the 2nd of February, 2015 (consisting of final year Bachelor of Information Technology students), separately. On the 13th of February, 2015, I again conducted a focus group interview for GBR participants consisting of second year Master of Art Communication Design students.

On the 21st of April, 2015, two focus group interviews involving one final year and four third year National Diploma (Public Relation Management) students in SAR were conducted respectively. Subsequently, on the 23rd of April, 2015, one focus group interview was conducted comprised of 3rd year Bachelor of Technology (Information Technology) students in SAR. Finally, the last two focus group interviews were conducted on the 27th of April, 2015 involving 2nd and 3rd year National Diploma (Journalism) students in SAR.

I played the dual role as a moderator (Vaughn *et al.*, 1996) and facilitator (Kitzinger, 1995). As a moderator, I guided the direction of the interviews through questions aligned with the exploratory research questions. *"The moderator works from a list of topics - listening, thinking, probing, exploring, framing hunches and ideas"* (Wells, 1974:2). My role as a facilitator was to encourage exploration of different perspectives directed at answering the research questions. Again, I remained neutral so as to prevent taking sides or swaying the opinions of participants (Krueger, 1986; Gibbs, 1997).

3.6.2 Limitations and mitigation measures

Like other data collection techniques, a focus group interview cannot spare itself from limitations (Wilkinson, 1998; Krueger & Casey, 2000). No data collection techniques, in fact, come without limitations. Vaughn *et al.* (1996) argued that focus group interviews are intended to collect opinions and experiences but not the strengths associated with those opinions. Though Vaughn *et al.'s* (1996) arguments can be debated, the strength of an opinion can be solicited through in-depth and probing questions. In this research, I compensated for this limitation through in-depth and probing questions as well as survey questions where differences in opinions about topics were tested statistically.

There are two sides to the moderator's control in a focus group interview. One of them is that a moderator's role can sometimes be usurped by excited participants. Secondly, in as much as participants' experiences are valued and expected, the quality of their experiences cannot be controlled by the moderator (Morgan, 1996). We did not face this kind of limitation in any of the group interviews, though, partly because the purpose, ground rules and role of the moderator was thoroughly discussed prior to any focus group interview. On the other hand, I did not assume that any participant shared low quality experiences or contributions. I treated every participant as a, extremely *"valuable source of information"* (Vaughn *et al.*, 1996).

Gibbs (1997) noted that trust is always compromised once a focus group interview is set in motion. She further alluded that the method cannot guarantee "confidentiality or anonymity." However, signing the consent form meant an agreement between each participant and me. The consent and ethical form stipulated matters concerning confidentiality binding on both parties. Beyond this point, I had little to do. Selecting a homogenous group was also one way of curbing participants' reluctance to make contributions due to trust and confidentiality issues.

An ineffectively guided interview (Williams & Katz, 2001) can result in poorly asked focus group interview questions and be complete waste of time. Following the recommendations of Burgess (1996:133), equal talking opportunities were availed to all participants to share their opinions and experiences, hence the use of clear questions. Prior to this, I had subjected my focus group interview questions to a review process of the Faculty's Ethics Committee. From that, my questions were piloted and later refined for more clarity and meaning to the participants (Krueger & Casey, 2000).

Some pictures from the focus group interviews are presented below.

Figure 3.4: Natural setting from one of the data collection days in BEL

Figure 3.5: Setting from a section of participants in a Focus Group Interview in GAR

3.7 Interviews

The study of students' technology use in their personal learning networks in higher education is a real-life situation which needs a real-life approach to data collection. Underlying reasons for including interviews for this study were based on the following, as interviews provide:

1. rich source of data and triangulation (Fraenkel & Wallen, 2000; Gillham, 2005);
2. usefulness for real-life, multiple realities about personal learning networks (Gillham, 2005);
3. trust (Arksey & Knight, 1999);
4. a good natural settings for in-depth data collection; and
5. a good match with surveys and focus group interviews.

Interviews are widely used data collection tools that involve two-way communication between a researcher (questioner) and a respondent (interviewee) with the sole aim of soliciting answers, experiences and perspectives to research questions (Yin, 2014:239). Interviewees, usually called 'respondents', serve as *"informants"* (Platt, 2012) on certain topics. Interviews are well-known to exploratory research. According to Gillham (2005:47) interview techniques are very helpful for *"narrative"* and *"exploratory"* studies. Figure 4.2 presents a pictorial view of the two-way communication between the interviewer and the interviewee.

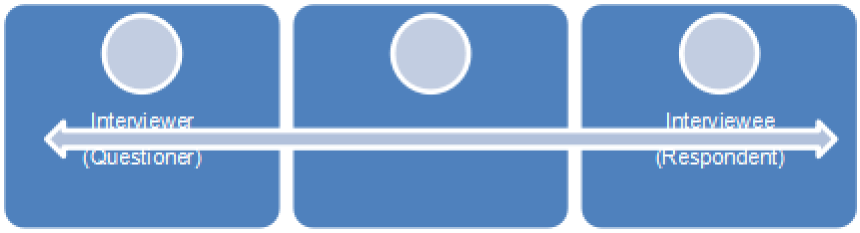


Figure 3.6: Relationship between the interviewer and the interviewee

3.7.1 Selection of participants for interview

Apart from BEL in Belgium, interviews were conducted for 22 lecturers in all the other three institutions. However, the student interviews only took place in BEL consisting of three respondents. The period of the interview lasted between 10 January and 14 June, 2015. All interviewees were purposively sampled based on their experiences or engagement with technology in learning networks. Snowball sampling was also used to identify some of the lecturer-interviewees. Until 'data saturation', a lecturer is requested to suggest other colleagues who could also be interviewed (Biernacki & Waldorf, 1981; Straits & Singleton, 2011). The referral approach continued until data saturation was attained (Glaser & Strauss, 1967; Francis *et al.*, 2010).

These lecturers had varying years of teaching experience, four years to 49 years. Professor Jophus Anamuah-Mensah, a former Vice-Chancellor in a University of Education, was purposively sampled as an 'expert' for this research. One significant reason for selecting him was his role as the chairman of Ghana's Educational Reform in 2007 and his experiences as crusader for technology enhanced learning in higher educational institutions. The three students sampled in BEL were conveniently sampled because the timing of data collection in Belgium coincided with the revision and examination period of the students. Around that time, students were scarcely available for interviews. Notwithstanding, the interview data was complemented by other sources of data. A snapshot of the number of respondents for the interviews per university is reported in Table 3.7.

Table 3.7: Distribution of participants for interviews

University	Number of Interviewees	
	Students	Lecturers
GAC		5
GBR		5
BEL	3	
SAR		11
*Expert		1
Total	**3**	**22**

3.7.2 Setting of the interviews

The interview sessions took between 30 minutes and 1 hour and 15 minutes (Stacey, 2013). In terms of a proper location for in-depth interviews, Kolb (2008:154) maintains that the *"researcher's office"* or the *"interviewee's home"* are desired. All my twenty-two interviews with lecturers took place either in their offices or in a lecture room when no office was available. For the three students, it was necessary to interview them because it was challenging to constitute a group of students for a focus group whiles in Belgium. All their interviews were also held in empty lecture rooms. Whereas Gillham (2005:52) proposes three stages of the interview process, a 4-stage approach is recommended by Jovchelovitch and Bauer (2000:62) and Kolb (2008). This study, then, adopted the 4-stage in-depth interview approach put forward by Jovchelovitch and Bauer, in these steps:

1. **Opening:** Prior to the commencement of every interview, the purpose of the interview and aim of the research is discussed with the interviewee. The role as a questioner (me) and interviewee (respondents) are also explained. Ethical provisions (such as digital voice recordings of interviews) are explained to them after which they are given consent forms to read and either accept or reject (Gillham, 2005:12). This first stage ensures a level of familiarity, trust and confidentiality (Kolb, 2008:142).

2. **Questioning:** This study made use of two sets of unstructured, open ended interview questions. The two sets of interviews scheduled were for students and teachers. During this stage, I maintained a posture which ensured that once the interviewee commenced a narration, I did not interrupt. Researchers are cautioned by Jovchelovitch and Bauer (2000:63) that *"when the narration starts, it must not be interrupted until there is a clear coda, meaning that the interviewee pauses and signals the end of the story."*

The interview schedules were comprised of predetermined questions under set themes in accordance with the research questions (Patton, 1990). Earlier on, these questions were piloted within a context of similar conditions, similar respondents with similar characteristics analogous to the conditions in the main study. The unstructured nature of the questions helped delve deeper into the themes as captured in the research questions. Again, this approach, reflecting the position as a critical realist provided the opportunity to delve deeper into the students' use of technology in their personal learning networks in higher education. In essence, this approach also echoes an ingrained position of the use of the rhizome theory which is a departure from formal structure, nevertheless, advancing a lens of multiple realities.

In their explanation, Straits and Singleton (2011) noted that:

> *In an unstructured interview, the objectives may be very general, the discussion may be wide-ranging, and individual questions will be developed spontaneously in the course of the interview. The interviewer is free to adapt the interview to capitalise on special knowledge experience, or insights of respondents. An everyday example of an unstructured interview might be a journalist's interviewing a celebrity to learn more about his or her personal background, interests, and lifestyle"* (Straits & Singleton, 2011:214).

3. **Probing:** Following an answer to a question (stage 2), follow-up questions were posed for clarity and for gleaning multiple perspectives on the students' use of technology in their personal learning networks. Probing supports triangulation of information (Reich, 2000). Jovchelovitch and Bauer (2000) disagree with the use of the word "*probe*" since it connotes a "climate of cross-examination." Nonetheless, probing is only used here for follow-ups and clarity.
4. **Closing:** Before the final question, the interviewee was gently prompted to expect the last question. At this stage, the respondents were then thanked and remaining questions answered, even those of the respondents of the interviewer.

A visual presentation of the 4-staged in-depth interview (adapted from Kolb, 2008) is presented in Figure 3.7 below.

Figure 3.7: The 4-stage in-depth interview process
Source of picture: author's own drawing based on Kolb's (2008:142) 4-stages of in-depth interview

3.7.3 Limitations and mitigation measures of interviews

In comparing individual interviews to focus group interviews, individual interviews are more expensive and time consuming. One way to circumvent this problem was to do 'clustering'. I proposed certain dates whereby I could easily interview two or three people from the same institution. These dates were then negotiated so that the period of individual interviews were not interspersed.

Since no definite sample size is recommended for in-depth unstructured interview, the road to data saturation can be very daunting and resource demanding (Francis *et al.*, 2010). As a mitigation measure, each 'cluster' was arranged once data saturation was still not met.

3.8 Surveys

The use of surveys in research is purposed to describe the occurrence of characteristics or opinions among a group of people with the aid of an opinionnaire, questionnaire or interviews (Merton, 1940; Singleton Jr *et al*., 1993; Straits & Singleton, 2011). Survey questions for this study were administered either through a paper-based questionnaire or online questionnaire. Participants in this survey were all students from the four institutions (s*ee Table 3.8*). The survey instrument was adapted from the 2014 Student Technology Survey of the EDUCAUSE Center for Analysis and Research (ECAR).

The survey was employed in this study because it allows the following:

1. Use of existing groups about what is being investigated. It also comes with the flexibility of group selection. The use of technology in students' personal learning networks in a higher education is not something that is not happening outside the four institutions I sampled (Plowright, 2011:27).

2. Convenient way of collecting data from large size of population as compared to interviews (Fink & Kosecoff, 1998; Plowright, 2011: 27).
3. Surveys can be used in an integrated framework and to complement other data collection techniques such as interviews.
4. Questionnaire surveys can be administered via paper or web (Manfreda *et al.,* 2002). It was well-suiting and a convenient way of collecting 72% of my survey data from all the institutions but one. Considering the youthful ages of the survey respondents, most of the students opted to answer the survey instrument over the Internet when given the option.

3.8.1 Selection of participants for the survey

First, I got approval to collect data from my targeted institutions and faculties. I then approached the head of departments who then assisted me in selecting a year group or class that met the characteristics we discussed. I had the opportunity to speak with the students earmarked for the surveys. In our discussions prior to answering the survey questions, I spelled out the purpose of the research, their role as respondents, and the ethical issues in relation to the research. The entire collection process was done in two phases: the ***Africa phase*** which began in South Africa from SAR on the 6th October, 2014 to 11th November, 2014. It then continued into Ghana beginning with GAC from the 6th December, 2014 to 4th April, 2015. In GBR, data collection took place on the 12th of February, 2015. The second phase, dubbed the **Europe phase** was also done from the 5th to 30th June, 2015, during the time I was residing in Belgium as a Visiting Scholar (*see Appendix G*).

Selection of respondents for surveys has always been characterised with the determination of the 'appropriate' sampling and sampling sizes. A number of researchers have suggested the size of a sample when conducting a research (Kish, 1965; Krejcie & Morgan, 1970; Lefever *et al.*, 2007; Ross 1991; Ross, 1978; Gay & Diehl, 1992). Since sampling in a paper-based questionnaire survey is different from a web-based questionnaire survey, two different approaches were used in this study to satisfy the two different modes of survey data collection. I followed the sample size suggestions by Krejcie and Morgan (1970) to sample respondents for the paper-based questionnaire, while following the study by Lefever *et al.* (2007) for sampling in a web-based survey.

According to Krejcie and Morgan (1970), when the population (N) is 150, the sample (n) for the study should be 108, whereas a population of 160 should have its sample as 113. The population for the paper-based questionnaire survey was 156. A 98.6% response rate constituting 141 respondents of the sample was achieved. Therefore, my sample of 143 for a population of 156 was far beyond the benchmark set by *ibid*. Since the web-based survey did not have any finite size, *ibid* suggest that the sample size table cannot be applicable in calculating for a sample size for the study. Web-based surveys do not necessarily make use of probability sampling techniques. The later suggestion was explained and corroborated by the use of volunteer sampling for the web-based survey (Evans & Mathur, 2005; Lefever *et al.*, 2007).

Table 3.8: Distribution of participants for survey

University	Country	Respondents
GAC	Ghana	85
GBR	Ghana	141
BEL	Belgium	20
SAR	South Africa	250
Total		**496**

3.8.2 The survey instrument

On the 23rd September, 2014, my application to adapt the 2014 Student Technology Survey (STS) instrument was approved (*See Appendix A*) by the Director of Research Data, Research and Analytics of the EDUCAUSE Center for Analysis and Research (ECAR).

EDUCAUSE is an internationally recognised not-for-profit organisation that is *"transforming higher education through the use of information technology."* As part of their modus operandi, EDUCAUSE run a number of conference and research engagements, especially in colleges and universities across the world, on the use of technology in education. One large scale research includes the yearly Student and Faculty Technology Surveys in higher educational institutions across continents.

The STS was adapted due to the following reasons:

1. It aligns well with my research aim, questions and hypotheses.
2. It is a standardised survey instrument not alien to my research.
3. The adaptation of a survey instrument is also used when data collection will be done across countries (Manfreda *et al.,* 2002)
4. For quality assurance reasons (Manfreda *et al.,* 2002)

Only part of the entire ECAR STS was used in this research. In total, the respondents were presented with 73 items in the survey instrument constituting five sections/themes in the following order:

1. About You
2. Device Use and Ownership
3. Technology and the College/ University Experiences
4. Learning Environment
5. Your Personal Computing Environment

The questions ranged from demographic (Section 1: About You), open-ended to closed-ended (including Likert scale) questions. Both the paper and web-based survey instruments had the same set of questions and a cover page, "Message to Respondent and Informed Consent." The cover page provided a description of the study, and conditions and stipulations concerning ethical issues.

3.8.3 Web-based survey questionnaire versus paper-based survey questionnaire

The Google Form Web-based Survey Questionnaire (WBSQ) and Paper-based Survey Questionnaire (PBSQ) are two instruments with the same questions but different method of administration. Each of the methods of administration has its own merits and demerits based on the conditions at a time. In participating in the survey, all respondents were given the option to choose between WBSQ and PBSQ. Apart from students in GBR, who chose the PBSQ because they could offer part of their Research Methods lecture to do so, all other respondents participated through the WBSQ. The WBSQ constituted 72% of the total respondents of the entire survey.

The 72% of WBSQ corroborates Kiesler and Sproull's (1987) characteristics of any web-survey populace. According to them,

> *"The population of interest for an electronic survey will be a community or organisation with access to and familiarity with computers or computer networks. These groups will tend to be relatively well educated, urban, white collar, and technologically sophisticated. Assuming the electronic survey is feasible with respect to this population, it seems to offer some advantages over a paper survey… [sic] the electronic survey, at least one administered within an organised setting, can elicit good response rates with faster turnaround time and fewer item incompletion than a regular mail survey"* (Kiesler & Sproull, 1987:411).

Other advantages of the WBSQ include the *"elimination of human or technology transcription"*, storage, and easy analyses of data (Ibid: 404). Furthermore, the WBSQ presented economic advantages because there was no need for the printing and distributing the PBSQ in three of the institutions.

One disadvantage with WBSQ is that a few students admitted that they forgot to click on the 'submit' button requiring them to restart the whole process again. This is one strong advantage of any paper-based questionnaire since no submit button is required. However, in the PBSQ, it is easier to skip questions, including questions in mandatory fields such as "Course offered." In the WBSQ, it is impossible to skip a mandatory field. PBSQs are also good for places where Internet access or stability is a challenge.

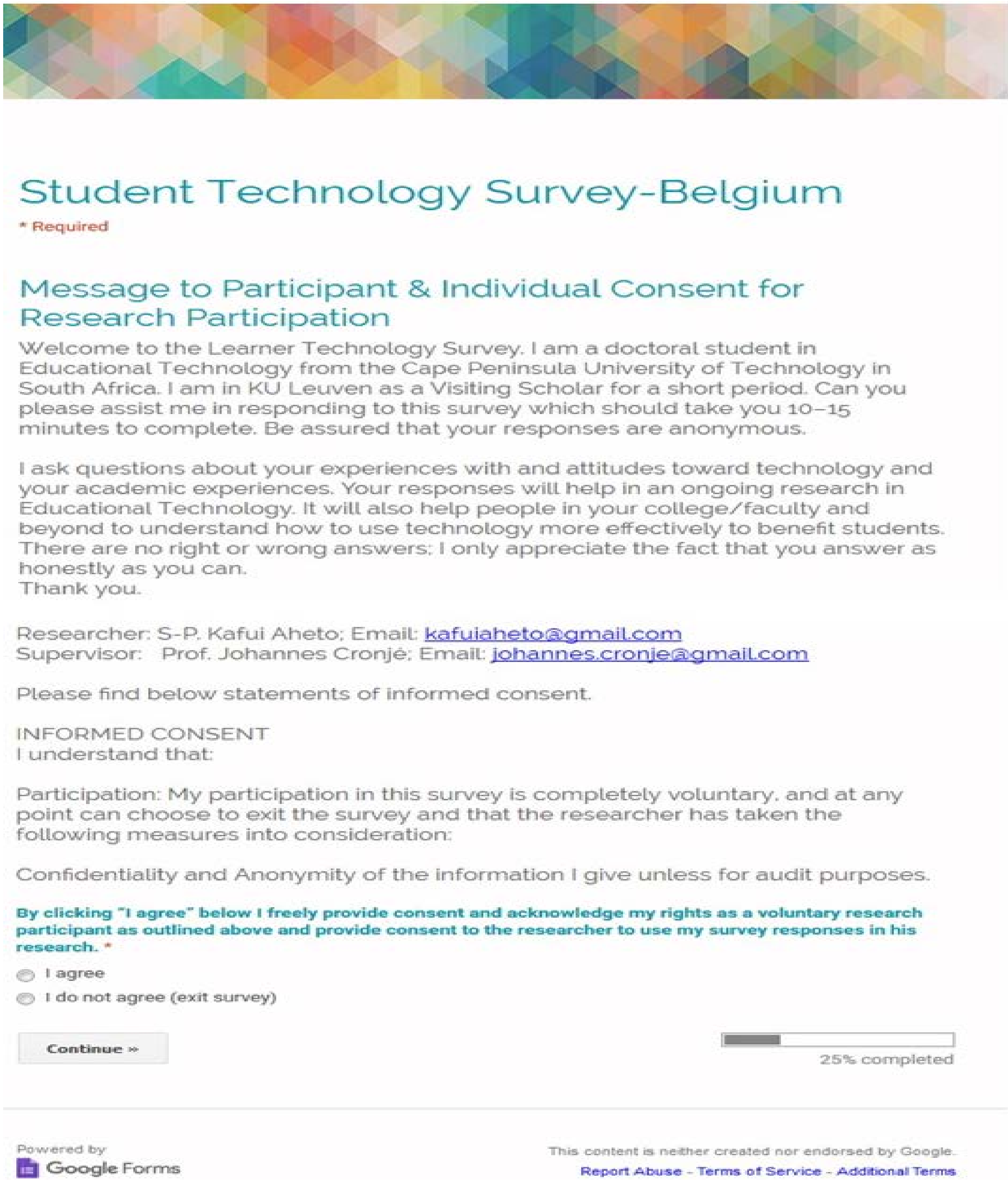
3.8.4 Access to the web-based survey questionnaire

Every web activity needs an address. For the sake of convenience, a long default web link to the Google WBSQ was shortened (https//bit.ly/1sSq3u9). The web link was also represented in two other forms – Quick Response (QR) code and Barcode – for ease of accessibility by the respondents. Through all these access links, the web-based questionnaire could be accessed on cell phones, tablets and other mobile devices. Figures 3.8 and 3.9 show the QR code and Barcode, respectively.

Figure 3.8: Quick Response (QR) code access to the Web-based Survey Questionnaire

Student Technology Survey

Figure 3.9: Barcode access to the Web-based Survey Questionnaire



Student Technology Survey-Belgium

* Required

Message to Participant & Individual Consent for Research Participation

Welcome to the Learner Technology Survey. I am a doctoral student in Educational Technology from the Cape Peninsula University of Technology in South Africa. I am in KU Leuven as a Visiting Scholar for a short period. Can you please assist me in responding to this survey which should take you 10–15 minutes to complete. Be assured that your responses are anonymous.

I ask questions about your experiences with and attitudes toward technology and your academic experiences. Your responses will help in an ongoing research in Educational Technology. It will also help people in your college/faculty and beyond to understand how to use technology more effectively to benefit students. There are no right or wrong answers; I only appreciate the fact that you answer as honestly as you can.
Thank you.

Researcher: S-P. Kafui Aheto; Email: kafuiaheto@gmail.com
Supervisor: Prof. Johannes Cronjé; Email: johannes.cronje@gmail.com

Please find below statements of informed consent.

INFORMED CONSENT
I understand that:

Participation: My participation in this survey is completely voluntary, and at any point can choose to exit the survey and that the researcher has taken the following measures into consideration:

Confidentiality and Anonymity of the information I give unless for audit purposes.

By clicking "I agree" below I freely provide consent and acknowledge my rights as a voluntary research participant as outlined above and provide consent to the researcher to use my survey responses in his research. *

- I agree
- I do not agree (exit survey)

Continue »

25% completed

Powered by
Google Forms

This content is neither created nor endorsed by Google.
Report Abuse - Terms of Service - Additional Terms

Figure 3.10: Example of the opening page of the Web-based Survey Questionnaire

3.9 Rhizomatic maps (artefact)

The term 'rhizomatic map' or 'rhizomatic learning network map' are terms coined for this research to graphically represent the networked connections of students' personal learning networks as an offshoot of technology in their personal learning environments. The etymological origin of *Rhizomatic* was inspired by *Rhizome* in the Rhizome Theory (Deleuze & Guattari, 1987). The rhizomatic map can be a simple, but usually complex, map of connections with no definite structure and centre.

In this research, the rhizomatic map shows a conceptual and relational mapping of connections within students' personal learning networks and technological uses in higher education. Aside mapping out the patterns to deduce interpretations through (dis)associations, the rhizomatic map can be interpreted using measures of Social Network Analysis. For instance, Betweeness Centrality, Closeness Centrality, Degree Centrality, Eigenvector Centrality, and Density of the Rhizomatic maps in this study were calculated to further understand the importance (Eigenvector Centrality), influence (Betweeness Centrality) or closeness (Closeness Centrality) of an actor (node) in a map.

Interweaving a narrative and a numerical approach to interpreting a rhizomatic map has numerous implications in Information Technology, Education and Society. It also shows how the complexity of a rhizomatic map cannot be interpreted using only one single approach. To gain a holistic view of the aggregated patterns of technologies used in students' personal learning networks, all the individual rhizomatic maps in each institution were put together to form a single map for analyses. Table 3.9 shows the distribution of the institutions and participants involved in the development of the rhizomatic maps.

Table 3.9: Distribution of participants in the construction of the rhizomatic maps

University	Participants
GAC	15
GBR	4
BEL	3
SAR	14
Total	**36**

3.9.1 Selection of participants for the rhizomatic map

After each focus group interview and main interview with the student participants, I appealed to them to draw a rhizomatic map of their personal learning networks. Since the term was not familiar with them, I explained what it meant. In some cases, time constraints could not permit the development of a rhizomatic map by students after the focus group interviews.

3.9.2 Limitations and mitigation measures of the rhizomatic map

One limitation of the rhizomatic map is that the maps get complicated and messy if the actors are many. Again, handling a rhizomatic map requires a set of intricate skills to help in the generation and interpretation of the maps. The initial problem mentioned was averted by first using colour discrimination to create a clearer visual impression and enhance easier mapping. The use of tables in Appendices K, Land M and the statistics that underpinned the relationships were employed for a holistic view of an interpreted rhizomatic map.

3.10 Analytical and statistical tools

3.10.1 Gephi for rhizomatic maps

Gephi 0.9.1 beta version 3 is Social Network Analysis software which was used to analyse the rhizomatic maps. Figure 4.10 is a screenshot of the Gephi software used for analyses of the rhizomatic maps for this study.

Figure 3.11: Screenshot of Gephi software used for analyses of rhizomatic maps

i. Creation of codes

Rhizomatic maps from individual participants were organised based on homogeneity considering the study groups, course offered and institution. Each rhizomatic map was given a serial number immediately after data was collected. This serial number indicated the institution, group name, individual's unique number and a date stamp (Example, **SAR**IT01FEB232015). Unlike Coding a Variable in SPSS, there is no specialised coding system in Gephi. The most important factor is to create two basic variable codes in a spreadsheet.

ii. Data entry

In this study, Excel spreadsheet saved in a Comma Separated Values (CSV) file format was used in capturing the data (Figure 3.14) from freehand sketches of rhizome maps drawn by respondents.

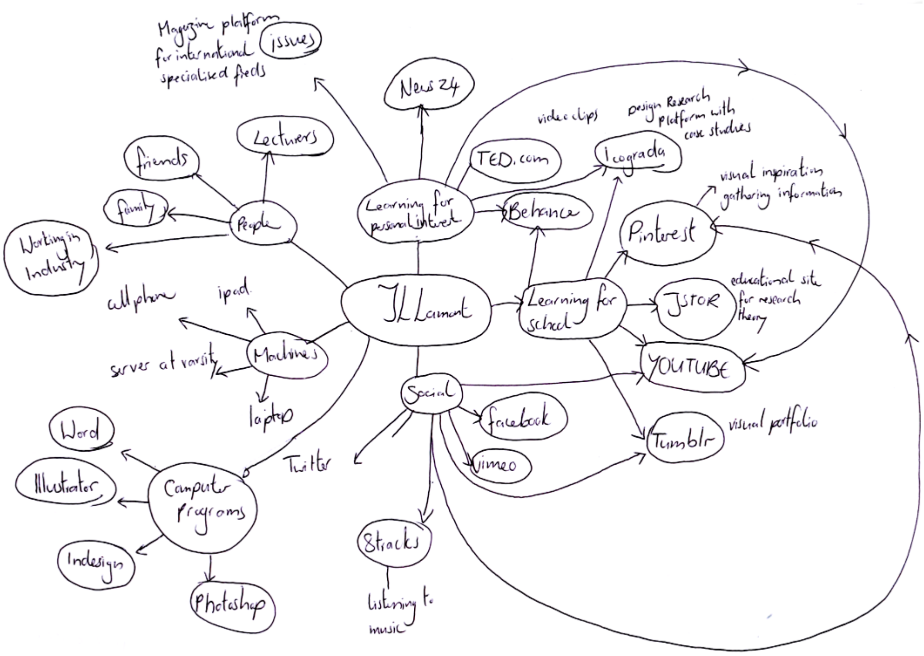


Figure 3.12: Freehand sketch of a respondent's rhizomatic learning network

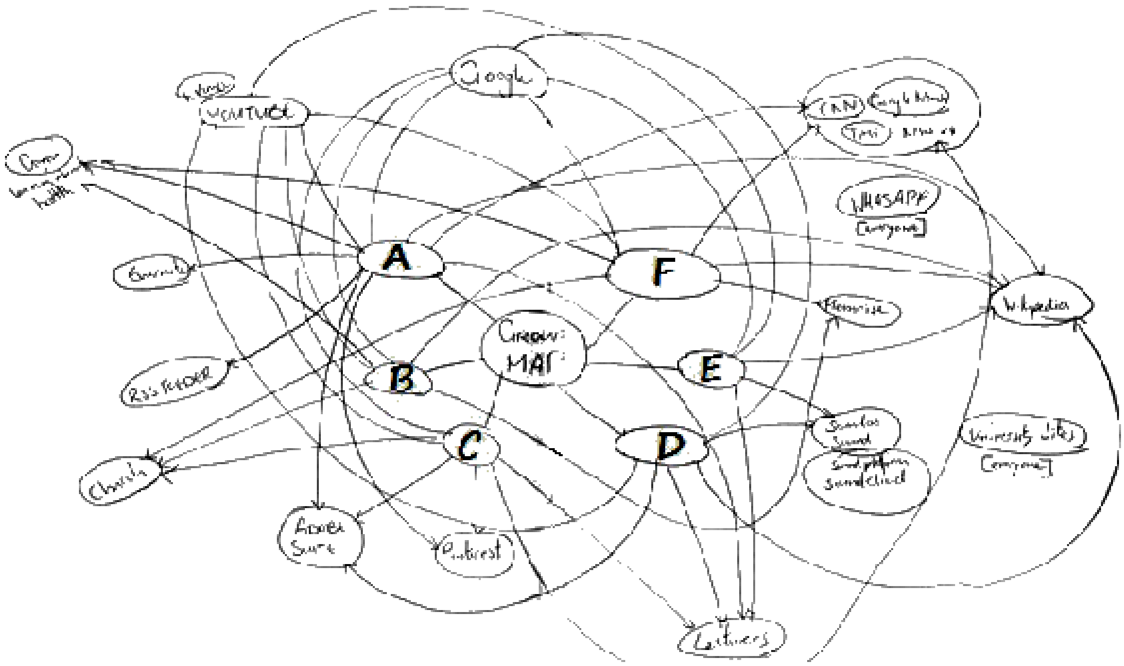
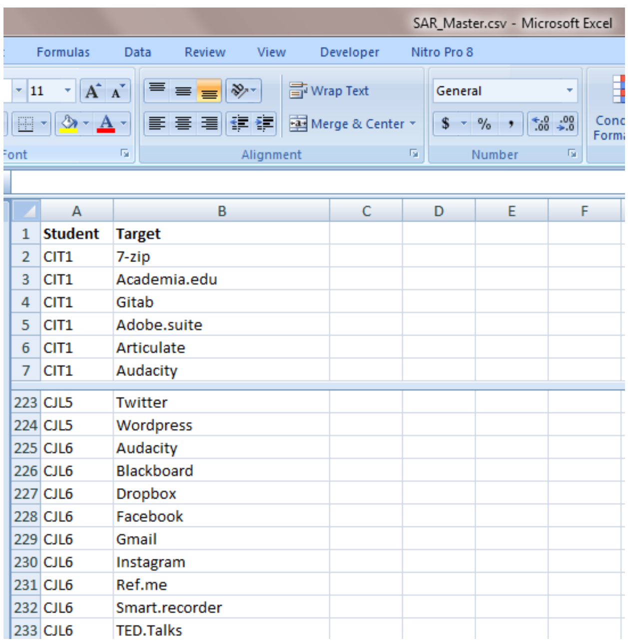


Figure 3.13: Freehand sketch of a respondents' (group) rhizomatic learning network



	A	B	C	D	E	F
1	**Student**	**Target**				
2	CIT1	7-zip				
3	CIT1	Academia.edu				
4	CIT1	Gitab				
5	CIT1	Adobe.suite				
6	CIT1	Articulate				
7	CIT1	Audacity				
223	CJL5	Twitter				
224	CJL5	Wordpress				
225	CJL6	Audacity				
226	CJL6	Blackboard				
227	CJL6	Dropbox				
228	CJL6	Facebook				
229	CJL6	Gmail				
230	CJL6	Instagram				
231	CJL6	Ref.me				
232	CJL6	Smart.recorder				
233	CJL6	TED.Talks				

Figure 3.14: Screenshot of sample data in Excel CSV file uploaded into Gephi software

3.10.2 Statistical Product and Service Solutions (SPSS) for surveys

The SPSS is well-known for analysing descriptive and inferential statistics where tables of frequencies, averages and graphs are conveniently generated (Field, 2009). I used SPSS version 18.0 for the analysis of survey data. The processes used are thematically reported as follows:

i. Creation of codes

The creation of codes took three levels: Creation of coding variables, Coding of answered questionnaire, Data capturing and Coding of WBQS. The creation of coding variables in SPSS was the last to be done when I completed collecting data via the paper based questionnaire. This was strategic to avert any further alterations after data collection. The interface was self-designed to cater for both open and closed-ended responses. Code variables were 270 in all. Example of the code variable name for a question is *S5AYInstitution*. S5AY represents 'Section 5: About You' while Institution means the name of respondent's institution. All closed-ended questions were assigned numeric data types while open-ended questions assigned string data types (to allow for direct data typing). Predetermined answers for the closed-ended questions were coded under the column labelled "Values" in the Variable View. For instance, "Male" and "Female" were assigned 1 and 2 respectively (Figure 3.16). The closed-ended questions had no assignments since responses could not be predetermined. Meanwhile, the "label" column on the Variable View was filled with the exact survey questions. The measures for the variables too were usually scale for the closed-ended questions and nominal for the open-ended questions. Figure 4.7 shows the interface of the Variable View for this study.

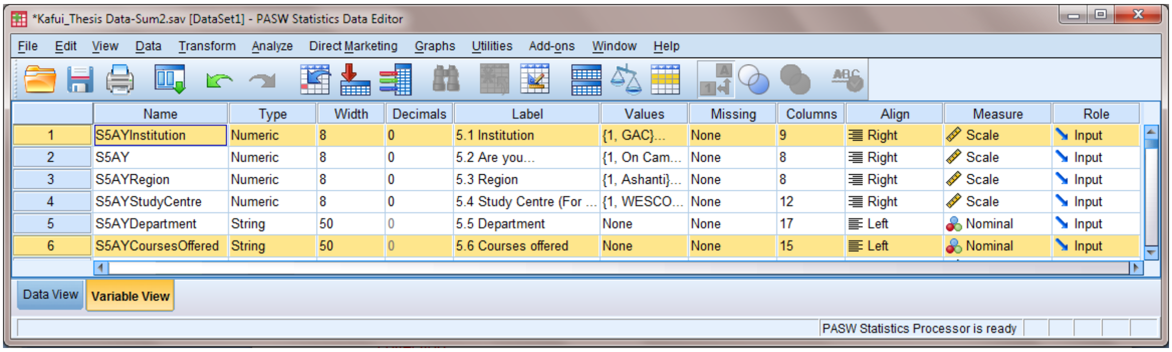


Figure 3.15: Variable View of SPSS Data Editor
(Source: author's doctoral data set)

WBQS was coded parallel to the SPSS interface to make data migration from Google Forms to an Excel Spreadsheet and then finally to the SPSS platform. The exporting tool in SPSS was used for the data migration.

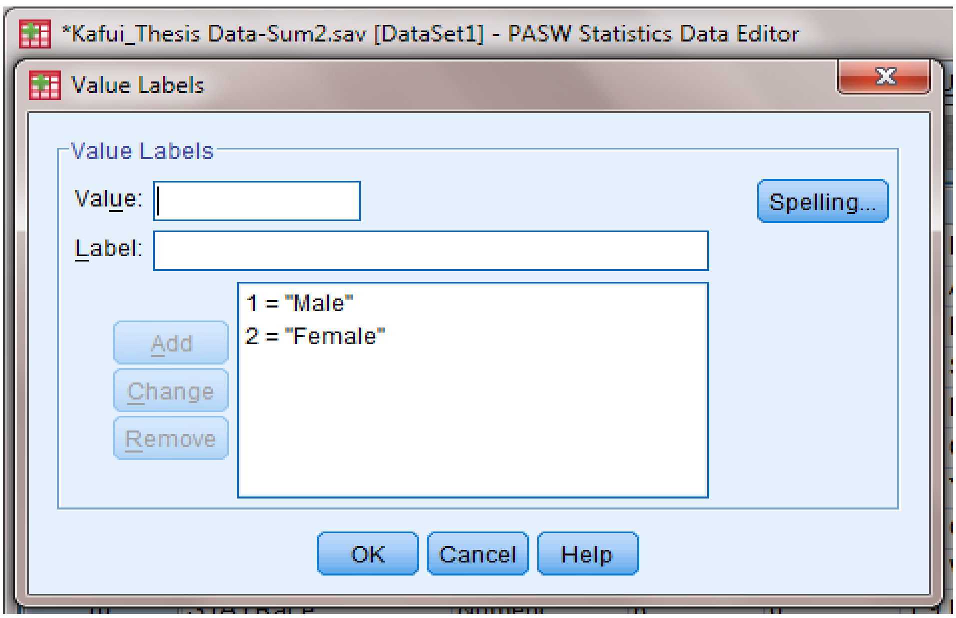


Figure 3.16: Variable View of SPSS Data Editor
(Source: author's doctoral data set)

2. Coding of answered questionnaire

All the 141 answered questionnaires (paper-based) were arranged and uniquely numbered serially using the Arabic numerals starting from 001. These numbers corresponded with the serial numbers that appear on the left side of the Data View (Figure 3.17).

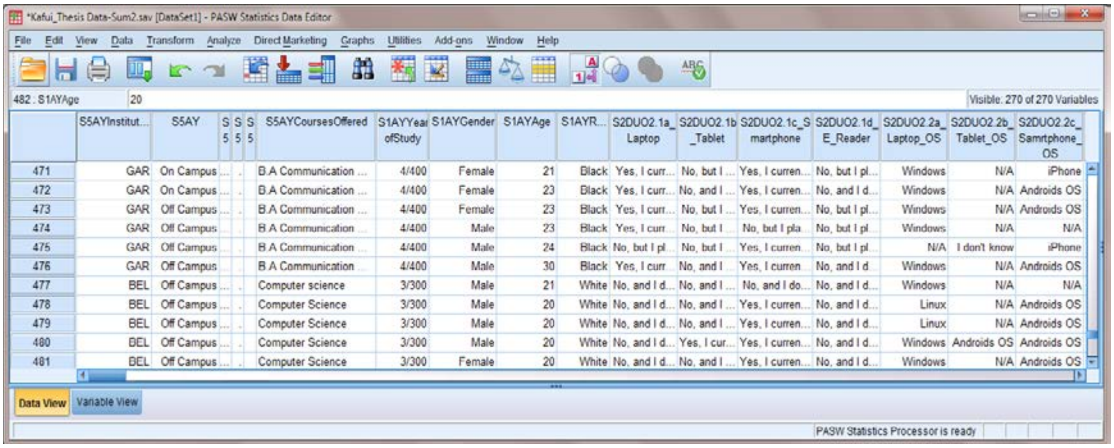


Figure 3.17: Data View of SPSS Data Editor
(Source: author's doctoral data set)

3. Data entry

Data was entered using the Data View. While one could use the Numeric View or the Alphabetic View of the SPSS Data View, I mainly used the Alphabetic View for the sake of ease. Each row in the Data View represented a respondent and all the responses of that respondent. Each column also stood for a Code Variable or a survey question. Each cell, therefore, represented a matrix of responses per question and respondent.

4. Data cleaning

The first stage of the data cleaning was the preliminary running of a basic frequency analysis of each Code Variable or question. It was easier to notice sections in the dataset which were wrongly inputted. For instance, in using the Numeric View of the Data View, one could enter '55' instead of '5'. Once more, missing values became evident. Missing values meant that a closed- ended question had not been answered. Some open-ended questions and mandatory questions were set not to report missing values. Cells that had irregular inputs like "55" and missing values were cleaned up by tracing the exact questionnaires for the right responses.

Two other stages of the cleaning up were done. One, the questionnaires were randomly selected and cross checked if the responses were rightly inputted. The last stage was a form of peer review where the dataset was again cross checked against all the responses from the survey. The last two stages did not exclude the web-based survey because it was very dangerous if columns from the web-surveys did not properly align with columns in the SPSS data Code Variables. This was to forestall 'data mix-up' or 'data pollution'.

5. Running of the analysis

Analysis of Sections 1 SPSS was primarily used for descriptive statistics to produce frequencies and percentages which were reported in cross tabulated formats (Tables 4.2 to 4.16 in Chapter Four).

Tables 2.5, 3.1, 3.2 and 4.1 of the questionnaire were analysed using multivariate statistics since those tables answered the main and sub-research hypotheses. The analyses adhered to the following steps:

1. factor analyses to determine the constructs;
2. determination of internal consistency through reliability analysis;
3. calculation of the value of the constructs per respondent (value is the average of items in the construct);
4. testing for differences in the construct between the four institutions using one-way analyses of variance; and
5. descriptive analyses from patterns identified in the numeric data. Related statements from interviews and focus groups are used to support the data from the field.

In sum, the under-listed steps served as a guide for capturing of data to final analysis:

1. Creation of coding variables
2. Coding of answered questionnaire
3. Coding of WBQS

iii. Coding of questionnaire

iv. Data Capturing

Online data was automatically captured after respondents had submitted their responses

v. Data cleaning

vi. Preliminary analysis

vii. Final analysis

3.11 Ethical reflections

I conducted this research in a process which considered a number of issues that were entirely *"ethical and reflective"* (Wellington & Szczerbinski, 2007:70). Research ethics were applied throughout the entire research process (Bell, 2005). An account of ethical reflections considered for this research is necessary and thus presented below(Marshall & Rossman, 2006; Cooper & Schindler, 2008).

3.11.1 Approval and permission

Approval and permission for this research began via an internal system established by the Cape Peninsula University of Technology (Bruce, 2001). Firstly, my title and proposal were subjected to rigorous title search, double blind review and subsequently, public defence. Approval by my Faculty's Research and Ethics Committee was also granted me after I subjected my data collection instruments, sites and possible participants to the Committee (Babbie, 2005). Data collection was permissible only if institutions and participants/respondents granted to me that privilege.

Institutions that participated granted me permission for the research to be carried out by handing me official letters to that effect (*Appendices H-J*).

3.11.2 Informed consent and implied consent

Though this research did not involve any risks to the research subjects, written (signed) consent was obtained prior to involvement in the research. The consent form, however, stated their guaranteed rights, stating that a signed form indicated agreement to be involved in the study while acknowledging the protection of rights (Creswell, 2012). An agreement for data collection was reached only when participants accepted to be part of the research and thereafter sign the Informed consent or tick the checkbox on the implied consent form obtained prior to their engagement *(Appendix B)*.

Implied consent was only used for the web-based questionnaire survey. Since these was no opportunity to physically meet respondents in the online exercise, checking (√) the checkbox and continuing to respond to the lengthy questionnaire implied their acceptance to participate in the research. Implied consent is used with neither the researcher nor the subject could obtain a written and signed consent form (Bruce, 2001).

3.11.3 Voluntary participation and harmlessness

Participation was free as participants were simply not obliged to sign their rights away when they conceded to participate as subjects. *"Participants and respondents were made aware that their participation in the study as being voluntary, that they had the freedom to withdraw from the study at any time without any unfavourable consequences or harm as a result of their participation or non-participation in the research"* (Bhattacherjee 2012:137). It was also possible to terminate their participation at any given time during the process.

3.11.4 Anonymity and confidentiality

Research subjects were assured of anonymity and confidentiality (Kozinets, 2002). The Identity of the subjects was not disclosed as data was reported as a whole, not per individual subjects (except for one professor who was not anonymously identified; even with that, he readily consented due to his role in his country's presidential educational review committee). Anonymity is evident throughout the style of reporting in research where, as much as possible, pseudonyms are used to reference the participants and their respective institutions.

Protection and storage of data in secured places were all part of issues that ensured anonymity and confidentiality. Data gathered were also kept safe in a password protected computer and used only for the purpose of the proposed study.

3.11.5 Designing of the research instruments

Items from the survey instrument were adapted from ECAR. Items were only used after attaining permission from the research group. All interview items and questions leading to the development of the rhizomatic maps were self- designed and piloted with subjects of similar characteristics.

3.11.6 Pilot testing of the research instrument

All the instruments were pilot tested in similar environments with participants having similar attributes in the substantive research. Reliability co-efficient of the pilot test from the survey was statistically significant and thereby reported (Frankfort-Nachmias & Leon-Guerrero, 2011).

3.11.7 Data collection and analysis

At an agreement with each research subject, a non-intimidating environment was always selected for data collection (especially for the interviews).Respondents had the option to respond to a paper or web-based survey. In certain instances where transcribers were used, a confidential non-disclosure agreement was signed before data was released to them. Data analysis was also conducted based on sound and trustworthiness of data types (Straits & Singleton, 2011). For instance, numerical data were analysed with appropriate statistical tools like SPSS and Gephi such that results and findings will not deviate from what was being measured. Narrative sources from literature, interviews and focus group interviews were also organised into a set of data with the aid of Atlas.ti, a tool appropriate for analysing the data. Data were analysed and presented to reflect the outcome from the research (Babbie, 2005).

3.11.8 Literature sources

It is ethically upright to build upon what others have done. All literature sources were acknowledged and duly cited since present research rests on the back of previous research. Literature sources were consulted with an open mind and considered in terms of relevance to this present study.

3.12 Data, claims and evidence

Data, claims and evidence form what is traditionally called results, findings and discussions. This part is divided in two subsequent chapters and presented to cover results, findings and discussions under the research questions and hypotheses perspectives. The next chapter is Results and Discussions I: Sub-Research Questions.

CHAPTER FOUR

Results and Discussions I – Sub-Research Questions

"a lot of what is learned (some claim up to 70 per cent) is informal and with a powerful enough network of connections to a personal learning network, there is no limit to what a student can achieve"

-Steve Wheeler (2012:2)

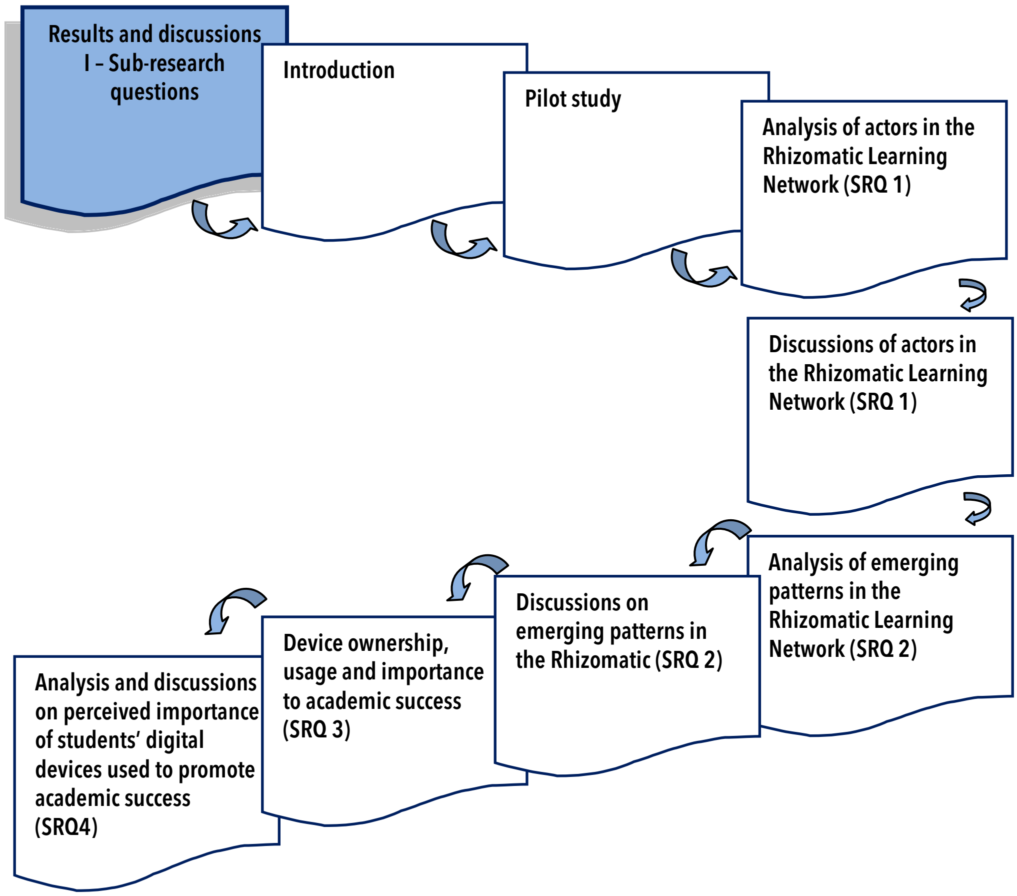


Figure 4.1: Map of Chapter Four

4.0 Introduction

The objective of this chapter is to present results and discussions emanating from the analysis of the four sub-research questions. Data analysed to answer the sub-research questions came mainly from the rhizomatic learning network maps gathered from the students. Other sources of data were from questionnaires, focus groups and individual interviews. The various levels of analyses were presented in rhizomatic learning network maps, tables and descriptive. In the final analysis, each of the results was mapped unto the conceptual model in Chapter One. The mapped model traced rhizomatic patterns developed as a result of interaction between students and other actors or resources in their personal learning networks. Basically, the analyses were reduced to both narrative and numeric presentations in order to answer the sub-research questions below:

1. What are the actors in a rhizomatic learning network?
2. How are the emergent patterns in a rhizomatic learning network related?
3. What digital devices are owned by students in higher education?
4. To what extent are the devices used by students perceived to be a promoter of their academic success?

Objectives 1 and 2 were intended to identify actors and map out the network relationships in a rhizomatic learning network. To achieve these objectives, sub-research questions 1 and 2 were formulated within a theoretical context.

The following sections presents results from the research. The results are presented according to the pilot study the four sub-research questions.

4.1 a. Pilot study

To set the tone for data collection and analysis, a pilot study to check the appropriateness of the instruments for data collection was conducted. The study, consisting of six subjects with similar characteristics of the main study, was conducted prior to the actual data collection. The pilot study took place in Cape Town, South Africa, and findings were published in the Design, Development and Research 2014, Cape Town Conference Proceedings under the title, "*A rhizoanalysis of learning connections among higher education learners.*" Figure 4.2 is a rhizomatic learning network map generated from the pilot phase of this research.

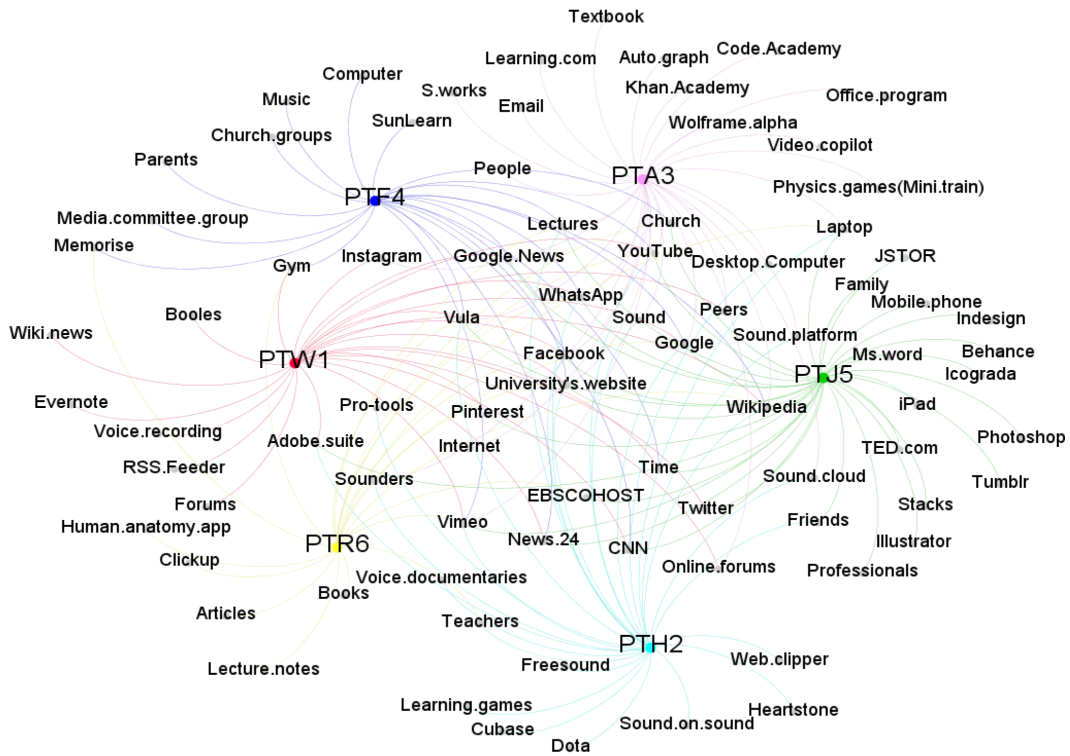


Figure 4.2: Rhizomatic map from pilot study

An initial analysis revealed that students are actors to other actors that are made of both human and socio-technical nodes in a network. One unique and emerging pattern from this map is that the network was homogenous in terms of the participants, but highly heterogeneous with the actor connections. It was also revealed that PTW1 had the most number of connections because he organised his participants from his learning network for the pilot study. The students also gave reasons why they used certain technologies in their learning networks which have been placed into categories (*See footnote of Appendix K*). Some of the technologies included devices like *phones*, *iPads* and *computers*. Connections of the participants reflected in their courses offered by the university. For example, PTJ5, who studies Sound Engineering, shares some common socio-technical actors with PTH2 Mechanical Engineering. Perhaps this is because they all study Engineering. Three of the participants (PTA3, PTF4, and PTR6) who were siblings had some peculiar actors such as church. Lone actors (lecture notes, stacks, music and Heartstone) run through each of the participants' personal learning networks. Participants were diverse in terms of courses studied and universities attended. Table 4.1 presents the profile of the participants.

Table 4.1:Profile of pilot study participants

Participant	Gender	Age (years)	Details of university studies	
			Course	Year/Level
PTW1	Male	22	Interactive media	3rd
PTA3	Male	19	Medicine	2nd
PTR6	Female	22	Information Design	4th
PTJ5	Male	20	Sound Engineering	2nd
PTH2	Male	21	Mechanical Engineering	3rd
PTF4	Male	19	Actuarial Science	2nd

At this stage, no statistical analysis in social network analysis was used. All the analysis was based on the observations and trends identified from the map. It was also revealed from interaction with the participants that connection was a lifeline to their learning network. For example, a participant had this to say:

> *"I get connected to my learning network either through machines like mobile later statement, one participant opined that the intensity of lecturers' encouragement phone, computer, tablet or personal contacts with people like friends, lectures and others*" (**PTW1**).

Further probing also suggested that students' closeness (connection) to their lecturers were dependent on their technological inclination which was sometimes affected by age. PTA3 said that "*our lecturers are closer to us based on how they adopt technology.*. Similarly, technology integration in their personal learning network depended on their age.

The pilot study brought the challenge for streamlining the main research for better and more appropriate ways of going about a Social Network Analysis, as this emerged after various presentations in conferences and in the Belgian institution in which I was a Visiting Scholar.

Figure 4.3: A session with participants during the pilot study

Main study

4.2 Analysis of actors in the rhizomatic learning network (Sub-Research Question 1)

To achieve this objective 1, this section answers the Sub-Research Question 1: What are the actors in a rhizomatic learning network? The research found a total of 218 actors in all (*Appendix K*) made of human and non-human agents which occurred as nodes in the rhizomatic maps. Some of the actors could be found across institutions. Distribution of actors in the institutions is as follows: GAC=64; GBA=72; SAR=135 and BEL=31.

First and foremost, visualisation of the structure of the rhizomatic learning networks (Figures 4.2, 4.4 to 4.7) favours Fenwick's (2011:119) assertion that learning *"networks grow through connections."* All actors/nodes are clustered and categorised with seven names: *Devices, Platforms/Software, Social media, Other Technologies, Pen and Paper, Interaction and Human actors*. The clustering was made based on characteristics that occurred in similar actors and data gathered from the interviews on how respondents use the various actors. Example: *Human (H)* actors were considered to include all human beings occurring under some of the following names; lecturers, peers, colleagues, people, mentors, parents and research assistants. Again, the actor, Devices (D) constituted *laptop, Smartphone, computer, camera, memory card*, to mention a few. Furthermore, other nodes or elements like *Cousera*, *Email, Microsoft Office Suite, Camtasia Studio, UC Browser* belong to *Platforms/Software* (P/S) category of actors. Mention can be made of the *Social media* (SM) actors which also consist of *Facebook*, *Instagram*, *WhatsApp*, *Mixlr, Tweek Deck* and many more.

Other Technologies (OT) form the category of actors that may be considered as 'mixed technologies'. Libraries, *Moon reader* and Study group call fit into OT. Pen and Paper (P&P) is the umbrella category of actors such as Books, Library, Textbooks, Articles, Dictionaries, Newspaper, Sketch notes and Pen and paper. Finally, the Interaction (Int) categorisation of actors considered essentials such as lectures, observation, seminars, mentor conferences and study groups. Basically, Int factored in all the human agents and their interactional roles viz-a-viz the rhizomatic learning networks of the students. Table 4.2 illustrates the 7 categories of actors and their frequencies.

Table 4.2: Category of actors identified

S/N	Category of actor	Total number of actors found
1	Devices	19
2	Platforms/Software	147
3	Social media	55
4	Other Technologies	3
5	Pen and Paper	10
6	Interaction	11
7	Humans	14

4.3 Discussions of actors in the rhizomatic learning network (Sub-Research Question 1)

Detailed visualisation results about the rhizomatic maps are presented, showing the actors and their relationships based on the four institutions. Rhizomatic learning maps in Figures 4.5 to 4.9 show the interrelationship of actors in students' personal learning network maps.

Occurrence of human agents as pivots in the network diagram including lecturers are consistent with Latour (1999); however, most students did not capture lecturers and peers as part of their personal learning network, they only dwelt on the technological part of their learning network. But as this era has been characterised so much with the kind of technological connections one builds to facilitate learning, devices are seen as key actors in present learning networks of students.

> *"Now every student has a mobile phone. Many of them are having smart phones and these smart phones are connected to the Internet so they use that. Also, there is an appreciable increase in the number of computers that our departments acquired so they use those computers as well to get the relevant information"* (***S.GBR.Selasi***).

Every LN strives for information access; hence digital devices in a rhizomatic learning network facilitates also form an important and integral number of actors that enable maximum access to information. According to another lecturer:

> *"They [students] are taught how to use Mendeley so some are using Mendeley to gather the literature that they want, some use the WhatsApp. Some are even using Facebook that they could be able to get access to information that their friends may have had so some of these applications actually enhance their access to information so especially Mendeley, WhatsApp and Facebook. I saw a few others also using Wikipedia to access information"* ***(L.GAC.Araba)***.

Fig. 4.4 highlights results in each category of actor in this study. The actors are mapped onto a conceptual model presented in Chapter One.

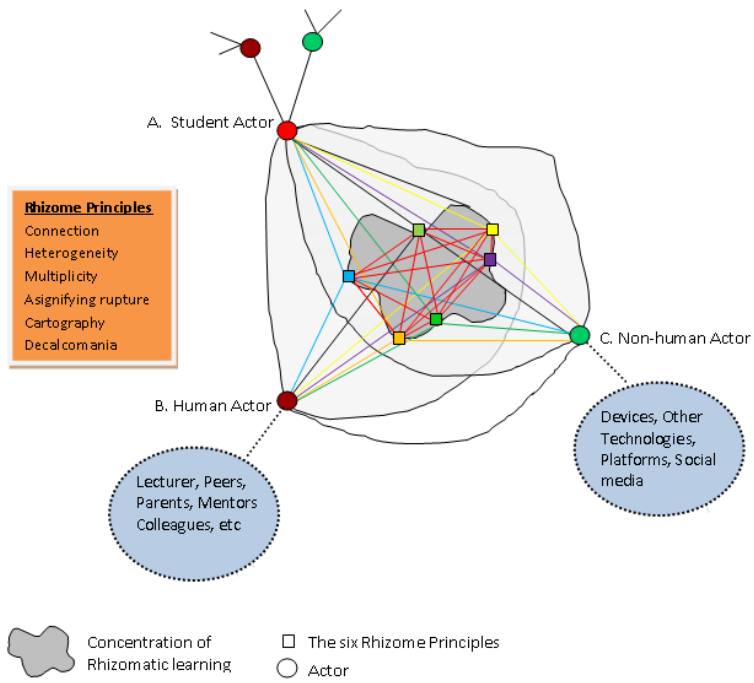
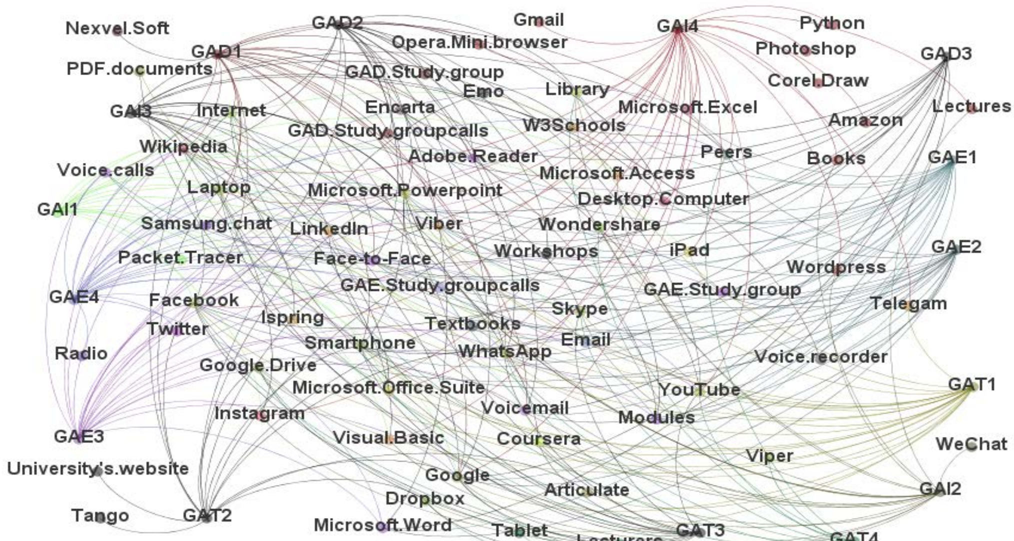


Figure 4.4: Mapping of human and non-human actors onto the conceptual model

To summarise, actors are complex elements or entities that scope ideas, learning communities (Siemens, 2005), devices, software and many more, that can be delineated into human and non-human actors or actants (Latour, 1987, 2005). In the personal learning network of the student, Figure 4.4 reveals that there are various human actors that interact with the student through other non-human actors. These other non-human actors also form part of the socio-technical aspect the students' personal learning networks. Again, as shown in Figure 4.4, the results revealed a total of seven categories: Devices, Platforms/Software, Social media, Other Technologies, Pen and Paper, Interaction and Human actors.

4.4 Analysis on emerging patterns in the rhizomatic learning network (Sub-Research Question 2)

This section, related to objective 2 of this study, sought to map the relationships in students' rhizomatic learning network. To achieve this objective, analysis and answers to sub-research question are provided. Research Question 2: *How are the emergent patterns in a rhizomatic learning network related?* (see section 4.5 for discussion on this research question).



81 nodes; 304 edges

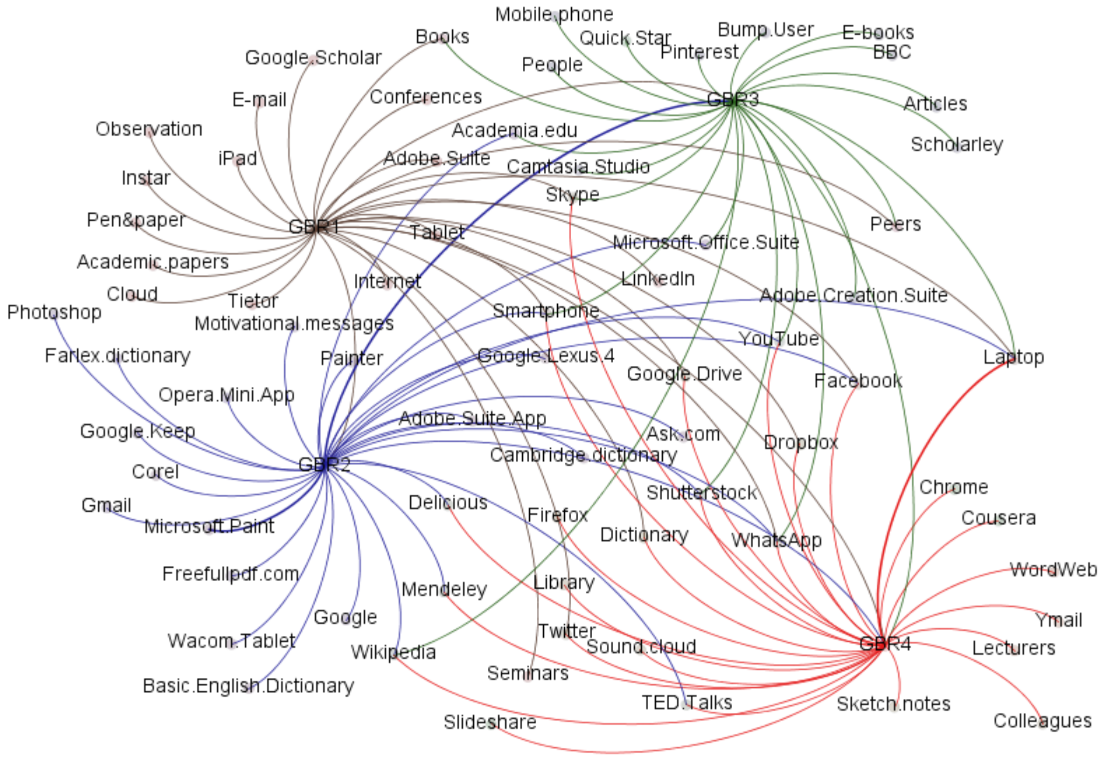
Figure 4.5: Rhizomatic learning network for GAC (Ghana)

A total of 81 actors (nodes) emerging from 15 participants were found to be interrelated in the rhizomatic learning network map in Figure 4.5. In sum, 304 connections (edges) were also established. It is evident from Figure 4.5 the rhizomatic learning network of GAC is made up of human and non-human actors (Latour, 2005) where students, peers and lecturers are the human agents and actors. Centrality and density measures of actors in the rhizomatic learning network of GAC in Figure 4.3 are described in Table 4.7. Reference to the full analysis can be found in Appendix K.

Table 4.3: Measures of centrality and density of actors in the rhizomatic learning network of GAC

Dimension	Interpretation	Actors with supporting values
Betweeness Centrality	Influence of an actor (bridging node, number of indirect connections to other actors)	GAI4 (1269.75) GAT1 (1157.75) GAT2 (967.25)
Closeness Centrality	Proximity (directly or indirectly) of an actor to every other actor (shortest pathways)	*Google* (0.55) *WhatsApp* (0.55) *Microsoft Powerpoint* (0.54)
Degree Centrality	Connectedness of an actor or the number of connections of an actor (social power)	GAI4 (31) GAE1 (25) GAE4 (24
Eigenvector Centrality	Importance of an actor (an actor's connection to other actors with high scores)	GAI3 (1.00) GAE1 (0.99) GAD1 (0.95)
Density	Possible number of connections	0.093

Table 4.3 indicates that actors that are closest to everyone in the learning network are Google and *WhatsApp*. Apart from closeness centrality, all other measures of centrality in Table 4.3 are human actors.



82 nodes; 117 edges

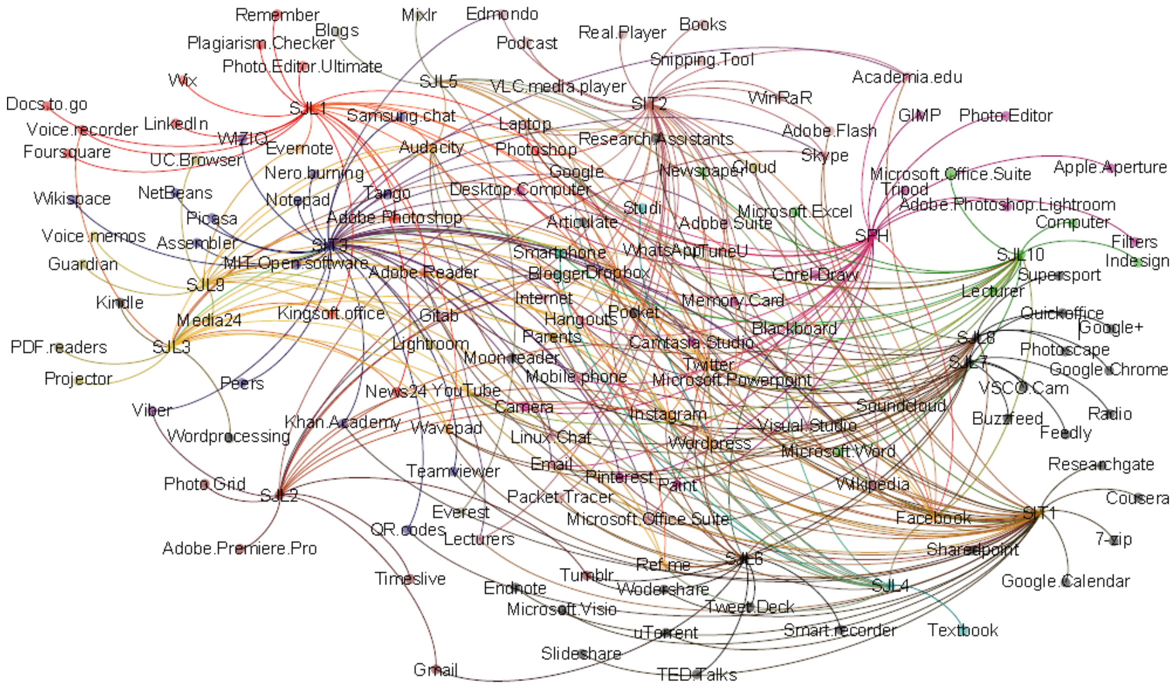
Figure 4.6: Rhizomatic learning network for GBR (Ghana)

In Figure 4.6, the actors (nodes) totalled 82. The actors emanated from 15 participants as a result of relationships in the rhizomatic learning network map of 117 connections (edges). Measures behind Figure 4.6 are presented in Table 4.4.

Table 4.4: Measures of centrality and density of actors in the rhizomatic learning network of GBR

Dimension	Interpretation	Actors with supporting values
Betweeness Centrality	Influence of an actor	GBR2 (0.63) GBR 1 (0.62) GBR 4 (0.62)
Closeness Centrality	Closeness of an actor to every other actor	GBR 2 (0.63) GBR 1 (0.62) GBR 4 (0.62)
Degree Centrality	Connectedness of an actor or the number of connections of an actor	GBR 2 (33) GBR 1 (29) GBR 4 (29)
Eigenvector Centrality	Importance of an actor	*Adobe Creation Suite* (0.1) Articles (0.1) BBC (0.1)
Density	Possible number of connections	0.034

In Table 4.4, the key actors are all human with the exception of Adobe Creation Suite that formed the most important actor to students in their learning networks. This is not surprising because students participating in the rhizomatic learning network map generation are design students. Figure 4.7 shows the rhizomatic learning network for SAR.



Nodes: 150; Edges: 315

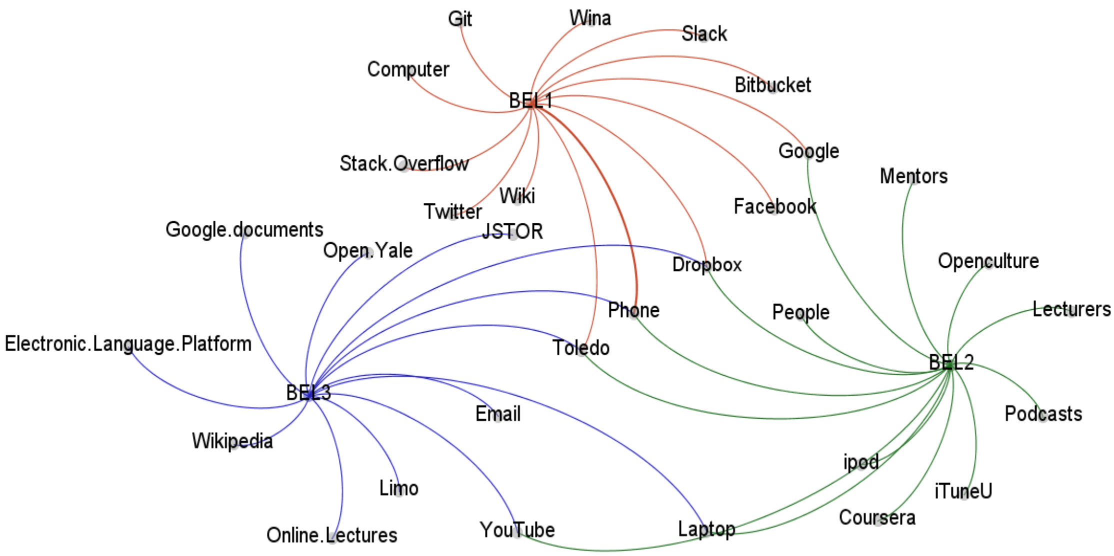
Figure 4.7: Rhizomatic learning network for SAR (South Africa)

A sum of 150 actors (nodes) emerged from 14 participants showing the interconnectedness in the rhizomatic learning network map in Figure 4.7. In sum, 315 for connections (edges) were also established. Figure 4.6 provides details on rhizomatic learning network for BEL.

Table 4.5: Measures of centrality and density of actors in the rhizomatic learning network of SAR

Dimension	Interpretation	Actors with supporting values
Betweeness Centrality	Influence of an actor	SIT1 (2881.58) SIT3 (2364.89) SPH (1664.792)
Closeness Centrality	Closeness of an actor to every other actor	Dropbox (0.52) *Facebook* (0.50) *YouTube* (0.47)
Degree Centrality	Connectedness of an actor or the number of connections of an actor	SIT1 (45) SIT3 (40) SIT2 (33)
Eigenvector Centrality	Importance of an actor	SIT1 (1.0) SIT3 (0.92) SIT2 (0.84)
Density	Possible number of connections	0.028

In SAR, the closest actors to every student are *Dropbox*, *Facebook* and *YouTube*. All other dimensions of centrality proved that humans were either the most important, influencing or connected actors. Figure 4.8 on rhizomatic learning network map of BEL is next.



34 nodes; 41 edges

Figure 4.8: Rhizomatic learning network for BEL (Belgium)

Figure 4.8 data shows that 34 actors (nodes) including three participants confirm a relationship of 41 connections (edges). Measures of centrality and density of actors in the rhizomatic learning network for BEL are also supplied in Table 4.6.

Table 4.6: Measures of centrality and density of actors in the rhizomatic learning network of BEL

Dimension	Interpretation	Actors with supporting values
Betweeness Centrality	Influence of an actor	BEL1 (257.88) BEL2 (253.05) BEL3 (241.07)
Closeness Centrality	Closeness of an actor to every other actor	*Dropbox* (0.52) *Phone* (0.52) *Toledo* (0.52)
Degree Centrality	Connectedness of an actor or the number of connections of an actor	BEL2 (14) BEL3 (13) BEL1 (13)
Eigenvector Centrality	Importance of an actor	BEL2 (1.0) BEL3 (0.88) BEL1 (0.82)
Density	Possible number of connections	0.071

Dropbox, *Phone* and *Toledo* (Learning Management System) formed the closest of all actors to students in their rhizomatic learning networks. All measures of centrality are human actors. Figure 4.9 describes a pictorial overlap of actors.

A number of patterns emerged from the analyses of the rhizomatic network maps. Figure 4.9 represents a summary of the convergences and divergences of actors per institution of occurrence. References will be made in regard to the detailed analysis of Figure 4.6 (*Appendix K*).

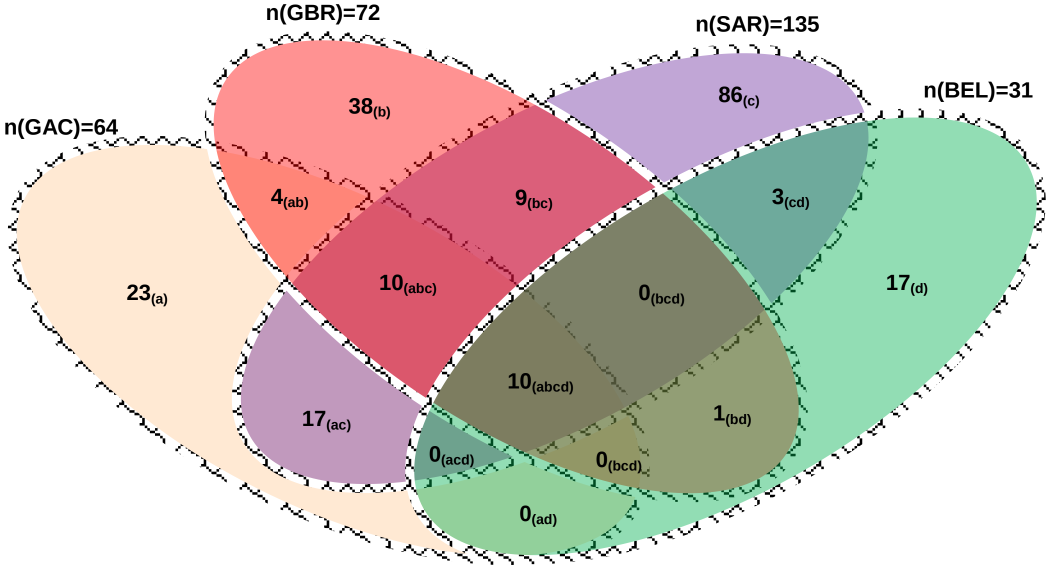


Figure 4.9: Rhizome diagram of convergence and divergence of actors per institution

Interpretation of subscripts

a	=	GAC only	ac	=	GAC and SAR only	abd	=	GAC, and BEL only
b	=	GBR only	ad	=	GAC and BEL only	acd	=	GAC, SAR and BEL only
c	=	SAR only	bc	=	GBR and SAR only	bcd	=	GBR, SAR and BEL only
d	=	BEL only	cd	=	SAR and BEL only	abcd	=	GAC, GBR, SAR and BEL
ab	=	GAC and GBR only	abc	=	GAC, and SAR only			

A total number of ten actors emerged as actors in all the four institutions (refer to 10_{abcd} of Figure 4.6 or Appendix K). Six of those actors fell under the category of *Platforms* or *Software* while three were under social media. Lecturers and laptops also featured under the categories of Devices and Humans, respectively.

Other patterns were in 3 and 2-institutional convergences. The 3-institutional, which also had actors converging, did not include BEL. It was noted that the following categories, having Paper and pen (Books), Humans (Peers), Devices (Smartphone) and Social media (*WhatsApp* and *Skype*), were all represented with at least one actor. Again, the analysis showed that six of the actors were for the category of Platforms or Software.

Table 4.7: Analysis of actor occurrences per institution

Actor Occurrence	GAC	GBR	SAR	BEL	Total	%
Lone	23	38	86	17	164	54
Twice	21	14	29	4	68	23
Thrice	10	10	10	0	30	10
Quadruple	10	10	10	10	40	13
Total	64	72	135	31	302	100

Table 4.7 indicates that 164 (54%) of the actors occurred as the only (lone) actors specifically occurring in particular institutions. While 68 (23%), 30 (10%) and 40 (13%) actors were found to have appeared among two, three and four pro rata. There are two kinds of lone actors: one occurs as the only occurring actor used by an individual in the entire research, and the second one, though it appears as a lone actor at institutional level, may be utilised by more than one or two other actors. For instance, *Limo* and *Photo Editor* are *lone* actors utilised only by individuals (actors) in the entire research in BEL (Belgium) and SAR (South Africa), respectively. An example of the second kind of lone actor includes *lectures* which has two connections but only appears in GAC (Ghana).

4.5 Discussions on emerging patterns in the rhizomatic learning network (Sub-Research Question 2)

This section addresses objective 2 of the sub-research question. The sub-research question 2 driving this section is this: *How are the emergent patterns in a rhizomatic learning network related?* Results from the rhizomatic maps show convergent and divergent relationships among the human and non-human actors. The results, which reveal traces of rhizomatic principles and resonate with Cormier (2008), Warburton (2010) and Guerin (2013) in understanding students' personal learning networks through relationships among actors (nodes) in a rhizomatic learning landscape, are discussed in the ensuing paragraphs.

4.5.1 Connection and heterogeneity

The rhizomatic learning networks presented in the above figures are built on the principle of connection and heterogeneity. All actors are heterogeneous in the sense that they all have varied number connections to their actants or degree centrality. From the four rhizomatic learning network maps from the four institutions, the topmost influencing actors are human actors (students) serving as bridges between other humans and or non-human actors. STI1 from SAR, the most connected in all the rhizomatic learning networks, was more connected to non-human actors mainly of technological. Furthermore, apart from GBR, results prove that generally, technology is closer to human actors implying that students' reliance on tools such as *Google, WhatsApp, Microsoft Powerpoint, Dropbox, Phone, Facebook, YouTube* and a learning management system (*Toledo*) must be explored further for fully determining their educational value.

> *"I don't think most students will go to the library looking for books there, maybe they go there to learn but the library even have internet connectivity where students can Google and see certain information"* (**L.GAC.Ato**).

For instance, the closest actors to every single actor in the rhizomatic learning network of GAC (Figure 4.5) are *Google* and *WhatsApp*. The University's website, *Emo* and *Tango,* are the farthest of actors from each other actor. Perhaps *Google* has become the closest actor to any other actor because it presents complex and rhizomatic interconnections in simplistic terms to students. Google has become a hotspot for information search and synonymous to the word 'search' making the platform an important learning tool in the 21stcentury digital world. In some cases, students prefer to consult Google for validation of information or teachers or lecturers rather than relying on human agents.

> *"When you look at the web per say, it is not linear (when you are searching for or reading information, it is not linear) but it is interconnected [sic] and so, you will have to be very careful. Because our students have that constrains of time (that this*

*thing has to be finished within a stipulated period of time), instead of going to the web to have his or her own learning path, you will see that all of them are going to have a fixed jacket. This is because, they are supposed to learn this and answer questions based on that learning objective or that constrains. At times, you will not see our students doing a lot of exploration and that is one thing I believe that I have seen and it is high time we encouraged them to know that learning is not fixed now. You can determine your own path of learning because each student do have their own individual objective of enrolling in a particular programme but our current situation where we fix them in that fixed jacket is not helping them to explore" (**L.GAC.Ato**).*

4.5.2 Degree centrality

First and foremost, visualisation of structure of the rhizomatic learning network (Figure 4.3) is skewed towards Fenwick's (2011:119) assertion that learning *"networks are webs that grow through connections."* As indicated in Figure 4.6 or Appendix K, the outliers for actors range from 1 to 31 connections while the first 14 elements or nodes in the rhizomatic learning network of GAC (Figure 4.5) are also made up of human actors. The most connected actor (GAI4) has 31 connections to both human and non-human actors. Again, findings in Table 4.3 show that *Google* and *WhatsApp* are the most popular non-human agents in the rhizomatic learning network of GAC. According to statements made by one of the lecturers in terms of *Google* and libraries, L.GAC.Ato said that:

"I don't think most students will go to the library looking for books there, maybe they go there to learn but the library even have internet connectivity where students can Google and see certain information."

He further substantiates his claims by suggesting that the traditional roles of libraries where people relied on 'physical' library books are fading due to web activities.

> *"Wikipedia is knocking off all the Encyclopaedia and I don't know the last time I saw Encarta Encyclopaedia by Microsoft; for Encyclopaedia Britannica I don't know the last time I saw their digital or multimedia version because Wikipedia is taking over now and so students go there (the Encyclopaedia) to look for information"*(L.GAC Papa).

The lecturer's observations about Google and Wikipedia can be buttressed by Billings (2003) and McKnights (2011) who hold the views that penetration of digital media in our society is fast surpassing access and usage of physical libraries. In addition, Student A4 alluded to her heavy dependence on those two platforms (*Google* and *Wikipedia*) identified by L.GAC.Ato for information.

> *"A platform like Wikipedia too is very helpful when you want to search for information. I use amazing tools and Google for all the information that I need so those are the platforms that I have been using much"*

At the least, all 15 human actors in the rhizomatic learning network depend on Google for information for their learning while 11 of them use Wikipedia. Again, an emerging pattern about libraries indicates that only about half of the human actors make use of the library. It could be possible that these students may see the library as an important actor in their learning network partly because of Internet facilities as earlier claimed by L.GAC.Ato.

It is important to note that sometimes, while lecturers do think that certain software or actors may be very important in students' learning networks, this might be an erroneous belief. According to L.GAC.Selasi:

"Especially for my students, there are so many applications they now use. They are taught how to use Mendeley so some are using Mendeley to gather the literature that they want; some also use the WhatsApp application. Some are even using Facebook that they could be able to get access to information that their friends may have had so some of these applications actually enhance their access to information so especially Mendeley, WhatsApp and Facebook. I saw a few others also using Wikipedia to access information."

In the analysis of the rhizomatic learning network of GAC (Figure 4.3) and in all the focus group discussions held with students in GAC, there is nowhere mention of student claiming that they use *Mendeley*. Though Wikipedia features here again, emphasis by L.GAC.Selasi on the use of Mendeley cannot be supported. However, except one student who does rely on *WhatsApp* in his rhizomatic learning network, all students find *Facebook* useful in their rhizomatic learning network (Backer, 2010). Claims by L.GAC.Selasi on *WhatsApp* and *Facebook* are consistent with emerging patterns in the rhizomatic learning network. He also pointed to the fact that students use *WhatsApp* for their group study and further alluded that lecturers are sometimes added to the group, but that they usually prefer assume passive roles.

In his assertion, *S.SAR.Tabisa* noted that:

"Our group has a WhatsApp group page and that's where we mostly share our information [sic] when we are given a topic, we all try to bring our views by using WhatsApp. So whatever you think is the right thing, you bring it out and then we would discuss it on WhatsApp"

Despite the popularity gained by the use of *WhatsApp* in various learning networks (Rooyan, 2015), the platform is not yet freed from its limitations. In the assertion of *S.SAR.Tabisa*, the use of

WhatsApp is sometimes challenged by connectivity issues; once more, he identified the use of telegram as a preferred choice to *WhatsApp*, because it allowed for file transfers in certain formats.

> *"Yea! That is why I prefer telegram. With WhatsApp, I am not able to send PDF files and other documents and this is one of the limitations I see with WhatsApp. Another limitation I see is with the issue of the network connectivity. At times if the network connectivity is not favourable, it also limits the discussion that you want to have so that's also another limitation"* (***S.SAR.Tabisa***).

Statements by Student *S.SAR.Tabisa* do not deviate from Rambe and Chipunza (2013) on challenges like Internet connectivity. However, Bere (2013) exploits this challenge into opportunities and vehemently justifies *WhatsApp* as a likable tool for asynchronous communication in study groups. Despite my agreement that network connectivity poses challenges (Adhi, 2014) to *WhatsApp* as a key actor in the rhizomatic learning networks of all 15 students, it presents related affordances such as record keeping, audio, visuals podcasts and messages which can always be accessed asynchronously.

S.SAR.Tabisa's experience in 2015 about the inability of Portable Document Format (PDF) file transfer on *WhatsApp* was also well-noted by Sonawane and Motwani (2014). But currently, it is possible to share PDF documents via *WhatsApp Messenger* Version 2.16.57 (WhatsApp, 2016). This is a clear example of how technology is moving fast and supports the stance that each rhizomatic learning network map is a *cartograph* of its own with its unique connections. A closer look at the connections indicates that no two actors share the same actants.

It is also not surprising to have Microsoft PowerPoint featuring prominently in the rhizomatic learning network of students. *PowerPoint* and presentation skills have become very important in higher education. Since students are trained in individual and group presentations, presentation packages have become increasingly useful tools. They present visual and audio attributes that allow for better expressions of self.

Two-thirds of the students indicated that their rhizomatic learning network include the Internet; nonetheless, other applications such as *Google* and *WhatsApp,* to which they all subscribe, run on the Internet. Though implied, all human actors in Figure 4.3 use the Internet, a third of them (human actors) do not recognise it as a key component of their rhizomatic learning network. Perhaps the Internet is taken for granted and seen as a passive actor once Google and Wikipedia are able to solve students' learning provisions.

4.5.3 Multiplicity

The various rhizomatic learning network maps show exactly the fluidity of learning connections built by students. There are opportunities for multiple entryways for students to connect to information or resources, as far as their learning is concerned. Clear evidence is motivated through actors such as GAI4 in GAR; GBR2 in GBR and SIT1 in SAR who are the most connected and at the same time the most influential in their rhizomatic learning networks. This suggests a high certainty that actors that are well-connected hold possible power of influence. It can be argued that phones in a learning network of students can be used to connect several resources for the benefit of students.

Indeed, through Google, the spirit of lifelong learning is enhanced. Perhaps, this is because of the proliferation of digital devices that are Internet enabled.

> *"With the advent of technologies, I believe that additional learning theories have come into the main stream like network learning (and) connective learning has come. This is because the rate at which knowledge is been churned out is faster than what it used to be. People are being encouraged to be lifelong learners and so learning pattern has changed as per (in relation) the world's standards"* (***L.GAC.Ato***).

4.5.4 Asignifying rupture

From the rhizomatic learning network maps, all the 144 lone actors (sometimes found at the peripherals) exhibit characteristics of asignifying rupture. In social network terms, asignifying rupture could represent a "local bridge" where actors do not share neighbours but are at the end points (SNA Theory and Application Book:6). Students perhaps have 'deviated' from the norms to find the affordances or educational use of certain resources which now appear as lone actors such as *Emo*, *Voicemail*, Workshops or Study group calls. These resources may have become actors because students possibly have broken away from the commonly used technologies for certain reasons that the functions do not work best with the common actors. Critical observation of any rhizomatic learning network map reveals that there is no clear termination point in the map since further research may lead to infinite and future connections to other actors that are eventually introduced to those actors. For instance, further engagement with GAI2 in GAC is likely reveal other learning associations to the use of *WeChat* (lone actor) in his learning network; therefore, *WeChat* cannot be at the terminal end of that network. It has potential for growth.

In the rhizomatic learning network, asignifying rupture can also be explained by how one student manages his virtual learning groups:

> *"I belong to so many virtual learning groups but I wade into discussions that are beneficial to me. However, I become passive contributor when topics are not interesting for me. If uninteresting topics trend for some time, I realign my focus to other networks without necessarily deleting my membership from my passive group"* ***(S.GAC.Tina).***

Once they are technologically equipped, students chart new paths provided their learning needs are met, while clinging to old connections for future use.

4.5.5 Cartography and decalcomania

Each individual student has his own unique learning network, a map of his own. From the focus group discussions, it did not appear that all technological actors were used in the same way. An example can be made of the Smartphone.

> *"My Smartphone does a lot of jobs in my university work. I sometimes use it as a storage device where my class presentations loaded. Other uses include group discussions especially if we have to agree on time for our meetings" (**S.GAC.Afi**).*

The outlook of the rhizomatic learning network maps and the later statements from the student are consistent with Beetham (2013) who believes that students support their learning via their digital networks and resources.

Again, values emanating from the maps also reveal variances in terms of value placed on actors (Eigenvector Centrality). The importance of an actor or a students' learning network also depends on the kind of actors or resources he connects to. Apart from GBR, students in all the institutions are closer to technological actors than human actors; this finding is in conformity with Raines (2002), Oblinger (2003) and Trilling and Fadel (2009). In my view, results and discussions so far do not concur with *EdTech Review (2009)* in the sense there is no strong indication that students understand and follow rules and procedures, or else results would have been more homogeneous, especially within the institutions. An example is the use of Wikipedia in their learning. Students defy their lecturers when it comes to this actor, which is very important to acknowledge in all the institutions.

> *"We have been seriously warned not to get near Wikipedia. I am not sure this will ever work. How can you not exist without Wikipedia in this age? Some of these platforms are written with simple language or directs you to other key sources" (**S.SAR.Ziyanda**).*

In sum, students show enough diversity and individual differences through their networks with an open inter-disciplinary mind (Eton, 2011). The value of importance of resources in the learning network depends on the relevance of specific actors to students at a time (Shelly *et al.*, 2012).

4.6 Device ownership, usage and their importance to academic success

4.6.1 Device ownership

Sub-Research Question 3: *What digital devices are owned by students in higher education?*

To answer this question, digital devices owned by students in higher education were limited to four major digital devices: Laptop, Tablet or iPad, Smartphone and E-Reader (Dahlstrom & Jacqueline, 2014). Results under this research question are first discussed and then presented two-fold according to the devices owned by the respondents and the kind of operating systems that ran on those devices. Figures 5.7 to 5.12 present an overview of whether or not respondents owned particular devices or planned to purchase device(s) within the next 12 months or not, through bar charts.

4.6.2 Significance of digital device ownership towards the academic success of higher education students

Objective 3 of the research questions was to determine the significance in higher education. Based on literature, digital devices owned by students were limited to the four major devices (Dahlstrom & Jacqueline, 2014): Laptop, Tablet or iPad, Smartphone and E-Reader. Variations in terms of ownership of digital devices among students was both inter and intra institutional. Across all the four institutions, ownership of Tablets or iPhones and E-readers is least. Across all the three institutions in Africa, results indicate that Smartphone and Laptop are the top three devices (Laptop, Smartphone and Tablets, consistent with the findings of Sharples *et al.* (2014). Ownership of devices extends to the kind of software to be used. One student explained that:

> *"In our case, we use a lot of software to capture and render videos. Obviously, we cannot do away with digital devices in our programme because the software run on them [sic] the Smartphone is one of the greatest tools of our time" (**S.SAR.Frank**).*

Other importance of digital devices in the promotion of students' academic success includes the use of mobile phones for group work.

> *"As distance education students, some of us come from deprived places; however, we can rely on our mobile phones to help us be part of group discussions after work. I never had this opportunity in my secondary school days but I now feel part of the student activities" (**S.GAR.Abena**).*

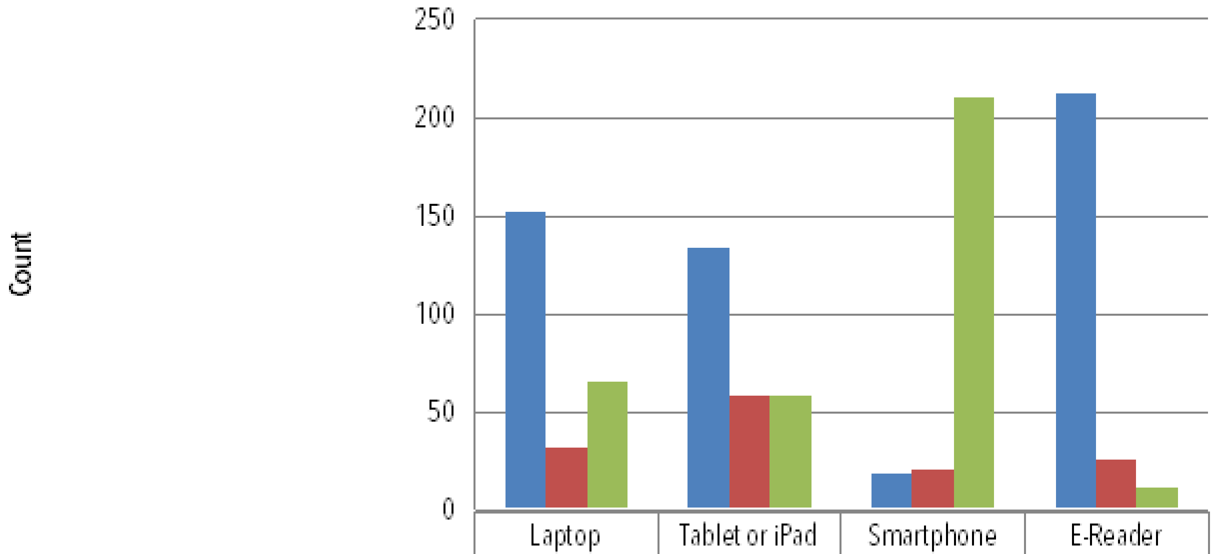
Abena's submission can be sustained by Falloon's (2015) position on digital devices for collaborative activities. Ownership of digital devices serves as educational tools that allow students to take advantage of certain educational *software* by virtue of their studentship.

> *"Most of us possess personal computers for our school work. The good thing about it is that we can download licensed programmes from the university's website (example some analytical software) which can be used everywhere, even at home" (**S.BEL.Hugo**).*

Results can be corroborated by Barry *et al*. (2015) and Oliver and Goerke's (2008) suggestions that students' digital device ownership connect them to various learning resources at their convenience. Results are further supported by Ng'ambi's (2011) position on personal digital devices like Smartphones as pedagogical tools. Figure 4.10 gives a pictorial impression of device ownership by the SAR cohort.

4.6.3 Graphs on digital device ownership in the four institutions

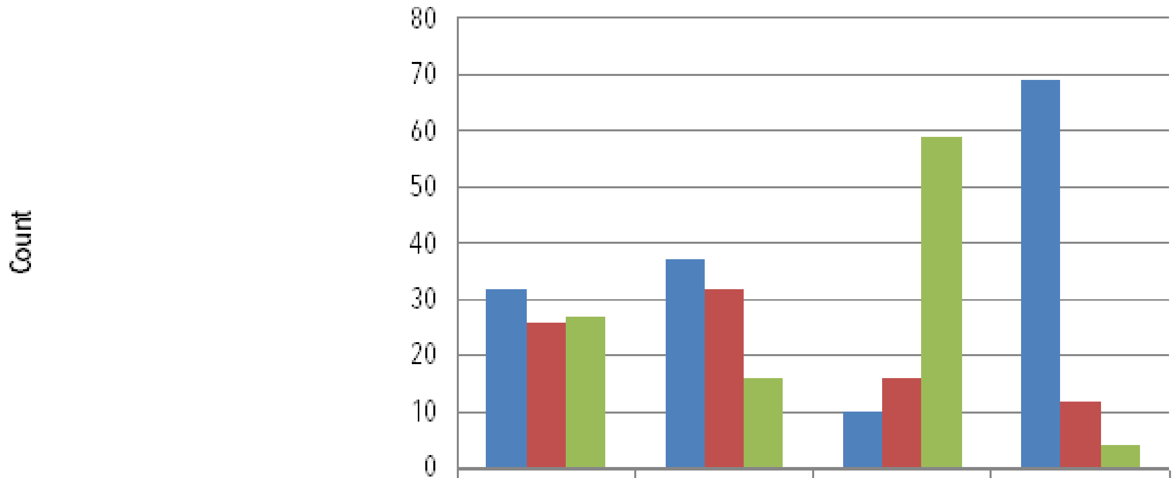
This section is a presentation of graphs on digital device ownership across the four institutions in this research.



	Laptop	Tablet or iPad	Smartphone	E-Reader
No, and I don't plan to purchase one within the next 12 months.	152	134	19	212
No, but I plan to purchase one within the next 12 months.	32	58	21	26
Yes, I currently own one(or more).	66	58	210	12

Figure 4.10: Device ownership by SAR (South Africa) respondents

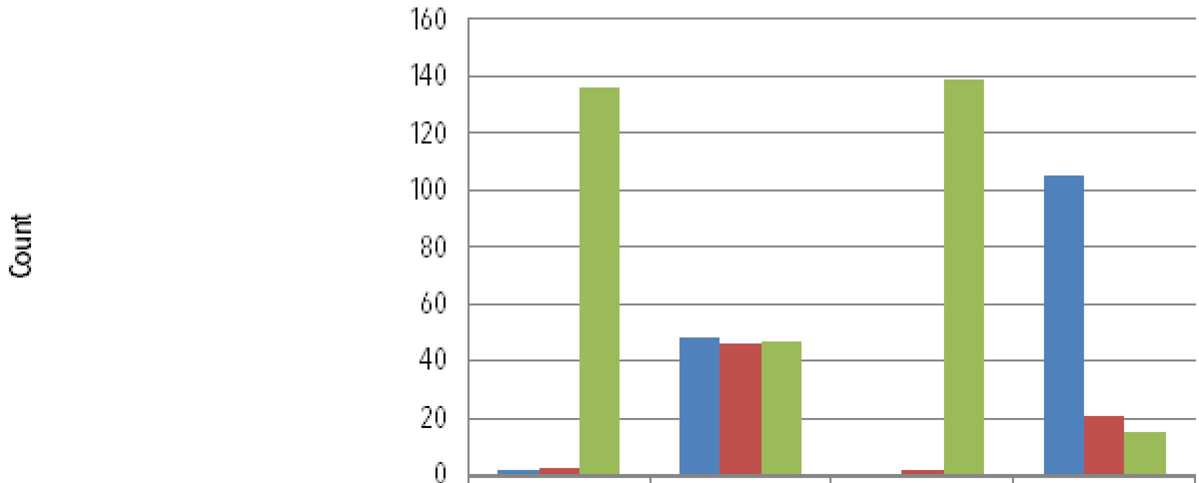
Figure 4.10 shows ownership of the four digital devices among respondents from the SAR cohort varied. Out of the 250 respondents, 210 (signifying 84%) owned one or more Smartphones. However, about 8% plan to own Smartphone(s) within the next 12 months. Out of the 73.6% who did not own Laptop(s), 61.8% of the total population has no plan of purchasing one within the next one year. Ownership of Tablets or iPads and E-readers among the SAR cohort recorded 23.2% and 4.8%, respectively. Figure 5.8 illustrates the distribution of device ownership by the GAC cohort.



	Laptop	Tablet or iPad	Smartphone	E-Reader
No, and I don't plan to purchase one within the next 12 months. Count	32	37	10	69
No, but I plan to purchase one withi n the next 12 months. Count	26	32	16	12
Yes, I currently own one(or more). C ount	27	16	59	4

Figure 4.11: Device ownership by GAC (Ghana) respondents

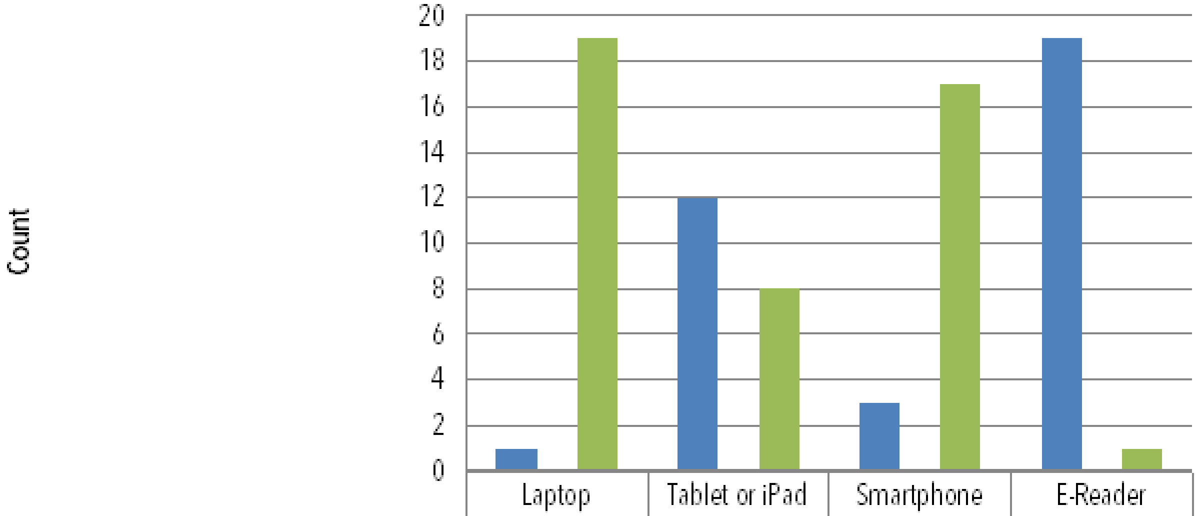
According to Figure 4.11, the majority of the respondents who owned devices owned Smartphones (69.4%) followed by 18% owning Tablets or iPads. Again, 31.7% indicated they are owners of Laptops. Furthermore, 37.7% of the GAC cohort said they have no plans of purchasing Laptops in the next one year. A plan for E-reader ownership within the next one year is virtually non-existent for 81.2% of GAC respondents who were without the device. Only 4.7% claimed ownership of an E-reader. Figure 4.12 gives details of digital device ownership by the GBR cohort.



	Laptop	Tablet or iPad	Smartphone	E-Reader
No, and I don't plan to purchase one within the next 12 months. Count	2	48	0	105
No, but I plan to purchase one withi n the next 12 months. Count	3	46	2	21
Yes, I currently own one(or more). C ount	136	47	139	15

Figure 4.12: Device ownership by GBR (Ghana) respondents

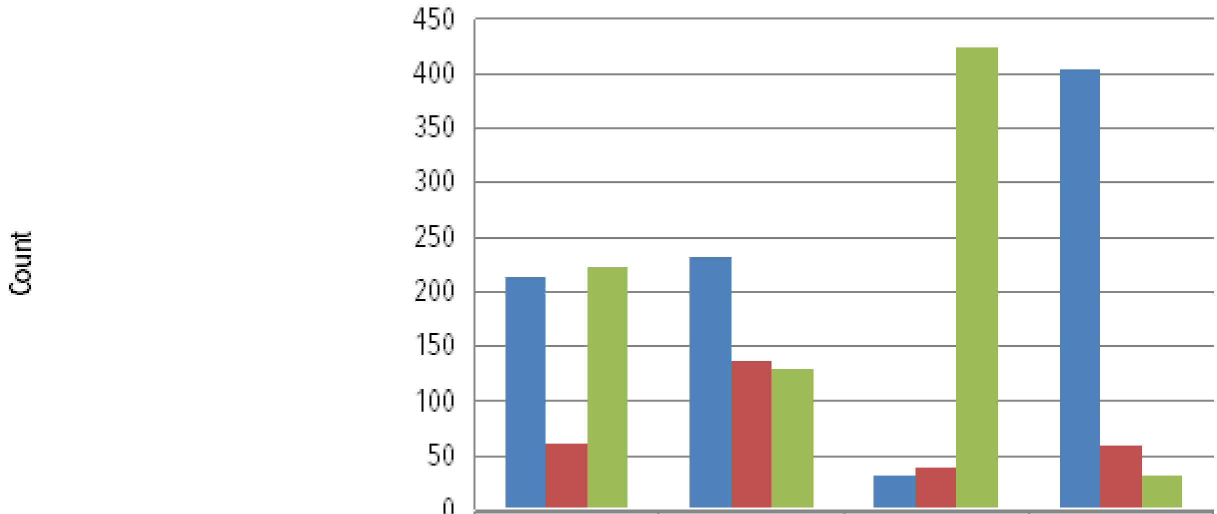
In Figure 4.12 Smartphones and Laptops are owned by 139 (98.6%) and 136(96.5%) of the respondents correspondingly. While two (1.4%) admit to having no plans to purchase a Laptop within the next 12 months, another two (1.4%) who also do not own Smartphone(s) intend to own one within the next the year. For Tablet or iPad, 47(33.3%) of GBR respondents possessed one or the other of them. The remaining 94(66.7%) mentioned that they do not have a Tablet or iPad. Ownership of an E-Reader, according to Figure 4.8, is 15 (10.6%) while 105 (74.4%) had no plan for E-reader ownership within the next 12 months. Figure 4.9 presents a bar graph of digital device ownership among BEL respondents.



	Laptop	Tablet or iPad	Smartphone	E-Reader
No, and I don't plan to purchase one within the next 12 months. Count	1	12	3	19
No, but I plan to purchase one withi n the next 12 months. Count	0	0	0	0
Yes, I currently own one(or more). C ount	19	8	17	1

Figure 4.13: Device ownership by BEL (Belgium) respondents

From Figure 4.12, 19(95%) of the respondents own Laptops with the exception of one person (5%) who has no plans in securing a Laptop within the next one year. Smartphones and Tablets or iPads are owned by 17(85%) and eight (40%) of the respondents, separately. Though 19(95%) of the respondents admitted to having no intent of owning an E-Reader, one person (5%) had the device. Figure 4.11 presents an aggregation of all four digital device ownership by the four cohorts.



	Laptop	Tablet or iPad	Smartphone	E-Reader
No, and I don't plan to purchase one within the next 12 months.	213	231	32	405
No, but I plan to purchase one within the next 12 months.	61	136	39	59
Yes, I currently own one(or more).	222	129	425	32

Figure 4.14: Device ownership by all the four cohorts

As seen in Figure 4.14, when all respondents are put together, 425(85.7%) own Smartphones. Next in sequence of ownership is Laptops at 222(44.8%) while 129(26%) and 32(6%) own Tablets or iPads and E-Readers. In Table 4.8, results of the Operating System used on devices by SAR respondents are introduced.

4.6.4 Digital devices owned and their operating systems used

This section presents results from the research on the operating systems students use on their devices. Results for SAR are presented accordingly in Table 4.8.

Table 4.8: Operating System used on the devices owned by SAR respondents

Device	Operating system	Count	Row N%
Laptop (n=66)	Windows	48	72.7%
	Mac	3	4.5%
	Linux	12	18.2%
	I don't know	3	4.5%
Tablet or iPad (n=58)	iOS	15	25.9%
	Windows OS	6	10.3%
	Androids OS	27	46.6%
	BlackBerry OS	1	1.7%
	I don't know	9	15.5%
Smartphone (n=210)	iPhone	25	11.9%
	Androids OS	125	59.5%
	Windows OS	7	3.3%
	BlackBerry OS	46	21.9%
	iPhone and android	2	1.0%
	I don't know	5	2.4%
E-reader (n=12)	Kindle	4	33.3%
	Kobo	1	8.3%
	Sony Reader	1	8.3%
	I don't know	6	50.0%

According to Table 4.8, the majority of the respondents, 48(72.7%), used Windows Operating System on their Laptops. A least three (4.5%) of the respondents said they do not know the kind of Operating System used on their Laptops.

Forty-seven percent of SAR's respondents who own Tablets or iPads also used Android Operating System for their Tablets or iPads. Furthermore, results in Table 4.9 show that iOS users form 25.9% (for Tablets or iPads) of the total respondents of SAR.

The majority of the respondents used Androids Operating System 125(59.5%) on their Smartphones. A BlackBerry Operating System is used on Smartphones by 46(21.9%) of the SAR respondents.

Fifty percent of SAR respondents do not know the Operating System on their E-reader devices. However, four 4(33.3%) of the E-reader users identified Kindle as their type of E-reader. Table 4.9 presents the distribution of the operating systems used on the devices owned by GAC respondents.

Table 4.9: Operating System used on the devices owned by GAC respondents

Device	Operating system	Count	Row N%
Laptop (n=27)	Windows	25	92.6%
	Linux	1	3.7%
	I don't know	1	3.7%
Tablet or iPad (n=16)	iOS	2	12.5%
	Windows OS	1	6.3%
	Androids OS	12	75.0%
	I don't know	1	6.3%
Smartphone (n=59)	iPhone	3	5.1%
	Androids OS	49	83.1%
	Windows OS	4	6.8%
	BlackBerry OS	3	5.1%
E-reader (n=4)	Kindle	2	50.0%
	Other E-reader	1	25.0%
	I don't know	1	25.0%

Table 4.9 shows the widely used Laptop operating system is Windows 25(92.6%). Linux operating system is used by only one person among the respondents while another one respondent did not know what kind of operating systems ran on their Laptops.

Androids Operating System 12(75%) and iOS (12.5%) are the top two operating systems used on the Tablets or iPads by two of respondents, as shown in Table 4.9. Once more, the Androids Operating System, 49(83.1%) appeared to be the main Operating System for Smartphones by GAC respondents. Nonetheless, four of the respondents use Windows Operating System on their Smartphone devices.

There are four E-reader users among the respondents. Two of them use Kindle while one of them uses another E-reader device. One of the respondents does not know the kind of E-reader Operating System used on the E-reader.

Table 4.10: Operating System used on the devices owned by GBR respondents

Device	Operating system	Count	Row N%
Laptop (n=136)	Windows	125	91.9%
	Mac	11	8.1%
Tablet or iPad (n=47)	iOS	11	23.4%
	Windows OS	12	25.5%
	Androids OS	20	42.6%
	BlackBerry OS	1	2.1%
	I don't know	3	6.4%
Smartphone (n=139)	iPhone	26	18.7%
	Androids OS	100	71.9%
	Windows OS	7	5.0%
	BlackBerry OS	2	1.4%
	Other Smartphone	3	2.2%
	I don't know	1	0.7%
E-reader (n=15)	Kindle	4	26.7%
	Sony Reader	1	6.7%
	Other E-reader	2	13.3%
	I don't know	8	53.3%

According to Table 4.10, either Windows 125(91.9%) or Mac 11(8.1%) Operating System runs on respondents' Laptop devices. Out of the 47 owners of Tablets or iPads, 20(42.6%) use Androids Operating System while 12(25.5%) use the Windows Operating System. Androids OS, for 100(71.9%), and iPhone OS, for 26(18.7%), are the two main Operating Systems used on GBR respondents' Smartphones.

Eight (53.3%) of E-reader user respondents in GBR do not know the kind of Operating System on their E-readers. However, four (26.7%) of them use Kindle. Operating Systems used on the devices owned by BEL respondents are highlighted in Table 4.11.

Table 4.11: Operating Systems used on the devices owned by BEL respondents

Device	Operating system	Count	Row N%
Laptop (n=19)	Windows	10	52.6%
	Linux	8	42.1%
	Dual boot	1	5.3%
Tablet or iPad (n=8)	iOS	2	25.0%
	Windows	1	12.5%
	Androids	5	62.5%
Smartphone (n=17)	iPhone	3	17.6%
	Androids	14	82.4%
E-Reader (n=1)	Kobo	1	100%

Referring to Table 4.11, Windows and Linux are the top Laptop Operating Systems used by 10 and eight BEL respondents correspondingly. For Tablets or iPads, five of the respondents preferred to use Androids and two, iOS. Androids (14 users) and iPhone (three users) Smartphone Operating Systems were the only two Operating Systems used by respondents. However, only one respondent owns an E-reader which runs on Kobo. Highlights of Table 4.12 are given as descriptive summaries.

Table 4.12: Distribution of Operating System used on devices owned by all four cohorts

Device	Operating System	Cohort									
		SAR(n=66)		GAC(n=27)		GBR(n=136)		BEL(n=19)		Total(n=248)	
Laptop	Windows	48	72.7%	25	92.6%	125	91.9%	10	52.6%	208	83.9%
	Mac	3	4.5%	0	0%	11	8.1%	0	0%	14	5.6%
	Linux	12	18.2%	1	3.7%	0	0%	8	42.1%	21	8.5%
	Don't know	3	4.5%	1	3.7%	0	0%	0	0%	4	1.6%
	Dual boot	0	0%	0	0%	0	0%	1	5.3%	1	0%
Tablet or iPad		SAR(n=58)		GAC(n=16)		GBR(n=47)		BEL(n=8)		Total(n=129)	
	iOS	15	25.9%	2	12.5%	11	23.4%	2	25.0%	30	23.3%
	Windows	6	10.3%	1	6.3%	12	25.5%	1	12.5%	20	15.5%
	Androids OS	27	46.6%	12	75.0%	20	42.6%	5	62.5%	64	49.6%
	BlackBerry OS	1	1.7%	0	0%	1	2.1%	0	0%	2	1.%
	I don't know	9	15.5%	1	6.3%	3	6.4%	0	0%	13	10.1%
Smartphone		SAR(n=210)		GAC(n=59)		GBR(n=139)		BEL(n=17)		Total(n=425)	
	iPhone	25	11.9%	3	5.1%	26	18.7%	3	17.6 %	57	13.4%
	Androids OS	125	59.5%	49	83.1%	10 0	71.9%	14	82.4 %	28 8	67.8%
	Windows OS	7	3.3%	4	6.8%	7	5.0%	0	0%	18	4.2%
	BlackBerry OS	46	21.9%	3	5.1%	2	1.4%	0	0%	51	12.0%
	Other Smartphone	0	0%	0	0%	3	2.2%	0	0%	3	0.7%
	iPhone and android	2	1.0%	0	0%	0	0%	0	0%	2	0%
	I don't know	5	2.4%	0	0%	1	0.7%	0	0%	6	1.4%
E-Reader		SAR(n=12)		GAC(n=4)		GBR(n=15)		BEL(n=1)		Total(n=32)	
	Kindle	4	33.3%	2	50.0%	4	26.7%	0	0%	10	31.3%
	Kobo	1	8.3%	0	0%	0	0%	1	100%	2	6.3%
	Sony Reader	1	8.3%	0	0%	1	6.7%	0	0%	2	6.3%
	Other E-reader	0	0.0%	1	25.0%	2	13.3%	0	0%	3	9.4%
	I don't know	6	50.0%	1	25.0%	8	53.3%	0	0%	15	46.9%

Distribution in Table 4.12 reveals that most respondents used Windows Operating System on their Laptops (GAC=92.6%; GBR=91.9%; SAR=72.7%; BEL=52.6%). Apart from one respondent from BEL who uses a dual boot operating system, some respondents use Linux and Mac Operating Systems.

Androids Operating System is the most highly ranked Tablet or iPad Operating System used among the cohorts (GAC=75%; BEL=62.5%; SAR=46.6%; GBR=42.6%). iOS and Windows Operating Systems followed Androids Operating System in sequence of use.

Androids Operating System (GAC=83.1%; BEL=82.4%; GBR=71.9%; SAR=59.5%) emerged as the mostly widely used operating system on the Smartphones of respondents. Some 13.4% and 12% of the total respondents used iPhone and BlackBerry Operating Systems in that order.

Generally, E-Reader usage is not widespread among respondents. Out of the total respondents, 10(31.3%) use Kindle, two (6.3%) use Kobo and another two (6.3%) use Sony Reader. The remaining respondents either use one of three other kinds (9.4%) of E-Reader, and 15 do not know (46.9%) the Operating System on their E-reader devices. Figure 4.15 shows a map model with the main digital devices.

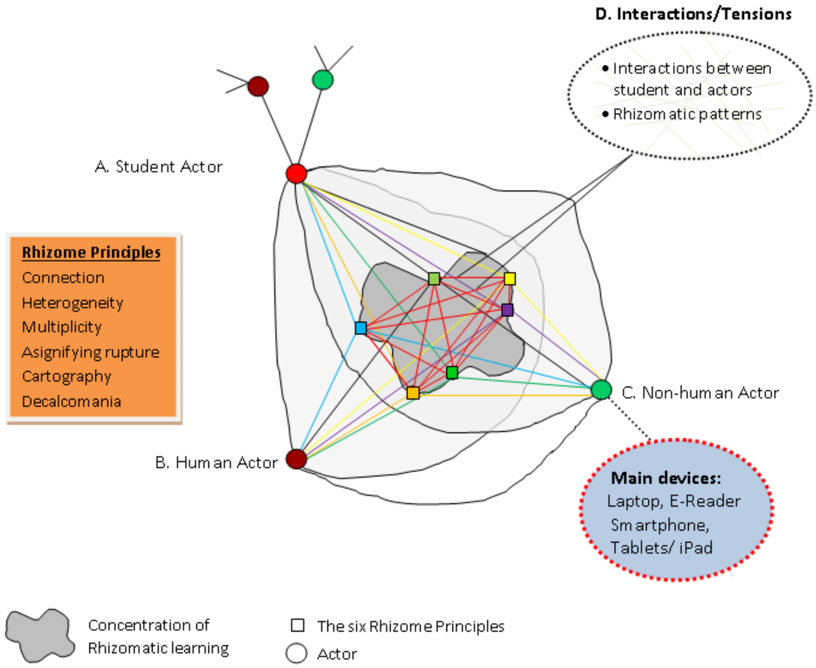


Figure 4.15: Mapping of the main digital devices onto the conceptual model

From Figure 4.15, the student in her/his personal learning network interacts with other learning resources sometimes through the four main digital devices identified which are usually used. The devices form part of the Non-human actors (C) under the socio-technical aspect of the conceptual model.

4.7 Analysis and discussions on perceived importance of students' digital devices used to promote academic success (Sub-Research Question 4)

Research Questions 4: *How important are the devices used by students perceived to be a promoter of their academic success?*

Objective 4 sought to find out about the perceived importance of devices used by students towards their academic success. Generally, across all the institutions, the majority (more than 75%) of students said Laptops were academically important to them, followed by Smartphones. E-Readers came as least in terms of importance. Perhaps the Laptop is a more universal device because it integrates the properties of all the other three devices identified as widely used for academic work in this study. Again, issues of sustainable battery power, large screen (Falloon, 2015) and storage and speed (Gupta & Koo, 2010) may also be militating factors affecting their perception in rating Laptop over Smartphone, Tablet or iPad and E-Reader. However, E-Reader may not be considered by many students because of its specialised purpose: reading materials. Differences identified in the perceived importance of devices used by students towards their academic success may also result in how students were previously trained. Obviously, students who are trained in or constantly use a particular device to achieve learning tasks will naturally be biased to it.

> *"Smartphones are very useful in the 21st Century in our societies. But in terms of academic work, laptops have their place. For me, I have been conditioned to do any serious studies on my laptop or a desktop computer. That is very important to help me separate my academic life from social life"* ***(S.BEL.Ethan).***

Submissions from *S.BEL.Ethan* and general findings are not consistent with Bryan and Clegg (2006). It is certainly possible that students are accustomed to seeing Laptops as more legitimate to their learning successes because institutions such as SAR and GAR have blocked access to certain other sites such as Skype on Smartphones. This later finding raises more questions as to digital/ mobile integration, and is considered by Day-Black and Merrill (2015) on technology integration in schools.

Prof. Anamuah-Mensah also noted the relevance of Smartphones in learning but was quick to add a caution:

> *"With Smartphones, students are more connected in their learning. They can chat, send messages, and collaborate. However, what type of messages do they send? When they write something, the language they use translates the kind of texts*

*they exchange. Things they should not write in essays find their way in there. They don't use proper language, for instance, 'gd' for 'good' in examinations. Yes phones are relevant but we need to exercise a sense of direction" (**Prof. Anamuah-Mensah**).*

Apart from issues associated with Smartphone, findings also raise concerns about why students cannot be encouraged to use E-readers for specific reading tasks since it has been proven that E-readers minimise distractions for students from Internet advertisements, emails and Internet calls for maximum concentration as compared to the other devices (Boroughs, 2010). Nonetheless, using Laptops and possibly Smartphones for academic work likely affects the choice of devices at times, as suggested by Galbus (2001) and Oblinger and Oblinger (2005).

Tables 4.13 to 4.17 showcase how respondents perceive their devices to be a promoter of their academic success according importance using academic, non-academic or both purposes as parameters. The results are presented in tables as frequencies and percentages according to respondents' institutions. Results from Table 4.17 consist of the aggregation of responses from the four cohorts (all respondents) from Tables 4.13 to 4.16 to show a global collective view of the respondent population.

Table 4.13: Uses of devices owned by SAR respondents (n=250)

Regardless of whether you own one, please tell us how you use...	Haven't used in the past year		Use for academic and other purposes		Use for academic purposes only		Use for other purposes only	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop	13	5.2%	199	79.6%	28	11.2%	10	4.0%
Tablet or iPad	111	44.4%	92	36.8%	21	8.4%	26	10.4%
Smartphone	21	8.4%	174	69.6%	10	4.0%	45	18.0%
E-reader	161	64.4%	57	22.8%	20	8.0%	12	4.8%

Table 4.13 shows that the majority of about 80% of the SAR respondents used laptops and Smartphones 174(69.6%) for academic and other purposes. Though some respondents (92) also use Tablets or iPads (36.8%), and E-readers (57) (22.8%) for academic and other purposes, fewer respondents use the devices listed in Table 4.13 solely for academic or other purposes. Eighteen percent of the respondents use their Smartphones for entirely other purposes only. Table 4.14 provides details on how GAC respondents use their devices in regard to perceived importance geared towards academic success.

Table 4.14: Uses of devices owned by GAC respondents (n=85)

Regardless of whether you own one, please tell us how you use...	Haven't used in the past year		Use for academic and other purposes		Use for academic purposes only		Use for other purposes only	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop	16	18.8%	64	75.3%	3	3.5%	2	2.4%
Tablet or iPad	44	51.8%	30	35.3%	6	7.1%	5	6.9%
Smartphone	17	20.0%	54	63.5%	1	1.2%	13	15.3%
E-reader	63	74.1%	11	12.9%	9	11.0%	2	2.4%

Results in Table 4.14 indicate that 64(75.3%) and 54(63.5%) of GAC respondents use their Laptops and Smartphones for academic and other purposes, respectively. Despite a majority of the respondents who have not used E-readers 63 (74.1%) and Tablets or iPads 44(51.8%) in the past one year separately, 30(35.3%) use Tablets or iPads for both academic and other purposes. Table 4.15 illustrates how GBR respondents use their devices based on perceived importance leading to academic success.

Table 4.15: Uses of devices owned by GBR respondents (n=141)

Regardless of whether you own one, please tell us how you use...	Haven't used in the past year		Use for academic and other purposes		Use for academic purposes only		Use for other purposes only	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop	9	6.4%	129	91.5%	3	2.1%	0	0%
Tablet or iPad	31	22.0%	87	61.7%	9	6.4%	14	9.9%
Smartphone	5	3.5%	122	86.5%	3	2.1%	11	7.8%
E-reader	45	31.9%	55	39.0%	29	20.6%	12	8.5%

According to Table 4.15, the majority of the respondents use their devices for academic and other purposes in the following order: laptop=129(91.5%); Smartphone=122(86.5%); Tablet or iPad=87(61.7%); E-Reader= 55(39.0%). Compared with other uses of devices, fewer respondents use their devices for academic purposes only [laptop=3(2.1%); Smartphone=3(2.1%); Tablet or iPad=9(6.4%); E-Reader= 29(20.6%)]. None of the respondents, in fact, use laptops for other purposes only.

Table 4.16: Uses of devices owned by BEL respondents (n=20)

Regardless of whether you own one, please tell us how you use...	Haven't used in the past year		Use for academic and other purposes		Use for other purposes only	
	Count	Row N %	Count	Row N %	Count	Row N %
Laptop	0	0%	20	100%	0	0%
Tablet or iPad	9	45%	7	35%	4	20%
Smartphone	3	15%	12	60%	5	25%
E-reader	17	85%	2	10%	1	5%

In reference to Table 4.16, respondents from BEL predominantly use laptops (100%) and Smartphones, 12(60%), for their academic and other purposes. On the other hand, E-readers, 17(85%), and Tablets or iPads, 9(45%), were not used in the past one year. Some respondents only use Smartphones, 5(25%), and Tablets or iPads, 4(20%), for other purposes.

Table 4.17: Uses of devices owned by all the four cohorts (n=496)

Regardless of whether you own one, please tell us how you use...	Haven't used in the past year		Use for academic and other purposes		Use for academic purposes only		Use for other purposes only	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop	38	7.7%	412	83.1%	34	6.9%	12	2.4%
Tablet or iPad	195	39.3%	216	43.5%	36	7.3%	49	9.9%
Smartphone	46	9.3%	362	73.0%	14	2.8%	74	14.9%
E-reader	286	57.7%	125	25.2%	58	11.7%	27	5.4%

Table 4.17 shows the summation of responses from all respondents based on how they use their devices as perceived in the promotion of their academic success. For academic and other purposes, respondents generally use Laptops, 412(83.1%), and Smartphones, 362(73.0%), followed by Tablets or iPads, 216(43.5%). Despite owning Tablets or iPads,4 (9.9%), E-readers, 27(5.4%), and Laptops,12(2.4%), fewer respondents [laptop=12(2.4%); Smartphone=74(14.9%); Tablet or iPad=49(9.9%); E-Reader= 27(5.4%)] preferred not to use these devices for their academic reasons.

Table 4.18: Importance of device usage towards academic success in SAR (n=250)

Device	Not at all important		Not very important		Moderately important		Very important	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop(n=250)	13	5.2%	7	2.8%	24	9.6%	206	82.4%
Tablet or iPad(n=240)	77	32.1%	62	25.8%	44	18.3%	57	23.8%
Smartphone (n=250)	27	10.8%	43	17.2%	80	32.0%	100	40.0%
E-reader (n=235)	114	48.5%	54	23.0%	34	14.5%	33	14.0%

Results from Table 4.18 indicate that 206(82.4%) and 100(40.0%) of the SAR respondents rate the use of Laptops and Smartphones as very important individually. Adversely, 114(48.5%) said the use of E-readers for academic success was not at all important to them. More than 55% of the respondents rated the use of Tablets or iPads as unimportant towards their academic success.

Table 4.19: Importance of device usage towards academic success in GAC (n=85)

Device	Not at all important		Not very important		Moderately important		Very important	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop	4	4.7%	2	2.4%	9	10.6%	70	82.4%
Tablet or iPad	13	15.3%	8	9.4%	20	23.5%	44	51.8%
Smartphone	6	7.1%	6	7.1%	15	17.6%	58	68.2%
E-reader	27	31.8%	11	12.9%	22	25.9%	25	29.4%

In reference to Table 4.19, the Laptop is rated as very important by 70(82.4%) of the GAC respondents. The same rating was provided for Smartphone at 58(68.2%) and Tablet or iPad at 44(51.8%) by the respondents. Furthermore, about 55% gave an "important" rating to E-reader. On the flip side, less than 30% of the respondents rated Laptop, Tablet or iPad or Smartphone as not at all important towards their academic success.

Table 4.20: Importance of device usage towards academic success in GBR (n=141)

Device	Not at all important		Not very important		Moderately important		Very important	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop (n=141)	0	0%	4	2.8%	3	2.1%	134	95.0%
Tablet or iPad (n=121)	8	6.6%	18	14.9%	34	28.1%	61	50.4%
Smartphone (n=141)	1	0.7%	11	7.8%	34	24.1%	95	67.4%
E-reader (n=116)	5	4.3%	18	15.5%	25	21.6%	68	58.6%

Respondents from GBR (Table 5.20) rated as very important, Laptop, 134(95%), Smartphone, 95(67.4%), E-reader, 68(58.6%) and Tablet or iPad, 61(50.4%), towards their academic success, accordingly. Respondents' ratings on devices that are not important to their academic success range from Laptop (3%) to E-reader (16%).

Table 4.21: Importance of device usage towards academic success in BEL (n=20)

Device	Not at all important		Not very important		Moderately important		Very important	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop	0	0%	0	0%	5	25%	15	75%
Tablet or iPad	13	65%	6	30%	0	0%	1	5%
Smartphone	7	35%	7	35%	4	20%	2	10%
E-reader	19	95%	1	5%	0	0%	0	0%

Data from Table 4.21 shows that all the 20 respondents rated Laptop as an important device towards their academic success. Beside Laptop, respondents rated E-reader as a "not important" device to their academic success. Only one respondent rated the contribution of Tablet or iPad to academic success as very important. Nonetheless, six(30%) of the respondents gave an "important" rating to the Smartphone in their academic success as opposed to the rest of the 14(70%) who assigned a "not important" rating.

Table 4.22: Importance of device usage to academic success by all the four cohorts

Device	Not at all important		Not very important		Moderately important		Very important	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Laptop(n=496)	17	3.4%	13	2.6%	41	8.3%	425	85.7%
Tablet or iPad(n=466)	111	23.8%	94	20.2%	98	21.0%	163	35.0%
Smartphone (n=496)	41	8.3%	67	13.5%	133	26.8%	255	51.4%
E-reader (n=456)	165	36.2%	84	18.4%	81	17.8%	126	27.6%

According to Table 4.22, more than 90% of the respondent population rated Laptop use as a contributory factor to their academic success. Other ratings of importance varied across the devices, with Smartphone at 388(78.2%) and Tablet or iPad at 261(56%) rated as important by the respondent population. Finally, 249(54.6%) of the respondents did not see any importance of E-reader towards their academic success.

In sum, digital devices are perceived to be important towards academic success at varying levels in the four institutions. The emerging patterns include what the device does, how the students can leverage on its uses and how it is accepted for use in the academic arena by institutions and stakeholders in education. For instance, Laptops are widely accepted and preferred as compared to Smartphones and other devices, though each one can support students in their endeavours toward academic success.

Chapter Five presents Results and Discussions on the hypotheses that guided this part of the research.

CHAPTER FIVE

Results and Discussions II– Research Hypotheses

"It has become exceedingly obvious that our technology has exceeded our humanity."
-Albert Einstein (n.d)

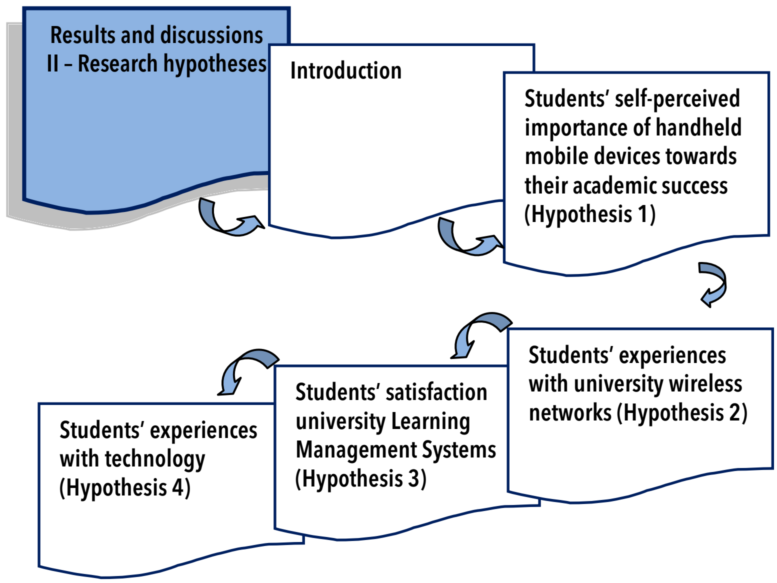


Figure 5. 1: Map of Chapter Five

5.0 Introduction

Results from the research hypotheses are presented and discussed in this chapter. To find answers, each of the hypotheses were analysed and interpreted in detail through a multivariate and descriptive analyses. The following steps were followed in order to answer all four research hypotheses and their sub-hypotheses:

1. Factor analyses to determine the constructs. Factor analysis is a statistical procedure used in reducing a large number of items into a smaller number of factors by identifying intercorrelations between the items (Pallant, 2016). This type of analyses allowed for "data reduction" to items of a workable size without compromising data integrity (Field, 2009:628);
2. Determination of internal consistency through the reliability analysis. A reliability analysis test was run to evaluate the internal consistency of survey instruments. Tavakol and Dennick (2011) noted that computation of the reliability supports the extent to which the survey instrument determined the intent of measurement-validity. Cronbach's alpha was used in this research as the measure of reliability because of its extensive use (Cronbach, 1951). There is no rule-of-thumb in setting values to determine a range for Cronbach's alpha. This research however, set 0.5 as the lowest limit for Cronbach's alpha reliability coefficient. This is premised on Gliem and Gliem's (2003:87) publication who argued that *"Cronbach's alpha reliability coefficient normally ranges between 0 and 1. However, there is actually no lower limit to the coefficient."* Furthermore, this research did not recognise analysis that returned Cronbach's alpha estimates for single items (see example on Table 5.10). *"Cronbach's alpha does not provide reliability estimates for single items"* (Gliem & Gliem, 2003:88).
3. Calculation of the value of the constructs per respondent (value is the average of items in the construct);

4. Testing for differences in the construct between the four institutions using a one-way analysis of variance (ANOVA). Analysis of variance is of the General Linear Models and used to find significant differences in three or more groups (Burns & Burns, 2008); and
5. Descriptive analyses from patterns identified in the numeric data coupled with excerpts from interviews and field focus groups.

A review of hypotheses guiding analyses are as follows:

1. There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success.
2. There is no statistically significant difference among the four of students in terms of experiences with their university wireless networks.
3. There is no statistically significant difference among the four cohorts of students in terms of their satisfaction level of Learning Management System in their institutions.
4. There is no statistically significant difference among the four cohorts of students in terms of their experiences with technology use in their institutions.

To get to a point where differences can be measured, it was important to determine constructs that could be compared with the cohorts and within the population. This was motivated because, for example, students' self-perceived importance of handheld mobile devices towards their academic success cannot be directly measured, hence, the creation of constructs (data reduction). To create these constructs, we created themes using factor analyses. In this study, factor analyses was deemed necessary to allow for *"data reduction for a more manageable size while retaining as much of the original information as possible"* based on Field's (2009:628) suggestions.

5.1 Students' self-perceived importance of handheld mobile devices towards their academic success (Hypothesis 1)

This section is presented in two parts, with the first part discussing findings under the section while the second part concentrates on multivariate and descriptive analysis.

5.1.1 Discussions

Hypothesis 1 was formulated to answer the objective which sought to explore a difference in self-perceived importance of handheld mobile devices for academic success among the four student cohorts. Hypothesis 1, which stated that *"there is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success*", had three sub-hypotheses. The three sub-scales (factors) – *Lecture room engagement & interaction, Access to administrative resources* and *Communication & Information*– were constructs for formulation of the sub-hypotheses developed from a factor analysis and reliability analysis (*see Table 6.1*). Hypothesis 1 was rejected because all the three sub-hypotheses differed significantly (*see Table 6.3*).

In a reliability test, the *Lecture room engagement & interaction* factor was found to be highly reliable (α = .813). From this factor, one can conclude that technology has become a vital part in teaching and learning processes. Face-to-face lectures are extending into virtual spaces rapidly through the use of handheld devices. Nonetheless, there are varied perceptions about how students should engage with handheld devices in lecture room interactions.

However, students from BEL in Belgium and GAC in Ghana perceive the importance of handheld mobile devices to be moderately important towards their academic success in terms of *Lecture room engagement & interaction*. Students from both institutions confirmed during the interviews that most of their lecturers do not encourage them to be using handheld devices during lectures. This later finding is consistent with Amedeker (2013) and Doward (2015):

> *"I do not think this issue of mobile phone and tablet usage during lectures is a written down policy in this university. It is not a bad idea to either capture notes or share or communicate with others during lecturers. Such lecturers insist that we copy every dot as notes though we claim to be in a technological age [sic] it is really boring and it sucks"**(S. GAC. Opoku).***

On the other hand, some lecturers support the opinion of ***S. GAC. Opoku***. In ***L. GBR. Addo's*** views, the use of mobile devices serve as enhancers to the entire teaching and learning process:

> *"…and you see, sometimes you are always explaining something on the board, they will take a photograph. They will take their Smartphones and capture it. It means they are a little bit ahead. While you are trying to draw, they are rather taking images, pictures of it so that they can later use it. This must be encouraged since it facilitates learning" **(L.GBR. Addo)**.*

According to ***S.BEL. Hugo*** in Belgium, *"there are no issues at all about using your digital devices in class; it is just a sign of respect to pay attention and listen to whoever talks during lectures."*

The similarities that exist between BEL and GAC may exist because these two institutions are both traditional universities. On the other hand, GBR and SAR rated the sub-scale, *lecture room engagement & interaction,* as very important because the institutions may be somewhat liberal on the use of these devices for recording instructors' lectures or in-class activities because they are Universities of Technology. Again, it may also be attributed to the kind of students who responded to questions, as students of Design, IT, and Photography and the like will certainly find it useful to use such devices in class. Nonetheless, students generally disagree on using their mobile devices as digital passports in accessing educational resources.

Access to administrative resources (reliability; α =.754)**:** It is obvious that in the 21st century, resources in general are evolving. Handheld devices have activated resource sharing possibilities, increased access to announcements, lecture rooms, course materials, and other resources in real-time; thereby reducing time and printing costs. This variety illustrates a heterogeneous pattern of connection in students' personal learning networks. Accessing university resources by students has predictably sees some modifications as time has gone on.

> *"Someone says that in the near future, there will be no universities with buildings [sic] they will only be places where people can go and rent rooms and stay there but then, the learning itself is not in any of those places. The learning is virtual, and so it can be anywhere and one can do it"* ***(Prof. Anamuah Mensah)***.

However, Prof. Anamuah's suggestions may deepen some challenges for certain students as suggested by Backer (2010). The virtual or technological environment may result in students with limited access and technology skills lagging behind, even if they know their content. Further arguments by Beland and Murphy (2015) also suggest digital devices do not aid low achieving students. In contrast with handheld digital devices, students feel closer to their institutions and their learning materials. According to one student:

> *"With Blackboard and the university's website, things are much easier for us. Unlike 10 years before, one has to resort to notice boards, friends and rumours to become abreast with school activities. Now, my mobile phone does it all. I get on-the-spot updates from this university's Mobile App, Blackboard and WhatsApp groups"* ***(S. SAR. Khayone)***.

Communication & Information (reliability; α =.683)**:** *Communication & Information* was the most important factor ranked across all four institutions despite the differences (See Mean Plot in Figure 6.1). *Communication & Information* have become enhanced via handheld mobile devices in the way students learn. Quality of learning depends on the quality of information gathered. This *communication &information* factor corroborates Warschauer *et al*.'s (2010) arguments that students exposure to a variety of digital resources makes them well-skilled in media content creation technologies. Handheld mobile devices have made access to learning, communication and information nearly ubiquitous. For example, a student in GBR in Ghana explains that "*these devices are our saviour. I wonder how people learnt or managed without it. I only need Internet to survive…learning made easier due to worth of information out there*" ***(S.GBR. Boadu)***. Submissions from the student, Boadu, can be supported by the outlook of Bruner and Kumar (2005) on how handheld digital devices act as catalysts for student learning motivation.

Figure 5.1 illustrates a student's personal learning network relative to the factors (importance of handheld digital devices towards academic success) mapped onto the conceptual model in Chapter One.

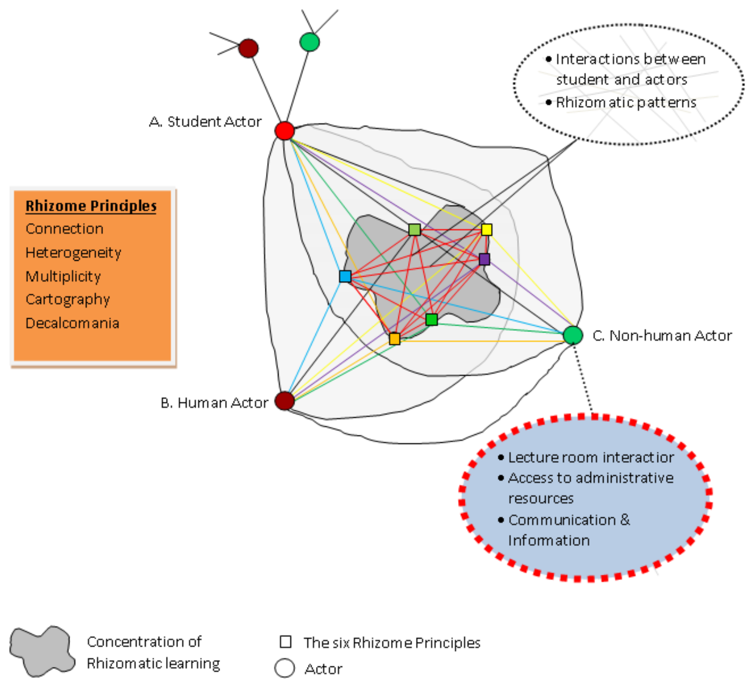


Figure 5.2: Mapping of factors of importance of handheld digital devices to learning onto the conceptual model

In Figure 5.1, the factors (sub-scales) classified under non-human (socio-technical) actors of the personal learning network resonate with five of the rhizome principles: 1) *Connection;* 2) *Heterogeneity;* 3) *Multiplicity*; 4) *Cartography;* and 5) *Decalcomania.*

Connection and *Heterogeneity*: Students are connected to learning resources and an interaction process in and out of their classes via handheld devices. There was high reliability (α =.819) on capturing of video and still recordings during in class activities. These devices are used to gather information through various communications and for access to a number of resources. *Multiplicity:* The handheld devices are also used to support different learning activities such as digital access to learning materials, checking of grades and even registering for courses from multiple locations.

Cartography and *Decalcomania:* Patterns exhibited in terms of handheld mobile devices show maps of similar but varied learning activities where different devices are used. For instance *Cartography* of how lectures are captured and with which devices indicates uniqueness of learning patterns of students in their personal learning networks. Generally, the Belgium University ranked least in terms of differences across self-perceived importance of handheld digital devices in the four institutions. This may be attributed to differences in handling of general access and policies (Blignaut *et al.*, 2010) in the various institutions concerning digital handheld devices. The next sub-section covers results from multivariate and descriptive analyses on students' self-perceived importance of handheld mobile devices towards their academic success.

5.1.2 Multivariate and descriptive analyses

This sub-section contains results on factor analysis and reliability analysis, descriptive statistics, and ANOVA for testing the differences self-perceived importance indicative of differences among the four institutions. A mean plot of the three constructs is also presented in this sub-section.

Table 5.1 provides factor analysis and reliability analysis results for students' self-perceived importance of handheld mobile devices towards their academic success.

Table 5.1: Factor analysis and reliability analysis results on importance of handheld mobile devices towards academic success (n=495)

Item	Component			Cronbach's Alpha (α)
	1	2	3	
Record your instructor's lecture or in-class activities	**0.819**	0.246	-0.038	0.813
Capture static images of in-class activities or resources	**0.785**	0.01	0.152	
Look up information while in class	**0.686**	0.048	0.315	
Participate in interactive class activities	**0.684**	0.305	0.218	
Use the mobile device as a digital passport for access resources	**0.562**	0.407	0.158	
Register for courses	0.143	**0.834**	0.063	
Use the course or Learning Management System (e.g. *Blackboard, Moodle*)	0.135	**0.744**	-0.05	0.754
Check grades	0.117	**0.742**	0.189	
Access library resources	0.175	**0.532**	0.307	
Communicate with other students	0.304	-0.086	**0.815**	
Read e-texts	0.065	0.329	**0.747**	0.683
Access information about events, student activities	0.27	0.5	**0.508**	

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
Components
1. Lecture room engagement & interaction
2. Access to administrative resources
3. Communication & Information

By inspection of items that load high on Component 1, Component 2 and Component 3, the labels "Lecture room engagement & interaction", "Access to administrative resources" and "Communication & Information" fit best.

5.1.2.1 Reliability

The *Lecture room engagement & interaction* subscale, consisting of five items, was found to be highly reliable (α = .813), followed by *Access to administrative resources* subscale which consisted of four items with a high reliability (α = .754), and *Communication & Information* subscale consisting of three items (α = .683).

Values for the construct were calculated using the average of the items in each construct. Academic success was thus measured based on three sub-hypotheses under Hypothesis 1.

Hypothesis 1: There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success.

1.1 There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for lecture room engagement & interaction.

1.2 There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for access to administrative resources.

1.3 There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for communication & information.

Table 5.2: Descriptive statistics of the cohorts' self-perceived importance of handheld mobile devices for academic success

Construct	Institution	n	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
Lecture room engagement & interaction	SAR	249	3.1118	.76471	.04846	3.0164	3.2073	1.00	4.00
	GAC	85	2.9412	.81406	.08830	2.7656	3.1168	1.00	4.00
	GBR	141	3.1560	.66466	.05597	3.0454	3.2667	1.00	4.00
	BEL	20	2.4900	.62399	.13953	2.1980	2.7820	1.00	3.40
	Total	**495**	**3.0700**	**.75227**	**.03381**	**3.0036**	**3.1364**	**1.00**	**4.00**
Access to administrative resources	SAR	249	3.1630	.76809	.04868	3.0671	3.2589	1.00	4.00
	GAC	85	3.1471	.84453	.09160	2.9649	3.3292	1.00	4.00
	GBR	141	3.0301	.72609	.06115	2.9092	3.1510	1.00	4.00
	BEL	20	2.3375	.63492	.14197	2.0403	2.6347	1.00	3.25
	Total	**495**	**3.0891**	**.78074**	**.03509**	**3.0201**	**3.1580**	**1.00**	**4.00**
Communication & Information	SAR	249	3.1627	.74143	.04699	3.0701	3.2552	1.00	4.00
	GAC	85	3.3294	.73911	.08017	3.1700	3.4888	1.00	4.00
	GBR	141	3.5603	.48028	.04045	3.4803	3.6402	1.67	4.00
	BEL	20	2.7833	.69480	.15536	2.4582	3.1085	1.00	3.67
	Total	**495**	**3.2892**	**.70177**	**.03154**	**3.2273**	**3.3512**	**1.00**	**4.00**

Scale/Interpretation of means:
0.1–1.0=Not at all important; 1.1–2.0=Not very important; 2.1–3.0=Moderately important; 3.1– 4.0=Very important.

The means range from 2.34 to 3.56 (from moderately important to very important). To test sub-hypothesis 1.1 to sub-hypothesis 1.3, we used One-way Analysis of Variance, with results presented below in Table 5.3.

Table 5.3: One-way Analyses of Variance: testing for differences among the cohorts' self-perceived importance of handheld mobile devices for academic success

Subscale		Sum of Squares	df	Mean Square	F	*p*-value
Lecture room engagement & interaction	Between Groups	9.618	3	3.206	5.832	.001
	Within Groups	269.939	491	.550		
	Total	279.557	494			
Access to administrative resources	Between Groups	13.433	3	4.478	7.642	.000
	Within Groups	287.690	491	.586		
	Total	301.123	494			
Communication& Information	Between Groups	19.605	3	6.535	14.345	.000
	Within Groups	223.682	491	.456		
	Total	243.287	494			

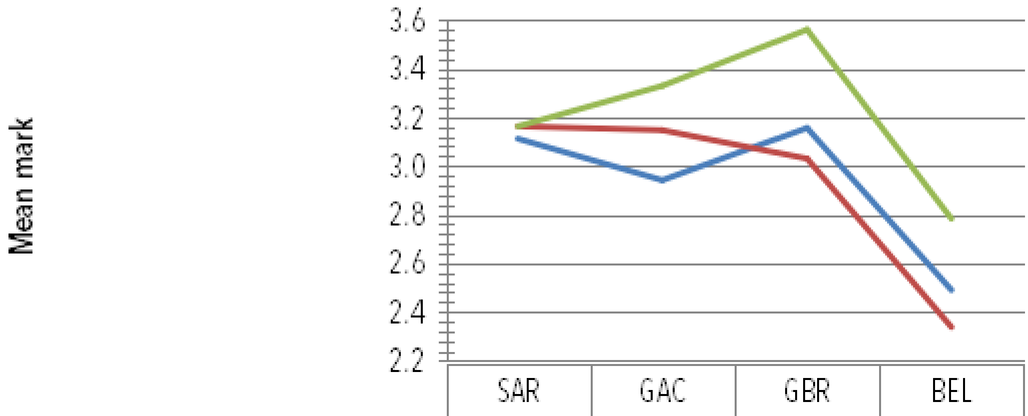
Results of the One-Way Analysis of Variance show a significant difference in the averages. *Lecture room engagement & interaction* was found to differ significantly among the cohorts ($F_{3, 491}$= 5.832, p <.001). While SAR (=3.11, *SD*=.76) and GBR (=3.16, *SD*=.66) reported significantly high importance in their use of handheld mobile devices for *Lecture room engagement & interaction*, with GAC (=2.94, *SD*=.81) reporting significantly less importance than BEL (=2.49, *SD*=.62).

Access to administrative resources subscale was found to differ significantly among the cohorts ($F_{3,491}$=7.642, p<.000). SAR (=3.16, *SD*=.77), GAC (=3.15, *SD*=.84) and GBR (=3.03, *SD*=.73) reported significantly high importance in terms of their use of handheld mobile devices for *Access to administrative resources.* However, only BEL (=2.34, *SD*=.63) reported significantly less importance on the subject.

Communication & Information subscale was found to differ significantly among the cohorts ($F_{3, 491}$ = 14.345, p <.000). While GBR (=3.56, *SD*=.48), GAC (=3.33, *SD* =.74) and SAR (3.16, *SD*=.74) reported significantly high importance in terms of their use of handheld digital devices for *Communication & Information,* BEL (=2.78, *SD*=.69) reported significantly less importance on the construct.

5.1.2.2 Mean plot

Figure 5.4 displays the mean plot of the three subscales of Hypothesis 1.



	SAR	GAC	GBR	BEL
Lecture room engagement & interaction	3.1118	2.9412	3.156	2.49
Access to administrative resources	3.163	3.1471	3.0301	2.3375
Communication & Information	3.1627	3.3294	3.5603	2.7833

Figure 5.3: Mean plot of self-perceived importance indicative of differences among cohorts according to the constructs

The mean plot in Figure 5.3 shows a mean range from 2.49 (moderately important) to 3.56 (very important) across the three subscales of Hypothesis 1. For all the subscales, BEL recorded lesser means as compared with the other cohorts. GBR, however, rated *Communication & Information* as very important. Furthermore, SAR, GAC and GBR generally indicated varying but moderate importance to all the three subscales that implied value attached to handheld mobile devices for academic success. Rating for *Communication & Information* subscale was the most important factor across each cohort.

In conclusion, after analysis, Hypothesis 1:*"there is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success"* was rejected on the basis that the three sub-hypotheses all differed significantly at ($F_{3, 491}$= 5.832, p <.001); ($F_{3, 491}$= 7.642, p <.000) and ($F_{3, 491}$ = 14.345, p <.000) successively.

5.2 Students' experiences with university wireless networks (Hypothesis 2)

This section on students' experiences with university wireless networks is in two parts: the first part discussing the findings and the second part covers the multivariate and descriptive analyses.

5.2.1 Discussions

The objective underpinning Hypothesis 2 is to explore the differences in students' experiences with their university wireless networks. Hypothesis 2 reads: "*There is no statistically significant difference among the four cohorts of students in terms of experiences with their university wireless networks*" An actor analysis and reliability analysis of all four items loaded on Component 1 and highly reliable (α = .813) (*see Table 5.4*). The analysis reveals differences in students' experiences with university wireless networks across the four institutions; therefore, Hypothesis 2 was rejected.

From Table 5.5, it can be observed that the average responses pertaining to students' university wireless networks experiences ranged from Neutral (GBR), Neutral (SAR), Fair (GAC) and to Good (BEL). In comparing GBR to GAC, the former has Campus Internet supplies of 5 STM-1(Synchronous Transport Module level-1) (155Mbps) =775Mbs more than the latter with four STM-1=620Mbs; yet students rated university wireless network as poor. These results confirm Oblinger and Linppincott's (2005) submissions on the need to co-ordinate in and out-of-class wireless network resources in higher education. Apparently, network performance received a generally poor rating showing a universal dissatisfaction of wireless network resources in the institutions. This statement also supports Eton's (2011) 21st student characteristics in which students desire to connect with others in real-time on their own terms.

In BEL, a student remarked that:

> *"My general impression about Europe and campus wide wireless networks is that it shouldn't be that difficult for us as students to access the wireless network because we really need it to access certain class and official resources of the university. If pups can provide wireless networks to their clients, universities and research institutes should do more. Our university wireless network is not a problem. This university even makes provision for guest users and is also subscribed to Eduroam. I should not struggle with Internet through any university's wireless network here in Belgium. Hahaha…Eduroam will detect my presence"* ***(S.BEL.Jules).***

The above statement shows some level of satisfied experiences with the university's wireless network, resonating with results in Table 5.5. From a more theoretical point of view, a possible *asignifying rupture* can also occur when connection or university wireless networks do not favour students and staff. Statements from lecturers also support the position of students in terms of their rating of their university's wireless networks. Together with the students, they find solace in another network which serves their course other than the university wireless network. A lecturer in GBR shared these experiences:

> *"…for the university, yes the university is also doing its part, but I think the landscape is not what we have now. We are not getting there but we will get there. For my master students, what we have done is they've now bought this bundle for Wi-Fi from a telecom company which we set up and everybody gets connected. Sometimes there is one person who has a phone which can also serve as a hotspot and then we link to it"* ***(L.GBR.Addo)***.

Another lecturer also tried to explain the relevance of university wireless for students by justifying it with the kind of learning environment the students' best operate in:

> *"…in contemporary, design and art education, wireless networks are very important to the students we teach. Current crop of students function very well in online and virtual learning environments and we need to support them, train them and encourage them to meet international standards. Some literature sources are the preserve of only university networks for access, else you have to buy"* ***(L.GBR.Ali).***

Statements from S.BEL.Jules are compatible with Kim *et al.* (2006) and can be sustained with McKenzie (2001) on the advantages of wireless resources in higher education. As compared to BEL, students are dissatisfied with university wireless networks once access to their regular devices is withdrawn.

> *"I find it very difficult to understand why management of SAR decides to block us from accessing Skype, WhatsApp, Facebook and other important educational sites from our mobile devices. It is totally unacceptable for a University of Technology to ever do that. I am an IT student and I think their excuses are indefensible. The trouble is that we cannot always be glued to our computers to perform all assignments. Again, some students do not even have personal computers and can only benefit from group discussions from their portable devices"* ***(S.SAR.Siyabonga)***.

An emerging issue here is that apart from BEL which is in Europe, to the disappointment of students, all the three other universities, at a certain point, block social media sites. The blockage may be permanent (GAC) or on certain devices (SAR), or for certain periods (GBR). For instance, in GAC, *Skype* is blocked (for both wireless and Local Area Networks) so students can simply not use

Skype via the wireless network of the university for group discussions. They also cannot use it to connect with other local and international students or staff around the world, due to cost implications for personal Internet. No matter the explanations, students are vehemently uncompromising, especially when they experience blockages in accessing certain resources related to wireless networks in their universities.

Figure 5.3 is a picture of a student's personal learning network relation to the factor (*University Wi-Fi user experiences*) mapped onto the conceptual model in Chapter One.

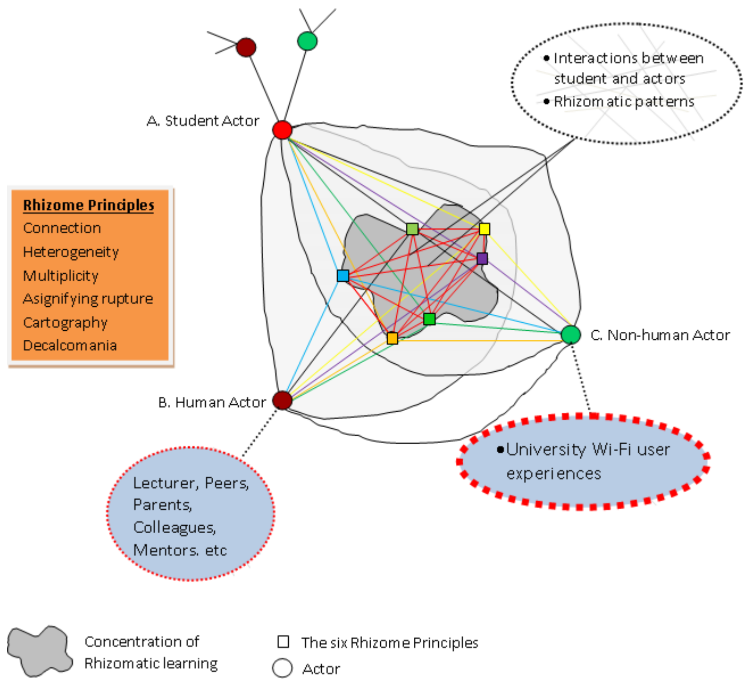


Figure 5.4: Mapping of factors of students' experiences of university wireless network onto the conceptual model

To summarise, results suggest that students primarily depend on university wireless networks for academic interaction before other uses come to play. The aforementioned results discussed (and Figure 5.4) indicate patterns of rhizomatic learning experiences with students' university wireless network experiences. *Connection* and *heterogeneity:* in Figure 5.4, the blue circles show the key actors that communicate/connect with the students in their personal learning networks. The *University Wi-Fi user experience* circle forms part of the socio-technical actor/actant in this network of the student. Connection from or to other actors (these may be human actors) through the university's network is largely dependent on its speed and efficiency. In African institutions, findings reveal displeasure of student about their institutions' wireless networks. However, in all the institutions, limitations of *university wireless networks* identified by Gilbus (2001) were not raised as issues in the findings. Issues raised do not deviate from bandwidth and access issues (Beeken, n.d.; Pahlavan & Levesque, 2005). This study is consistent with literature and research gathered from McKenzie (2001), Gupta and Koo (2010) and Castells (2010).

Multiplicity: Students are open to multiple entry connections to other people or devices via the university's wireless networks. Different devices are used to access the wireless networks in the universities differently. The later statement can also support the principle of *Cartography* and *Decalcomania*. The *Cartography* and *Decalcomania* of human actors and platforms every student on a university wireless network connects to vary. All four institutions have varied experiences of maps in terms of bandwidth and access.

Asignifying rupture: Once more, when universities' wireless sites get blocked, either temporarily or permanently, the idea of permanently discontinuing using Internet or those certain blocked sites does not arise. Other wireless network resources are explored by students for wireless access.

5.2.2 Multivariate and descriptive analyses

This sub-section contains results of factor analysis and reliability analysis, descriptive statistics, and ANOVA for testing the differences on students' experiences with university wireless networks among the four institutions. A mean plot of the construct is also presented in this sub-section.

In Table 5.4, factor analysis and reliability analysis results for students' experiences with their university wireless networks are presented.

Table 5.4: Factor analysis and reliability analysis on university wireless networks (n=496)

Item	Component 1	Cronbach's Alpha (α)
Reliable access to WiFi specifically in classroom/instructional spaces	.903	.813
Reliable access to WiFi throughout campus	.891	
Ease of login to WiFi network(s) provided by the institution	.861	
Network performance (e.g. speed/bandwidth)	.478	

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
1. University WiFi user experiences

By inspection, all four items were loaded on Component 1 and subsequently labelled as "University Wi-Fi user experiences."

5.2.2.1 Reliability

University WiFi user experiences subscale, consisting of four items, was found to be highly reliable (α = .813). The value for the construct was calculated using the average of the items. Experiences with their university wireless networks was thus measured based on the Hypothesis 2.

Hypothesis 2: There is no statistically significant difference among the four cohorts of students in terms of experiences with their university wireless networks.

Table 5.5: Descriptive statistics of the cohorts' experiences with their university wireless networks

Institution	n	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min.	Max.
SAR	208	2.2893	.90486	.06274	2.1656	2.4130	1.00	4.25
GAC	52	2.8237	1.16663	.16178	2.4989	3.1485	1.00	5.00
GBR	141	1.4273	.55945	.04711	1.3342	1.5205	1.00	4.00
BEL	20	3.6125	.60955	.13630	3.3272	3.8978	2.50	4.50
Total	**421**	**2.1295**	**1.01612**	**.04952**	**2.0321**	**2.2268**	**1.00**	**5.00**

Scale/Interpretation of means:
0.1–1.0=Poor; 1.1–2.0=Fair; 2.1–3.0=Neutral; 3.1– 4.0 =Good; 4.1–5.0=Excellent.

The means range from 1.43 to 3.61 (from fair to good). To test Hypothesis 2, we used One-way Analysis of Variance, with results presented in Table 5.5 below.

Table 5.6: One-way Analysis of Variance: testing for differences among the cohorts' experiences with their university wireless networks

Subscale		Sum of Squares	df	Mean Square	F	*p*-value
University Wi-Fi user experiences	Between Groups	143.880	3	47.960	69.017	.000
	Within Groups	289.774	417	.695		
	Total	**433.653**	**420**			

Results of the One-way Analysis of Variance shows a significant difference in the averages of university wireless networks user experiences among the cohorts ($F_{3,417}$= 69.017, p <.000). Whereas BEL (=3.61, *SD*=.61) reported significantly good user experiences with their university wireless networks, GAC (=2.82, *SD*=1.17) and SAR (=2.29, *SD*=.90) reported significantly neutral user wireless experiences with their networks. GBR (=1.43, *SD*=.56) reported fair user experience on the construct.

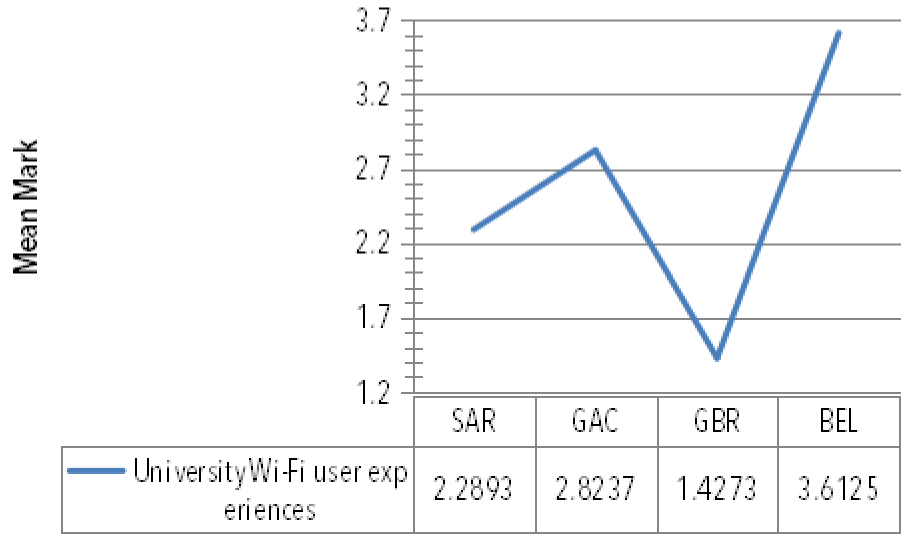


Figure 5.5: Mean plot of differences among cohorts in terms of experiences with their university wireless networks

The graphical presentation in Figure 5.5 shows a distribution of mean values (1.43-3.61) of university WiFi experiences from GBR (neutral), SAR (neutral), GAC (fair) to BEL (good).

To conclude on the basis of the analysis, among the four cohorts of students, respondents' experiences with their university wireless networks was statistically significant. Therefore, Hypothesis 2 was rejected: there is no statistically significant difference among the four cohorts of students in terms of their experiences with their university wireless networks.

5.3 Students' satisfaction with University Learning Management Systems (Hypothesis 3)

This section regarding student satisfaction with University Learning Management Systems covers a discussion of findings and multivariate and descriptive analyses.

5.3.1 Discussions

The objective for the preceding theme was to explore the differences in students' satisfaction level of the Learning Management System in their institutions among the four student cohorts. Hypothesis 3 was rejected because a test revealed differences in students' satisfaction level of Learning Management System across the four universities. Hypothesis 3 states that "*there is no statistically significant difference among the four cohorts of students in terms of satisfaction level of Learning Management System in their institutions.*" There is enough evidence that Learning Management System (examples, *Blackboard* in SAR and *Toledo* in BEL) form part of students' personal learning networks in higher education. This objective also responds to Naveh *et al*. (2010) whose publication recommended further research into the use and satisfaction of the Learning Management System in more than one university. Two factors found to be reliable were also derived from a factor analysis: information quality (α = .924) and user connectedness (α = .863). According to Figure 5.6, the mean differences for the two subscales ranged from neutral (3.0) to satisfied (4.0) on the scale. Respondents from GAC and BEL expressed satisfaction with their university's Learning Management System with some differences in terms of user connectedness. Generally, mean values for information quality centred on a neutral rating. In a closer analysis of the factor loadings on Table 5.7, it will be noticed that *Accessing course content (syllabus, recorded lectures, blogs)* and *Collaborating on groups work* and *managing your assignments* in a sequential order, all loaded very high.

Findings across the four institutions are not very clear since responses were more skewed towards a neutral position. Accordingly, the findings may be as a result of limited technical and staff support as indicated in findings of Green (2015). Green earlier explained that staff, while admitting pedagogical value in Learning Management Systems, is limited in expertise. Literature from Graf *et al.* (2009)and Govender and Govender (2014) corroborates results on information quality. The pattern deduced from the results show that students may not be relying so heavily on the Learning

Management System in their personal learning networks. Some of the student confirmed this from GAC.

> *"As for Blackboard, we never use it. We are forced to use it but we only pretend to be using it. What we do to get away with it is simple. Our class prefect is the watch dog who monitors the portal. He quickly shares announcements and assignments on our WhatsApp group page and this has always worked very well for the class"* ***(S.SAR.Thando).***

In fact, such diversity of students draws seriously on three rhizomatic patterns: connection, asignifying rupture and multiplicity. Beside the institutional Learning Management System, students are connected through the affordances of *WhatsApp*. It is interesting to note that new users to the Learning Management System platform and the social media platform may get lured into 'hating' the Learning Management System but then be ready to learn all about operations in *WhatsApp*. The students exhibit traces of asignifying rupture because they are only passive users on the Blackboard Learning Management System: they are fully registered, keep their places there but have halted in the skills development with the Learning Management System. This may also be a reason why some universities have shifted to the use of social media to 'replace' Learning Management Systems in certain institutions. According to a lecturer in GAC in Ghana:

> *"We learnt that some universities have moved from this traditional learning management system to Facebook. The reason is that, it is known that a typical student can visit Facebook (for) several times or spend several hours on Facebook than any other thing so why not move learning from the traditional system to where they go often and so other people as a learning platform. We shouldn't forget that, when we were students in Ghana we had discussion groups and it's something that had been with us before the advent of the Internet. We had that philosophy or saying that: "if you learn alone, you will go home alone" so we learn in groups and that is social learning" (**L.GAC.Ato**).*

It is evident that behaviour or practices in traditional classrooms continue to find their way through the digital spaces. Though Learning Management Systems are also designed to create an environment for collaboration, through the principles of connection, asignifying rupture and multiplicity, students do not rely on the Learning Management System for collaborative works; they prefer to work elsewhere and report on the Learning Management System.

In Belgium, students did not raise issues with the *Toledo* Learning Management System. Students appeared to be fine with it. Perhaps, the pedagogical uses of the Learning Management System has seen much improvement in BEL partly because they approached issues surrounding Learning Management Systems with more research, as suggested by Lonn and Teasley (2009b). Two students had this to say:

> "*I am not a computer geek but Toledo works for me, I hear Toledo was customised for our use so I think it simply fits for me. Sometimes, it is difficult to use it for some courses in my field of medicine but, trust me, Toledo is helpful for content*" ***(S.BEL.Jules).***

On the flip side, the second student also said this:

> *"In our visualisation class, our professor prefers to use Slack in place of Toledo. I have no problem with any of these tools. All I need to do is to get my assignments done"* ***(S.BEL.Ethan).***

Findings from ***S.BEL.Ethan*** support recent studies by Murshitha and Wickramarachchi (2016) who noted that the Learning Management System is underpinned by student and lecture interaction, experience and self-efficacy. The research could not clearly establish in detail various uses of an institutional Learning Management System (Annku, 2014).

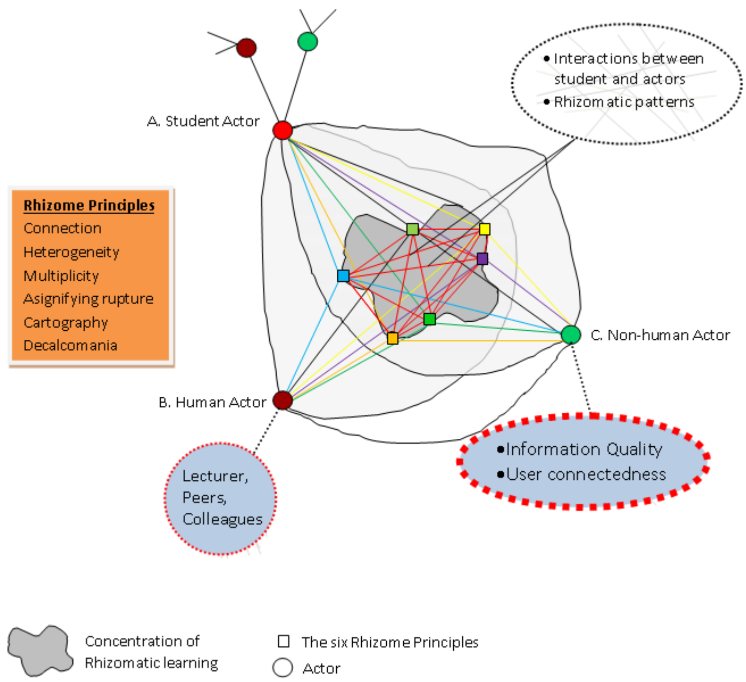


Figure 5.6: Mapping of factors of students' satisfaction of University Learning Management System onto the conceptual model

According to Figure 5.5, a student's interaction with the Learning Management System (socio-technical aspect) may involve other human actors such as lecturers, classmates or administrators, whereas this research established differences in terms of Learning Management System usage in students' personal learning networks in higher education. Traces of *asignifying rupture* reflected on the pattern of student use of alternative systems to replace institutional Learning Management System through their *connections* to *multiple* media (social media) if they were not satisfied with it. *Heterogeneity* explains students resorting to other Learning Management Systems for information quality and successful learning. *Cartography* and *Decalcomania*: Though institutional Learning Management Systems may be common to all students, there are differences of paths, experiences and satisfaction from each system accessed by the various students.

5.3.2 Multivariate and descriptive analyses

This sub-section forms part of results on factor analysis and reliability analysis and descriptive statistics. Results from ANOVA that tested the differences on students' satisfaction levels in the use of their University Learning Management Systems among the four institutions are also presented. Mean plot of the two constructs is also presented in this sub-section.

In Table 5.7 factor analysis and reliability analysis results for students' experiences with their University Learning Management Systems is presented.

Table 5.7: Factor analysis and reliability analysis results for students' satisfaction levels in the use of their university Learning Management Systems (n=421)

Item	Component		Cronbach's Alpha (α)
	1	2	
Collaborating on groups work	**.854**	.152	0.924
Meaningful online interactions with your instructors	**.843**	.240	
Engaging in meaningful interactions with other students	**.825**	.158	
Timely feedback on assignments	**.775**	.381	
Meaningful feedback on assignments	**.738**	.371	
Overall satisfaction	**.676**	.542	
Accessing course content (syllabus, recorded lectures, blogs)	.115	**.868**	0.863
Managing your assignments	.178	**.846**	
Checking course progress	.417	**.717**	
Accessing information about your institution's news, events, or activities	.307	**.712**	
Submitting assignments reliably	.510	**.581**	

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

1. Information quality
2. User connectedness

By inspection of items that load high on Component 1 and Component 2, the labels "Information quality" and "User connectedness" fit best.

5.3.2.1 Reliability

The *information quality* subscale which consists of six items was found to be highly reliable (α=.924), followed by *User satisfaction* subscale which consisted of five items with a high reliability score (α = .863).

Values for the construct were calculated using the average of the items in each construct. Learning Management System was thus measured based on two sub-hypotheses under Hypothesis 3.

Hypothesis 3: There is no statistically significant difference among the four cohorts of students in terms of satisfaction level of Learning Management System in their institutions.

3.1. There is no statistically significant difference among the four cohorts of students in terms of satisfaction level of Information quality.

3.2. There is no statistically significant difference among the four cohorts of students in terms of satisfaction level of user connectedness.

Table 5.8: Descriptive statistics of the students' satisfaction level of the Learning Management System in their institutions

Subscale	Institution	n	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
Information quality	SAR	230	3.0055	.93548	.06168	2.8840	3.1270	1.00	5.00
	GAC	63	3.4439	.99852	.12580	3.1924	3.6954	1.00	5.00
	GBR	110	3.1482	.96584	.09209	2.9657	3.3307	1.00	5.00
	BEL	18	2.7454	.78615	.18530	2.3544	3.1363	1.17	4.00
	Total	**421**	**3.0973**	**.95920**	**.04675**	**3.0054**	**3.1892**	**1.00**	**5.00**
User connectedness	SAR	231	3.2398	.96269	.06334	3.1150	3.3646	1.00	5.00
	GAC	58	3.7784	.75296	.09887	3.5805	3.9764	1.00	5.00

Subscale	Institution	n	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
	GBR	114	3.0425	.90030	.08432	2.8755	3.2096	1.00	5.00
	BEL	19	3.5044	.65106	.14936	3.1906	3.8182	2.40	5.00
	Total	**422**	**3.2725**	**.93346**	**.04544**	**3.1832**	**3.3618**	**1.00**	**5.00**

Scale/ Interpretation of means:
0=Not offered; 0.1–1.0= Don't use this feature at all; 1.1–2.0=Very dissatisfied; 2.1–3.0= Neutral; 3.1– 4.0 = Satisfied; 4.1–5.0=. Very Satisfied

The means range from 2.75 to 3.78 (from neutral to satisfied). To test the two sub-hypotheses of Hypothesis 3, we used One-way Analysis of Variance, with results presented in Table 5.9.

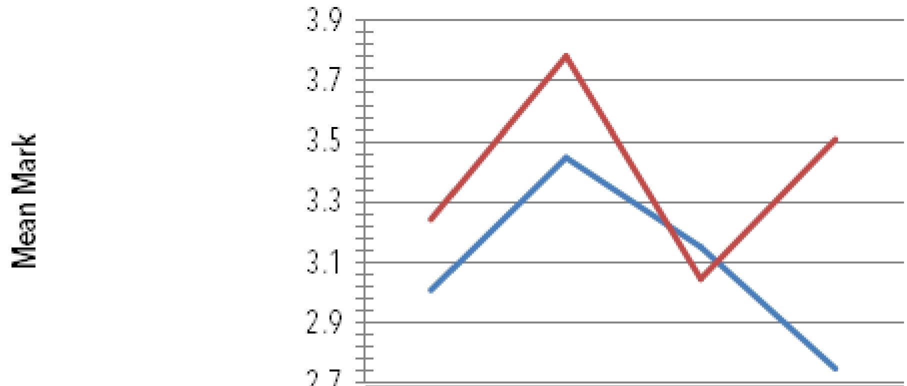
Table 5.9: One-way Analyses of Variance: testing for differences among the cohorts' satisfaction level of the Learning Management System in their institutions

Subscale		Sum of Squares	df	Mean Square	F	*p*-value
Information quality	Between Groups	12.021	3	4.007	4.463	.004
	Within Groups	374.406	417	.898		
	Total	**386.427**	**420**			
User connectedness	Between Groups	22.144	3	7.381	8.951	.000
	Within Groups	344.694	418	.825		
	Total	**366.838**	**421**			

Results of the One-way Analysis of Variance shows a significant difference in the averages where *Information quality* was found to differ significantly among the cohorts ($F_{3,\ 417}$= 4.463, p <.004). GAC (=3.44, *SD* =1), GBR (=3.15, *SD* = .97) and SAR (=3.01, *SD* =.94) reported significantly neutral satisfaction level of *Information quality* of the Learning Management System in their institutions. Though BEL (=2.75, *SD* =.79) also reported a significantly neutral satisfaction level with the Learning Management System in their institution, they reported a lesser satisfaction level as compared to the other institutions.

User connectedness subscale was found to differ significantly among the cohorts ($F_{3,\ 418}$= 8.95, p <.000). While GAC (=3.78, *SD* =.75) and BEL (=3.50, *SD*=.65) reported significantly high satisfaction level of connectedness to the Learning Management Systems in their institutions, SAR (=3.24, *SD* =.96) and GBR (=3.04, *SD* = .90) reported a significantly neutral satisfaction level on the same construct.

5.3.2.2 Mean plots



	SAR	GAC	GBR	BEL
Information quality	3.0055	3.4439	3.1482	2.7454
User connectedness	3.2398	3.7784	3.0425	3.5044

Figure 5.7: Mean plot of satisfaction level of their university's Learning Management System indicative of differences among cohorts according to the constructs

Hypotheses 3 established statistically significant differences in the satisfaction levels of Learning Management Systems used in their institutions. The differences warranted a rejection of Hypothesis 3: There is no statistically significant difference among the four cohorts of students in terms of their satisfaction level of the Learning Management System in their institutions.

5.4 Students' experiences with technology (Hypothesis 4)

This section focuses on discussions, multivariate and descriptive analyses on students' experiences with technology in their institutions.

5.4.1 Discussions

In measuring this particular objective, Hypothesis 4, stating "*There is no statistically significant difference among the four cohorts of students in terms of their experiences with technology use in their institutions*" was formulated. Hypothesis 4 was subsequently rejected as a test indicated significant differences in students' experiences with use of technology in their institutions. Four factors emerged from a factor analysis and three of those factors were reliable. Apart from *Skipping of classes* ($F_{3,\ 485}$= .757, p >.519), the reliable factors that differed significantly are *Techno-connection*, *Techademics* and *Pre-university orientation*.

The results are consistent with literature that reports that students are technology savvy and will want to take advantage of technology for the benefit of their learning networks (Boyd, 2014; Eton, 2011; Shelly *et al*., 2012). Students from all four institutions had varied technological experiences from their institutions but the underlying revelation is that as much as possible, students feel connected to other resources (lecturers, students, materials, and university's webpage) in their personal learning networks as long as they also have technology. A student from BEL shared his technological experiences with his institution:

> "*I personally don't have any issues with the kind of technologies provided by our school authorities [sic] at least, this university is resourced compared to other universities around the world*" ***(S.BEL.Hugo)***.

Similar statements were recorded from another student from SAR:

> *"SAR proofs to the world that it is a leading University of Technology, the technological experiences do not reflect a new university; my experiences are positive not because this is my university"**(S.SAR.Khayone)***.

However, one student from GAC was not very pleased with her technological experiences in her university. She noted the following:

> *"This university is doing its best but honestly, some areas of technology for teaching and learning need to be beefed up"* ***(S. GAC.Mensah)***.

The results also confirm some characteristics of the 21st century student who is described by Shelly *et al.* (2012) as 'media-centric'. Despite technology being ubiquitous, students are not likely to skip lectures or classroom work which proves that physical human interaction is still necessary, even for the techademics, incongruent to the report by Bita (2016). It is difficult to establish whether the physical human interaction is as a result of how institutional policies have been modelled for students. For instance, in all the institutions, class attendance is a requirement for successful completion of course.

Findings on *Pre-university orientation* run inconsistently with the decision by Sydney Grammar School to restrict pre-university students from laptop ownership and use at school. Findings from the analysis reiterate the importance of pre-university technological experiences since this may provide strong foundations to students in basic technological operations such as downloads (Gupta & Koo, 2010), configuration of campus wireless networks and web searches for assignments (Mcknight, 2011; Motwalla, 2015).

Students leverage on their knowledge in technology for academic benefits; nonetheless, students may have a difficult time integrating social media in their learning despite patterns that reveal some positive use of social media in higher education. For instance, unlike Moran *et al*. (2011) who reported on teachers' integration of social media into teaching and learning, in GBR staff and students are unable to use *Facebook* during lecture hours due to its blockage. But GBR students argued that blocking of *Facebook* was detrimental to their academic work; hence, they resorted to the use of their own Internet resources during times when the university blocks social media.

A lecturer from GBR confirmed the blockage of *Facebook* with a reason by saying:

> *"In fact it was becoming too much. We had to block Facebook from the university's Internet. Things were really getting out of hand to the extent that students paid attention to the social media site rather than their lectures"* ***(L. GBR.Ali)***.

The lecturer's statement corroborates statements from a student in BEL who made mention of cyber libelling (constantly checking out what messages have landed on phones or what people say about posts or pictures within short intervals).

> *"In this age of technology, blocking any social media site on the university's Internet portal will not help them [sic] you expect us to be able to compete with the world, you expect us to be current yet you do not want to see social media as a learning to that helps us to connect with other students. Example, you are kept constantly updated on our class group on WhatsApp and Facebook. I personally learn a lot from there. Our authorities must discuss the whole issue very well with us because blocking one site on the university's portal can never prevent us from accessing that site through a back door from virtual remote sites or personal Internet bundles"* ***(S.GBR.Asiedu)***.

Comments on the view of social media as a learning tool by GBR 6 can be supported by Rooyan (2015).

According to some lecturers from SAR, students do not apply technology to their learning the way it should be. This is causing

> *"More harm than good [sic] making students find difficulty in differentiating between credible and un-credible sources"* ***(L.SAR.Isaacs)***.

A similar remark from another lecturer from the same institution about students' experiences with technology was that:

> *"Advance technology does not increase your knowledge. Students experience wide array of information to access but on the other hand, some students who aren't open minded have become very lazy and encouraged to be seriously distracted by technology which also raises ethical issues like copying and cloning"* ***(L.SAR.Robert)****.*

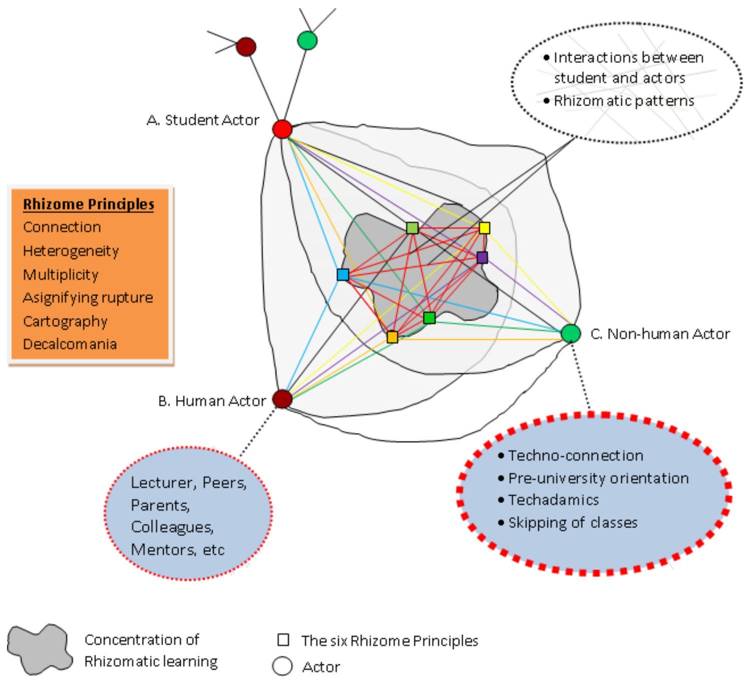


Figure 5.8: Mapping of factors of students' experiences with technology in their onto the conceptual model

To wrap up, there are varied levels of technological experiences among students in the four institutions of higher education based on policies, practices and prior exposure to technology before university education which and similar to the Rhizome principles of *Connection* and *Cartography* and *Decalcomania* (refer to 2.9.1 and 2.9.5 of Chapter 2). The principles of *Cartography* and *Decalcomania* in this research reveal that students' technological experiences in higher education are not a tracing but a map (unique and varied). The research also backs findings in other areas that recommend the presence of technological infrastructure in higher education (Moran *et al*., 2011; Tess, 2013). However, if the institutions are to attend to the recommendations of Ersoy and Güneyli (2016), students can get better experiences if technology in higher education is to be approached with a more object eye to harness its personal and educational values.

5.4.2 Multivariate and descriptive analyses

This sub-section is on results from factor analysis, reliability analysis and descriptive statistics. Results from ANOVA and Mean plot that tested the differences on students' experiences with technology in their institutions are also presented in this sub-section.

Table 5.10: Factor analysis and reliability analysis on students' experiences with technology (n=489)

Item	Component 1	Component 2	Component 3	Component 4	Cronbach's Alpha (α)
Technology makes me feel more connected to what's going on at the college/university.	**.811**	.069	.229	.046	0.807
Technology makes me feel connected to other students.	**.801**	.174	.099	-.045	
Technology makes me feel connected to instructors.	**.716**	.246	.146	.066	
I wish I had been better prepared to use basic software programs and applications (e.g. MS Office, Google Apps) when I first started university	.326	**.787**	-.035	-.012	0.66
I wish I had been better prepared to use institutionally specific technology (e.g. the course registration system, Learning Management System, the library search system) when I first started university	.338	**.741**	-.045	-.108	
In-class use of mobile devices is distracting.	-.039	**.625**	.022	.447	
When I entered college, I was adequately prepared to use technology needed in my courses.	.324	-.071	**.658**	.061	0.513
I get more actively involved in courses that use technology.	.352	-.071	**.622**	.073	
When it comes to social media (e.g., *Facebook, Twitter, LinkedIn*), I like to keep my academic life and my social life separate	-.029	.457	**.534**	.149	
I am more likely to skip classes when materials from course lectures are available online.	.020	.072	.206	**.699**	*

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

1. Techno-connection (A state or feeling of always wanting to connect to technology in a learning space)
2. Pre-university orientation
3. Techademics (State of a student's preparedness to use technology for academic work)
4. Skipping of classes

* No Cronbach's alpha for a single value; this variable did not load on any of the factors (.699 is on its own in a column)

By inspection of items that load high on Component 1 and Component 2, the labels 'Techno-connection' and 'Pre-university orientation' fit best. 'Techademics' and 'Skipping of classes' are labels assigned to Component 3 and Component 4 which have items with relatively high loadings on them.

5.4.2.1 Reliability

Apart from Component 4, *Skipping of classes* had only one item loading, while all the other three components had three items each loaded. *Techno-connection* subscale was found to be highly reliable (α=.807), followed by *Pre-university orientation* subscale with moderate reliability (α=.66). *Techademics* subscale reported a poor reliability (α=.51) while. Finally, component 4 *Skipping of classes* subscale did not belong to any cluster of items, standing alone. Since the subscale is a single value, there is no Cronbach's alpha value for reporting (Field, 2009).

Hypothesis 4: There is no statistically significant difference among the four cohorts of students in terms of their experiences with technology use in their institutions.

4.1. *There is no statistically significant difference among the four cohorts of students in terms of their* ***techno-connection*** *experiences* in their institutions.
4.2. *There is no statistically significant difference among the four cohorts of students in terms of their* ***pre-university orientation*** *in their institutions.*
4.3. *There is no statistically significant difference among the four cohorts of students in terms of their* ***techademic experiences*** *in their institutions.*
4.4. *There is no statistically significant difference among the four cohorts of students in terms of* ***skipping classes*** *when materials from course lectures are made available online in their institutions.*

Table 5.11: Descriptive statistics of the cohorts' experiences with technology use in their institutions

Subscale	Institution	n	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
Techno-connection	SAR	243	3.8875	.93605	.06005	3.7692	4.0058	1.00	6.00
	GAC	85	4.2706	.89899	.09751	4.0767	4.4645	1.00	6.00
	GBR	141	4.1986	.73027	.06150	4.0770	4.3202	2.00	6.00
	BEL	20	4.5000	.93346	.20873	4.0631	4.9369	1.00	5.00
	Total	**489**	**4.0688**	**.89246**	**.04036**	**3.9896**	**4.1481**	**1.00**	**6.00**
Pre-university orientation	SAR	243	3.2702	1.03104	.06614	3.1399	3.4005	1.00	6.00
	GAC	85	4.0510	.97387	.10563	3.8409	4.2610	1.00	6.00
	GBR	141	3.7872	.85753	.07222	3.6445	3.9300	1.00	5.33
	BEL	20	4.1000	.72628	.16240	3.7601	4.4399	3.00	5.00
	Total	**489**	**3.5890**	**1.01575**	**.04593**	**3.4987**	**3.6792**	**1.00**	**6.00**
Techademics	SAR	243	3.8765	.81500	.05228	3.7736	3.9795	1.00	6.00
	GAC	85	3.9412	.93035	.10091	3.7405	4.1418	1.00	5.33
	GBR	141	4.0213	.77788	.06551	3.8918	4.1508	1.67	5.33
	BEL	20	4.4833	.54585	.12206	4.2279	4.7388	3.00	5.00
	Total	**489**	**3.9543**	**.82424**	**.03727**	**3.8811**	**4.0276**	**1.00**	**6.00**
Skipping of classes	SAR	243	2.6831	1.3615	.0873	2.5111	2.8552	1.00	6.00
	GAC	85	2.6941	1.4144	.1534	2.3890	2.9992	1.00	6.00
	GBR	141	2.8369	1.3450	.1133	2.6129	3.0608	1.00	6.00
	BEL	20	2.4000	1.7889	.4000	1.5628	3.2372	1.00	5.00
	Total	**489**	**2.7178**	**1.3842**	**.0626**	**2.5948**	**2.8408**	**1.00**	**6.00**

Scale/ Interpretation of means:
0=Don't know; 0.1–1.0=Strongly disagree; 1.1–2.0=Somewhat disagree; 2.1–3.0=Neutral; 3.1– 4.0=Somewhat agree; 4.1–5.0=Strongly agree

The means range from 2.40 to 4.50 (from neutral to strongly agree). To test the sub-hypotheses 4, we used One-way Analysis of Variance, with results below in Table 5.12.

Table 5.12: One-way Analysis of Variance: testing for differences among the cohorts' experiences with technology use in their institutions

Subscale		Sum of Squares	df	Mean Square	F	*p-value*
Techno-connection	Between Groups	17.540	3	5.847	7.641	.000
	Within Groups	371.142	485	.765		
	Total	**388.682**	**488**			
Pre-university orientation	Between Groups	53.596	3	17.865	19.259	.000
	Within Groups	449.895	485	.928		
	Total	**503.491**	**488**			
Techademics	Between Groups	7.714	3	2.571	3.851	.010
	Within Groups	323.822	485	.668		
	Total	**331.536**	**488**			
Skipping of classes	Between Groups	4.359	3	1.453	.757	.519
	Within Groups	930.696	485	1.919		
	Total	**935.055**	**488**			

One-way Analysis of Variance results proved significant differences in the averages in terms of respondents' experiences with technology use in their institutions ($F_{3,\ 485}$= 7.641, p <.000). Differences in *Techno-connection* were significant among the cohorts BEL (=4.50, *SD* =.93), GAC (=4.27, *SD* =.90), GBR (=4.20, *SD* = .73) and SAR (=3.89, *SD* =.94). Rating for the *Techno-connection* subscale is generally that of an agreement to the statements that make up the subscale.

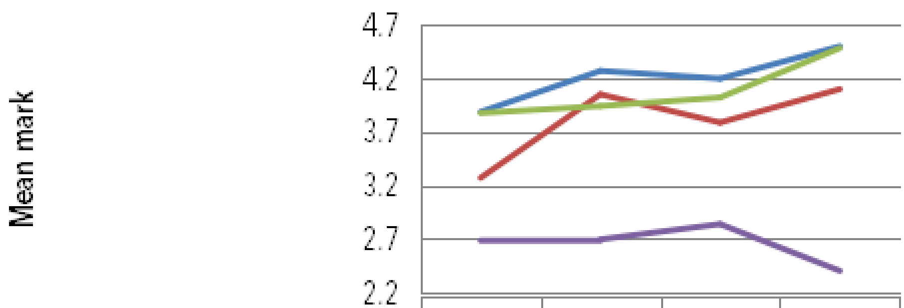
Table 5.12 displays significant differences among the cohorts in terms of *Pre-university orientation* subscale ($F_{3,\ 485}$= 19.259, p <.000). The differences are BEL (=4.10, *SD* =.73), GAC (=4.05, *SD* =.97), GBR (=3.79, *SD* = .86) and SAR (=3.27, *SD* =.103). With the exception of the SAR cohort who gave a neutral rating to the *Pre-university orientation* subscale, all the other cohorts assigned a somewhat agree rating to the subscale.

On *Techademics,* the institutions reported significant differences ($F_{3,\ 485}$= 3.851, p <.010) with BEL (=4.48, *SD* =.55) and GBR (=4.02, *SD* = .78) somewhat agreeing. Though GAC (=3.94, *SD* =.93) and SAR (=3.87, *SD* =.82) somewhat agreed to their experiences with technology in their experiences viz-a-viz Techademics construct, their ratings were lower than the BEL and GBR.

Finally, results for *Skipping of classes* subscale failed to indicate significant differences among the cohorts ($F_{3, 485}$= .757, p >.519). Apart from BEL (=2.4, *SD* = 1.7) which gave opposition to skipping classes when their when materials from course lectures are available online, the other three cohorts reported neutral to the same construct in the order of SAR (=2.68, *SD* =1.36), GAC (=2.69, *SD* =.41) and GBR (=2.84, *SD* = 1.35).

5.4.2.2 Mean plot

Mean plots for differences among the cohorts' experiences with technology use in their institutions per the four subscales are illustrated in Figure 5.8.



	SAR	GAC	GBR	BEL
Techno-connection	3.8875	4.2706	4.1986	4.5000
Pre-university orientation	3.2702	4.0510	3.7872	4.1000
Techadamics	3.8765	3.9412	4.0213	4.4833
Skipping of classes	2.6831	2.6941	2.8369	2.4000

Figure 5.9: Mean plot of differences among cohorts' experiences with technology use in their institutions per the constructs

Differences among the cohorts' experiences with technology use per their institutions for each of the four subscales varied. Apart from the *Skipping of classes* subscale where all cohorts disagreed to it at varied levels, all other mean values show agreement with the various subscales. For the *Techno-connection* subscale, BEL's mean score shows very strong agreement of their feelings towards technology use.

Chapter six contains the conclusion of this report.

CHAPTER SIX
CONCLUSION

"It is difficult to determine the value of information to a particular consumer without disclosing the information"

-Yurow (1981:54)

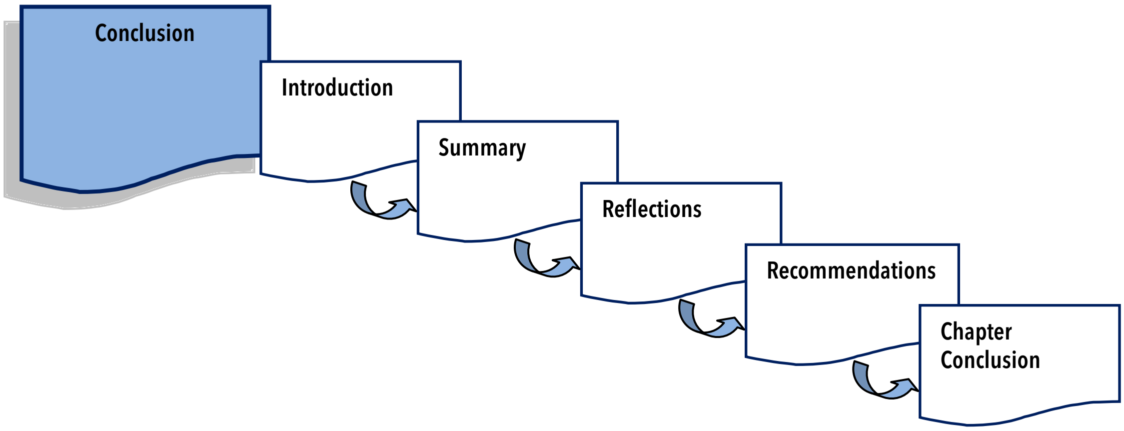


Figure 6.1: Map of Chapter Six

6.0 Introduction

This concluding chapter aims at providing an overview of the research report. The outcome of this chapter includes an overview of the aim, research question and reflections which touched on methodology, findings and recommendations from the research. The research found patterns of multiple entryways (rhizomatic) to students' personal learning networks. It also established differences in students' self-perceived importance of handheld mobile devices for academic success, satisfaction of their institutional Learning Management System, experiences with their institutions' wireless networks and technological uses. The subsequent section is a presentation of the summary.

6.1 Summary

The aim of this research was to explore the underpinnings of students' use of technology in their personal learning networks in a higher educational environment. The research problem sought to construct the argument that there is continuous growth of students' personal learning networks founded on connections owing to emerging technologies in the 21st century (Richardson & Mancabelli, 2012). Irrespectively, curriculum developers and educators in higher education have failed to engage students to find out the extent to which their (students') personal learning networks are underpinned by a rhizomatic model. In that students are influenced by a pervasive technological environment, exposing them to multiple sources of formal and informal learning connections (Pineda, 2013; Dron & Anderson, 2016).

This research was guided by a main research question with four sub-research questions and four research hypotheses after understanding the research problem.

6.1.1 Research question

To what extent does technological influence on students' personal learning networks show traces of Rhizomatic Learning in higher education? The research was further atomised into four sub-research questions and four hypotheses.

6.1.2 Sub-research questions

All sub-research questions were primarily formulated within the theoretical context of the study. However, in addition, the last two sub-research questions also occurred within a professional context (Plowright, 2011).

1. What actors are in a rhizomatic learning network?
2. How are the emergent patterns in a rhizomatic learning network related?
3. What digital devices are owned by students in higher education
4. To what extent are the devices used by students perceived to be a promoter of their academic success?

6.1.3 Research hypotheses

The research hypotheses were formulated within the theoretical, professional and organisational contexts of this research (Plowright, 2011).

1. There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success.
2. There is no statistically significant difference among the four cohorts of students in terms of experiences with their university wireless networks.
3. There is no statistically significant difference among the four cohorts of students in terms of their satisfaction level of Learning Management System in their institutions.
4. There is no statistically significant difference among the four cohorts of students in terms of their experiences with technology use in their institutions.

Chapter Two gathered sufficient motivation from literature and empirical studies to show that emerging patterns of technological use in students' personal learning networks in higher education were of varied levels. These levels touch on various issues such as policy, device ownership and use, and students' experiences and satisfaction with technology (social media, Learning Management Systems, university wireless networks). The crux of the conception of this research centred on a main theory known as the Rhizome Theory and a second theory, the Actor Networks Theory. Rhizome Theory provided a lens for understanding the patterns, complex relationships and multiple entryways to learning that emerged from students' personal learning networks in a technological learning environment. The Actor Network Theory further guided the research in mapping the human and non-human actors that interact with the student within his personal learning networks.

Chapter Three enabled the unravelling of the philosophy and methodological choice for this research. This research was aligned with the views and beliefs of critical realists (Bhaskar, 1997; Mingers, 2004; Smith, 2010) that reality is subjective, intrinsic and cannot be known. Nonetheless, being unknown, there may be multiple realities only discoverable and understood through many viewpoints by engaging with participants and respondents in research. Hence, actors in students' personal learning networks in a technological environment cannot be understood through a lens of one single reality (Dobson, 2002). The methodological choice which paved way for further understanding of the research issues is explained in section 6.2.1 in the methodological reflection.

Chapter Four presented results and discussions of findings from the pilot study and sub-research questions. Results from analyses and findings were captured in Rhizomatic Learning Network maps, tables of figures, narratives or texts. This chapter dealt with the actors in students' Rhizomatic Learning Network, the relationship between emerging patterns of Rhizomatic Learning Networks, students' experiences with digital device ownership and the importance of digital devices used towards academic success.

Chapter Five deciphered results and discussed findings from the research hypotheses. Results from analyses and findings were reported in tables of figures and supported with narratives or texts. The chapter reported statistically significant differences among the four cohorts of students studied across four constructs. These constructs were students' self-perceived importance of handheld mobile devices for academic success, satisfaction of their institutional Learning Management System, experiences with their institutions' wireless networks and technological uses.

Chapter Six aimed at recapping this research report, show an overview of the aims, research question and reflections which touched on methodology, results and recommendations from the research. Apart from revealing results on the rhizomatic patterns in students' personal learning network, the chapter again reviewed differences in the hypothesis tested.

6.2 Reflections

This reflective part of the concluding chapter overviews issues emerging from this research which will be presented under methodological, substantive and scientific reflections. Moreover, it briefly covers the extent to which findings of this research relate to other studies.

6.2.1 Methodological reflection

The intent of this research was not to generalise findings from the research except for a generalisation within the context of the population in this research. Generalisation is not ideal due to the purposive sampling methods and that interpretation of rhizomatic learning network maps is subjective in nature reflecting multiple realities. Issues of multiple realities and entry pathways of actors also influenced the use of the two theoretical foundations (Rhizome Theory and Actor Network Theory) in this research.

Framework for Integrated Methodologies (FraIM) was used in this research because it provided a better way of exploring and understanding current perspectives on patterns of students' use of technology in higher education and personal learning networks (Plowright, 2011:181). Two main approaches to data handling and interpretation were used – numerical and narrative approaches. The approaches used allowed for triangulation of the results and emergent issues which led to a focus on specific attributes in the interpretation of the results (Patton, 2002; Merriam, 2009).

Results from surveys were supported and discussed with key issues that emanated from the individual interviews and focus group interviews. For instance, the most important influential actor in a student's rhizomatic learning network or personal learning network was best identified through numerical results generated from the rhizomatic maps rather than mere inspection of the maps. In any case, this scenario allowed for further precise discussions on the most important or influential actors, supported with evidence from the narratives or interviews.

The research was conducted within the ambit of an ethical context. This is critical since the credibility, reliability and acceptance of this research is imperative when it comes to ethical concerns. The chapter gives further ethical foundations of this research.

6.2.2 Substantive reflection

Emerging findings from this research are briefly discussed and related to other findings from literature. In short, this reflection provides overview of this research outcome. Figure 6.2: *Patterns of students' technology use in higher education* summarises the outcome of this entire research into a model inspired by the initial conceptual model in Chapter One.

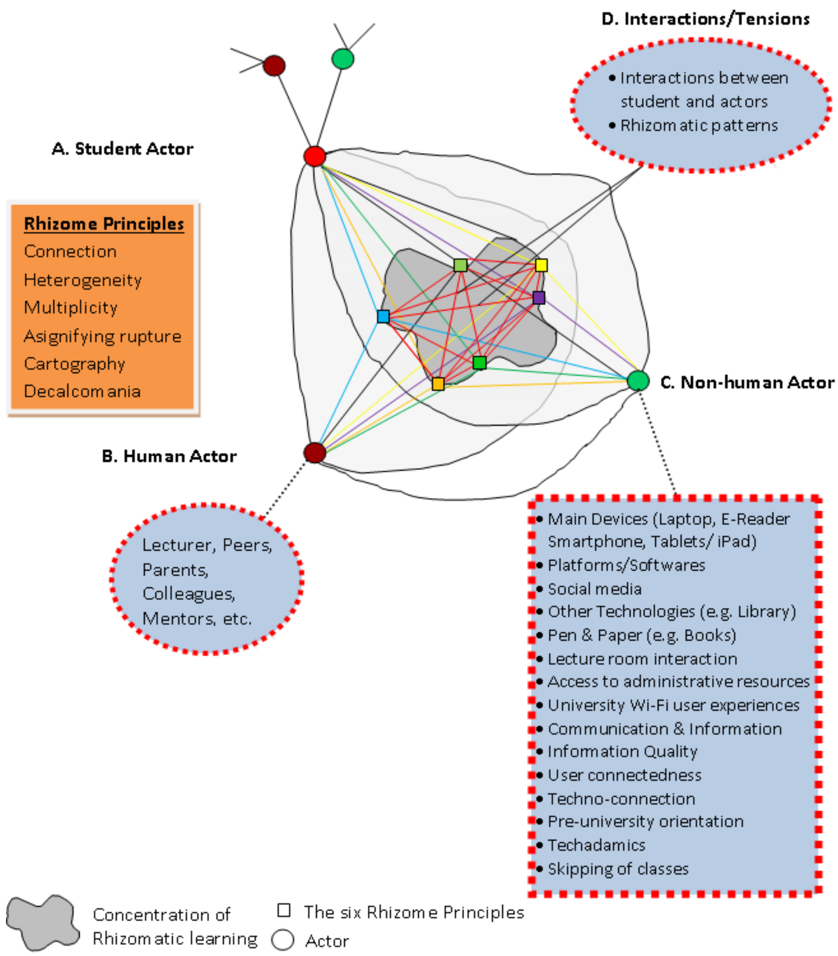


Figure 6.2: Patterns of students' technology use in higher education

Figure 6.2 is a pictorial overview and answer to the main research question that asks, *"to what extent does technological influence on students' personal learning networks show traces of Rhizomatic Learning in higher education?"* This research found one category of human actors; six categories and ten factors of non-human (socio-technical) actors that are key to students' rhizomatic learning networks in higher education. Being the principal actor (A), the student who is also a human actor organises and interacts with a number of actors within his personal learning network. From Figure 6.2, Human actor (B) includes all human beings the student interacts with within his personal learning network. The Non-Human actor (C) includes all the socio-technical aspects of student's personal learning networks. They again cover the artefacts and interactions between the principal actor (student) and all other resources within the confines of his personal learning network (e.g. devices, social media and user connectedness). All 10 factors found in the factor and reliability analyses are also classified in (C) but more under interactions. Findings of the patterns that were being mapped within the students' personal learning networks were situated in Interactions/Tensions (D). This research also established the roles played by the principles of the Rhizome Theory; *Connection* and *Heterogeneity, Multiplicity, Asignifying rupture, Cartography* and *Decalcomania.* Reflections based on four research questions and four sub-research hypotheses are presented below.

6.2.2.1 What are the actors in a rhizomatic learning network?

A total of 218 actors constituting human and non-human agents were found in the Rhizomatic Learning Networks (*Appendix K*). They occurred as nodes in the rhizomatic learning network maps. The actors were also categorised under Devices (D), Platform/Software (P/S), Social media (Sm), Other Technologies (OT), Pen and Paper (P & P), Interaction (Int) and Humans (H) actors. Some of the actors overlapped across the categories of actors. Platforms/Software (147) followed by Social Media (55) had the most number of actors occurring under them. Ten actors occurred in the four institutions, including *YouTube, Wikipedia, Twitter, laptop, Google, Facebook* and Lecturers. Another ten actors occurred in three institutions (all in Africa) which excluded the European

(Belgian) university. The actors are Books, Gmail, Internet, *LinkedIn, Microsoft Office Suite*, Peers, *Photoshop*, *Skype*, Smartphone and *WhatsApp*. Some 34 actors also converged and occurred at two different institutions while 164 actors occurred as lone or divergent actors in the various institutions.

6.2.2.2 How are the emergent patterns in a rhizomatic learning network related?

From the findings, patterns emerged that students' personal learning networks also show rhizomatic traces and resonated with authorities such as Cormier (2008), Guerin (2013) and Warburton (2010). Relationships among actors in the rhizomatic learning network maps differed from actor to actor and institution to institution. In Ghana (GAC specifically), *Google* and *WhatsApp* appeared to be the closest actor to all other actors. While *Dropbox, Facebook* and *YouTube* appeared to be the closest actor in the personal learning network of students in South Africa (SAR), students in Belgium (BEL) were also closer to *Dropbox*, phone and their Learning Management System, *Toledo*. This finding stresses the point of students' awareness on data security, storage and their connections to resources and data to assist their learning. One key pattern revealed was that in all four institutions, the most connected as well as the most important actors were human actors. The connection of human actors suggests the importance of students' control and ownership in their personal learning networks. Again, students used a number of non-traditional teaching and learning tools to achieve their learning objectives, including *WhatsApp* and other virtual groups. Most of the actors fell under Platforms/Software. These findings are corroborated by Beetham (2013) that students support their learning through their digital networks and resources. A careful observation of the rhizomatic learning networks reveals that students (the human actors) are progressively becoming more inter-disciplinary (Eton, 2011). And the more inter-disciplinary they become, the more easily they diversify (*asignifying rupture*) to seek and construct their own knowledge, irrespective of their fields, providing support of their own learning. Lastly, another observation also showed that there is no clear termination point for these rhizomatic learning networks of students since their networks constantly grow and *multiply* through their existing connections.

6.2.2.3 What digital devices are owned by students in higher education?

The essential digital devices found were Laptop, Tablet or iPad, Smartphone and E-Reader (Dahlstrom & Jacqueline, 2014). The research also established the kind of operating systems that ran on the essential devices identified. Smartphone, Laptop and Tablet in all the three institutions in Africa, came out as top devices (Sharples *et al.,* 2014). Apart from 69% ownership of Smartphones among students in Ghana (GAC), results resonate with studies conducted by Song and Lee (2012) who also discovered 82% ownership of Smartphone among international business students in the United States of America. Even so, Ghana (GBR) recorded about 99% ownership, with the remaining 1% planning to own a Smartphone in the upcoming year. Finally, ownership of Laptops and sometimes Tablets were influenced by school policies (Ito, 2005; Czerniewicz & Brown, 2013; Mahenge & Sanga, 2016). For instance, almost all students in Ghana (GBR) owned a Laptop simply because there were no computer laboratories for those cohorts of students, directly opposite to the cohorts of South Africa (SAR) who had many computer laboratories at their disposal.

6.2.2.4 To what extent are the devices used by students perceived to be a promoter of their academic success?

This study revealed that digital devices play numerous roles as far as academic work is concerned. Each of the devices played varied roles but closely similar. Across all the institutions, Laptop and Smartphone appeared to be most important digital device that supported academic success though students all indicated that they also use it for other purposes as well. These findings are incongruous to Campbell (2005) and Hawkridge (1990) who find such digital devices are disruptive and luxurious learning tools. However, the findings are consistent with empirical studies by Backer (2010) and Warschauer *et al*. (2010) whose arguments suggest that students' knowledge and skills are built once they are versed in the use of digital devices for their learning.

6.2.2.5 There is no statistically significant difference among the four cohorts of students in terms of their self-perceived importance of handheld mobile devices for academic success

Self-perceived importance of handheld mobile devices for academic success differed among the four institutions. The differences can be accounted for by general willingness of faculty members to incorporate the devices into the curriculum (Day-Black & Merrill, 2015) and by policies (Blignaut *et al*., 2010). In terms of lecture room digital device usage, students perceive lecturers who do not allow them usage as unsupportive. Nonetheless, this research established that handheld mobile devices assist students to connect to peers and staff in real time (Eton, 2011; Boyd, 2014), download resources (Gupta & Koo, 2010); access information course materials and assignments from the university portal; and also allow for the compression of large resources to be in compressed and virtual formats. It was also found that students are reliant on these devices across institutions because it made learning more ubiquitous so that they could run their own checks to validate information from the Internet, and negotiate learning, especially through virtual groups.

In the final analysis, Hypothesis 1 was rejected on the grounds that the three sub-hypotheses all differed significantly at *Lecture room engagement & interaction* ($F_{3, 491}$= 5.832, p <.001), *Access to administrative resources* ($F_{3, 491}$= 7.642, p <.000) and *Communication & Information* ($F_{3, 491}$ = 14.345, p <.000) successively. The three constructs were also reliable at (α=.813), (α=.754), and (α=.683) accordingly, meaning the results can be relied upon for making educational determinations. The findings are congruent with Ng'ambi (2013) in that students find educational uses for digital devices with greater exposure to a variety of digital devices (Warschauer *et al.*, 2010).

6.2.2.6 There is no statistically significant difference among the four cohorts of students in terms of experiences with their university wireless networks

First and foremost, this sub-section is a follow-up on Henderson *et al.*'s (2008) research on emerged patterns of students' wireless network behaviour which is explicit to their experiences. Apart from the Belgian institution, students and lectures are dissatisfied with their university wireless networks in all three African institutions. One of the key findings deals with access and bandwidth, consistent with findings of Beeken (n.d.) and Pahlavan and Levesque (2005). While school authorities use bandwidth as an excuse, students and lecturers find this unacceptable. It was also found that university authorities in the African institutions block certain sites temporarily (*Facebook*) or permanently (*Skype*), especially social media sites, under the excuse of limited bandwidth or misuse of academic time for social activities. Students and lecturers find this intolerable since the problem here is not about the wireless infrastructure in higher education (Tess, 2013) but about excuses.

The emerging pattern discovered was that blockages are not deterrents to students or staff in the bid to access Internet or wireless networks elsewhere. This pattern exhibits traces of *asignifying rupture* and *connection* where there are breakaways in the search of resources to reconnect and support learning. The cost element of owning wireless network did not feature in any of the institutions, and this digresses from studies by Galbus (2001) and Oblinger and Oblinger (2005) pertaining to cost. Perhaps, wireless networks have been accepted as very important teaching and learning resource, irrespective of the cost.

Finally, findings align with research by Kim *et al.* (2007) that indicate the strong necessity for Internet and wireless networks to promote academic, research and administrative activities in higher education.

In sum, the hypothesis to measure the differences among the four cohorts of students' experiences with their university wireless networks was statistically significant ($F_{3,417}$= 69.017, p <.000), proving that there are differences among students' experiences with their university wireless networks and warranting a rejection of the hypothesis. A reliability test on the four items under this construct was found to be highly reliable (α = .813) implying that the results could aid decision making.

6.2.2.7 There is no statistically significant difference among the four cohorts of students in terms of their satisfaction level of Learning Management System in their institutions

To answer Hypothesis 3, two sub-hypotheses were formulated following a test for differences among the four cohorts of students. In the final analysis, Hypothesis 3 was rejected due to statistically significant differences in the two sub-hypotheses, *Information quality* ($F_{3,\ 417}$= 4.463, p <.004) and *User connectedness* ($F_{3,\ 418}$= 8.95, p <.000) which impacted Learning Management Systems in their institutions. From a reliability test performed on the two constructs, these items were found to be highly reliable: *Information quality* (α = .924), *User connectedness* (α = .863). The implication for this research is that the results can be depended upon for conclusions.

As part of pattern tracing in this study, this sub-research hypotheses also responds to Naveh *et al.* (2010) who recommended further research into the use and satisfaction of Learning Management Systems in more than one university. Though the analysis established differences across the institutions, the findings were not clear since results skewed more towards neutral satisfaction of institutional Learning Management System usage. This is an indication that students may not be relying so much on the institutional Learning Management Systems in their personal learning networks. Some of participants admitted to various levels of challenges with their Learning Management System and found ways of accessing general announcements through a 'watch dog' class representative who is active on the Learning Management System and relays information via other social networking sites. These findings corroborate findings from Green (2015) who noticed that a Learning Management System has pedagogical value except that there is limitation in terms of staff expertise of who can guide the students to appreciate it better. Lessons from BEL (Belgian institution) indicate that students are satisfied with their *Toledo* Learning Management System which has been customised and improved following constant research and feedback from students. This gesture supports Eton's (2011) first point that the 21st century student wants to be involved in his education.

6.2.2.8 There is no statistically significant difference among the four cohorts of students in terms of their experiences with the use of technology in their institutions

For students' experiences with technology in their institutions, results revealed statistically significant differences among the four cohorts in three of the sub-hypotheses formulated: *Techno-connection* ($F_{3,\ 485}$= 7.641, p <.000), *Pre-university orientation* ($F_{3,\ 485}$= 19.259, p <.000) and *Techademics* ($F_{3,\ 485}$= 3.851, p <.010); therefore, the three sub-research hypotheses were rejected. Results of sub-hypothesis on *Skipping of classes* were not rejected because it did not indicate statistically significant differences among the cohorts ($F_{3,\ 485}$= .757, p >.519). In terms of reliability, items under the three constructs were reliable at *Techno-connection* (α = .807), *Pre-university orientation* (α = .66) and *Techademics* (α = .51). In simple terms, we may depend on the results to influence decision.

There are variations in the experiences with technological usage among students in the institutions. This section is a culmination of all other sub-sections under in this research. Characteristics of the biological rhizome plant are evident in the experiences noticed. Students are connected and networked to construct knowledge through their personal learning networks. There is a level of constituency in literature that explains that current students take advantage of technological tools to support their personal learning networks, or at the least, provide opportunity (Cormier, 2008; Eton, 2011; Shelly *et al.*, 2012; Boyd, 2014). There is diversity in terms of the sources that are consulted for learning and the kinds of devices used by students. This diversity strongly shows signs of cartography and decalcomania. It shows that personal learning networks are maps but not tracings. These personal learning networks also get stronger through the principle of connection and multiplicity once a student finds a source useful to their personal learning networks. Students indicated that even though they rely heavily on Wikipedia, they rarely cite it because lecturers disregard it as a credible source. To be specific, the pattern of technology use by students is fluid and amenable to timely relevance. Hence, continuous research and discussions on this subject matter are critical to future curriculum development rather than holding to unilateral stance by certain institutions to ban aspects of technology or entire technology, as reported by Bita (2016). Results prove that after all, students are also comfortable with face-to-face interaction with humans in their personal learning network provided they could still leverage on technology to achieve learning goals. Finally, if higher education institutions claim to be providing international education to their students, then we must interrogate issues of technological influence in curriculum development.

6.2.3 Scientific reflection – The contribution of this study

Other than contributing to the body of knowledge in students' personal learning networks and technology use in higher education, a practical scientific contribution is that the findings from this research could inform curriculum development decisions involving technology in the four institutions. This research found 218 human and non-human actors in students' Rhizomatic Learning Networks in higher education. Furthermore, 164 lone (unique) actors were also established as playing various roles in the success of students' Rhizomatic Learning Networks.

Through the use of Rhizome Theory and Actor Network Theory as theoretical lenses, the real complexities in the use of technology in students' rhizomatic/personal learning networks are revealed. The complexities are better understood as fluid and dynamic because of students' constant engagement with technology. This research contributes to emerging issues underpinning students' use of technology in their rhizomatic/personal learning networks in higher education. Various actors in students' rhizomatic/personal learning networks have been identified to inform higher education curriculum decisions. The use of multiple sites, and numerical and narrative approaches, better explain the complexities from multiple perspectives and realities of the kind of patterns formed when personal learning networks of students are influenced by technology.

Aspects of this research serve as follow-up research on recommendations and gaps identified by Henderson *et al.* (2008) and Naveh *et al*. (2010) in their studies on university wireless network and Learning Management Systems. This research not only attempted to find answers to patterns and identify gaps, but it also located this substantive research in literature for the purposes of contextualisation. A number of other related issues that have emerged are the context within which all the objectives, research questions, sub-research questions and research hypotheses were formulated. They were formulated based on the provisions by FraIM purely on professional, theoretical and organisational grounds, rendering this research unique.

6.3 Recommendations

From the findings in this research, recommendations on the patterns of technological uses in higher education are presented under sub-headings to address policy, practice and further research.

6.3.1 Recommendations in relation to actors in students' rhizomatic personal learning network

This recommendation is based on the reason that this research found 164 lone (unique) actors among the institutions that played various roles in the success of students' Rhizomatic Learning Networks. Actors that occurred as lone actors in various institutions are worth investigating. The institutions should investigate further how uniquely those actors contribute to success in students' rhizomatic/personal learning networks. Knowing more about lone actors may inform certain learning practices in the institutions. An added advantage of these lone actors is that they would not incur financial cost to the institutions on sensitisation and trainings of how to engage them for learning.

6.3.2 Recommendations related to rhizomatic learning network maps

Because this research established the connections and learning resources that (actors) students in their rhizomatic/personal learning networks relate to, the following recommendation is made: since rhizomatic learning network maps give students the opportunity to explore and construct their own knowledge, periodic rhizomatic learning network maps in the institutions must be generated to advise students on their learning achievements.

6.3.3 Recommendations viz-a-viz digital device ownership and uses by students in their academics

On the basis of widespread ownership and use of Smartphones and laptops among students' across all the four institutions, the following recommendation is made: ownership and uses of digital devices should not be seen as the ultimate solution to all pedagogical challenges. Rather, institutions should leverage on the devices owned (especially Smartphones and laptops) by the students to support their learning.

6.3.4 Recommendations linked to handheld mobile devices towards academic success

Following the findings in this research, students will definitely find their own ways of integrating handheld mobile devices into their learning, even without institutional support. Hence, it is recommended that with the engagement of students, handheld devices are fully integrated (practically) into mainstream curriculum by curriculum developers and faculty. By so doing, some positive aspects of connecting with students in real-time, group collaborations, and compressing textbooks and lecture materials into lighter virtual formats will be harnessed.

6.3.5 Recommendations linked to university wireless network

The research found some limitations with respect to access and bandwidth in GAC and GBR, both in Ghana. Based on the limitations identified, the institutions should take steps to start the implementation of an inter-university-wide wireless network system such as Eduroam which exists in South Africa and Belgium. This, to some extent, will curtail excuses related to bandwidth issues raised by authorities and make Internet and university wireless network systems more ubiquitous in support of student learning.

The African universities in this research should rethink their stance on policies that promote the blocking of certain sites (namely *Facebook* and *Skype*) whether temporarily or permanently. The educational values of those sites should be explored further to the advantage of the personal learning networks of students in achieving their learning goals. Lessons from the Belgian university on *Eduroam* and wireless network can be useful to the African institutions.

6.3.6 Recommendations linked to Learning Management Systems

This recommendation is based on efficiency, and student and staff sense of ownership of Toledo (the Learning Management System in the Belgian university). Students and staff continuously customise Toledo to suit their use. From the findings in the Belgian university, conscientious effort by all three African universities to engage students and staff to make their Learning Management Systems more user-friendly is recommended.

6.3.7 Recommendations in relation to experiences with students' technological uses in their institutions

This recommendation is formulated on the fluidity of how students use and experience technology in the universities to advance their personal learning networks. The universities should engage in continuous research to explore how students can leverage on technology in their personal learning networks. The institutions and curriculum developers should have clear policies that exhibit a willingness to implement strategies to integrate technology in all areas of students' personal learning networks.

6.3.8 Recommendations for further research

Further research into the detailed roles performed by actors will be beneficial, particularly how individual technological actors relate to students personal learning networks. The in-depth roles played by actors to achieve learning goals by students could not be fully explored. This will help curriculum designers to understand what tools to recommend and for which tasks. Further research to include a wider sample could result in identifying more actors (especially technological) that match learning needs of students to achieve their learning goals.

6.4 Final thoughts

Knowledge and reports suggest that emerging technologies can support students to be prepared internationally to have competitive advantages for their future through emerging technologies. Institutions claim they are educating their students for the future at international standards. Why then are some institutions still lagging behind in integrating the relevant, basic and emerging technologies into teaching, learning and university operations?

6.5 Epilogue

If not handled with utmost professionalism, educational goals will remain unachieved because technology in education has become highly contentious due to varied differences in technology integration experiences in learning. It is hoped that the richness of this research will be beneficial to students, institutions and other educational researchers. It is hoped that institutions in Ghana, South Africa and Belgium will better strategise and leverage upon the usefulness of technology in learning and pedagogy in general.

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APPENDICES

Appendix A: Permit to use EDUCAUSE survey instruments

Application to adopt survey instrument for my doctoral study(6)

Eden Dahlstrom Sep 23 at 12:34 AM

To Me

CC Jody Tracy, Jamie Reeves

Kafui,

Thank you for sharing your interest in ECAR's student and faculty technology research. Yes, you have our permission to use the survey instruments for the 2014 research in part or in whole. Please cite the EDUCAUSE Center for Analysis and Research as the source of the survey items you choose to use, and please send us a brief summary of your most interesting findings when your research is complete. The latter allows us to curate a body of knowledge that is beyond what we can do in our own research shop.

Best of luck on your research,

-Eden

Eden Dahlstrom Director of Research

Data, Research, and Analytics

EDUCAUSE

Uncommon Thinking for the Common Good

1150 18th Street, NW, Suite 900 Washington, DC 20036

direct: 303.939.0330 | mobile: 530.903.2305 | educause.edu

Appendix B: Survey Instrument for Students

Student Technology Survey

Message to Participants and Informed Consent

Dear Participant,

Welcome to the Student Technology Survey. This survey should take you 10–15 minutes to complete, and your responses are anonymous. We ask questions about your experiences with and attitudes toward technology and your academic experiences. Your responses will help the researcher towards his doctoral degree. It will also help people in your university and beyond to understand how to use technology more effectively to benefit students. There is no right or wrong answers; we'd just like you to answer as honestly as you can. Participation in the survey is completely voluntary, and at any point you can choose to exit the survey.

Study Description

Technology is a critical part of students' experiences in higher education. This study explores technology ownership, use patterns, and expectations as they relate to the student experience. The results of this study can be used to improve IT services, increase technology-enabled productivity, prioritise strategic contributions of information technology to higher education, plan for technology shifts that impact students, and become more technologically competitive among peer institutions.

Conditions and Stipulations

1. I understand that all information I provide in this survey will be kept confidential. I will not be personally identified in any reports. I agree to complete this survey for research purposes and that the data derived from this anonymous survey may be made available to my academic institution in unitary and aggregate formats and/or to the general public in the form of public presentations, reports, journals or newspaper articles, and/or in books.
2. I understand the survey involves questions about my information technology (IT) experiences and expectations in higher education. Beyond demographics, all questions will address IT-related issues.
3. I understand that this survey is expected to take 15–20 minutes to complete. I understand that my participation in this research survey is totally voluntary and that declining to participate will involve no penalty or loss of benefits. Choosing not to participate will not affect my college/university status in any way. If I choose, I may discontinue my participation at any time. I also understand that if I choose to participate, I may decline to answer any question that I am not comfortable answering.

4. I understand that I can contact the researcher through Kafuiaheto@yahoo.com if I have any questions about the research survey and my rights as a participant. I understand that the survey does not contain any questions that are a foreseeable risk, nor any questions likely to create discomfort to participants. I am aware that my consent will not directly benefit me, but will provide data to inform higher education institutions on how to best improve IT experiences for students and faculty.
5. Responses will be kept confidential to the degree permitted by the technology used. However, no absolute guarantee can be given for the confidentiality of electronic data. Your survey responses are anonymous; once responses are submitted, the researchers will not be able to identify you or remove anonymous data from the database should you wish to withdraw it. The University of Cape Peninsula and Technology in South Africa owns the data collected for the project. These data are contained in systems that can only be accessed through password protected accounts of the researcher.
6. By ticking **"I agree"** below I freely provide consent and acknowledge my rights as a voluntary research participant as outlined above and provide consent to the researcher and his institution to use my survey responses in the technology research in the academic community projects.

☐ I agree ☐ I do not agree

Section 1: About You

1.1 Institution* ______SAR _______GAC _______GBR_______BEL

1.2 Are you _____on campus _____off campus _____a distance learning student

1.3 Region* ____

1.4 Centre* *(For Distance Education Students only)*: ______________________

1.5 Course offered* *(E.g. M.Ed IT, PDE, B.com DBE,)* ______________________

1.6 Year of Study/level* ____

1.7 Gender* ______ Male______ Female

1.8 What is your age?* ____

1.9 Race?*______ Black ______ Coloured ______ White ______

Other (*Please specify*)__________________

Section 2: Device Use and Ownership

2.1 Do you own any of these devices?

Device	No, and I don't plan to purchase one within the next 12 months.	No, but I plan to purchase one within the next 12 months.	Yes, I currently own one (or more).
Laptop	<<skip 2.2a>>	<<skip 2.2a>>	
Tablet or iPad	<<skip 2.2b>>	<<skip 2.2b>>	
Smartphone	<<skip 2.2c>>	<<skip 2.2c>>	
E-reader	<<skip 2.2d>>	<<skip 2.2d>>	

2.2a What type of operating system (OS) does your *laptop* have?

If you have more than one *laptop*, please select the one that you use most often for school-related work.

( ) Windows ( ) Mac ( ) Linux ( ) Other ( ) Don't know

2.2b What type of operating system (OS) does your *tablet or iPad* have?
If you have more than one *tablet*, please select the one you use most often for school-related work.

( ) iOS (iPad) ( ) Windows OS ( ) Android OS ( ) BlackBerry OS ( ) webOS ( ) Other OS ( ) Don't know

2.2c What type of *Smartphone* do you have?
If you have more than one *Smartphone*, please select the one that you use most often for school-related work.

( ) iPhone ( ) Android phone ( ) Windows phone ( ) BlackBerry phone ( ) Other Smartphone ( ) Don't know

2.2d What type of *E-reader* do you have?
If you have more than one *E-reader* , please select the one that you use most often for school-related work.

( ) Kindle ( ) Kobo ( ) Nook ( ) Sony Reader ( ) Other E-reader ( ) Don't know

2.3 Regardless of whether you own one, please tell us how you use each device.

Device	Haven't used in the past year	Use for academic and other purposes	Use for academic purposes only	Use for other purposes only
Laptop	<<skip 2.4/2.5/3.3>>			
Tablet or iPad	<<skip 2.4/2.5/3.3>>			
Smartphone	<<skip 2.4/2.5/3.3>>			
E-reader	<<skip 2.4/2.5/3.3>>			

2.4 How important is each device to your academic success?

Device	Not at all important	Not very important	Moderately important	Very important
Laptop				
Tablet or iPad				
Smartphone				
E-reader				

2.5 How important is it that you are able to do the following activities *from a handheld mobile device* (e.g., Smartphone or tablet)?

Item	Not at all important	Not very important	Moderately important	Very important
Access library resources				
Check grades				
Register for courses				
Use the course or Learning Management System (e.g., Blackboard, Moodle, etc.)				
Access information about events, student activities				
Read e-texts				
Communicate with other students				
Look up information while in class				
Capture static images of in-class activities or resources				
Record your instructor's lecture or in-class activities				
Participate in interactive class activities				
Use the mobile device as a digital passport for access resources				

Section 3: Technology and the College/University Experience

3.1 Thinking about the past year, please rate your experiences with college/university wireless networks:

Item	Poor	Fair	Neutral	Good	Excellent
Reliable access to Wi-Fi throughout campus					
Reliable access to Wi-Fi specifically in classroom/instructional spaces					
Ease of login to Wi-Fi network(s) provided by the institution					
Network performance (e.g., speed/bandwidth)					

3.2 Please indicate your satisfaction with the following activities associated with the Learning Management System (e.g., Blackboard, Moodle, Sakai, Desire2Learn, Canvas by Instructure) at your institution.

Item	Not offered	Don't use this feature at all	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Accessing course content							
Managing your assignments							
Checking course progress							
Accessing information about your institution's news, events, or activities							
Submitting assignments reliably							
Engaging in meaningful interactions with other students							
Collaborating on groups work							
Meaningful online interactions with your instructors							
timely feedback on assignments							
meaningful feedback on assignments							
Overall satisfaction							

Section 4: Learning Environments

4.1 To what extent do you agree with the following statements?

Item	Don't know	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
I get more actively involved in courses that use technology.						
I am more likely to skip classes when materials from course lectures are available online.						

Item	Don't know	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
When I entered college, I was adequately prepared to use technology needed in my courses.						
Technology makes me feel more connected to what's going on at the college/university.						
Technology makes me feel connected to other students.						
Technology makes me feel connected to instructors.						
In-class use of mobile devices is distracting.						
When it comes to social media (e.g., *Facebook, Twitter, LinkedIn*), I like to keep my academic life and my social life separate.						
I wish I had been better prepared to use institutionally specific technology (e.g., the course registration system, the Learning Management System, the library search system) when I first started college/university.						
I wish I had been better prepared to use basic software programs and applications (e.g., MS Office, Google Apps, etc.) when I first started college/university.						

4.2 Tell us ONE thing that *your instructors* can do with technology to better facilitate or support your academic success.

___

4.3 Tell us ONE thing that *your institution* can do with technology to better facilitate or support your academic success.

___

4.4 When you need technology support or assistance for school-related activities, which sources to you typically use? Select all that apply.

[ ] Ask your peers, friends, or family [ ] Ask your instructors or teaching assistants
[ ] Contact the company or vendor [ ] Use the college/university help-desk services
[ ] Search Google, YouTube, or another online source
[ ] Other, please specify: ____________________________________

Section 5: Your Personal Computing Environment

5.1 How many Internet-capable devices do you own? Only include devices you actively use.

( ) None ( ) One ( ) Two ( ) Three ( ) Four ( ) Five ( ) Six or more

5.2 What is your typical in-class experience with the following devices?

Device	N/A	Banned from using it in class	Discouraged from using it in class	Neither discouraged nor encouraged about using it in class	Encouraged to use it in class	Required to use it in class
Smartphone						
Tablet or iPad						
Laptop						
Wearable technologies (e.g., Google Glass)						

5.3 Which social media platform(s) support(s) you in learning?

____

____

5.4 Which online platform(s) or websites do you usually use to support your assignments/learning?

____

____

Any comments? ____

Thank you for participating in this survey!

Appendix C: Interview Guide for Student Focus Group

Cape Peninsula University of Technology

Interview Guide for Focus group (students)

Research Title: Patterns of the use of technology by students in Higher education

Research Aim: To explore the underpinnings of students' technology use in their personal learning networks in higher educational environment.

Problem Statement: The contributions made by students in curriculum planning and development are equally important inputs to achieving the learning outcomes of students (Niemiec & Ryan 2009; Smyth, 2012). Despite a continuous growth of students personal learning networks founded on connections owing to emerging technologies in the 21st Century (Richardson & Mancabelli, 2012); curriculum developers and educators in higher education have failed to engage students to find out the extent to which students' personal learning networks are underpinned by rhizomatic model and anchored to a pervasive technological era which exposes students to multiple sources of formal and informal learning connections (Pineda, 2013; Dron & Anderson, 2016).

Research Question:

To what extent does technological influence on students' personal learning networks show traces of Rhizomatic Learning in higher education?

PART A

Characteristics of self-directed learners in a connected environment

1. On the scale of 1 to 5 (lowest to highest), how would you rate yourself in terms of technology use for learning?
2. Discuss how you learn through your personal network.
3. Discuss the role of human beings your learning network?
4. Which technologies* support you in learning?
5. Discuss how these technologies* support you in learning?
6. Discuss the disadvantages/limitations that come with the technologies* you use in learning?

   ** means: apps, platforms, devices, etc*

PART B

Construction of personal learning networks (rhizomatic maps)

7. Please draw your personal learning network by showing the connection/ relationship(s) **between** you and the machines, software and people in your learning network.
8. Please draw a collective learning network and show who learns from whom and what is learnt. Also show what student A learns from B's friends/network and vice versa. (Please include people, machines and tools).

Any comment?

Thank you

Appendix D: Interview Guide for Lecturers

Cape Peninsula University of Technology

Interview Guide for Specialists (One-on-one)

Research Title: Patterns of the use of technology by students in Higher Education
Research Aim: To explore the underpinnings of students' technology use in their personal learning networks in higher educational environment.

PART A
Demographic Details

University: ………………………………………………………………………………

Faculty: ………………………………………………………………………………….

Field of Expertise: …………………………………………………………………….

Profession: ……………………………………………………………………………...

Highest educational level: …………………………………………………………

Gender: Male/ Female

Age: …………………….

PART A
Characteristics of self-directed learners in a connected environment

1. On the scale of 1 to 5 (lowest to highest), how would you rate yourself in terms of technology use for teaching?
2. With the current proliferation of technology do you see any changes in how higher education students learn as compared to the years when you started teaching in the university?
3. On the scale of 1 to 5 (lowest to highest), what will be your rating on how institutions of higher education use technology to support learning in your country?

4. Discuss changes in the trend of how students learn as compared to about 5 years ago.
5. Discuss how students learn through their personal network.
6. Discuss your role as a lecturer in the learning network of students.
7. Discuss how the role of human beings your learning network?
8. Discuss how these technologies* support them in learning?
9. Discuss the disadvantages/limitations that come with the technologies* you use in learning?

   ** means: apps, platforms, devices, etc*

Any comment?

Thank you

Appendix E: Introductory Letter from Supervisor for Data Collection

Cape Peninsula University of Technology

Introductory letter for the collection of research data

Mr. Simon-Peter Kafui Aheto is registered for the Doctor of Technology (IT) degree at CPUT (**214267024**). The thesis is titled **Patterns of the use of technology by students in higher education**, and aims to **explore the underpinnings of students' technology use in their personal learning networks in higher educational environment**. The supervisor for this research is:

Prof. Johannes C. Cronjé,
Dean, Faculty of Informatics and Design
Cape Peninsula University of Technology
Cape Town
South Africa
Tel: (0027)214691018
cronjej@cput.ac.za

In order to meet the requirements of the university's Higher Degrees Committee (HDC) the student must get consent to collect data from organisations which they have identified as potential sources of data. In this case the student will use **interviews**, **observations, rhizomatic network maps** and **questionnaires** to gather data from random students in the university.

If you agree to this, you are requested to complete the attached form (an electronic version will be made available to you if you so desire) and print it on your organisation's letterhead.

For further clarification on this matter please contact either the supervisor(s) identified above, or the Faculty Research Ethics Committee secretary (Ms V Naidoo) at 021 4691012 or naidoove@cput.ac.za.

Yours sincerely
Prof. Johannes C. Cronjé
Dean, Faculty of Informatics and Design
26 May, 2014

Appendix F: Individual Consent Form for Research Participation

Cape Peninsula
University of Technology

FID/REC/ICv0.1

<u>FACULTY OF INFORMATICS AND DESIGN</u>

Individual Consent for Research Participation

Title of the study: **Patterns of the use of technology by students in higher education**

Name of researcher: Simon-Peter Kafui Aheto
Contact details: email: kafuiaheto@yahoo.com/ kafuiaheto@gmail.com phone: 0027-619339302 (SA) 00233-244222904 (Gh)

Name of supervisor: Prof. Johannes C. Cronjé
Contact details: email: cronjej@cput.ac.za phone: 0027-825585311

Purpose of the Study: The aim of the proposed research is to explore the underpinnings of students' technology use in their personal learning networks in higher educational environment.

Participation: My participation will consist essentially as an interviewee, mind-mapper and a participant to be observed.

Confidentiality: I have received assurance from the researcher that the information I will share will remain strictly confidential unless noted below. I understand that the contents will be used only for Doctor of Technology thesis, conference papers, workshops and journal articles and that my confidentiality will be protected keeping data gathered from me safe in a password protected computer and used only for the purposes of the study unless for *audit purposes*.

Anonymity will be protected in the following manner by not disclosing my identity by reporting data as whole but not per individual participants, where necessary to use names, I understand that pseudonyms shall be used in referring to me.

Conservation of data: The data collected will be kept in a secure manner that data gathered from me shall be kept safe in a password protected computer and used only for the purposes of the study unless for *audit purposes.*

Voluntary Participation: I am under no obligation to participate and if I choose to participate, I can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences. If I choose to withdraw, all data gathered until the time of withdrawal will be destroyed.

Additional consent: I make the following stipulations (please tick as appropriate):

	In thesis	**In research publications**	**Both**	**Neither**
My image may be used:				
My name may be used:				
My exact words may be used:				
Any other (stipulate):				

Acceptance: I, __***(Name of respondent or participant)***__ agree to participate in the above research study conducted by Mr. Simon-Peter Kafui Aheto of the Faculty of Informatics and Design, Information Technology Department at the Cape Peninsula University of Technology, which research is under the supervision of Prof. Johannes C. Cronjé.

If I have any questions about the study, I may contact the researcher or the supervisor. If I have any questions regarding the ethical conduct of this study, I may contact the secretary of the Faculty Research Ethics Committee at 021 469 1012, or email naidoove@cput.ac.za.

Participant's signature: ______________________________ Date: ______________________

Researcher's signature: ______________________________ Date: ______________________

Appendix G: Letter of Invitation as a Visiting Scholar in Belgium

KU LEUVEN

INTERNATIONAL ADMISSIONS AND MOBILITY
NAAMSESTRAAT 63 BOX 5410
3000 LEUVEN, BELGIUM

Mr Simon-Peter Kafui Aheto
Roeland Street 80
8000 Capetown
South Africa

OUR REFERENCE TOELVisVISA / SESUP
YOUR REFERENCE ID 0609334 / Contract 000000071765
LEUVEN 2015-04-17

LETTER OF INVITATION
Visiting Scholar - Short stay
Aheto Simon-Peter Kafui, Ghana, 1981-07-13

Dear Mr Aheto,

We are pleased to inform you that you have been accepted by the Academic Authorities of the KU Leuven for a short study visit.

You are invited as a Visiting Scholar from 2015-05-12 to 2015-06-15 for a study visit at the Faculty of Engineering Science. Your academic host will be Prof. Dr. Erik Duval.

You will be granted accident and medical insurance during your stay cfr. insurance policy number 9.600.639 between the KU Leuven Association and AIG (see attachment).

Follow carefully the instructions on the reverse side of this letter.

We look forward to having you among our scholars and wish you an enriching study period.
Yours sincerely,

Jan Raeymaekers
Head of Organisation of Teaching and Learning Processes
for
International Admissions and Mobility Unit

Copy: Prof. Dr. Erik Duval

MEMBER OF ASSOCIATIE KU LEUVEN

Appendix H: Permit for Data Collection at GAC

[illegible]

TO WHOM IT MAY CONCERN

INTRODUCTORY LETTER FOR THE COLLECTION OF RESEARCH DATA
MR. SIMON-PETER KAFUI AHETO

I, [illegible], in my capacity as the Senior Assistant Registrar at the [illegible] give consent in principle to allow Mr. Simon-Peter Kafui Aheto, a student at the Cape Peninsula University of Technology, to collect data in this university as part of his Doctor of Technology (IT) research. The student has explained to me the nature of his research and the nature of the data to be collected.

This consent in no way commits any individual student to participate in the research, and it is expected that the student will get explicit consent from any participant. I reserve the right to withdraw this permission at some future time.

I shall therefore be grateful if he is given the necessary assistance needed.

We count very much on your co-operation.

[illegible]
Senior Assistant Registrar [illegible]
For: **REGISTRAR**

[illegible]

Appendix I: Permit for Data Collection at SAR

<u>TO WHOM IT MAY CONCERN</u>

I **Prof.** [redacted], in my capacity as **Deputy Vice Chancellor: Academic** at [redacted] give consent in principle to allow **Mr. Simon-Peter Kafui Aheto**, a student at the Cape Peninsula University of Technology, to collect data in this university as part of his **Doctor of Technology (IT)** research. The student has explained to me the nature of his research and the nature of the data to be collected.

This consent in no way commits any individual student to participate in the research, and it is expected that the student will get explicit consent from any participant. I reserve the right to withdraw this permission at some future time.

In addition, the university's name may or may not be used as indicated below. (Tick as appropriate)

	Thesis	**Conference paper**	**Journal article**	**Research poster**
Yes	√	√	√	√
No				

Prof. [redacted]

June 4, 2014

Appendix J: Permit for Data Collection at GBR

[redacted]

<u>TO WHOM IT MAY CONCERN</u>

I **Dr.** [redacted], in my capacity as **Head of Department of** [redacted] at [redacted] give consent in principle to allow **Mr. Simon-Peter Kafui Aheto**, a student at the Cape Peninsula University of Technology, to collect data in this university as part of his **Doctor of Technology (IT)** research. The student has explained to me the nature of his research and the nature of the data to be collected.

This consent in no way commits any individual student to participate in the research, and it is expected that the student will get explicit consent from any participant. I reserve the right to withdraw this permission at some future time.

In addition, the university's name may or may not be used as indicated below. (Tick as appropriate)

	Thesis	**Conference paper**	**Journal article**	**Research poster**
Yes	√	√	√	√
No				

Dr. [redacted]

February 15, 2015

Appendix K: Cross tabulation of Rhizomatic Learning Actors per Institution

S/N	Actor	Institutions				Category of actor						
		GAC	GBR	SAR	BEL	D	P/S	Sm	OT	P& P	Int	H
Convergence of all 4 institutions (GAC, GBR, SAR and BEL)												
1	Coursera$_{abcd}$	■	■	■	■		■					
2	Dropbox$_{abcd}$	■	■	■	■		■					
3	Email$_{abcd}$	■	■	■	■		■					
4	*Facebook*$_{abcd}$	■	■	■	■			■				
5	Google$_{abcd}$	■	■	■	■		■					
6	Laptop$_{abcd}$	■	■	■	■	■						
7	Lecturers$_{abcd}$	■	■	■	■						■	■
8	Twitter$_{abcd}$	■	■	■	■			■				
9	Wikipedia$_{abcd}$	■	■	■	■		■					
10	YouTube$_{abcd}$	■	■	■	■		■	■				
Convergence of 3 institutions(GAC, GBR and SAR)												
11	Books$_{abc}$	■	■	■						■		
12	Gmail$_{abc}$	■	■	■			■					
13	Internet$_{abc}$	■	■	■			■					
14	LinkedIn$_{abc}$	■	■	■			■					
15	Microsoft Office Suite$_{abc}$	■	■	■			■					
16	Peers$_{abc}$	■	■	■								■
17	Photoshop$_{abc}$	■	■	■			■					
18	Skype$_{abc}$	■	■	■			■	■				
19	Smartphone$_{abc}$	■	■	■		■						
20	*WhatsApp*$_{abc}$	■	■	■				■				
Convergence of 2 institutions (GBR and SAR)												
21	Academia.edu$_{bc}$		■	■			■	■				
22	Adobe Reader$_{ac}$	■		■			■					
23	Adobe Suite$_{bc}$		■	■			■					
24	Articulate$_{ac}$	■		■			■					
25	Camtasia Studio$_{bc}$		■	■			■					
26	Cloud$_{bc}$		■	■			■					
27	Computer$_{cd}$			■	■	■						

S/N	Actor	Institutions				Category of actor						
		GAC	GBR	SAR	BEL	D	P/S	Sm	OT	P& P	Int	H
28	Corel Draw $_{ac}$	■		■			■					
29	Desktop Computer $_{ac}$	■		■		■						
30	Google Drive $_{ab}$	■	■				■					
31	Instagram $_{ac}$	■		■				■				
32	iPad $_{ab}$	■	■			■						
33	iTuneU $_{cd}$			■	■		■	■				
34	Library $_{ab}$	■	■						■	■		
35	Microsoft Excel $_{ac}$	■		■			■					
36	Microsoft Powerpoint $_{ac}$	■		■			■					
37	Microsoft Word $_{ac}$	■		■			■					
38	Mobile phone $_{bc}$		■	■		■						
39	Packet Tracer $_{ac}$	■		■			■					
40	People $_{bd}$		■		■							■
41	Pinterest $_{bc}$		■	■				■				
42	Podcast $_{cd}$			■	■			■				
43	Radio $_{ac}$	■		■		■						
44	Samsung chat $_{ac}$	■		■				■				
45	Slideshare $_{bc}$		■	■				■				
46	Soundcloud $_{bc}$		■	■			■					
47	Tablet $_{ab}$	■	■			■						
48	Tango $_{ac}$	■		■				■				
49	TED Talks $_{bc}$		■	■			■	■				
50	Textbooks $_{ac}$	■		■						■		
51	Viber $_{ac}$	■		■				■				
52	Voice recorder $_{ac}$	■		■		■						
53	Wondershare $_{ac}$	■		■			■	■				
54	Wordpress $_{ac}$	■		■			■					
Lone actors												
55	7-zip $_{c}$			■			■					
56	Academic papers $_{b}$		■				■					
57	Adobe Creation Suite $_{b}$		■				■					
58	Adobe Flash $_{c}$			■			■					
59	Adobe Photoshop $_{c}$			■			■					

S/N	Actor	Institutions				Category of actor						
		GAC	GBR	SAR	BEL	D	P/S	Sm	OT	P& P	Int	H
60	Adobe Photoshop Lightroom $_c$			■			■					
61	Adobe Premiere Pro $_c$			■			■					
62	Adobe Suite App $_b$		■				■					
63	Amazon $_a$	■					■					
64	Apple Aperture $_c$			■			■					
65	Articles $_b$		■							■		
66	Ask.com $_b$		■				■					
67	Assembler $_c$			■			■					
68	Audacity $_c$			■			■	■				
69	Basic English Dictionary $_b$		■				■			■		
70	BBC $_b$		■				■	■				
71	Bitbucket $_d$				■		■					
72	Blackboard $_c$			■			■	■				
73	Blogger $_c$			■			■	■				
74	Blogs $_c$			■				■				
75	Bump User $_b$		■				■					
76	Buzzfeed $_c$			■			■	■				
77	Cambridge dictionary $_b$		■					■				
78	Camera $_c$			■		■	■					
79	Chrome $_b$		■				■					
80	Colleagues $_b$		■									■
81	Conferences $_b$		■							■	■	
82	Corel Painter $_b$		■				■					
83	Delicious $_b$		■					■				
84	Dictionary $_b$		■							■		
85	Docs to go $_c$			■			■					
86	E-books $_b$		■				■	■				
87	Edmondo $_c$			■			■					
88	Electronic Language Platform $_d$				■		■					
89	Emo $_a$	■						■				
90	Encarta $_a$	■					■					
91	Endnote $_c$			■			■					
92	Everest $_c$			■			■					
93	Evernote $_c$			■			■					

S/N	Actor	Institutions				Category of actor						
		GAC	GBR	SAR	BEL	D	P/S	Sm	OT	P& P	Int	H
94	Face-to-Face $_{a}$	■										■
95	Farlex dictionary $_{b}$		■				■					
96	Feedly $_{c}$			■			■					
97	Filters $_{c}$			■			■					
98	Firefox $_{b}$		■				■					
99	Foursquare $_{c}$			■				■				
100	Freefullpdf.com $_{b}$		■				■					
101	GIMP $_{c}$			■			■					
102	Git $_{d}$				■		■					
103	Gitab $_{c}$			■			■					
104	Google Calendar $_{c}$			■			■	■				
105	Google Chrome $_{c}$			■			■					
106	Google documents $_{d}$				■		■					
107	Google Keep $_{b}$		■				■					
108	Google Nexus 4 $_{b}$		■			■						
109	Google Scholar $_{b}$		■				■					
110	Google+ $_{c}$			■				■				
111	Guardian $_{c}$			■			■	■				
112	Hangouts $_{c}$			■				■				
113	Indesign $_{c}$			■			■					
114	Instar $_{b}$		■				■					
115	iPod $_{d}$				■	■						
116	iSpring $_{a}$	■					■					
117	JSTOR $_{d}$				■		■					
118	Khan Academy $_{c}$			■			■	■				
119	Kindle $_{c}$			■		■						
120	Kingsoft Office $_{c}$			■			■					
121	Lecturer $_{c}$			■							■	■
122	Lectures $_{a}$	■									■	
123	Lightroom $_{c}$			■			■					
124	Limo $_{d}$				■		■					
125	Linux Chat $_{c}$			■				■				
126	Media24 $_{c}$			■			■	■				
127	Memory card $_{c}$			■		■						

		Institutions				Category of actor						
S/N	Actor	GAC	GBR	SAR	BEL	D	P/S	Sm	OT	P& P	Int	H
128	Mendeley$_{b}$		■				■	■				
129	Mentors$_{d}$				■						■	■
130	Microsoft Paint$_{b}$		■				■					
131	MIT Open software$_{c}$			■			■					
132	Mixlr$_{c}$			■				■				
133	Modules$_{a}$	■										■
134	Moon reader$_{c}$			■			■		■			
135	Motivational messages$_{b}$		■									■
136	Microsoft Access$_{a}$	■					■					
137	Microsoft Visio$_{c}$			■			■					
138	Nero burning$_{c}$			■			■					
139	NetBeans$_{c}$			■			■					
140	News24$_{c}$			■			■	■				
141	News24 App$_{c}$			■			■	■				
142	Newspaper$_{c}$			■				■		■		
143	Nexvel Soft$_{a}$	■					■					
144	Notepad$_{c}$			■			■					
145	Observation$_{b}$		■								■	
146	Online Lectures$_{d}$				■		■					
147	Open Yale$_{d}$				■		■					
148	Openculture$_{d}$				■		■					
149	Opera Mini browser$_{a}$	■					■					
150	Opera Mini App$_{b}$		■				■					
151	Paint$_{c}$			■			■					
152	Parents$_{c}$			■								■
153	PDF documents$_{a}$	■					■					
154	PDF readers$_{c}$			■			■					
155	Pen and paper$_{b}$		■							■		
156	Phone$_{d}$				■	■						
157	Photo Editor$_{c}$			■			■					
158	Photo Grid$_{c}$			■			■					
159	Photo Editor Ultimate$_{c}$			■			■					
160	Photoscape$_{c}$			■			■					
161	Picasa$_{c}$			■				■				

S/N	Actor	Institutions				Category of actor						
		GAC	GBR	SAR	BEL	D	P/S	Sm	OT	P& P	Int	H
162	Plagiarism checker $_{c}$			■			■					
163	Pocket $_{c}$			■			■					
164	Projector $_{c}$			■		■						
165	Python $_{a}$	■					■					
166	QR codes $_{c}$			■				■				
167	Quick Star $_{b}$		■				■					
168	Quickoffice $_{c}$			■			■					
169	Real Player $_{c}$			■			■					
170	Refme $_{c}$			■			■					
171	Remember $_{c}$			■			■					
172	Research Assistants $_{c}$			■							■	■
173	Researchgate $_{c}$			■			■	■				
174	Scholarley $_{b}$		■				■	■				
175	Seminars $_{b}$		■								■	■
176	Sharedpoint $_{c}$			■			■	■				
177	Shutterstock $_{b}$		■				■					
178	Sketch notes $_{b}$		■							■		
179	Slack $_{d}$				■			■				
180	Smart recorder $_{c}$			■		■						
181	Snipping Tool $_{c}$			■			■					
182	Stack Overflow $_{d}$				■			■				
183	Study group $_{a}$	■									■	■
184	Study group calls $_{a}$	■							■		■	■
185	Super sport $_{c}$			■			■	■				
186	Team viewer $_{c}$			■			■	■				
187	Telegam $_{a}$	■						■				
188	Tietor $_{b}$		■				■					
189	Timeslive $_{c}$			■			■	■				
190	Toledo $_{d}$				■		■					
191	Tripod $_{c}$			■		■						
192	Tumblr $_{c}$			■				■				
193	Tweet Deck $_{c}$			■				■				
194	UC Browser $_{c}$			■			■					
195	University's website $_{a}$	■					■					

S/N	Actor	Institutions				Category of actor						
		GAC	GBR	SAR	BEL	D	P/S	Sm	OT	P& P	Int	H
196	uTorrent $_c$			■			■					
197	Viper $_a$	■					■					
198	Visual Basic $_a$	■					■					
199	Visual Studio $_c$			■			■					
200	VLC media player $_c$			■			■					
201	Voice calls $_a$	■					■					
202	Voice memos $_c$			■			■					
203	Voicemail $_a$	■					■					
204	VSCO Cam $_c$			■			■					
205	W3Schools $_a$	■					■					
206	Wacom Tablet $_b$		■			■						
207	Wavepad $_c$			■			■					
208	WeChat $_a$	■						■				
209	Wiki $_d$				■		■					
210	Wikispace $_c$			■			■	■				
211	Wina $_d$				■		■	■				
212	WinRaR $_c$			■			■					
213	Wix $_c$			■			■					
214	WIZIQ $_c$			■			■					
215	WordWeb $_b$		■				■					
216	Word Processing $_c$			■			■					
217	Workshops $_a$	■									■	
218	Ymail $_b$		■				■					
Total		**64**	**72**	**135**	**31**	**19**	**147**	**55**	**3**	**10**	**11**	**14**

Category/Factors

1. D-Devices
2. P/S-Platforms/Software
3. Social media
4. OT-Other technologies
5. P & P-Pen and paper
6. Interaction
7. Humans

Interpretation of subscripts

a	= GAC only	bc	= GBR and SAR only
b	= GBR only	cd	= SAR and BEL only
c	= SAR only	abc	= GAC, and SAR only
d	= BEL only	abd	= GAC, and BEL only
ab	= GAC and only	acd	= GAC, SAR and BEL only
ac	= GAC and SAR only	bcd	= GBR, SAR and BEL only
ad	= BEL only	abcd	= GAC, SAR and BEL

Appendix L: Actors in the rhizomatic learning network based on how they occur

Number of occurrences of actors	Percentage
164 actors that occurred once	75.2%
34 actors occurred two times	15.6%
10 actors occurred three times	4.6%
10 actors occurred four times	4.6%
Total actors =218	100%

Appendix M: Numeric analysis of rhizomatic learning network relationships of GAC

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
Adobe Reader	5.988802	0.352423	5	0.364482	0.093
Amazon	0	0.329218	1	0.074409	
Articulate	1.807272	0.321285	2	0.114074	
Books	1.339431	0.337553	2	0.1286	
Corel Draw	0	0.329218	1	0.074409	
Coursera	10.29758	0.358744	5	0.273854	
Desktop Computer	48.7667	0.446927	7	0.444843	
Dropbox	6.676513	0.334728	4	0.215947	
Email	5.074348	0.355556	3	0.201799	
Emo	0	0.29304	1	0.049202	
Encarta	2.405375	0.334728	4	0.265945	
Facebook	178.8793	0.536913	14	0.856057	
Face-to-Face	10.51781	0.358744	7	0.479006	
GAD Study group	1.070002	0.321285	3	0.185304	
GAD Study group calls	1.070002	0.321285	3	0.185304	
GAD1	277.478	0.444444	23	**0.946665**	
GAD2	197.1872	0.425532	19	0.793653	
GAD3	87.41659	0.408163	15	0.628372	
GAE Study group	1.967767	0.337553	4	0.293702	
GAE Study group calls	1.967767	0.337553	4	0.293702	
GAE1	289.8631	0.454545	**25**	**0.990883**	
GAE2	119.2788	0.425532	19	0.838468	
GAE3	198.5529	0.444444	23	**1**	
GAE4	289.3371	0.449438	**24**	0.934251	
GAI1	190.843	0.416667	17	0.642691	
GAI2	224.1016	0.421053	18	0.68202	
GAI3	142.4294	0.421053	18	0.687394	
GAI4	**774.5888**	0.487805	**31**	0.92175	
GAT1	**347.2637**	0.444444	23	0.815041	
GAT2	**307.7664**	0.412371	16	0.620412	
GAT3	85.9156	0.40404	14	0.624743	
GAT4	268.9779	0.416667	17	0.667528	
Gmail	0	0.329218	1	0.074409	
Google	206.0603	**0.551724**	15	0.92926	
Google drive	6.676513	0.334728	4	0.215947	
Instagram	13.60952	0.390244	5	0.312099	

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
Internet	69.27916	0.437158	10	0.645655	
iPad	6.991616	0.368664	3	0.190395	
Ispring	5.252492	0.361991	3	0.193874	
Laptop	118.0223	0.509554	11	0.675188	
Lecturers	0	0.295203	1	0.052788	
Lectures	1.339431	0.337553	2	0.1286	
Library	68.29127	0.467836	8	0.524974	
LinkedIn	48.00467	0.437158	8	0.499258	
Microsoft Access	5.848219	0.349345	4	0.234307	
Microsoft Excel	10.82103	0.390244	3	0.225094	
Microsoft Office Suite	9.355968	0.372093	4	0.244988	
Microsoft Powerpoint	184.8024	**0.544218**	14	0.879962	
Microsoft Word	7.32193	0.352423	6	0.405067	
Modules	10.51781	0.358744	7	0.479006	
Nexvel. oft	0	0.30888	1	0.073939	
Opera Mini browser	0.680986	0.334728	2	0.129002	
Packet Tracer	0	0.295203	1	0.051114	
PDF documents	0.359122	0.311284	2	0.113957	
Peers	56.04952	0.457143	8	0.549432	
Photoshop	0	0.329218	1	0.074409	
Python	0	0.329218	1	0.074409	
Radio	0	0.311284	1	0.073202	
Samsung chat	3.633618	0.343348	4	0.258506	
Skype	43.10533	0.39801	7	0.39914	
Smartphone	80.45995	0.441989	11	0.694953	
Tablet	0	0.295203	1	0.052788	
Tango	0	0.29304	1	0.049202	
Telegam	3.367552	0.358744	2	0.139281	
Textbooks	0	0.313725	1	0.077482	
Twitter	0.237139	0.321285	2	0.150994	
University's website	0	0.29304	1	0.049202	
Viber	118.8079	0.503145	11	0.710727	
Viper	1.051248	0.318725	2	0.11766	
Visual Basic	5.848219	0.349345	4	0.234307	
Voice calls	4.364891	0.349345	5	0.367642	
Voice recorder	1.14167	0.33195	3	0.216647	
Voicemail	10.51781	0.358744	7	0.479006	
W3Schools	3.042652	0.343348	3	0.180116	
WeChat	0	0.297398	1	0.054191	
WhatsApp	206.0603	**0.551724**	15	0.92926	

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
Wikipedia	93.23436	0.457143	11	0.713313	
Wondershare	1.051248	0.318725	2	0.11766	
Wordpress	1.339431	0.337553	2	0.1286	
Workshops	0	0.299625	1	0.062066	
YouTube	76.62379	0.479042	9	0.605636	

Interpretation of colours in each category: Highest Higher High

Appendix N: Numeric analysis of rhizomatic learning network relationships of GBR

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
Academia.edu	0	0.422222	2	0.21776	0.034
Academic papers	0	0.383838	1	0.106214	
Adobe	0	0.376238	1	0.101419	
Adobe Suite	0	0.383838	1	0.106214	
Adobe Suite App	0	0.389744	1	0.116341	
Articles	0	0.376238	1	0.101419	
Ask.com	0	0.389744	1	0.116341	
Basic English dictionary	0	0.389744	1	0.116341	
BBC	0	0.376238	1	0.101419	
Books	0	0.41989	2	0.207634	
Bump user	0	0.376238	1	0.101419	
Cambridge	0	0.389744	1	0.116341	
Camtasia	0	0.376238	1	0.101419	
Chrome	0	0.383838	1	0.115364	
Cloud	0	0.383838	1	0.106214	
Colleagues	0	0.383838	1	0.115364	
Conferences	0	0.383838	1	0.106214	
Corel	0	0.389744	1	0.116341	
Cousera	0	0.383838	1	0.115364	
Delicious	0	0.426966	2	0.231705	
Dictionary	0	0.422222	2	0.221578	
Dropbox	0	0.422222	2	0.221578	
E-books	0	0.376238	1	0.101419	
E-mail	0	0.383838	1	0.106214	
Facebook	0	0.475	3	0.337919	
Farlex dictionary	0	0.389744	1	0.116341	
Firefox	0	0.383838	1	0.115364	
Freefullpdf.com	0	0.389744	1	0.116341	
GBR1	**1157.75**	**0.617886**	**29**	0.906723	
GBR2	**1269.75**	**0.633333**	**32**	0.99761	
GBR3	887.25	0.598425	25	0.874877	
GBR4	**967.25**	**0.617886**	**29**	1	
Gmail	0	0.389744	1	0.116341	
Google	0	0.389744	1	0.116341	
Google drive	0	0.422222	2	0.221578	
Google keep	0	0.389744	1	0.116341	
GoogleLexus.4	0	0.389744	1	0.116341	

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
Google scholar	0	0.383838	1	0.106214	
Instar	0	0.383838	1	0.106214	
Internet	0	0.383838	1	0.106214	
iPad	0	0.383838	1	0.106214	
Laptop	0	0.513514	4	0.439338	
Lecturers	0	0.383838	1	0.115364	
Library	0	0.383838	1	0.115364	
LinkedIn	0	0.383838	1	0.106214	
Mendeley	0	0.426966	2	0.231705	
Microsoft office suite	0	0.422222	2	0.21776	
Microsoft paint	0	0.389744	1	0.116341	
Mobile	0	0.376238	1	0.101419	
Motivational messages	0	0.389744	1	0.116341	
Observation	0	0.383838	1	0.106214	
Opera mini App	0	0.389744	1	0.116341	
Painter	0	0.389744	1	0.116341	
Peers	0	0.41989	2	0.207634	
Pen & paper	0	0.383838	1	0.106214	
People	0	0.376238	1	0.101419	
Photoshop	0	0.389744	1	0.116341	
Pinterest	0	0.376238	1	0.101419	
Quick star	0	0.376238	1	0.101419	
Scholarley	0	0.376238	1	0.101419	
Seminars	0	0.383838	1	0.106214	
Shutterstock	0	0.463415	3	0.333124	
Sketch notes	0	0.383838	1	0.115364	
Skype	0	0.457831	3	0.322997	
Slide share	0	0.383838	1	0.115364	
Smartphone	0	0.513514	4	0.439338	
Sound cloud	0	0.383838	1	0.115364	
Tablet	0	0.383838	1	0.106214	
TED Talks	0	0.426966	2	0.231705	
Tietor	0	0.383838	1	0.106214	
Twitter	0	0.422222	2	0.221578	
Wacom tablet	0	0.389744	1	0.116341	
WhatsApp	0	0.513514	4	0.439338	
Wikipedia	0	0.463415	3	0.333124	
WordWeb	0	0.383838	1	0.115364	
Ymail	0	0.383838	1	0.115364	
YouTube	0	0.463415	3	0.333124	

Interpretation of colours in each category: Highest Higher High

Appendix O: Numeric analysis of rhizomatic learning network relationships of SAR

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
SIT1	2881.576	0.43314	45	1	0.028
7-zip	0	0.302846	1	0.089948	
Academia.edu	73.99277	0.354762	4	0.298435	
SIT2	1548.021	0.404891	33	0.837321	
SIT3	2364.887	0.420904	40	0.920927	
SPH	1664.792	0.388021	25	0.565872	
Adobe Flash	6.218743	0.315678	2	0.164311	
SJL1	1437.675	0.382051	22	0.445604	
Adobe Photoshop	5.620912	0.286538	2	0.081714	
SJL3	1011.869	0.376263	19	0.4286	
Adobe Photoshop Lightroom	0	0.280075	1	0.051552	
SJL2	742.2179	0.370647	16	0.458233	
Adobe Premiere Pro	0	0.270909	1	0.041061	
SJL10	1031.817	0.378173	20	0.498314	
Adobe Reader	69.11312	0.311715	4	0.158424	
SJL4	488.4148	0.366995	14	0.418931	
SJL7	1169.424	0.3725	17	0.35767	
Adobe Suite	22.08613	0.335586	3	0.246883	
Apple Aperture	0	0.280075	1	0.051552	
Articulate	0	0.302846	1	0.089948	
Assembler	0	0.296813	1	0.082572	
Audacity	315.8354	0.388021	8	0.363604	
SJL5	539.9528	0.36165	11	0.328442	
SJL6	626.6212	0.368812	15	0.437813	
SJL8	784.1225	0.3725	17	0.521534	
SJL9	903.6106	0.370647	16	0.426072	
Blackboard	59.40086	0.309129	5	0.191826	
Blogger	3.577268	0.279026	2	0.078752	
Blogs	0	0.266071	1	0.02972	
Books	0	0.28876	1	0.074363	
Buzzfeed	0	0.271898	1	0.03366	
Camera	0	0.280075	1	0.051552	
Camtasia Studio	48.35521	0.343318	3	0.224072	
Cloud	4.676614	0.280075	2	0.085073	
Computer	0	0.274908	1	0.045158	
Corel Draw	0	0.280075	1	0.051552	
Cousera	0	0.302846	1	0.089948	

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
Desktop computer	21.68142	0.296813	2	0.091351	
Docs to go	0	0.276952	1	0.041915	
Dropbox	1351.07	0.524648	14	0.69197	
Edmondo	6.084598	0.311715	2	0.156935	
Email	128.872	0.370647	5	0.343593	
Endnote	0	0.302846	1	0.089948	
Everest	0	0.266071	1	0.02972	
Evernote	8.021841	0.285441	2	0.080667	
Facebook	1085.673	0.496667	13	0.65831	
Feedly	0	0.271898	1	0.03366	
Filters	0	0.280075	1	0.051552	
Foursquare	0	0.276952	1	0.041915	
GIMP	0	0.280075	1	0.051552	
Gitab	22.08613	0.335586	3	0.246883	
Gmail	3.508539	0.279026	2	0.08052	
Google	422.4928	0.418539	9	0.498386	
Google Calendar	0	0.302846	1	0.089948	
Google Chrome	0	0.271898	1	0.046321	
Google+	0	0.271898	1	0.046321	
Guardian	0	0.270909	1	0.038752	
Hangouts	122.8299	0.366995	5	0.344756	
Indesign	0	0.274908	1	0.045158	
Instagram	594.5569	0.425714	10	0.482968	
Internet	60.79933	0.346512	4	0.287944	
iTuneU	6.218743	0.315678	2	0.164311	
Khan Academy	9.782791	0.323913	2	0.17252	
Kindle	0	0.273897	1	0.039799	
Kingsoft office	5.620912	0.286538	2	0.081714	
Laptop	128.872	0.370647	5	0.343593	
Lecturer	0	0.274908	1	0.045158	
Lecturers	22.08613	0.335586	3	0.246883	
Lightroom	0	0.270909	1	0.038752	
LinkedIn	0	0.276952	1	0.041915	
Linux Chat	22.08613	0.335586	3	0.246883	
Media 24	0	0.270909	1	0.038752	
Memory Card	0	0.280075	1	0.051552	
Microsoft Excel	16.15738	0.317021	2	0.135105	
Microsoft Office	0	0.274908	1	0.045158	
Microsoft Office Suite	27.76187	0.322511	3	0.203256	
Microsoft Powerpoint	65.18489	0.349765	4	0.292041	

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
Microsoft Visio	0	0.302846	1	0.089948	
Microsoft Word	16.15738	0.317021	2	0.135105	
MIT Open software	0	0.296813	1	0.082572	
Mixlr	0	0.266071	1	0.02972	
Mobile phone	73.99277	0.354762	4	0.298435	
Moon reader	0	0.271898	1	0.03366	
Nero burning	0	0.296813	1	0.082572	
NetBeans	0	0.296813	1	0.082572	
News24	5.620912	0.286538	2	0.081714	
Studi	0	0.268953	1	0.037691	
Newspaper	0	0.274908	1	0.045158	
Notepad	0	0.296813	1	0.082572	
Packet Tracer	6.218743	0.315678	2	0.164311	
Paint	0	0.280075	1	0.051552	
Parents	0	0.302846	1	0.089948	
PDF readers	0	0.273897	1	0.039799	
Peers	0	0.296813	1	0.082572	
Photo Editor	0	0.280075	1	0.051552	
Photo Editor Ultimate	0	0.276952	1	0.041915	
Photo Grid	0	0.270909	1	0.041061	
Photoscape	0	0.271898	1	0.046321	
Photoshop	120.725	0.344907	4	0.212988	
Picasa	0	0.296813	1	0.082572	
Pinterest	48.35521	0.343318	3	0.224072	
Plagiarism Checker	0	0.276952	1	0.041915	
Pocket	0	0.271898	1	0.03366	
Podcast	0	0.28876	1	0.074363	
Projector	0	0.273897	1	0.039799	
QR codes	9.782791	0.323913	2	0.17252	
Quickoffice	0	0.271898	1	0.03366	
Radio	0	0.271898	1	0.03366	
Real Player	0	0.28876	1	0.074363	
Ref me	102.3884	0.319742	6	0.231276	
Remember	0	0.276952	1	0.041915	
Research Assistants	0	0.302846	1	0.089948	
Researchgate	0	0.302846	1	0.089948	
Samsung chat	0	0.296813	1	0.082572	
Sharedpoint	0	0.302846	1	0.089948	
Skype	60.79933	0.346512	4	0.287944	
Slideshare	0	0.302846	1	0.089948	

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
Smart recorder	0	0.269928	1	0.039459	
Smartphone	20.22737	0.295635	3	0.122648	
Snipping Tool	0	0.28876	1	0.074363	
Soundcloud	9.625617	0.280075	2	0.06338	
Supersport	0	0.271898	1	0.046321	
Tango	0	0.296813	1	0.082572	
Teamviewer	9.782791	0.323913	2	0.17252	
TED Talks	0	0.269928	1	0.039459	
Textbook	0	0.268953	1	0.037691	
Timeslive	0	0.270909	1	0.041061	
Tripod	0	0.280075	1	0.051552	
Tumblr	18.77861	0.289883	3	0.11418	
Tweet Deck	0	0.269928	1	0.039459	
Twitter	839.8148	0.448795	12	0.527659	
UC Browser	0	0.270909	1	0.038752	
uTorrent	0	0.302846	1	0.089948	
Viber	12.46431	0.306584	2	0.123633	
Visual Studio	22.08613	0.335586	3	0.246883	
VLC media player	0	0.28876	1	0.074363	
Voice memos	0	0.270909	1	0.038752	
Voice recorder	5.620912	0.286538	2	0.081714	
VSCO Cam	0	0.271898	1	0.03366	
Wavepad	116.1694	0.325328	6	0.239905	
WhatsApp	186.3931	0.384021	6	0.389914	
Wikipedia	22.08613	0.335586	3	0.246883	
Wikispace	0	0.296813	1	0.082572	
WinRaR	0	0.28876	1	0.074363	
Wix	0	0.276952	1	0.041915	
WIZIQ	0	0.296813	1	0.082572	
Wodershare	0	0.302846	1	0.089948	
Wordpress	783.5201	0.451515	11	0.555461	
Word processing	0	0.273897	1	0.039799	
YouTube	875.0658	0.474522	11	0.582645	

Interpretation of colours in each category: Highest Higher High

Appendix P: Numeric analysis of rhizomatic learning network relationships of BEL

Actor	Centrality				Density
	Betweeness	Closeness	Degree	Eigenvector	
BEL1	257.875	0.464788732	13	0.820374	0.071
BEL2	253.0536	0.47826087	14	1	
BEL3	241.0714	0.464788732	13	0.881207	
Bitbucket	0	0.32038835	1	0.17964	
Computer	0	0.32038835	1	0.17964	
Coursera	0	0.326732673	1	0.213668	
Dropbox	76.66429	0.523809524	3	0.583607	
Electronic Language Platform	0	0.32038835	1	0.1903	
Email	0	0.32038835	1	0.1903	
Facebook	0	0.32038835	1	0.17964	
Git	0	0.32038835	1	0.17964	
Google	25.35714	0.407407407	2	0.393308	
Google documents	0	0.32038835	1	0.1903	
ipod	0	0.326732673	1	0.213668	
iTuneU	0	0.326732673	1	0.213668	
JSTOR	0	0.32038835	1	0.1903	
Laptop	17.325	0.397590361	2	0.403968	
Lecturers	0	0.326732673	1	0.213668	
Limo	0	0.32038835	1	0.1903	
Mentors	0	0.326732673	1	0.213668	
Online Lectures	0	0.32038835	1	0.1903	
Open Yale	0	0.32038835	1	0.1903	
Openculture	0	0.326732673	1	0.213668	
People	0	0.326732673	1	0.213668	
Phone	76.66429	0.523809524	3	0.583607	
Podcasts	0	0.326732673	1	0.213668	
Slack	0	0.32038835	1	0.17964	
Stack Overflow	0	0.32038835	1	0.17964	
Toledo	76.66429	0.523809524	3	0.583607	
Twitter	0	0.32038835	1	0.17964	
Wiki	0	0.32038835	1	0.17964	
Wikipedia	0	0.32038835	1	0.1903	
Wina	0	0.32038835	1	0.17964	
YouTube	17.325	0.397590361	2	0.403968	

Interpretation of colours in each category: Highest Higher High

Appendix Q: Ethics Approval Certificate

Cape Peninsula
University of Technology

Office of the Research Ethics Committee (REC)
Faculty of Informatics and Design
Ethics Approval certificate

Date: 31st July, 2014
Applicant Name: Aheto Simon-Peter Kafui
Student Number: 214267024
Qualification?: Doctor of Technology (Information Technology)

14. Declaration of Investigators

I /we apply for approval to conduct research. If approval is granted, the research will be undertaken in accordance with the information provided in this application, the protocols described in this application, and any other relevant guidelines, regulations and laws.

Investigator / Researcher	Department	email	extension
1. Aheto Simon-Peter Kafui	Information Technology	kafuiaheto@yahoo.com	021 4691018/22
2.			

15. Declaration of Supervisor/s (if applicant is a student)

I /we have read over this application in its entirety and will endeavour to ensure my/our student undertakes his/her research according to all CPUT ethics protocols.

	Name	Signature	Date
Supervisor:	Prof. Johannes Cronjé		31st July, 2014
Co-Supervisor:			

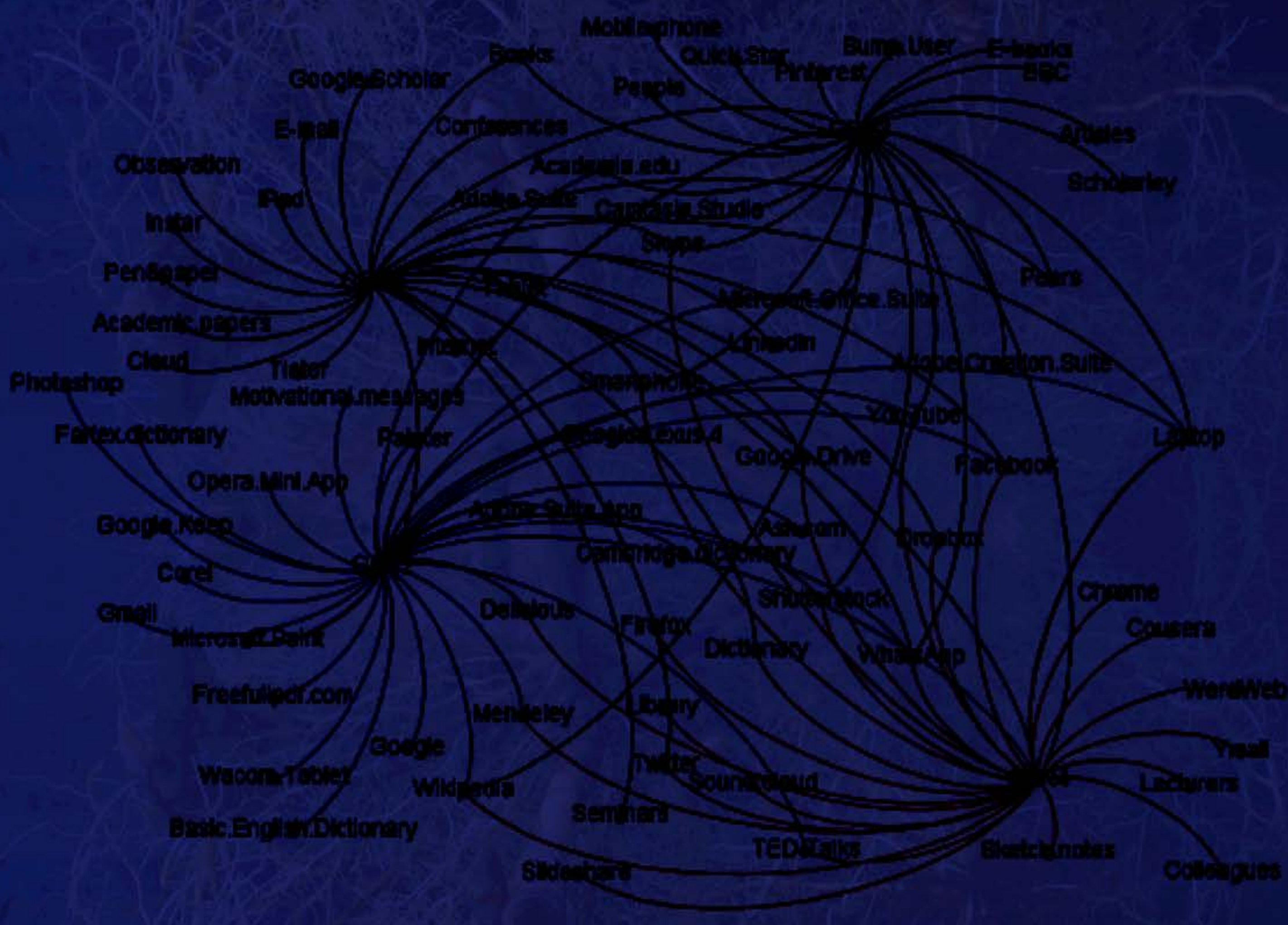
FID Research Ethics Committee comments:

Ethics approval is granted	RESEARCH ETHICS COMMITTEE INFORMATICS AND DESIGN ETHICS APPROVAL GRANTED Ethics Stamp 14 AUG 2014 Cape Peninsula University of Technology

Faculty of Informatics and Design Research Ethics Committee (REC) - FID/REC/A0.8
P.O. Box 652 • Cape Town 8000 South Africa •Tel: +27 21 469 1012 • Fax +27 21 469 1002•FIDEthics@cput.ac.za
80 Roeland Street, Vredehoek, Cape Town 8001

Appendix R: List of Interviewees whose speeches were used

S/N	Interviewee	Designation	Institution	Gender
1	S.BEL.Ethan	Student	BEL	Male
2	S.BEL.Hugo	Student	BEL	Male
3	S.BEL.Jules	Student	BEL	Male
4	S.GAC.Mensah	Student	GAC	Male
5	S.GAC.Tina	Student	GAC	Female
6	S.GAC.Afi	Student	GAC	Female
7	S.GAR.Abena	Student	GAR	Female
8	S.GBR.Asiedu	Student	GBR	Male
9	S.GBR.Selasi	Student	GBR	Male
10	S.SAR.Frank	Student	SAR	Male
11	S.SAR.Khayone	Student	SAR	Female
12	S.SAR.Siyabonga	Student	SAR	Male
13	S.SAR.Tabisa	Student	SAR	Female
14	S.SAR.Thando	Student	SAR	Female
15	S.SAR.Ziyanda	Student	SAR	Female
16	L.GAC.Araba	Lecturer	GAC	Female
17	L.GAC.Ato	Lecturer	GAC	Male
18	L.GAC.Opoku	Lecturer	GAC	Male
19	L.GAC.Papa	Lecturer	GAC	Male
20	L.GBR.Addo	Lecturer	GBR	Male
21	L.GBR.Ali	Lecturer	GBR	Male
22	L.SAR.Isaacs	Lecturer	SAR	Male
23	L.SAR.Roberts	Lecturer	SAR	Male
24	Prof. Anamuah-Mensah	Lecturer/Expert	-	Male



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