

An investigation of the usage and success of blended e-learning material for computer networking students

by

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DECLARATION

I declare that

An investigation of the usage and success of blended e-learning material for computer networking students

is my own work and that all the resources that I have used or quoted have been indicated and acknowledged by means of complete references.

C van Aardt

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ABSTRACT

Key words: learning styles, action research, e-learning, intervention, empirical, interpretive

Students enrolled for the Network Systems III module at the Vaal University of Technology are experiencing problems with passing this module. Many of them fail due to the fact that they do not understand the subnet masking part of it. In an attempt to increase the students' pass rate, this study will make additional study material available to them, complying with their learning style preferences. This material will be available as e-learning material on the Internet.

The usage and success of e-learning material implies a holistic approach towards learning styles. Learning styles consist of different interrelated learning elements. This study will make use of an action research approach comprising four phases. In the first phase, different learning styles are diagnosed by means of a literature study. The information obtained is applied to compile an interpretive questionnaire for completion by students. This questionnaire will enable the researcher to do an empirical study with regard to their learning preferences. The data obtained from the questionnaires will be analysed and information obtained will be applied to make additional module related e-learning material available on the Internet.

During the second phase, results obtained from the empirical investigation will be used to develop e-learning material on subnetting, while also addressing the identified learning styles of participants. The e-learning material is provided on the Moodle learning management system, enabling students to use it according to their own preferences.

In the third phase, the success of the intervention on the e-learning material is investigated. In this phase, the activities of students using the e-learning material are analysed and tests and examination results processed to determine whether there is any correlation between time spent on e-learning material and these results. The usage of e-learning material is tested by means of an interpretive questionnaire to the students.

The last part of the action research approach deals with the question of whether the research was conducted successfully. A second iteration of the process proved the results to be satisfactory.

The e-learning material was positively received by students participating in the research, while a growing interest in this material was noticed from the last semester in 2007 to the first semester in 2008.

OPSOMMING

Sleutelwoorde: leerstyle, aksienavorsing, e-leer, intervensie, empiries, interpretief

Ingeskrewe studente vir die module Netwerk Stelsels III aan die Vaal Universiteit vir Tegnologie ondervind probleme om die module te slaag. Baie van hulle druipt weens die feit dat hulle nie die gedeelte oor “subnet masking” verstaan nie. Hierdie studie sal addisionele studiemateriaal aan studente ooreenkomstig hul leerstyl voorkeure beskikbaar stel. Die materiaal sal as e-leermateriaal op die Internet beskikbaar wees. Die navorsing sal poog om die slaagsyfer van studente in hierdie module te verhoog.

Die gebruik en sukses van e-leermateriaal impliseer ‘n holistiese benadering tot leerstyle. Leerstyle bestaan uit verskillende elemente wat onderling verwant is. Hierdie studie maak gebruik van ‘n aksienavorsing benadering bestaande uit vier fases. In die eerste fase word verskillende leerstyle deur middel van ‘n literatuurstudie gediagnoseer. Inligting aldus verkry, word aangewend om ‘n interpretiewe vraelys aan studente op te stel. Die vraelys stel die navorser in staat om ‘n empiriese studie van studente se leerstyl voorkeure te doen. Data uit die vraelys verkry, word ontleed en inligting voortspruitend word aangewend om addisionele module verwante e-leermateriaal oor die Internet aan studente beskikbaar te stel.

Gedurende die tweede fase word resultate van die empiriese ondersoek geïmplementeer ten einde die e-leermateriaal meer effektief te maak. Die materiaal word daarna op die Moodle leer bestuurstelsel beskikbaar gestel, waar studente volgens eie voorkeur daarvan gebruik kan maak.

In die derde fase word die sukses van intervensie op die e-leermateriaal ondersoek. In hierdie fase word aktiwiteite van studente op die e-leermateriaal ontleed. Resultate van toetse, asook van die eksamen word verwerk om te bepaal of daar ‘n verwantskap bestaan tussen tyd bestee op e-leermateriaal en toets- en eksamen resultate. Die mate waartoe daar van die e-leermateriaal gebruik

gemaak is, word ook getoets deur middel van 'n interpretiewe vraelys aan die studente.

Die laaste gedeelte van die aksienavorsing benadering bepaal of die navorsing suksesvol deurgevoer is. Bevredigende resultate is met die tweede iterasie verkry.

Die e-leermateriaal was met 'n positiewe gesindheid deur deelnemende studente ontvang. Belangstelling daarin het vanaf die laaste semester in 2007 tot die eerste semester in 2008 toegeneem.

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CHAPTER 1

PROBLEM DEFINITION

1.1 INTRODUCTION

Students following the Network Systems III module at the Vaal University of Technology do not perform satisfactorily. This dissertation reports on a blended e-learning project aimed at improving the performance of these students. The developed material accommodates different learning styles.

E-learning is used by a large number of organisations across the world. Many different types of e-learning applications exist and the growing rate of online courses exceeds the growth of their face-based (traditional) programs (Duffy & Kirkley, 2004:3). A huge advantage of e-learning is its 24 hours a day availability. It is flexible and customisable to different needs, while learning is no longer limited to prescheduled periods and/or locations (Rosenberg, 2001:30).

Educational content is distributed to learners through a blended e-learning option offering a mixed variety of activities. Blended e-learning activities include face-to-face classrooms, live e-learning and self-paced learning opportunities (Piskurich, 2003:102). A student may attend a classroom session but feel insecure about his/her knowledge of the particular topic, then go to the Internet making use of the self-paced blended asynchronous learning option to augment his/her understanding of the topic by means of other available learning styles (Littleton & Light, 1998:11).

According to Gunter *et al.* (2003:4), research on learning styles has indicated that people learn differently, resulting in learners using different learning styles that works best for them. Progress towards mastering a teaching and learning style, is a very dynamic process of learning and adapting to changes for both teachers and learners. Computers can support a range of teaching and learning styles (Littleton & Light, 1998:11), and the most effective way of integrating learning differences into teaching styles is by using computers in a student-centred environment. A student-centred environment will support them in deciding what is necessary to be successful within the classroom and educational context. It will enable students to

take responsibility for their own learning (Glasgow, 1997:34), while remembering those things they understand best (Gunter *et al.*, 2003:26).

Understanding as such is based on the cognitive interpretation of data available through the senses, and there is a dynamic interaction between the individual and the stimulation he/she receives (Gunter *et al.*, 2003:108). Multimedia combines sound, text and still or moving pictures (Chan & Black, 2006:1). Carefully crafted illustrations can contribute to the improvement of cognitive adaptation to learning material (Harp & Mayer, 1997:92). Multimedia learning let people take control of their own learning and pace (Collins *et al.*, 1997:3).

By utilising a variety of learner style approaches through multimedia instruction and blended e-learning, more students will be reached and encouraged to learn in a variety of ways (Gunter *et al.*, 2003:58).

Most of the students enrolled for the Network Systems III module, did poorly on the section about subnet masking (also called subnetting), because they did not understand it. Previous semester tests and examination results indicated that they might have passed the module, had they understood subnetting. This view is supported by lecturers. This study will look at opportunities to make “subnetting” more understandable, thereby trying to improve the pass rate on this module. This will be done by enriching the current lecture environment with e-learning material to create a blended e-learning environment.

1.2 OBJECTIVE OF THE STUDY

The aim of this study is to improve student performance in the Network Systems III module at the VUT. In order to achieve this, the following objectives must be achieved:

1. Understanding of learning styles based on a literature review.
2. Understanding of learning styles of Network Systems III module students based on an interpretive survey.

3. Creating of e-learning material accommodating different students' learning styles.
4. Analysing the usage of the e-learning material by means of web logs created with the learning management system (Moodle).
5. Analysing performance of students in terms of examination results and e-learning material usage.
6. Applying statistical methods to the results of objectives 4 and 5 to establish the presence of a meaningful correlation, if any.
7. Conducting an interpretive survey in order to understand the students' attitude towards the e-material.
8. Make recommendations to the stakeholders in order to sustain and further improve the student performance in the Network Systems III module at the VUT.

Students enrolled for the Network Systems III module will be enabled to improve and expand their understanding of the module content.

Influences of teaching have an effect on learning thoughts and achievement (McMillan & Schumacher, 2006:297). A section of the module, Network Systems III module, will be used to determine whether multimedia instruction is effective.

Effective use of multimedia involves the identification of clearly defined, but at the same time learner-centred tasks. The shift from teacher-centred to learner-centred tasks includes identification of skills and processes involved and making these explicit to students (Collins *et al.*, 1997:60). Multimedia is used in the e-learning material to be developed as part of the proposed blended e-learning environment for this module.

The computer based program providing the interaction between the student and his/her study material, is called a learning management system (Rosenberg, 2001:161). Many open source learning management systems are available on the market, such as ATutor, Bodington, Caroline and Sakai Project. Other commercial learning management systems are ANGEL, Apex Learning and Blackboard Inc. For this research, we will use the Moodle learning management system, which

serves to hold the blended e-learning environment together, having the ability of tracking and measuring student activities within the e-learning content. (Piskurich, 2003:307; Collins *et al.*, 1997:62).

1.3 RESEARCH QUESTIONS

The following questions will guide the research:

- How can we establish more appropriate learning and teaching combinations for the Network Systems III module class in terms of the accommodation of students with different learning styles?
- How can we develop e-learning material to be used in the blended e-learning environment that accommodate student learning styles?
- How can we determine whether a student actually makes use of the additional e-learning material?
- What effect will additional multimedia study material have on the test and examination results of students? What is the relationship between the time spent on additional e-learning material and test and examination results?

1.4 RESEARCH METHODOLOGY

An action research approach has been selected to investigate and improve the learning environment of the Network Systems III module students at the VUT. The topic of subnet masking will be focused on. Subnet masking was identified from previous examination evaluations, as well as discussions with lecturers as a problematic topic within the Network Systems III module. This research will be done in collaboration with all role players, and various blended e-learner strategies and pedagogical techniques will be formulated during the course of this study. The research methodology is further discussed in chapter 2.

The study will consist of the following action research phases:

- Initial diagnoses phase
- Planning and implementation of intervention phase
- Analyse success of intervention phase

- Advise improvements phase

Each phase will be discussed in more detail.

1.4.1 Initial diagnoses phase

Students enrolled for the module Network Systems III are struggling with the concept of subnet masking, as reflected in their poor test and examination results and reported by lecturers. In order to achieve the most from the planned e-learning material, it was decided that the e-learning material should accommodate more learning styles of students than the current face-to-face learning environment.

Following on a literature review of present learning and teaching styles, a set of preliminary interpretive questions will be given to participants to determine their learning preferences in this regard.

1.4.2 Planning and implementation of intervention phase

E-learning material on subnet masking will be developed, using the Moodle learner management system (LMS). This e-learning material, made available through the Internet, will support a blended e-learning approach and will use multimedia material accommodating the learning styles of most participants. The new e-learning material will be used in conjunction with face-to-face lecturing to create a blended e-learning environment.

1.4.3 Analyse success of intervention phase

The impact of the blended e-learning material environment will be analysed by evaluating and comparing test and examination results before and after introduction of the e-learning material.

A click stream analysis will be done using web logs. Time spent on Moodle LMS e-learning material will be recorded and compared to test and examination results obtained.

A second interpretive questionnaire will be used to analyse the success of the intervention from a qualitative perspective.

1.4.4 Advise improvements phase

The results obtained from the analysis in the intervention phase will guide the research team in deciding what action to take with regard to more iterations.

1.5 LITERATURE REVIEW

In order to reach the objectives of the study as stated in section 1.2, a literature review is conducted on learning and learning styles (objective 1), as well as a review on literature on subnet masking (objective 3) and the use of the Moodle LMS (objective 3).

The research plan is justified by means of a literature review of research paradigms and approaches presented in chapter 2.

1.6 PARTICIPANTS

The module in Network Systems III is offered in its entirety every semester at the VUT. This means that the complete module, including the examination is repeated every six months.

All students enrolled for the Network Systems III module during the first semester of 2007 will be evaluated by measuring their test and examination results before implementing the e-learning material. Students in the second semester of 2007 and the first semester of 2008 will be exposed to formative multimedia resources using the Moodle LMS.

With ethical aspects and other possible restraints in mind, consent was obtained from the following relevant role players:

- The Head of Process Control and Computer Systems for granting permission to use the department's students and module content.
- Lecturers for sharing the problems regarding this module and making test

and examination results available.

- Students for taking part in the research project voluntarily.

Data will be collected from all participants for each semester (6 months) for the duration of this research.

1.7 LIMITATIONS OF THE STUDY

The selection of a particular model for using in an instructional design depends on the desired outcome or objective of the instruction (Duffy & Kirkley, 2004:3). The researcher does not have total control over the instructional environment and module content, as well as the surety that users will utilise the e-learning material. Research will be conducted within the current lecturing environment. The researcher may however design and add electronic learning content as deemed necessary.

The Network Systems III module is part of the final semester modules needed for the qualification. Student groups are therefore only available for six months (semester). The part of the module addressing subnetting is being lectured during the second half of the semester, thereby not allowing much time for test and examination results to be analysed before the students leave the VUT. Unfortunately, these students are no longer available on campus after completion of the module for any follow-up actions in terms of this research project.

The study will primarily focus on statistical evidence acquired by the web log analysis of students' interaction on the LMS.

Although any discipline may be incorporated into Moodle, this study will focus on the implementation of a specific category of the module Network Systems III, called subnet masking, for formative assessment.

1.8 IMPORTANCE OF THE STUDY

One hundred and eighty nine students enrolled for the Network Systems III module in the first semester of 2007. The total number of dropouts and students who failed

for this semester was 108. Lecturers reported that students were having great difficulty with understanding the subnetting section of the module. The blended e-learning environment, created by this research project will serve to make subnetting more understandable, thereby striving to improve the pass rate of students.

E-learning and interactive media will enable VUT students to access information beyond classroom activities and conventional study material. Interaction with the computer and multimedia information let the user take control of and responsibility for his/her own learning (Collins *et al.*, 1997:27).

Web log analysis on the Moodle LMS will allow the researcher to collect useful information on all student activities relating to the usage of e-learning material. More measurements will enable better decision making, as well as improvement of the learning environment.

Learning is reinforced by repeated information, especially in the case of material difficult to understand. The use of multimedia to accommodate different learning styles will help and encourage VUT learners. The ability to direct attention appropriately and processing relevant information may improve their learning abilities. This acquired proficiency is an intentional processing skill (Whimbey & Whimbey, 1975:122).

A powerful trait of multimedia is that of immersing the user in a learning environment. This approach is necessary to acquire the imaginative engagement of the learner (Boyle, 1997:35). Measurement of teacher effectiveness is based on gains in student achievement (McMillan & Schumacher, 2006:51).

The role of imagery thinking is increasingly recognised in the pedagogical environment, as people can absorb visual information much faster than verbal information. Technology of computer graphics and techniques for manipulating visual information are improving rapidly, while the role of graphics in computer-assisted learning is bound to increase (O'Shea & Self, 1984:204). Visual

instructional methods have great potential as an instruction medium for low experienced learners (Mayer & Gallini, 1990:715).

These methods of instruction are also meaningful for this research conducted at the VUT. The way in which multimedia are used, will advance the development and improvement of education and training in general (Kozma, 1994:7; Fording, 2004:1). Students will benefit greatly from all available cognitive resources (Moreno & Mayer, 1999:358).

Multimedia as a visual instructional method will be used in this research as an important instrument to restructure traditional learning material and to address multiple learning styles in a blended e-learning environment for VUT students.

1.9 OUTLINE OF PROPOSED STUDY

The first part of this study will cover action research methodology with reference to different research paradigms. In chapter 2, different research methodologies and paradigms will be discussed, explaining why this research is based on the action research methodology.

The second part of this action research will deal with the initial diagnoses phase of action research, covering a literature review and interpretive questionnaires on learning styles. The first chapter in this phase (chapter 3), will focus on learning and learning styles. E-learning is also reviewed. The second chapter (chapter 4), will analyse the learning styles of VUT students through interpretive questionnaires.

The third part of this action research will discuss planning and implementation of intervention, addressing subnet masking in particular. Chapter 5 is part of this phase. The literature review of chapter 3 and questionnaire results of chapter 4 will be applied to the development of e-learning material relevant to specific areas of the Network Systems III module, as identified by lecturers involved. The learning material will be developed with the purpose of presenting it on the Moodle Learning Management System for learners to explore.

The fourth part of this action research will discuss the analysis of intervention on e-learning material. In Chapter 6, the success of intervention on learners' material will be interpreted through web log analysis to establish whether there is a relationship between time spent on this material and improved examination results. Chapter 7 reports on interpretive questionnaires used to investigate the students' attitude towards the e-learning material.

Part 5, which is also the last part of this action research, will discuss advice on improvements. Chapter 8 will conclude the findings as formulated in this chapter and also provide a recapitulation of findings for the complete research project.

CHAPTER 2

LITERATURE REVIEW OF RESEARCH METHODOLOGY

2.1 INTRODUCTION

Research is a critical way of thinking and examining the effectiveness of various aspects of day-to-day professional work. It demonstrates a meticulous understanding of the principles of a particular procedure and strives towards developing and testing new theories to enhance specific practices in research methodologies (Kumar, 2005:2). Different approaches and an understanding of research paradigms are necessary to investigate and enhance research practices.

The purpose of this chapter is to discuss some of the more important research methodologies and the most appropriate data analysis research instruments that have been adopted in pursuit of this study to obtain the required goals.

Section 2.2 discusses research generally in terms of basic and applied research, paradigms and research methods. Included are discussions on research approaches, such as positivism, interpretivism, constructivism and critical social theory, explaining how it is implemented in a research process. Section 2.2 further discusses data collection methods, as well as quantitative and qualitative data analysis methods, all of which are integral parts of research.

Research strategies followed in this research are discussed in section 2.3. This research follows an action research approach and the data is analysed by using quantitative and qualitative methods. Section 2.4 contains the specific strategies selected for this research. An action research approach was selected as it provides an ongoing dynamic interaction within the experimental process, thus improving the effectiveness of this study. Qualitative data and quantitative data will be collected and analysed during the action research process.

Conclusions are given in section 2.5.

2.2 RESEARCH PARADIGMS

2.2.1 Introduction

Berg and Latin (2003:10) argue that research is a process conducted for a specific purpose. It is an investigation that is done systematically and in a scientific manner through information gathering. This information is then analysed in order to suggest improvements for the situation. Booth *et al.* (2003:57) noted that the most important aspect of research is to know exactly what to investigate.

Walsh and Wiggins (2003:8) note that “research needs to be relevant, comprehensively accurate, easily accessible and understandable”. Kumar (2005:154) argues that the validity of a research methodology depends on the research philosophy, the research strategy, research instruments, research objectives and the research question.

The authors Berg and Latin (2003), Booth *et al.* (2003), Walsh and Wiggins (2003) and Kumar (2005) argue that research should be done for a specific reason, which is exactly what this research intends to do for Network Systems III students at the VUT. The aim of this study, as discussed in section 1.2, is to improve student performance in the Network Systems III module at the VUT.

Kerlinger (1986:10) describes scientific research as “a systematic, controlled empirical and critical investigation of propositions about the presumed relationships about various phenomena”. Bulmer (1977:5) describes research as “primarily committed to establishing systematic, reliable and valid knowledge about the social world”.

A systematic approach to research is important according to the authors Kerlinger (1986) and Bulmar (1977). The researcher intends to apply the same approach to this study through action research.

There are different research paradigms. This section describes the difference between applied and basic research followed by a discussion on the different paradigms, namely positivism, interpretivism, constructivism and critical social

theory. It concludes with a discussion on data collection and analysis in terms of qualitative and quantitative research methods.

2.2.2 Basic versus applied research

Before embarking on a research project, a researcher should familiarise him or herself with the ethics of research and adhere to it. According to McKay (2006:4), there are two approaches to research, namely basic research and applied research.

These two approaches will be discussed next.

2.2.2.1 Basic research

Researchers refer to basic research as a theoretical, pure and fundamental type of research basically practiced on paper (Houser, 2008:44). It tends to be conceptual rather than practical and builds on work that has been done before and in most cases involves finding out something new (Walsh & Wiggins, 2003:15). This type of research is the interim phase through which researchers may develop questions and theories and form new concepts to enrich research strategies (Mikkelsen, 2005:131).

2.2.2.2 Applied research

Applied research refers to an organised, structured, specific and purposeful challenge to gather new information in order to make general conclusions and for testing the validity of the argument (Garard & Taylor, 2004:167).

Before any research should be attempted, it is necessary to know how to approach research and what the strengths and weaknesses of each research segment are. According to Trochim (2006:1), “a research project has a well known structure, a beginning, middle and end” with a special way in which data about a certain phenomenon should be gathered, analysed and used.

This study can be seen as applied research, since it is applied to a specific situation with the objective to make improvements.

2.2.3 Research approaches

Vogel (1997:19) argued that there is no single research methodology or combination thereof that is intrinsically better than another research methodology. Many of the research methodologies used in the educational environment tend to be drawn from psychology and other social sciences and may include more than one methodology for different phases of a single research project.

2.2.3.1 Positivism

The positivistic approach has a long historical, basic principle belief that all factual knowledge gained through observation is trustworthy (Ethridge, 2004:60) irrespective of the research process (Hesse-Biber & Leavy, 2005:13). Positivists are determined to believe that only direct measurements are valid for scientific verifications (Ethridge, 2004:61). Furthermore, Wimmer and Dominick (2005:115) found that all empirical studies that had a positivistic approach, were particularly successful in association with the physical and natural sciences model, dealing with facts and also closely associated with quantitative analysis methods.

Positivists believe that one can explain and predict what happens in the social world through systematically observing data for patterns and relationships among people (Sprague, 2005:32). They also believe that reality is stable and can be observed and described from an objective viewpoint (Terre Blanche *et al.*, 2008:93) without interfering with the object being studied. Kerfoor and Winberg (1997:16) give the following definition of positivism: "The positivist approach is one which states that only observable and measurable data should be taken into account in research".

Positivists generally attempt to test the predictive understanding of phenomena by assuming that reality is objective and can be explained through measurable properties which are independent of the researcher and his or her instruments.

Certain difficulties in research, such as the inconsistency of results, may be attributed to the inaptness of the positivist paradigm for this specific process (Briton, 1996:22). Therefore, by limiting observations to things that already exist, positivism remains an effective descriptive research instrument.

Parts of this study have a positivistic nature (refer to objectives 4, 5 and 6 in section 1.2). The role of the researcher as agent of change depicts the overall nature of the study as post-positivistic.

2.2.3.2 Interpretivism

“Interpretive research is characterised by a strong sense of connection between the researcher and the subjects who are part of an interpretive study” (McNabb, 2004:106). The interpretivistic approach to research rests upon idealism and holds the view that the world is interpreted through the mind (Williams & May, 1996:59). According to interpretivists, the human experience such as language, consciousness, and how humans make sense out of everyday events in their lives, is a process of interpretation (Kirk *et al.*, 2006:23).

The key of the interpretivistic methodology is to understand, not to explain and predict. Understanding begins with the assumption that there is at least some common ground between the researcher and the researched (Walliman & Baiche, 2001:15). The perception of own lived experiences plays an important role throughout the research (Walliman & Baiche, 2001:71). Interpretivists argue that only through the subjective interpretation of intervention in reality, can that reality be fully understood. There may be many interpretations of reality, but these interpretations are in themselves part of scientific knowledge.

According to Crotty (1998:67), “Interpretivism is often linked to the thought of Max Weber”. Jackson and Sorensen (2007:164) emphasise Weber’s beliefs that “the social world is very different from the natural world” and cannot be described without a meaningful perspective about how humans interact with one another. According to Williams (1996:28), interpretivists believe that human behaviour is too diverse and its complexity too difficult to describe through generalisation and theories. It means that when the perspective of understanding individuals makes sense, then the social world will become more clearly understandable.

Parts of this study has a strong interpretive nature, as stated in objectives 2 and 7 in section 1.2.

2.2.3.3 Constructivism

Constructivism refers to the nature of human learning and understanding. Constructivists believe that perception is reality, which is influenced through social, spatial and historical context (Jackson & Sorensen, 2007:162). Bachman and Schutt (2003:389) describe this paradigm as an interactive relationship emphasising the importance of exploring what people do and how they construct their beliefs in a social society.

Knowledge and interpretation in a constructivist research paradigm is the result of perspective theory generation in a collective process. According to Hoover *et al.* (2004:23), knowledge emerging from interviews with participants is at least in part created, not discovered, by the researcher.

Constructivist inquiry is a robust individual and contextual educational intervention that will empower the researcher and contribute to positive change (Rodwell & O'Connor, 1998:219). Rodwell and O'Connor (1998:219) further argue that constructivism emphasises the construction of knowledge as a natural result of the constructivist process, while Kirk *et al.* (2006:242) argue that it offers only a theoretical perspective on learning. Gliner and Morgan (2000:8) state that constructivist's methods of data analysis are closely associated with qualitative methods of analysis.

Although interpretivism and constructivism are very closely related, interpretivism is about how knowledge is interpreted, whereas constructivism is about knowledge construction (McDrury & Alterio, 2003:44). The view of McDrury & Alterio (2003:1) is supported in this study, as the human construction characteristic of this paradigm, explained by other authors, is clearly summarised.

This study demonstrates a characteristic of constructivism, as the blended e-learning environment is a constructed reality.

2.2.3.4 Critical social theory

Critical research focuses on the relationship between two opposites or contradictions in society and attempts to eliminate the causes of separation and

control (Alvesson & Deetz, 2000:1). It is assumed that the social reality is historically constituted and therefore encourages rethinking of the emotional repressive ideas and identities (Alvesson & Deetz, 2000:9).

Critical social theory has as its main goal the improvement of the human conditions. Furthermore, Myers (2008:42) argues that critical researchers believe “that social reality is historically constituted and that it is produced and reproduced by people”. People can make conscious efforts to change their social and economic circumstances. However, their ability to do so may be negatively influenced by social, cultural and political factors.

This study can overall be classified as critical social theory with the objective to improve student performance at the VUT. An example of critical social theory is action research as discussed in section 2.2.4.3.

2.2.4 Research methods

Data collection, data analysis and action research are discussed in this section.

The nature of data can be qualitative or quantitative. Quantitative analysis is based on measuring numerical values submitted for statistical analysis and interpretation. These would include variables varying in size, magnitude, duration and amount. Qualitative analysis is based on observations summarised and interpreted in a report. The difference between quantitative and qualitative analysis is the type of data to be analysed.

2.2.4.1 Data collection

Data collection can be done in a laboratory experiment or as a field study and can be quantitative and qualitative. Data may be collected through non-experimental designs, such as surveys and predetermined instrument based questions. “Good quantitative data, such as performance data, observational data, attitude data and census data allow scientists to make a statistical analysis through comparison of different situations” in a real world situation (Terre Blanche *et al.*, 2008:132).

Research in a laboratory environment permits the researcher to have greater control over independent variables ensuring that everyone gets the same treatment (Presser *et al.*, 2004:214). The weakness of laboratory experiments is that it is done in a restricted environment as opposed to a real world situation (Robson, 2002:111). A positivist, quantitative approach is adopted in the development of the research instrument.

Field studies take the laboratory research one step further and are executed in real organisations and real life situations (Presser *et al.*, 2004:216). In this type of scientific situation, there will be more distractions but the research will achieve greater realism and can be applied more effectively. Case studies are especially useful to test theoretical models in a real world situation (Shuttleworth, 2008:1).

Data for this research project is collected electronically through the Moodle LMS and manually through class lists, test and examination scripts and questionnaires.

Quantitative data

Quantitative data is obtained through measurement and the reliability of assessments in quantitative educational research through replications (Terre Blanche *et al.*, 2008:140). Significant contributions to the assessments of quantitative research reliability were made by using Alpha, a widely used measuring instrument developed by an educational psychologist, Chronbach (Chronbach *et al.*, 1991:4). Quantitative researchers use the statistical method Alpha to test for internal consistency of questionnaires (Andersen & Taylor, 2005:30).

Quantitative data for this study is obtained from the questionnaires, the Moodle LMS, test and examination scripts used in objectives 4, 5 and 6, discussed in section 1.2.

Qualitative data

Qualitative methods are used in studies with the intention of gathering enough data to describe events and processes of significance (Cohen *et al.*, 2007:462). Qualitative methods are typically approaches to gather information from individuals

on more than one occasion (Cohen *et al.*, 2007:126). Information is gathered through case studies, grounded theory involving the categorisation of data into relationships and open-ended questions, as well as data gathered through interviews, observational data and audiovisual data.

Qualitative data for this research will be obtained from comments in the open questions of the questionnaires used in objectives 2 and 7, discussed in section 1.2.

2.2.4.2 Data analysis

Data analysis encompasses methodologies for processing quantitative (numerical) and qualitative (non-numerical) data.

The planning of data analysis is done before the actual data is collected, i.e. when an idea of what is to be studied is formed. Data analysis is about the search for patterns in data and the reasons that could explain the patterns (Bernard, 2006:452). It is also about the interpretation of findings and linking these findings to other research (Bernard, 2006:420).

Quantitative methods

When thinking of quantitative methods, it will be about statistics and numbers. The quantitative method is used to collect numerical data in order to explain a certain occurrence. Quantitative analysis is widely preferred by researchers to summarise experimental designs and similarities among large sets of variables. According to Kerfoor and Winberg (1997:18), quantitative methods are often associated with positivism. Quantitative research is done when the size or segmentation of markets is needed, it concerns how many or how much is done through questionnaires, personal intercept at shopping malls, internet, telephone or a survey to measure the size of television audiences (Mariampolski, 2001:22). Quantitative techniques fall into two broad categories. The first category is an interval estimation where a sample of data is taken and an estimation of the true parameter interval value is made (Watsham & Parramore, 1997:162). The second category is hypothesis

tests, attempting to contest a specific claim about a population parameter based on sample data (Evans, 2007:117).

Quantitative research focuses on a single person, organisation, event, or other entities and assumes the possibility of replication. It requires some type of control but researchers believe that if the same methods are used with the same sample, the results should be the same (Cohen *et al.*, 2007:148).

Qualitative methods

According to Cohen *et al.* (2007:461), qualitative data analysis is about organising, accounting for and explaining gathered data. Hitchcock and Huges (1995:296) describe qualitative research as actions in words and meanings concerned with description and explanation. This type of research does not make extensive use of statistical methods and therefore allows more detailed interpretation of what people say and do, thus providing a very in depth look at particular social behaviours (Andersen & Taylor, 2005:30). Grounded theory and content analysis are two main forms of qualitative data analysis (Cohen *et al.*, 2007:475; Flick, 2009:441).

Grounded theory is a qualitative research method through which theory is generated from systematically acquired data (Davis, 1997:64). Cohen *et al.* (2007:461) explain that grounded theory and content analysis will systematically proceed through coding and categorisation until what is being analysed is clear and can be used for predictive purposes.

The intent of grounded theory is to generate an abstract analytical schema developed from the data relating to a particular situation. Grounded theory is an action oriented, qualitative research method using procedures systematically for further development (Straus & Corbin, 1998:12). There are three types of coding in grounded theory, namely open, axial and selective coding. The purpose of coding is to deconstruct data into manageable groups in order to extract sensible information (Cohen *et al.*, 2007:493). Classifying and categorising interpretive data into discrete structures make it easier for researchers to identify the similarities to study. The structuring process is called coding (Edwards & Lampert, 1993:169; Morse & Richards, 2002:122), which is also central to grounded theory.

According to Bernard (2006:443), grounded theory is a set of techniques for:

- Identifying categories and concepts emerging from text, and
- Linking the concepts into substantive and formal theories.

Content analysis can be either quantitative or qualitative, or a mixture of the two approaches and consists of interpretation and subjective meaning (Kaid, 2004:53). According to Cohen *et al.* (2007:457), “content analysis can be described as a method that defines the process of summarising and reporting written data” and the analysis thereof. In qualitative content analysis the emphasis is on how to address attitudes, values and motivations (Payne, 2004:51).

Another qualitative method is narrative analysis. This method focuses on how respondents impose order to the flow of experience in their lives and make sense of events and actions in which they have participated (Chambliss & Schutt, 2009:265).

This research agrees with the views of Davis (1997), Cohen *et al.* (2007), Straus and Corbin (1998) and others with regard to the way in which coding should be done. The comments of the open-ended questions in the questionnaire (refer to objectives 2 and 7 in section 1.2), will be categorised and analysed through the principles of an open coding process to detect a basic theme.

Qualitative data analysis in general involves methods that organise respondents’ data into useful groupings that will make sense to the researcher.

2.2.4.3 Action research

Action research is an action oriented, democratic process supporting the viewpoint that research of complex social systems can only be successful when improvement or change is desirable (McTaggart, 1997:27). The change is then implemented and the effect thereof studied in a participatory fashion (Reason & Bradbury, 2006:1; Burgess, 1985:139). Action research allows the researcher more than one iterative cycle in order to collect data which can be evaluated quantitatively or qualitatively.

Reason and Bradbury (2006:2) noted that the main aim of action research is to produce practical knowledge that will be useful and working towards practical outcomes, problems and solutions. Elden and Chisholm (1993:127) describe action research as change-oriented with the purpose of bringing about positive social values.

Koshy (2005:1) defines action research as “an enquiry undertaken with rigor and understanding so as to constantly refine practice”. Argyris *et al.* (1985:4) informatively describe action research as follows: "Action science is an inquiry into how human beings design and implement action in relation to one another. Hence it is a science of practice".

Action research is concerned with practical, real world situations and focuses on actual problems of the past, using them as a starting point for solving current problems, such as the performance of Network Systems III module students at the VUT. When undertaking action research, the researcher starts with planning; it entails gathering of information relating to the practical problem, “with the intent of improving the quality of life for themselves and others” (McNiff *et al.*, 1996:38).

Glanz and Sullivan (2000:102) view the basic process of action research as follows:

1. Selecting a focus
2. Collecting data
3. Analysing and interpreting data
4. Taking action

McNiff and Whitehead (2006:7) believe that action research has become increasingly popular around the world as a form of scientific research.

An action research approach was chosen for this research, since it is a dynamic research method allowing changes to the design where necessary as research proceeds. The effect of these changes will be evaluated at a certain point to determine whether or not more changes are necessary. The authors Reason and

Bradbury (2006) describe action research as “research to produce practical knowledge useful”. The researcher endorses the research value of action research in this statement, as it describes how action research enriches the body of knowledge rather than only solving one specific problem.

Student groups change every six months at the VUT, with academic classes lasting only 16 weeks. Although the time for each semester is very restricted, the fast pace makes it possible to compare each new group with results of the previous semester’s group.

2.3 RESEARCH STRATEGY OF THIS STUDY

The aim of this study, as specified in section 1.2, is to improve the performance of Network Systems III students at VUT. This is done by creating a blended e-learning environment where lectures are augmented with e-learning material. The e-learning material will be developed in such a way as to accommodate students with different learning styles. In order to achieve this, the first action is to determine and understand the learning styles of the students at the VUT. Performance in the module will be measured in tests and examination papers. Web logs of the e-learning material will be analysed to determine the usage of the material through individual study.

After a literature review on research paradigms, such as positivism, interpretivism, constructivism and critical social theory, it was decided that critical social theory by means of action research was the most appropriate research method for this research. This decision was taken because action research allows the researcher the opportunity to evaluate, adjust and improve the material continuously through iterations, thus finding the best solution. The researcher is permitted only in the critical social theory paradigm to become the agent of change.

Action research as a research method is a suitable instrument for this research, as it gives the researcher the opportunity to change (if necessary) the learning material and allows him or her to look at the effect of the change.

The course of this research will be discussed with the aid of figure 2.1. The action research process consists of the following main phases:

- Initial diagnosis
- Planning and implementation of intervention
- Analyse success of intervention
- Advise improvements

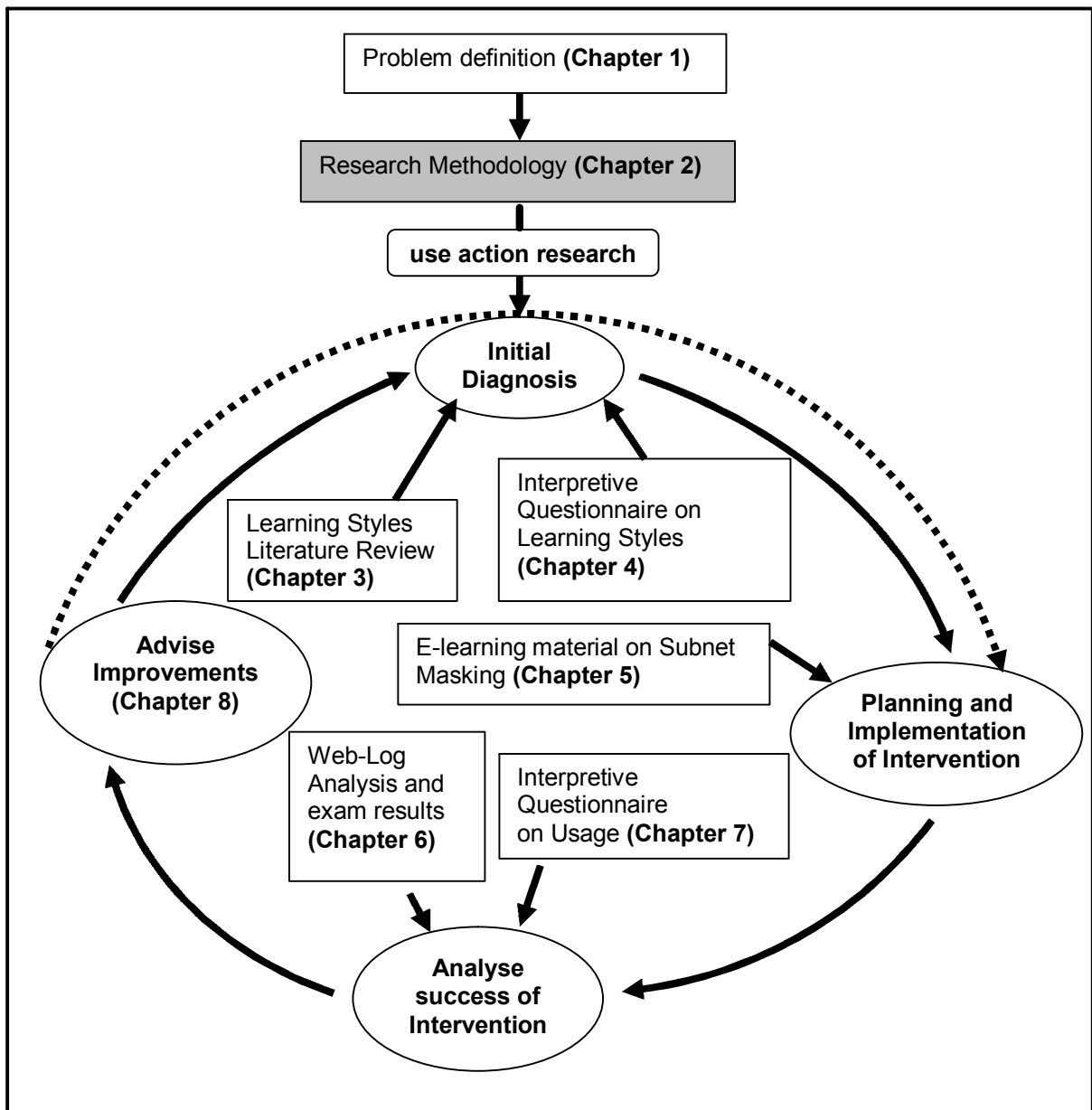


Figure 2.1 Schematic layout of this research

2.3.1 Phase 1: Initial diagnosis

Phase 1 addresses objectives 1 and 2 reported on in section 1.2. The Initial diagnosis phase consists of 3 sub-phases i.e. discussions with lecturers, a

literature review of learning styles and finally formulation and analysis of preliminary interpretive questions to determine learning preferences of learners. Sub-phase 1 of the diagnosis, entails discussions with lecturers to identify specific problem areas in the learning material and is reported on in section 5.1. Sub-phase 2 of the diagnosis, namely the literature review is reported on in chapter 3. This review emphasises the importance of e-learning and blended e-learning in future learning experiences. This knowledge will be used to develop a questionnaire to determine the most preferred learning styles of learners.

Sub-phase 3 of the diagnosis as reported on in chapter 4, investigates through an interpretive survey the learning styles of the students following the Network Systems III module used for this research. The study is conducted by means of interpretive questionnaires. The index of learning styles (ILS) model of Felder and Soloman (Felder, 2009:1) is used as guideline to develop the most suitable questionnaire for this research. This ILS model was designed to test the learning preferences of engineering students within a pedagogical environment, which is highly applicable to this research. Questionnaires will be analysed and the open-ended answers coded, whilst the outcome will be used to serve as input for the planning of intervention phase.

2.3.2 Phase 2: Planning and implementation of intervention

Phase 2 addresses objective 3 as stated in section 1.2. The Planning and implementation of intervention phase is reported on in chapter 5. This is the second phase in the action research cycle where literature and questionnaire results are applied directly to the development of e-learning material relevant to a specific area of the Network Systems III module as identified by lecturers involved. The learning material is developed to accommodate the learning styles of the majority of the learners. The adjusted e-learning material is loaded onto a learning management system (Moodle LMS) for learners to explore.

2.3.3 Phase 3: Analyse success of intervention

Phase 3 addresses objectives 4, 5, 6 and 7 as stated in section 1.2. The Analysis of success of intervention phase consists of 2 sub-phases. Sub-phase 1 is reported

on in chapter 6. In this sub-phase the success of intervention on learners' material is analysed through web log analysis and evaluation of results to establish whether there is a relationship between time spent with e-learning material and the performance of the students.

Sub-phase 2 is reported on in chapter 7. This sub-phase entails the composition and analysis of an interpretive questionnaire on the usage of e-learning material using the Moodle LMS. The purpose of this questionnaire is to determine what the general feeling of learners is with regard to the functionality of the learning material. The results of the questionnaire will be interpreted and analysed in order to suggest improvements to the learning material.

2.3.4 Phase 4: Advise improvements

The Advise improvements phase is the last phase in the action research approach. Results obtained in the previous phases will be evaluated and analysed to decide whether any more actions are necessary to improve the results. Further iterations in an action research approach entail planning and implementation of intervention and analysis of success of intervention. This part of the action research process can be repeated as many times as deemed necessary in order to improve the e-learning material and hopefully the performance of the students.

2.4 SPECIFIC SELECTED RESEARCH STRATEGIES

2.4.1 Basic vs applied research

The study undertaken follows an applied research approach as it is organised, structured, specific and purposeful and gathers information that will be analysed qualitatively to determine the necessary strategies in a real life environment.

2.4.2 Research approach

The most appropriate research methodology for this study will be the critical social theory supported by action research. The goal is to improve human conditions in society, in this case the performance of the VUT learners.

2.4.3 Action research

Action research allows the researcher to take action before observing the results of the action. It reflects on what was happening and evaluates the data or consequences of the action, modifies the material and implements an improved solution. Iterations allow the researcher to evaluate and analyse data and take appropriate action before the next iteration. What makes action research such a powerful research tool, is the fact that there is room for improving learning material continuously.

2.4.3.1 Data collection

This research has five different streams of data collection:

- Qualitative data will be collected through discussions with lecturers with the intention of interpreting the areas in which learners had the least success with their studies.
- Interpretive questionnaires with closed and open-ended questions to determine the best combination of learning styles. The questionnaires contain qualitative and quantitative questions.
- Moodle log streams on e-learning material usage.
- Semester tests and examination results.
- Qualitative data from interpretive questionnaires from students who completed the module.

2.4.3.2 Data analysis

The first sub-phase of the initial diagnoses phase will address discussions with lecturers. This data will be analysed interpretively, using content analysis. During sub-phase two of the initial diagnoses phase, the knowledge obtained through literature review of the learning styles enabled the researcher to compile an interpretive questionnaire. This serves to determine the learning styles of participants implemented in the second sub-phase of the initial diagnoses phase. For analysing closed questions, quantitative methods are used as these are based on numbers and numerical measurements. Open-ended questions are qualitative in respect of explanations and interpretations. Content analysis is used to analyse these answers.

In the third phase, analyse success of intervention, a quantitative approach will be followed in analysing the Moodle keystrokes and the test and examination results of learners.

Content analysis is used to analyse the interpretive answers of the final questionnaire given to the students to understand their attitude towards the blended e-learning environment.

2.5 CONCLUSION

The main goal of this chapter is to understand and interpret research paradigms in order to choose an appropriate paradigm for this research.

Action research was chosen as research method and critical social theory as paradigm.

The theory-guided action research approach is selected as most suitable for this study and was chosen to meet the goals for a framework based on visual and conceptual models, as well as reusable patterns of learning scenarios.

The action research model comprises of the four stages, i.e. Initial diagnosis, Planning and implementation of intervention, Analyse success intervention and Advise improvements.

Action research will start with the initial diagnose phase which consists of three sub-phases addressing the following:

- Qualitative analysis of discussions with lecturers (section 5.1)
- Literature review of learning styles (chapter 3)
- Learning styles of students, qualitatively and quantitatively by means of interpretive questionnaires (chapter 4).

The second phase, Planning and implementation of intervention, is reported on in chapter 5. The results of the questionnaire data are applied to developing the e-learning material.

The third phase, Analyse success of intervention, consists of two sub-phases. Sub-phase one addresses the success of intervention on learning material through web log analysis and test and examination results of learners (chapter 6). Sub-phase two entails the composition and analysis of an interpretive questionnaire on the usage of the e-learning material on the Moodle LMS (chapter 7).

The last phase, Advise improvements, evaluates and analyses the results of previous phases to determine whether any further actions are necessary to improve results (chapter 8).

Chapter 3 will report on literature addressing learning styles in sub-phase 1 of the initial diagnosis phase. This literature study addresses important aspects about learning and learning styles, as well as the use of multimedia to improve learning and other important strategies that may improve learning. The knowledge obtained from this literature study will enable the researcher to discover, through the help of an interpretive questionnaire, important information about the learning style preferences of the students at the VUT.

CHAPTER 3

EFFECTIVE LEARNING AND TEACHING STYLES

3.1 INTRODUCTION

This chapter addresses objective 1 identified in section 1.2. It provides an understanding of learning styles based on a literature review.

Effective teaching, according to Kizlik (2008:1) is difficult to describe and measure; it is in this context that Gareis and Grant (2008:1) argue that “the act of teaching is not complete until learning has occurred.” Materna (2007:49) argues that effective combinations of learning and teaching strategies form the foundation for education. Tomlinson (1995:60) takes it one step further and argues that the connection between teaching, thinking and learning is critical and learners must use these resources effectively to progress towards success.

Teachers at the VUT must recognise the essential principles of effective instruction techniques explained by the authors Kizlik (2008), Gareis and Grant (2008), Materna (2007) and Tomlinson (1995) and broaden their own authenticity to develop intellectual tools through which knowledge can be created. Knowledge and creativity are some of the most important factors needed to develop a successful and effective learning system that will encourage learners to attain the desired pedagogical outcome (Gero & Maher, 1992:4).

The skills necessary to create an environment that encourages and broadens thinking and “completes the act of teaching” will be discussed through this research. VUT lecturers can improve the way in which information is conveyed to learners through very selective dynamic teaching styles, which according to Jackson (2007:31), is amendable to the learning styles of most learners. Learners who are able to manage information successfully and effectively, will retain the obtained information easier and for longer periods.

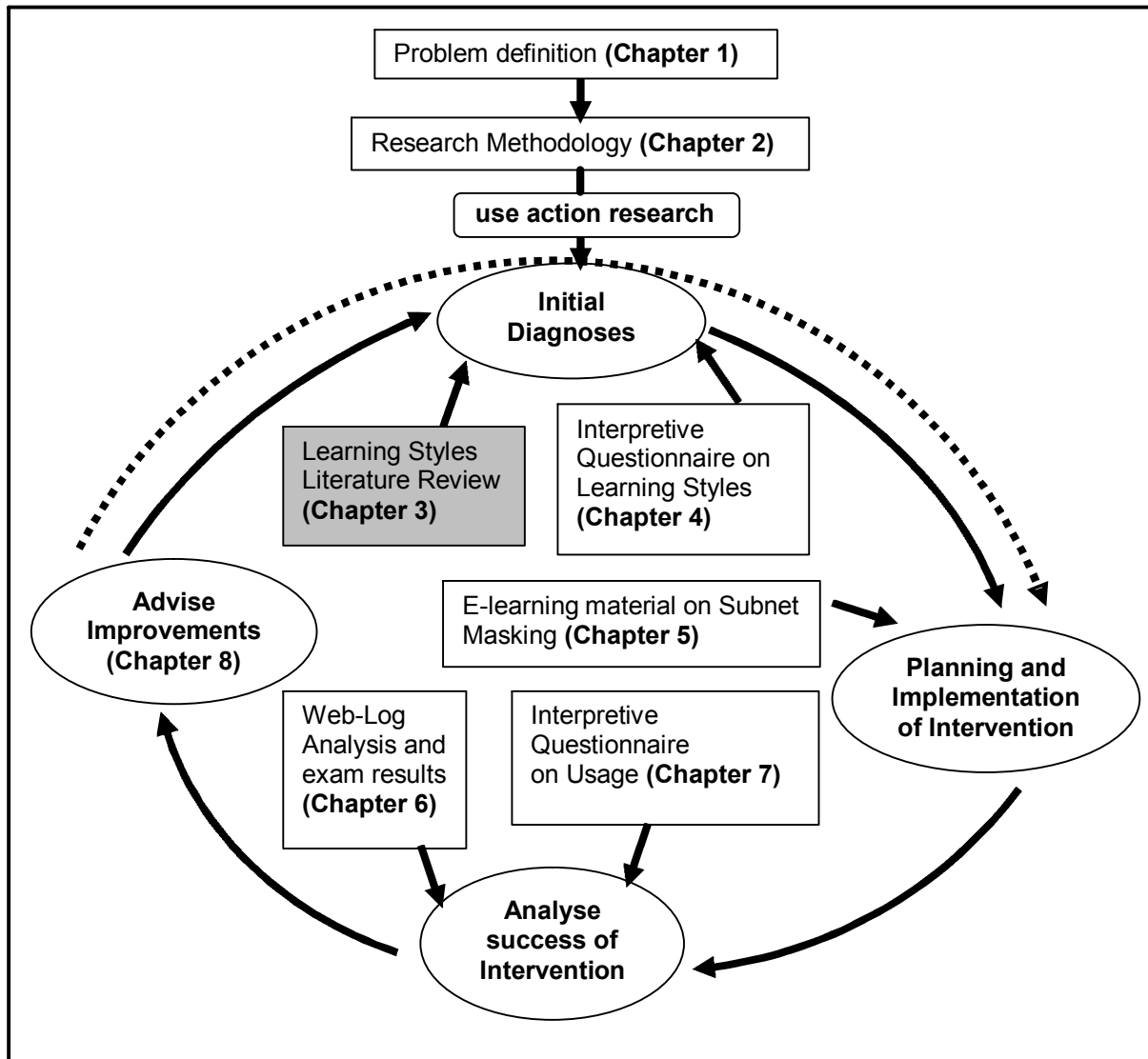


Figure 3.1 Schematic layout of this research

In chapter 3, different learning styles are discussed as part of the initial diagnoses phase of action research as shown in figure 3.1. This chapter addresses two objectives, discussed in section 1.2, namely objective 1 and 3. These two objectives can be divided into sub-objectives to ease linkage between different sections.

Objective 1: Understanding of learning styles based on a literature review, can be sub-divided into the following parts:

- 1.1 Understanding learning by means of a literature review on learning and learning formations (presented in section 3.2.1).

- 1.2 Understanding learning styles in general by means of a literature review on learning styles based on a review on learning domains, learning modalities and multiple intelligence (presented in section 3.2.2 and 3.2.3).
- 1.3 Summarising different learning style models in terms of specific models, learning dimensions and a description (presented in section 3.2.3).
- 1.4 Understanding the model of Felder and Silverman (1988:678) used in this study (presented in section 3.2.4).

This chapter also provides the literature background for objective 3. Creating of e-material accommodating different students' learning styles is divided into the following sub-objectives:

- 3.1 A literature review on learning styles (accomplished in objective 1).
- 3.2 An understanding of the learning styles of the VUT students (accomplished in objective 2 and presented in chapter 4).
- 3.3 A literature review on learning effectiveness to ensure the development of effective material (presented in section 3.3).
- 3.4 A literature review on learning and technology usage to ensure that the special aspects of using modern technology is taken into account in the development of e-learning. This review should focus on e-learning (presented in section 3.4.1 to 3.4.4).
- 3.5 A literature review on blended e-learning as this is the preferred model chosen in this study (presented in section 3.4.5).
- 3.6 Identify specific characteristic features that the e-learning material should contain in order to support any learning style (presented in section 3.4.6 to 3.4.8).
- 3.7 Teaching strategies to improve learning and the method to measure the learning success of learners was identified (presented in section 3.5).

Objective 3 is further explored in chapter 5. This chapter begins with a discussion on learning.

3.2 LEARNING

A discussion on learning is part of sub-objective 1.1, stated in section 3.1. According to Driscoll (2000:3), learning is an intelligent change in performance resulting from experience and interaction with the world. Learning can be seen as any intentional or non-intentional act through which learners absorb information that will enable them to develop a broad and valuable learning system to their advantage (Engelbrecht *et al.*, 1996:232).

Piaget believes that collaborative learning occurs where sufficient evidence exists that knowledge development has increased (Lefranzois, 2006:6). While Wells and Claxton (2002:84) and Muijs and Reynolds (2005:14, 17) endorse the constructivist Vygotsky's main idea that "learning is not development; however, properly organised, learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning."

Although Muijs and Reynolds (2005:18) believe that development of the mind takes place during the course of social experiences, they agree that Vygotsky's ideas about learning and knowledge creation were instrumental in the development of collaborative learning programmes.

Bastable (2005:58) suggests that the principle of learning is to focus on the learner's desire for growth, subjective feelings, needs, choices in life and interpersonal relationships. He also believes that the individual is responsible for his or her life and that behaviour can be changed if there is personal awareness and desire.

Pierce and Cheney (2004:208) believe that learning is something people do in response to external stimuli. Massaro (1997:96) describes Ernst Weber's law of perception amongst others as, "the ability to identify one stimulus as different from another is dependent on the overall magnitude of the stimuli".

Sternberg (1982:225) describes Weber's law as follows: "as the intensity of stimulation increases, proportionally greater increases in stimulation are required if they are to be noticeable." Lefranzois (2006:33) holds the view that Weber's law appears to be true because some people are more sensitive to stimuli changes than others. The main purpose for Weber's law was to distinguish between small differences in stimuli or the just-noticeable difference (JND) as he referred to it. The following is an example of Weber's just-noticeable difference:

Weber took two envelopes, one with a single coin in it and the other with two coins. He wanted to determine the difference in weight of these envelopes. When comparing these two envelopes directly, it will not be difficult to determine which envelope contains the two coins. Now, take these two envelopes and put one in each of your shoes, and then compare the weight of your shoes. What Weber found was that the discrimination of weight differences was based on a proportional rather than arithmetic difference. This means that a very small difference in stimuli is barely noticeable but can make a difference in learning when the intensity of these stimuli is powerful.

Hill (2002:198) believes that "learning occurs when experience causes a relatively permanent change, deliberate or accidental, in an individual's knowledge or behaviour."

Rogers (1983:20) argues that the following elements are involved in experiential learning:

- Personal involvement.
- Self-initiation.
- Pervasiveness.
- Learner evaluation.
- Meaningfulness.

According to Hilgard and Bower (1975:17), "learning refers to change in a subject's behaviour to a given situation, brought about by his repeated experiences in that

situation, provided that the behaviour change cannot be explained on the basis of native response tendencies, maturation or temporary state of the subject.”

Jacobs and Gawe (1998:176) defined learning as “a change in the pupil’s ability to perform as a result of experience.” Wittrock (1977:ix) defined learning as “the term we use to describe the processes involved in changing through experience”.

Bandura (2008:1) stated that there are four conditions that should be complied with before an individual can replicate the behaviour of someone else:

- Pay attention to the instruction.
- Retention is important to remember the behaviour that is observed. This can be achieved through rehearsal techniques.
- Motor reproduction is the ability to replicate demonstrated behaviour.
- Learners must be motivated to demonstrate the learned behaviour.

Good and Brophy (1990:125) see learning as “a change induced through experience (including inner reflection) rather than defining it more restrictively as change induced through encounters with the external environment.”

According to Hilgard *et al.* (1979:38), learning may be defined as a “relatively permanent change in behaviour that occurs as a result of prior experience.”

When reading the work of these authors, the following observations can be made:

- Driscoll (2000), Engelbrecht *et al.* (1996), Lefranzois (2006) argue that intelligent changes in performance lead to development of learning systems that will increase knowledge.
- Wells and Claxton (2002) and Muijs and Reynolds (2005) believe that learning must be properly organised to allow mental development. However, Bastable (2005), Pierce and Cheney (2004) and Massaro (1997) individualised learning and believe that it depends on the need for growth and stimuli of individuals for learning to occur.

- Sternberg (1982), Hilgard and Bower (1975), Jacobs and Gawe (1998), Wittrock (1977), Good and Brophy (1990), Hilgard *et al.* (1979) and Hill (2002) argue that the intensity of stimuli and experience play a very important role in learning success.

In this study, “learning” will be used to describe the process when the intensity of repeated stimuli (external and internal) together with experience, cause a change in knowledge development and intellectual performance ability. The work of Rogers (1983) is especially helpful in the development of the e-learning material in this study at the VUT.

3.2.1 Learning formations

Learning formations are part of sub-objective 1.1, stated in section 3.1. Learning formations are different approaches, or different ways of learning that allow an individual to learn best (Morgan, 1993:72). Patterns of learners’ intellectual development are necessary to prescribe the way in which people develop learning theories with an appropriate balance of challenge and support (Felder & Brent, 2005a:62).

Felder and Brent (2005:1) looked at the work of William G. Perry at Harvard University regarding learner intellectual development and came to the conclusion that new suggestions are needed to help learners to grow intellectually. O’Neil and Marsick (2007:180) discussed Perry’s work (Perry, 1989:4) which focussed on a process of new awareness of the self, on environmental influences on the self and the complex balance between this awareness of the self and the external influences from the environment. Perry and his colleagues identified nine interactive cognitive development positions grouped into four categories, namely dualism with basic duality and full dualism, multiplicity with early multiplicity and late multiplicity, relativism with contextual relativism and “pre-commitment” and finally commitment with commitment, challenges to commitment and “post-commitment” (Rapaport, 2008:1).

The approach to learning was discussed with regard to Perry's (1989) work by the authors Morgan (1993), Felder and Brent (2005a), O'Neil and Marsick (2007) and Rapaport (2008). They have different approaches to learning, but agreed that the environment has an effect on how learning occurs. This research at the VUT will combine the traditional methods of learning with new concepts of learning, namely e-learning. The outcome will be visible through the assessment results of learners in tests and the examination.

Teachers should assess different learning formations of their learners and adapt their classroom teaching methods in every possible way to accommodate each learner's learning style.

This section discusses some of the most common informal, formal and interconnected learning formations. Interconnected learning refers to learning formations that occur in both informal and formal learning.

3.2.1.1 Informal learning

Informal learning is not intentional and is a form of learning that occurred from the beginning of times, which makes it the oldest form of learning (Longworth, 2003:45).

Sloan (2006:34) describes informal learning as an unstructured and non-routine process of learning. Diamond (1999:32) argued that people accept informal learning as an instrument that reinforces learning.

There are many facets of informal learning, such as the following:

Play

Play describes behaviour on a smaller scale in a protected environment, which might improve performance for similar situations in the future outside the protected environment. Playing and interacting with the world is the most important fact for children's learning (O'Hagan & Smith, 1999:67, 68). Children learn to play with their hands and explore objects through all their senses.

Most play activities involve verbal interaction. Such interaction assists the development of social skills, verbal skills and co-operation, which in turn will be further developed by the teacher at a later stage in life (Muijs & Reynolds, 2005:181).

Sensitisation

Howard (1995:38) describes sensitisation as an increasing response to repeatedly presented stimulus. For example, when dogs bark repeatedly, it leads to increased annoyance.

Sensitisation refers to the extent to which individuals feel comfortable to learn a new process without any kind of experience, whether the learning task is easy or difficult (Riding & Rayner, 1998:91). Think of how small children begin to observe and explore the world through constantly active looking, touching and tasting (Moll *et al.*, 2001:76).

Imprinting

“Imprinting is the term used in psychology and ethology to describe any kind of phase-sensitive learning (learning that occurs at a particular age or at a particular life stage)” (Moll *et al.*, 2001:332).

A very good example of imprinting is that of Konrad Lorenz being followed by his imprinted geese. Lorenz demonstrated the fact that when animals are born without a mother, the young will form a bond with whatever animal is present and adopt this animal as their “mother”. This is exactly what Lorenz did to greylag goslings (Flanagan, 1999:26).

Operant conditioning

Operant conditioning is part of associative learning and associates responses with their consequences. This then serves to modify the occurrence and form of behaviour. Acts that are reinforced tend to be repeated, suggesting that learning takes place as subjects’ response to various stimuli, either with reward or punishment (O’Hagan & Smith, 1999:10).

Habituation

Habituation is a simple form of repeatedly performed learning that occurs without the subject's awareness of a change in behaviour (Gapta *et al.*, 2003:37). Baddeley (1999:92) describes habituation as an example of non-associative learning in which there is no connected stimulus that causes a progressive decrease in reaction due to inappropriate feedback.

When an action is performed often, it becomes easier and more automatic. Constant repetition will form a habit requiring almost no thought. An example of a habit is when an animal first responds to a stimulus, but if it is neither rewarding nor dangerous, the animal reduces successive responses (Sternberg, 1982:173).

Observational learning

Bandura (2008:1) explained observational learning based on the principles of operant conditioning as the personal repetition of an observed process, such as smiling. Lefranzois (2006:366) describes Bandura's theory of social learning as an assumption that imitation is a type of emitted behaviour that occurs as a function of observing a model. Individuals, who are perceived as prestigious, influential or physically attractive, are often effective and their behaviours are imitated or reinforced (Sundel, 2004:107).

Observational learning is a natural mechanism for infants and children to observe the behaviour of others and to display the same significant behaviour to effect relationships (Lefranzois, 2006:364).

Study groups

Study groups are forms of informal learning that happen outside the formal learning system. You could learn from role models or people with the same interests and viewpoints (Moll *et al.*, 2001:174). Alexander and Winne (2006:228) revealed through a detailed video analysis, that group learning situations are both a social and cognitive function where everyone capitalise on collective knowledge.

3.2.1.2 Formal learning

Formal learning in contrast to informal learning is structured, planned, classroom based learning that takes place within a formal pedagogical environment (Sloan, 2006:34).

The goal of formal learning is the development of learning and therefore learners, to reach higher levels of knowledge and strive towards self-actualisation and personal empowerment (Engelbrecht *et al.*, 1996:229). Learning should be emphasised through continuous encouraging support and motivation to master the learning content (Engelbrecht *et al.*, 1996:231; D'Andrea & Gosling, 2005:22, 23).

The following formations are a selection of formal learning that takes place in any pedagogical environment:

Surface learning

Surface learning primarily concentrates on memorising the facts rather than the meanings of what is studied (Amin & Khoo, 2004:33). Motivation of the surface learner occurs mainly through fear of failure, and therefore such learner tries to please the teacher by providing what is necessary. It leads to superficial retention of the learning material for examination purposes. Understanding and retention of knowledge is not promoted in this way. Rowntree (1988:19) discusses the diverse approaches to learning and how it could influence the value of studies.

Passive learning

Passive learning is described by the theory of behaviourism as the passive accumulation of information where the learner just takes in what the lecturer teaches. This encourages surface learning rather than deep learning (Grubb & Worthen, 1999: 31).

The most serious form of passive learning is where learners take no notes, reading books without purpose and browsing the web with no intent to require valuable information (Barnes, 1992: 17).

The teaching process in this case involves a series of technical events feeding progressively more difficult bits of data to the learner and putting the emphasis on active teaching and passive learning to enhance the probability of learning approaches through environmental stimuli (Moll *et al.*, 2001:19).

Deep learning

Deep learning encourages critical analysis of new ideas, linking them to already known concepts and principles and promotes the understanding and meaning of what is learned. It involves the grouping of learning materials according to a principle that helps understanding and long-term retention of concepts in order to organise knowledge into meaningful memory units (Maddox, 1967:59).

Active learning

The term active learning is synonymous with a learner's attitude, or teaching methods that may force a him or her to be academically active, retaining what is needed to understand and to create new meanings from this interaction (Moll *et al.*, 2001:20).

Constructivists believe that humans generate knowledge and meaning from their experiences (Dillon & Maguire, 2007:165). The learner will construct his own knowledge through a learner-centred approach, thus shifting the responsibility of active learning to himself. This shift of learner responsibility encourages teachers to guide learners and provide active learning, thereby involving them to interact and to think about what they are doing (Bonwell & Eison, 1991:1).

Rote learning

Rote learning is a method which avoids the difficulties of the subject learned and focuses on the memorisation of the material in order to be recalled in exactly the way it was read or heard. Maddox (2001:1) explains rote learning as isolated and meaningless bits of knowledge. The surface learner concentrates on facts rather than the meaning of information whereas the rote learner focuses on any information that was read or heard.

The main purpose of rote learning techniques is to learn by repeating the information, which is based on the idea that the more the material is repeated, the easier it will be to recall.

3.2.1.3 Interconnected learning

Some learning formations are almost impossible to be classified simply as formal or informal learning, as it is interconnected in human learning actions. Hager and Halliday (2008:36) explain that when a learning action is accompanied by formal and Informal learning, it is interconnected.

The following interconnected learning formations are present in formal learning and informal learning.

Analogy

An important aspect of cognition is analogy. Analogy can be used to evoke learners' imaginations through images that force an association with something else (Moll *et al.*, 2001:62).

Analogy is important for the tasks of problem solving, decision making, perception, memory, creativity, emotion, explanation and communication. It is an aid that can be used to identify places, objects and people, for example in facial recognition systems.

Thinking

Arnheim (2004:105) explains thinking as a cognitive operation that understands reality through analysis and coherent assumption based on the intellectual understanding of things and their interrelationships. Thinkers focus more on graphic representations of information and dismiss from visibility what is not.

Hermeneutics

Gadamar and Linge (1977:xxiii) argued that hermeneutics is concerned with the human understanding and interpretation of the meaning of written texts and symbolic artefacts from somebody else's point of view. Hermeneutics has to do

with designation of applications and meanings expressed in text. In order to understand the meaning of the whole, it is necessary to understand the meaning of the parts (Abrams & Harpham, 2008:158).

Attention

Almost everything we do requires at least some attention (Wulf, 2007:2). Learning is associated with attention in such a way that we only learn that portion to which we have paid attention to (Deth, 2003:1).

Attention is not required for common activities. Learning takes place depending on the usefulness of the information (Lefranzois, 2006:365).

According to Broadbent's Filter Theory (1958:1), perceptual processes are influenced by attention culminated in his Filter theory. According to this theory, a large amount of sensory information can be absorbed at once. A selective "filter" then reduces the input from one source, while the brain is processing the information from another source.

Thematic curriculum

According to Caine and Caine (1994:82), thematic curriculum is about connecting intellectual content for specific intended learning purposes. Thematic units are designed for the purpose of engaging learners' imaginations and understanding, allowing them to reconstruct for example, the Industrial Revolution period. If the construction of a thematic unit is successful, learners will through engagement of emotions, cognitive processing and intellectual challenge think and talk about this topic, not only in class but also outside the class (Caine & Caine, 1994:192).

Memory

Memory is the term that refers to the availability of information and the retrieving of previously acquired skills or information from storage (Lefranzois, 2006:297). Memory involves change and plays a key role in the learning process. If you are unable to remember anything from the past, you could find it difficult to learn anything new.

Human memory is divided into three main groups, i.e. sensory memory, short-term memory and long-term memory. Memory is used for storing and retrieving information acquired through our senses (Baddeley, 1998:9).

Sensory memory is an instantaneous memory. It only holds information for a fraction of a second. For example, the image of a picture enters your eyes and is immediately transmitted to the brain in less than a second. Sensory memory refers to a phenomenon that lasts milliseconds while short-term memory lasts seconds (Lefrançois, 2006:302).

Short-term memory can hold a piece of information for as long as you actively think about it.

Long-term memory extends considerably beyond a matter of seconds and is used for studying and to retain information for much longer periods when we learn by means of visual material (Baddeley, 1998:14).

Informal learning and formal learning are part of learning formations as indicated in the first objective in section 1.2. Morgan (1993) and Felder and Brent (2005a) describe learning formations as an approach to different types of learning and learning theories. O'Neil and Marsich (2007) and Rapaport (2008) explain through Perry's work that the environment and external factors have a strong influence on the commitment to study. Informal learning describes the most common forms of learning that occur naturally and forms the basic foundation for formal learning. Formal learning is different from informal learning, it is more structured, group-orientated and happens mostly in a formal pedagogical environment.

Although the development of the e-learning material at the VUT should facilitate formal learning, some of the principles of informal learning, such as imprinting and habituation, are as important to keep in mind when designing the new e-learning material.

The next section discusses the different content areas where instructional procedures are addressed.

3.2.2 Learning domains

Learning domains are part of sub-objective 1.2, stated in section 3.1 and are used to divide learning into categories called domains. McDonald (2002:44) describes learning domains as the content areas where different instructional procedures can be addressed. These domains are Cognitive learning, Affective learning and Psychomotor learning (Kaufhold, 2002:3).

3.2.2.1 Cognitive learning

The cognitive domain is seated in the mind. It involves rational and analytical thinking processes. It describes the way individuals think, perceive and remember information (Jacobsen *et al.*, 1999:127; Riding & Rayner, 1998:118).

The goal of cognitive education is to recognise the processes involved in teaching and to identify the meaning of understanding (Egelbrecht *et al.*, 1996:162). In an academic environment, such as the VUT, it is important what learners do with information and whether they can understand and make use of it.

Tolman's theory of learning, also called cognition, is a broad concept that refers to the mental activities involved in a pedagogical environment to promote learning (Engelbrecht *et al.*, 1996:252; Roeckelein, 1998:456).

Cognition refers to the development of cognitive skills and the processing of essential information in order to turn expectations into behaviour (Engelbrecht *et al.*, 1996:165).

According to Piaget's perspectives, all our knowledge is constructed through actions in the world. He argued that actions continue to be very important for all thinking throughout our lives, but we can only act on things if we know about it (Moll *et al.*, 2001:45). Cognitive thinking is related to behaviour and affects the way in which an individual thinks about internal situations in the external world.

If the learner and teacher have the same cognitive styles, the chances that learning will take place are improved. Teachers can promote critical thinking in a classroom

by involving learners in cognitive activities (Jacobsen *et al.*, 1999:138). Teachers should be able to identify students' cognitive styles through observation and interaction.

3.2.2.2 Affective learning

Affective learning deals with designing for emotional impact like feelings, likes and dislikes (Power, 2008:8). Learners become more skilled at learning as their experiences and contact with the learning process develop and expand through communication with national cultures and languages (Forsyth *et al.*, 1995:44; Hofer *et al.*, 2007:21).

Teachers must attempt to request and respond to learners' emotions towards attitudes and values (Jacobsen *et al.*, 1999:119). Feelings and emotions play an important role in learning and can be measured with multiple measures over time (Sansone & Thomas, 2005:509).

Affective learning motivates learners to find the information they need. It also encourages them to understand it in a way that they can apply what they learn with a more positive attitude towards their subject, themselves and others.

3.2.2.3 Psychomotor learning

Psychomotor learning skills result from physical activities in response to stimuli from the environment including activities such as cutting with a pair of scissors, getting dressed, swimming, walking, using a computer keyboard and writing (Westwood, 2004: 4).

There is a tendency to retain psychomotor skills longer than we retain learned text material. This happens because these skills are practiced regularly.

The three major factors affecting the achievement of psychomotor skills are feedback, motivation and the amount of practice undertaken. This kind of learning demonstrates the effect of coordination and manipulation with regard to feedback. The more specific the feedback we receive, the faster we will learn the necessary

skills (Maier & Warren, 2000:136). Practice is a very powerful factor, but the effect of the amount and intensity of practice is unique to each person.

3.2.2.4 Importance of learning domains for study at VUT

Learning domains use different methods to describe the way in which learning takes place. This section forms part of objective 1, described in section 1.2. It indicates how information is received and perceived in order to distribute this information to other learners. The emotional way in which information is assimilated to learners is described, as well as the influence thereof on the physical activities during the learning experiences.

Multimedia approaches towards learning, described in section 3.4 of this chapter, will address cognitive learning through the use of sketches, video presentations and animation, whereas affective learning allows the learner to use any part of the learning material through e-learning that matches his or her learning style. Psychomotor learning allows the learner to participate actively with the learning content. Feedback on questions and study related information is very important and almost instantly available through e-learning, thus enhancing the learning experiences of VUT learners.

3.2.3 Learning styles

A description of learning styles is part of sub-objective 3.1. Various important approaches for learning are discussed, expressing different ways in which learners experience learning. Learning modalities describe the way in which the mind accepts and retains information through visual, auditory and kinesthetic approaches. Multiple intelligences look at different learning types which is an extension of learning modalities. This particular information allows the researcher to approach the e-learning environment with knowledge and a new understanding of making learning material more attractive and more accessible for the VUT students.

Learning styles are ways of learning and involve instructional methods for individuals or groups to allow them to learn in the best possible way.

Approximately 98% of all new learning enters the brain through the senses. Variation in teaching strategies will benefit learners with different learning abilities (Tilestone, 2007:7).

To understand the learning process, a variety of instructional methods should be used to engage learners through their own learning preferences (Sims, 1995:88). Section 3.2.3.1 on learning modalities, discusses three approaches to address learning styles. Section 3.2.3.2 on multiple intelligences discusses a group of approaches also addressing learning styles. Section 3.2.3.3 on learning style models deals with different sets of rules pertaining to learning styles.

All types of learning styles must be evaluated in order to find the most appropriate learning style or combination thereof that will address most of the learning styles in this research project. The most important learning style models for the purpose of this research project will be discussed in more detail in the section on learning style models.

3.2.3.1 Learning modalities

Learning modalities are part of sub-objective 1.2, stated in section 3.1 and refer to a combination of perception and memory, meaning the way the mind receives and stores information. Learning modalities refer to a particular style used by learners to concentrate on the process of information retention. In properly constructed educational psychology, learning is defined as a change in behaviour and perception (Popham *et al.*, 1969:39). Behaviour may affect the way in which the learner selects, acquires, organises, or integrates new acquired knowledge. Perception can make a substantial difference in individual learning styles, and learners will process information more effectively (Bonwell & Eison, 1991:1).

The three basic types of learning modalities are visual, auditory and kinesthetic. Learning modality theorists argue that all learners prefer one or more of the above-mentioned sensory modalities (University of South Dakota, 2004:1).

A discussion of each sensory modality follows hereunder.

Visual learners

Visual learners learn through observing. They need to observe the teacher's body language and facial expression. This enables better understanding of the content of a lesson.

Visual learners prefer sitting at the front of the classroom to avoid visual obstructions, such as people's heads. They think in pictures and learn from visual displays, such as diagrams, illustrated textbooks, overhead transparencies, videos, flipcharts and handouts. These learners also prefer to take detailed notes during a lecture to absorb the information (Torres *et al.*, 2004:20).

Auditory learners

More than 80% of learners in any given classroom are not auditory learners (Tilestone, 2007:3). Auditory learners learn through listening. The best way for them to learn is through verbal lectures, discussions, talking about things and listening to what others have to say (Feinstein, 2006:98). Auditory learners interpret the meaning of speech through listening, written information may have little meaning until it is heard.

Kinesthetic

The word kinesthetic refers to movement of the body. During kinesthetic learning the learner has to carry out a physical activity while listening to a lecture or watching a demonstration.

Kinesthetic learners do not like to sit still for long periods without being engaged in an activity. "Kinesthetic learners need movement and action," (Maal, 2005:1). These learners learn more effectively if they write information down. Kinesthetic intelligence is well coordinated. Learners need motion to perform and should use all five senses for studying.

3.2.3.2 Multiple intelligence

Multiple intelligence is part of sub-objective 1.2, stated in section 3.1. The multiple intelligence approach to learning is not exactly the same as learning modalities and

contains more learning types or learning intelligence than learning modalities. A summary of Gardner's (1983:1) multiple intelligence is given, in no particular order, in table 3.1.

Different Intelligences	Like to	Good at	Learns best by
Linguistic Learner	Read, write and tell stories.	Memorising names, places, dates and trivia.	Saying, hearing and seeing words.
Logical/Mathematical Learner	Do experiments, figure things out, work with numbers, asking questions.	Maths, reasoning, logic and problem solving.	Categorising, classifying and working with abstract patterns and relationships.
Spatial Learner	Draw, build, design and create things, daydream, look at pictures and slides, watch movies and play.	Imagining things and reading maps and charts.	Visualising, dreaming, using the mind's eye and working with colours and pictures.
Musical Learner	Sing, hum tunes, listen to music, play an instrument and respond to music.	Picking up sounds, remembering melodies, noticing pitches and rhythms.	Rhythm, melody and music.
Bodily/Kinesthetic Learner	Move around, touch and talk and use body language.	Physical activities (sports, dance, acting) and crafts.	Touching, moving, interacting with space and processing knowledge through bodily sensations.
Naturalistic Learner	Be outside with animals, geography and weather, interacting with surroundings.	Organising a living area, planning a trip, preservation and conservation.	Studying natural phenomenon in a natural setting, learning how things work.
Interpersonal Learner	Have lots of friends, talk to people and join groups.	Understanding people, leading others, organising, communicating and manipulating.	Sharing, comparing, relating, co-operating and interviewing.
Intrapersonal Learner	Work alone and pursue own interests.	Understanding self, focusing inward on feelings and dreams, following instincts and being original.	Working alone, individualised projects, self-paced instruction and having own space.

Table 3.1 Multiple Intelligence (Gardner, 1983:1)

3.2.3.3 Learning style models

Learning style models are part of sub-objectives 1.3 and 3.2 as stated in section 3.1. Individual authors developed their own models of learning styles which are presented in table 3.2.

Learning styles deal with characteristic styles of learning and emphasise the fact that individuals perceive and process information differently (Sternberg & Zhang, 2001:16). Learning style models use different approaches to accommodate learning and teaching. Through knowledge of learning style models, learners may determine what learning style is the most appropriate model for them.

Pask (1975:1) described learning styles through means of serialist versus holist. Serialists prefer to learn sequentially, whereas holists prefer to learn in a hierarchical manner (top-down) (McCarthy, 2004:1).

In 2004, the Learning and Skills Development Agency published a review of different learning styles (CIPD, 2004:1). This work combined with other literature is summarised in table 3.2.

Learning Style Models	Styles or Dimensions	Description
Gregorc – Mind styles delineator	Concrete-abstract and sequential-random	Prefer variety of instructional approaches. Issues with validity and reliability. There is no empirical evidence that Gregorc's model brings learning benefits.
Dunn and Dunn – Learning style questionnaire	Environmental, sociological, emotional, physical	Identify individual learning preferences and adapt pedagogy and learning environment to preferences. Not enough evidence to support this model.
Kolb – Learning styles inventory	Active, reflective, abstract, concrete	Learning styles are not fixed personality traits (MacKeracher, 2004:84) Gain competence in all four learning styles to become balanced.
Vermunt – Inventory of learning styles	Meaning-directed, application-directed, reproduction-directed, undirected	Each style affects five dimensions: cognitive processing, learning orientation (motivation), affective processes (feelings about learning), mental model of learning and regulation of learning. Combines cognitive and emotional aspects. Concentrate on the teaching-learning environment rather than individual differences.

Learning Style Models	Styles or Dimensions	Description
Riding – Cognitive styles analysis	Holist-analytic, verbalise-imager	Connection between cognitive styles and instructional preferences. Working memory and cognitive styles important. Riding's cognitive style is not reliable for measuring.
Allinson and Hayes – Cognitive styles index	Intuition-analysis	High level of validity and reliability. Primarily for use in business.
Meyers and Briggs – Meyers-Briggs type indicator (MBTI)	Based on Jung's theory of personality- (perceiving, judging, sensing/intuition, thinking/feeling, extraversion/introversion) (Materna, 2007:54). Producing 16 personality types	Categorise personality, not just approaches to learning. Not enough evidence that matching teacher and learner types increase performance.
Honey – Meyers Briggs Model	Activists, reflectors, theorists, pragmatists	Learning style defined as attitudes and behaviour that determine an individual's preferred way of learning. More than one trait exhibit by most people.
Apter-Motivational style profile	Based on motivational states, not fixed types, in four domains: means-ends, rules, transactions, relationships.	Theory of personality, not learning style. Emphasise that motivation may have considerable relevance for education.
Jackson-Learning Styles	Initiator, reasoner, analyst, implementer	Mostly used in business. Concentrate on importance of personal development through building multiple strengths.
Entwistle – Approaches and study skills inventory for learners (ASSIST)	Deep, surface, strategic	Deep learning is most effective and beneficial. Characterise approaches, not individuals. Recommend designing instruction to promote deep learning.
Hermann-Brain dominance instrument	Theorists, organisers, innovators, humanitarians	People have two or more strong preferences. Cultural and experiential factors are more important in determining learning preferences. Develop flexibility to respond to particular learning situations. Well established in business.
Sternberg – Thinking Styles	13 thinking styles divided into three functions, four forms, two levels, two scopes and two leanings.	Determine between styles and abilities – a style is a preferred way of using the abilities one has. Learners have different styles. Profiles of styles may differ according to gender, cultural and background Variety of teaching and assessment methods is desirable.

Learning Style Models	Styles or Dimensions	Description
Index of learning styles – Felder and Soloman	Sensing/intuiting, visual/verbal, active/reflective and sequential/global	Developed by Felder and Soloman. Self-scoring, web-based instrument that assesses preferences on four scales of the learning style model.
Fleming's Vark learning style test (Fleming, 2001:1)	Visual, aural, read/write and kinaesthetic	Questionnaire that provides users with a profile of their learning preferences regarding how they obtain and provide information.
Kuhlthau's theory – retrieval of info resources (Kuhlthau, 2004:1)	Initiation, selection, exploration, formulation, collection, presentation and assessment	Model describes thoughts, actions and feelings commonly experienced by users in each stage of the learning process. When users engage in a new task, their thoughts evolve from vague, unclear to focused and personalised. Actions change from simple, exploratory to specific and comprehensive. Feelings emerge from uncertain, hesitant to interest and directed. Critical component is the person's own formulation of thoughts while using a variety of sources of information.
Perry model of intellectual development	Dualism, Multiplicity, Relativism and commitment within relativism	One correct answer – by authority learner must memorise or repeat. Want facts/formulas. Questions without answers but they will be answered. Knowledge and values depend on context and individual perspective. Individuals make personal commitments in personal direction and values.
The social (interpersonal) learning style (Goldstein, 1984:238)	Behaviour, Expectancy, Reinforcement and Psychological situation	Combine behaviourism and study of personality, without relying on physiological instincts or drives as a motive force (Rotter, 2008:1).

Table 3.2 Learning Style Models (extended from CIPD, 2004:1)

The most appropriate learning style model that will be used for this research is that of Felder and Silverman, discussed in more detail in section 3.2.3.4.

The learning style model of Felder and Silverman was developed specifically for engineering students. This model is widely used in research on learning styles by authors, such as Graf *et al.* (2007) at the Massey university in New Zealand and Vienna university of technology in Austria, Visser *et al.* (2006) at the North-West university in South Africa and Glasgow Caledonian university, Zywno (2003) at the Ryerson university in Toronto, Canada and Litzinger *et al.* (2007) at the

Pennsylvania state university with students in engineering, liberal arts and education.

As students of the VUT are also engineering students this model appears to be suitable for this research. The model also contains an interpretive questionnaire called the Index of learning styles, developed by Felder and Soloman that will be adapted for use in this study.

3.2.3.4 Learning Styles Model – Felder and Silverman

According to Felder (2009:1), the learning styles model was originally formulated by Felder and Silverman to be used on tertiary level by lecturers and students in engineering sciences to determine individual learning style preferences.

The Felder and Silverman model incorporates two dimensions, perception and processing, duplicating certain aspects of the Meyers-Briggs and Kolb models, as well as Jung's theory of psychological types (Felder & Silverman, 1988:675). According to Felder and Silverman (Felder, 2009:1), "A learning style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information."

The learning styles model of Felder and Silverman was exclusively developed for engineering students, but is now used in a broad range of disciplines by many researchers all over the world (Jarvis, 2005:85). The complete model consists of four dimensions, namely perception, processing, input and understanding. Each dimension is divided into two sections.

Perception addresses intuitive learners and sensing learners. Intuitive learners look at possibilities and relationships within the learning environment, while sensing learners prefer to learn facts. Processing addresses active and reflective learners. Active learners like to participate in lectures and class discussions, while reflective learners like to work in a quiet environment on their own. Input addresses visual and verbal learners. Visual learners learn what they see and verbal learners learn words, both written and spoken. Understanding addresses sequential and global

learners. Sequential learners like to study in clear linear steps, while global learners first like to see the bigger picture and then learn smaller sections.

Learning style assessment

The Index of Learning Styles, developed by Felder and Soloman, is a self-scoring questionnaire that can be accessed on-line to determine individual learning styles. This instrument allows the user to evaluate his or her own learning style preferences according to the four dimensions of the Felder-Silverman model (Felder & Brent, 2005:61).

The Index of Learning Styles (ILS) is a 44 question-instrument where each dimension has 11 questions and every answer of the student is measured against the appropriate dimension to indicate the specific learning preference of the student. The purpose of the Felder and Soloman ILS is to determine all the learner preferences of students. No distinction will be made between the small or large percentages of each learning style preference. All the learning style dimensions are in some or other way parallel to one another and in some cases may overlap.

Conventional teaching approaches in engineering education indicate that students prefer an active approach rather than a reflective approach (Felder & Silverman, 1988:678).

ILS applications for this research

When there is inequality between the learning styles of students and the way in which lecturers transfer information, students may lose interest, fail tests, get discouraged about the courses and in some extreme cases change to another course or drop out of the institution (Felder & Silverman, 1988:674; Felder & Henriques, 1995:21; Felder & Spurlin, 2004:103). The opposite is possible when students understand the information in class; it will lead to self-confidence and they will be enthusiastic to learn more (Pritchard, 2008:42).

All dimensions will be discussed with regard to its functionality and applicability (Felder & Silverman, 1988:676; Felderman & Henriques, 1995:22; Felder, 1993:287; Felder & Spurlin, 2004:103; Felder & Brent, 2005:60).

Intuitive learning is a component of the dimension that deals with perception. It means that learners react according to what they observe about learning material with regard to their knowledge framework. They will frequently refer to previous knowledge and thoughts when trying to understand new information. Before new information is memorised, innovative interpretations of the learning material will be done in order to avoid too much detail and repetitions.

The learners in this section like to make use of principles and theories and have a preference for symbols and words. They easily get bored and careless with too much detail, but they are quick at understanding new concepts.

Sensory learning is a component of the dimension that deals with perception. Sensory learners perceive things according to what they find as well-known to them. They will give more attention to detail and well known procedures, and they like to experiment in order to solve difficult problems. These learners are patient and they do not like to solve problems that are too complicated. It is also very important for them to know the reason for learning certain information. They like to learn by using many examples and gather data through their senses. They prefer to memorise facts but do not like surprises.

Active learning is a component of the dimension that deals with processing. These learners need to process information by summarising the material and take time to think about it before discussing it with others. Active learners learn and process information more effectively when they explain to others in group situations or externally. They are more at ease in an environment where they participate actively in social and intellectual experiments. They do not learn much in passive situations like lecturing, listening in a class. Active learners appraise ideas, participate and design experiments in a group relationship to uncover workable solutions.

Reflective learning is a component of the dimension that deals with processing. Decision making takes place through meditation, alone, in a quiet place. They are practical in applying the information in a very discreet manner. In the case of observation, information is manipulated and introspectively examined. In a situation

where no time is provided to think about the information at hand, reflective learners will not learn much. Reflective learners are theoreticians and mathematical modellers, able to define problems and provide possible solutions.

Visual learning is a component of the dimension that deals with input. Visual learners obtained their information (input) from visual images, such as pictures, diagrams, PowerPoint demonstrations, graphs and many more. These learners concentrate more on the visualisation part than on words. Colour in any lecture will enhance these learners' ability to memorise visual material. Visual learners remember most of what they see.

Verbal learning is a component of the dimension that deals with input. Words are very important for these learners, whether written or verbal. Verbal learners prefer any material designed to reduce learning time, therefore diagrams and sketches can be used when presenting information. They will remember most of what they hear, but more of what they hear and say. Verbal learners learn much from verbal explanations and less from visual demonstrations. They learn best when they explain to others.

Sequential learning is a component of the dimension that deals with understanding. These learners prefer to receive their learning material in many short lessons. They are able to solve difficult problems without knowing all the theory around the problem. In formal education, learning material is presented linearly in a logical and orderly way that is easy to follow and has a definitive end date. Sequential learners learn better in schools and in universities where learning material is presented linearly in a series of balanced complexity and increased difficulty.

Global learning is a component of the dimension that deals with understanding. It is important for global learners to understand the learning material and relate it to their knowledge and experience. They have to see the entire picture in order to understand the smaller parts. It happens from time to time that global learners see the connection between the parts before sequential learners see it, because they have a broader understanding of the whole. When complicated learning material is

presented to global learners, they will have difficulty understanding all the sections straight away, but will prefer to think of the bigger picture.

When they know the purpose of the lesson, they will deal with the more complex and difficult material first by using linear steps to understand the significance of the learning material. They will become more comfortable and positive about the learning process and education in general.

Conclusion

The Learning Styles Model of Felder and Silverman is preferred since it was developed for engineering students and therefore would fit perfectly into this research environment. The different learning style dimensions are very closely structured and may have the effect of learners' learning style preferences overlapping from one dimension to another.

Internet technology supports a blended learning style approach (an approach combining both technology and face-to-face teaching styles), providing a stimulating and engaging learning experience for the learner.

Chapter four, as part of the diagnostic phase of action research will address the questionnaire and the analysis of the results. Sections 3.3 to 3.5 serve as a literature background for objective 3, creating of e-material accommodating different students' learning styles.

3.3 LEARNING EFFECTIVENESS

Learning effectiveness, as part of sub-objective 3.3 in section 3.1, is all about interaction, learners with co-learners, teachers with learners, high level of participation in class activities and effective usage of learning material. Duffy and Kirkley (2004:362) argue that there is a significant correlation between satisfaction and learning when high levels of interaction are present.

3.3.1 Factors that affect learning

When learning styles, learning modalities and learning models are considered to improve learning conditions, other environmental factors have to be considered as well. Environmental factors ensuring favorable learning conditions are cultural theory, autonomous learning, self-efficacy, communication techniques, self-development, self-directed learning and intended learning outcome.

Specific factors affecting learning will be discussed.

3.3.1.1 Cultural theory

According to Crook (1994:13), learners in a cultural theory actively seek to construct meanings in a dialogue with regard to their culture. Contact with culture, material and social resources should capture and express the thinker's interaction with the environment and support cognitive activity. The stability of cultural meanings, as well as their possibilities for variation may affect learning positively.

3.3.1.2 Autonomous learning

Roberts (2008:1) explains autonomous learning as a means of self-directed learning, as it encourages an independent style of study. Autonomous learning means to independently do intensive reading for study purposes. Autonomous learners are able to work towards a certain goal without systematic help from others.

3.3.1.3 Self-efficacy

Self-efficacy is built on positive experiences of individuals. It relates to the learning of a subject (Tilestone, 2007:9). Learners have a good sense of what they are capable of doing and therefore have accurate opinions about their self-efficacy.

Judgement of personal efficacy does not only influence what people will do, but also determines how much effort and time they will devote to a task. The more you believe in yourself, the more likely you will persist, especially in difficult times (Lefranzais, 2006:351).

The challenge is to increase learner self-efficacy by understanding his or her resources. A resource is anything a person can use to help reach a goal (Wanat *et al.*, 2006:18), such as previous successes and failures (of self and others) and messages received from others.

Learners with a low self-efficacy may avoid tasks, whereas those who feel self-assured will participate in all learning activities. Self-regulation as an attribute of self-efficacy is an important technique in social learning theory. The individual has his or her own ideas about what is appropriate or inappropriate behaviour with regard to retrieval of information and will choose to act accordingly.

The individual should also be taught to reward himself after having behaved according to prerequisites. For example, after completion of a certain task, a learner should allow himself a break.

Teachers and parents must foster appropriate behaviour and promote self-efficacy by letting learners receive messages that build their confidence, watching others being successful and experiencing independent successes.

Self-regulated learners have certain goals in mind and evaluate progress during task engagement to ensure that appropriate learning takes place.

3.3.1.4 Communication techniques

Communicating with other learners may help a learner to solve learning problems. Role-playing is a technique that works well, whether it is one on one, or with a group of people.

Learners in a classroom can influence the instruction through feedback. It includes non-verbal expression, or an instructor answering a learner's questions (Piskurich, 2003:22). If you are a social learner, work with others as much as possible. Try to study with a class, or form a study group with others on the same level.

3.3.1.5 Self-development

Self-development occurs when an individual takes personal responsibility for his or her learning strategies through controlled emotions and motivation during the actual learning process (Järvenoja & Järvelä, 2005:466). Time management skills are important in order to plan your learning needs and goals more effectively (Hofer *et al.*, 2007:21). Find a mentor who can provide you with support, advice and assistance in your career direction.

3.3.1.6 Self-directed learning

Through self-directed learning, learners become more responsible for their own decisions with regard to learning needs, formulation of learning goals, identification of resources for learning, implementation of learning strategies and evaluation of learning outcomes. Self-directed study can involve various activities and resources.

According to Gibbons (2002:2), self-directed learning is something the learner selects and brings about by his or her own efforts, as well as using any method to improve learning.

3.3.1.7 Intended learning outcome

In classes where the quality of work is of a high standard, learners find themselves to be more self-determined, motivated and effective and keep their interest with clear goal clarity and coherence (Seidel & Prenzel, 2006:237). Intended learning outcomes can be specified in terms of performance and behaviour towards learning achievement.

The next section discusses learning improvement methodologies.

3.3.2 Improving learning achievement

Learning styles, learning domains, learning models, external factors and learning effectiveness were considered. The internal factors to be discussed are factors that may contribute to better results, such as intelligence, information retrieval from resources, academic learning and long term retention.

Learning achievement starts when a child is ready and able to learn to walk and talk, relate to people, think, reason and solve problems (Jeffords, 2000:6). Learning achievement in school depends on attention given to children in their early years. Children experiencing a quality childhood, have a greater chance of doing well in school. Such children contribute to society, as their experiences provide the foundations for language, maths and problem solving, strengthen security, self-esteem and the ability to interact with, and learn from others.

An important factor to improve learning achievement is to retain information that was learned. The next section discusses aspects that may improve learning.

3.3.2.1 Aspects of learning that may be improved

The pace of learning will depend on the way learning material is formulated. Learners' learning and recollection of results improve when they integrate knowledge obtained from both verbal and visual representations with prior knowledge or belief (Pennsylvania State University, 2007:1).

The role learners and teachers play to address principles of good practice in and out of classroom, influences the aspects of the learning and teaching process (D'Andrea & Gosling, 2005:139). The following is a summary of an extraction of Wozniak's article (1999:1), which discusses twenty rules on how to improve learning:

1. Understand what you learn

Try to understand what it is that you have to learn. The information has to make sense before it can be learned.

2. Globalise before memorise

It is better to understand the bigger picture before one starts to memorise.

3. Start with the basics

Begin with a basic and simple picture, then build up to a more complex finish. When you know the basics, it is easier to fill in the rest.

4. Minimum information principle

Formulate the learning material in the simplest way possible. The brain processes easy information faster when such information does not imply losing information and skipping the difficult parts. Repetition items make it easier to remember. If it takes too long to remember learning material, it will be more practical to simplify the items.

5. Make use of close deletion to learn

“Close deletion is a sentence with some parts missing and replaced by dots to speed up formulating. For example, Bill ...[name] was the second US president to go through impeachment” (Wozniak, 1999:1). This is a valuable technique when learning.

6. Imagination

One picture is worth a thousand words. “The power of imagery explains why the concept of mind maps is so popular” (Buzan, 2008:1). A mind map is a picture constructed between components in such a way that it reflects logical connections for individual concepts. Students may find this way of studying interesting and helpful.

7. Use mnemonic techniques

Mnemonic techniques make remembering easier and are very effective. Buzan’s (2008:1) book on mnemonic techniques discusses mind maps, peg lists and mnemonic techniques as the most popular and respected. These techniques make it easier to convert memories into funny pictures.

8. Use graphic images

Graphic deletion works similar to close deletion, but instead of using a phrase, it uses a missing image. For example, when presenting a complex illustration, leave a small part of it out, then ask the learner to name or draw the missing part.

9. Avoid lists

A set is a collection of objects, for example, a set of tools is made up of pliers, a screw driver and a hammer. Lists are necessary, try to convert them into

enumerations. The advantage of enumerations over sets is that they force the brain to list them in the same order.

10. Avoid numbered lists

Enumerations are ordered lists, for example the alphabetic listing of all ministers in parliament. Although they are hard to remember, they can be dealt with by using close deletion.

11. Describe similar things differently

When learning about similar things, it can be very confusing. Use examples, different methods and emotions, as well as personal experiences to describe learning material.

12. Optimise wording

Optimising the wording of networking items ensures that the right bulb lights up in one's brain. Reduce complex sentences into smaller, smarter and more compact sentences.

13. Use different memorising techniques

Refer to other memory techniques to place an item in a better context. Build on the basics and use other methods to fill the gaps when explaining networking concepts.

14. Personalise with examples

One of the most effective ways of enhancing memories of students is to link them to personal life experiences. A personal reference will save time and allow faster memorisation.

15. Rely on emotional states

If possible, use illustrations with valid examples, as long as they are produced to enhance learning.

16. Use clever wording techniques

Use clever wording techniques to simplify the learning content for students.

17. Learn from different angles

There is little harm in memorising the same fact as viewed from different angles. Passive and active approaches are particularly practicable in learning word pairs. Students may learn in many different ways through multimedia techniques.

18. Use correct sources

Students may use sources to manage the learning process; knowledge may be improved and reliability can be tested. In a real life situation it is often possible to be confronted with challenges to one's knowledge.

19. Provide date stamping

It is important to provide items with start and end dates to indicate the degree of invalidation.

20. Prioritise study material

It can happen that one will face far more knowledge than can be mastered. That is why effective learning is all about prioritising. Prioritising is necessary to gain quality knowledge for long term retention. The way in which knowledge is prioritised will affect the way in which it will be retrieved by learners.

These 20 points should be kept in mind when developing the e-learning material for the Network Systems III module students of the VUT, thereby ensuring effective learning. All of these rules are important, but rules 1, 2, 3, 6, 11, 12, 13, 14, 16, 17, 18 and 20 will be especially helpful. For instance, rule 3 reminds the researcher that the basic binary logic may be helpful for students to understand subnetting, therefore explanation of these basics will be included in the material.

3.3.2.2 Intelligence

Intelligence alone is not sufficient for learning achievement. Learning information without meaning makes it difficult to store such information into the long-term memory of the brain (Tilestone, 2007:9; Atherton, 2005:1). Many regard creativity as the highest form of human intelligence (Scheier, 2001:10).

3.3.2.3 Retrieval of information from resources

Knowledge is a resource of information that may result into knowledge by using experience, study and intuition. Information resources should be used consciously and effectively (Pinto & Couso, 2007:459).

According to Manning and DeBakey (2003:127), useful information has “three attributes: relevant to everyday practice, correct and easy to obtain.” The relevance and usefulness of information depend on the person who uses it, how wisely it is used and for what purposes.

3.3.2.4 Academic learning

Verbal contact between learners and the instructor is associated very significantly with learner learning and is critical for success (Arbaugh, 2008:1). The advantages of synchronous interaction as elements which benefit learners working in different times and locations (Park & Bonk, 2007:1), highlight teachers’ immediacy and dynamic interaction.

Active learning techniques allow learners to participate with a sense of ownership in their methods of study. Active learning includes everything that helps learners to absorb what they hear, react to lecture material and apply course material to "real life" situations and new problems (Paulson & Faust, 2008:1).

Effective and timely feedback augments both classroom and post-classroom learning and enhances learner achievement so that timely and adaptive instruction can be realised (Luczaj & Han, 2001:1).

Academic learning, such as social learning, cognitive factors in social learning and managing learning abilities will be discussed next.

Social learning

Social learning refers to the process where people learn by observing the behaviours and outcomes of others without changing their own behaviour. According to social learning theorists, learning takes place through a lengthy process of social interaction (Lefranzois, 2006:361).

Social learning theory has become increasingly cognitive over the last 30 years in its interpretation of how human learning takes place. Bandura (2008:1) explained that people are often reinforced by modelling the behaviour of others. When a teacher notices good behaviour, he or she would praise the observer for modelling such behaviour.

Cognitive factors in social learning

Social learning theory has a cognitive factor, such as attention that is critical for learning. Through reinforcement, expectations are formed about the consequences that future behaviours might bring. The suggested assessment approach procedure is critically dependent on analysis of behavioural structures used by learners to solve problems (Kalyuga, 2006:7). Bandura (2008:1) proposed that behaviour can influence the person's individual behaviour and the environment. Certain behaviours are expected to bring reinforcements, while others lead to punishment.

Bandura (2008:1) distinguishes between learning through observation and the actual reproduction of the learned knowledge. Engaging learners in a critical thinking activity by using multiple variations seems to be a most beneficial method for acquiring knowledge (Guiller *et al.*, 2008:188).

Manage learning abilities

One of the most important issues in the application of learning theory is the sequencing of instruction. Learners have different preferences when it comes to how they concentrate and how they remember new terms and difficult academic information. By making associations or connections with regard to the new term, it is remembered as it is connected to something already known and stored in memory (University of Maryland, 2003:1).

Matching instructional strategies to learning style preferences and emotions enhances learner engagement and promotes academic success (Muijs & Reynolds, 2005:25).

3.3.2.5 Long term retention

Intellectual effectiveness and academic progress depend on the ability of retaining information for long periods. Gonzalez (2009:1) discusses the following four guidelines to improve long term retention of information:

Relaxation

During excessive stressful situations, the brain cells expand and make it difficult for the neurons to pass through the brain. The most important factor for long term retention of information is relaxation. Relaxed people remember well.

Ridiculous

Things need to be humorous, laughter produces a relaxed mind, and a relaxed mind is critical to exceptional learning. The basic law of memory is all about things that will stay in the mind because they were done with passion and emotion (Burkins, 2007:183).

Repetition

Repetition is very important. If something is repeated enough times, it will settle in the mind no matter how difficult it is. A way of reducing the number of repetitions is to apply the two secrets of relaxation and being ridiculous. The average person needs at least 15 repetitions of the same thing to initiate storage into long-term memory.

Retroactivity

Retroactivity is almost the same as repetition. Repetition is about how many times something is done; retroactivity is about the time that one stays with it. It is possible to do 20 repetitions of something over ten minutes, or it is possible to do 20 repetitions over five days. When repeated over five days, it will store more easily into long-term memory than if repeated in ten minutes. Different people need different amounts of repetition and retroactivity.

These guidelines for long term retention which can be addressed by e-learning material, motivated the research team to change the learning environment of the Network Systems III students to a blended e-learning environment.

The next section discusses the most important changes of learning since the introduction of widely used computers and the Internet.

3.4 LEARNING: TECHNOLOGY USAGE AND LEARNING

Since objective 3 of this study is to develop new e-learning material for the Network Systems III students at the VUT, an understanding of technology usage (as stated in objective 3.4) and learning is important.

Certain characteristics of modern technology are advantageous for reaching this objective. These include animation, simulation and personalised classrooms that can be used to manipulate learning material through multimedia e-learning on the Internet. New technology learning allows lecturers at the VUT to introduce learning material that is more attractive, understandable and more acceptable for the learners. More effective methods of teaching and learning are possible through a blended e-learning approach. Blended e-learning material is a mixture of traditional lectures and e-learning material. This approach allows the learner to attend normal traditional classes and afterwards use the e-learning facility through the Internet to seek more appropriate learning material that will match their learning styles in order to understand difficult concepts of the syllabus.

Today's reality is that there is a massive growing demand for higher education throughout the world, whilst learner numbers increased rapidly. For example, in 1996 Malaysia received 65 000 applications for only 15 000 university openings (French *et al.*, 1999:132).

As the demand for learners in higher education grew exponentially over the last decade, technology changed, more experience was gained and new ways of developing and delivering Internet-based learning were found (French *et al.*, 1999:87).

The Internet has become a very powerful medium for dispersing course material effectively and conveniently in a pedagogical environment by means of a computer, thus providing equal opportunities for all (Clarke, 2000:1). Computers

are flexible and effective audio-visual communication instruments, offering learners different ways of accessing a vast knowledge base and searching for information over the Internet in order to achieve their goals (Oak, 2008:1; Carliner, 2004:40).

Teachers need to adopt a learning-oriented teaching environment to become more of a facilitator, guide and consultant to develop the needs of learners and to focus on their academic capabilities (D'Andrea & Gosling, 2005:191). Learners on the other hand have more responsibility and must be proficient with computer equipment and have reliable network access and connections.

Higher education in large numbers, flexible modes of study and widening participation are becoming the rule rather than the exception. What we teach and how we teach, will have a profound affect on whether our learners will fit into the new job market of this century (Tilestone, 2007:2).

Some of the most effective changes in the teaching environment, such as animation, simulation, personalised classrooms, e-learning and blended e-learning are discussed in the next sessions.

3.4.1 Animation

Animation is an effective way to communicate concepts, processes, procedures and other ideas through movement in a multimedia environment. It is more useful than static pictures, especially when the motion depicted in the animation is the content to be learned (Höffler & Leutner, 2007:733).

The animation features of Adobe flash player (W3Schools, 2009:1) allow developers to create engaging visual presentations and short instructional movies for entertainment, but also conveying a strong message. Sometimes the animation runs automatically, while in other cases the learner has control over it and can choose the sequence or speed of the action (Horton, 2006:63).

3.4.2 Simulation

Simulation software is adaptable, most effective and practical to simulate a virtual classroom. A virtual classroom exists on the Internet without traditional class meetings. Learners retrieve information via telephone, modem and computer from anywhere in the world. A virtual class is unlimited by geographical location, time or space (French *et al.*, 1999:134).

By using multiple representations, teachers could transfer their knowledge in the learning environment to other comparable situations (van der Meij & de Jong, 2006:200). An important motivation for multiple representations is the small or large number of learners needed in a group to construct deeper learning about topics in mathematics and other domains (Lehman, 2006:1).

3.4.3 Personalised classrooms

Successful teaching requires learner understanding and learner engagement. In a tutor-based learning environment, the tutor prepares the material to be learnt with clear explanations and interactive exercises to encourage deep learning. Sneiderman *et al.* (1995:23) discussed electronic classrooms as the future design for education simulation.

Resource-based learning uses open learning in a wide range of multimedia teaching and learning to support an effective pedagogical environment (Maier & Warren, 2000:74).

In open learning, learners must really understand, or make sense of what they have studied (Maier & Warren, 2000:70), and teachers become partners with their learners (Tomlinson, 1999:2).

Multimedia instruments allow teachers to create interactive presentations through integration of text, images and audio to facilitate critical thinking, group and networked learning communities (Dowse *et al.*, 2002:1). It is these traits that attracted the research group of the VUT to change the Network Systems III

module's teaching environment to a blended e-learning environment where multimedia is used to enhance the traditional classroom lectures.

Multimedia will be used through the Internet to make learning material available and more understandable for students. The students can still attend the traditional lectures during their formal classes and afterwards work through the e-learning material to see whether a different type of multimedia explanation will make that specific topic easier to understand.

E-learning material content is available on the Internet for students to use in their own time and in an educational environment (Carliner, 2004:1). The next section will discuss e-learning.

3.4.4 E-learning

New technology in the 21st century has led to electronic learning (e-learning) becoming a fast, efficient and effective way for businesses to provide job training to employees. Tertiary institutions can apply e-learning to extend the pedagogical environment beyond their borders. Kopf (2007:1) predicts that "by the year 2010, the e-learning market will be a \$52.60 billion dollar business." The advantages of e-learning are clear for both the organisation and the learner (Kruse, 2004:1).

E-learning is a term used to describe the fields of on-line learning, webbased training and technology-delivered instruction by dealing with both technologies and associated methodologies (Horton, 2001:71).

Online learning refers to learning and other supportive resources available through a computer on the Internet (Carliner, 2004:1). Carliner's (2004:6) studies show that online courses are taught exclusively asynchronously (instructor and learner are not on line at the same time).

Whattananarong (2002:1) says that learning time is reduced by about a third because of online learning. As a result, we are seeing a shift in learning and

teaching modes, which increases learner independence and interdependence (Maier & Warren, 2000:24).

The major differences between traditional skills and e-learning skills are: the E-learner learns at a distance and needs to be more independent (Clarke, 2004:3; Piskurich, 2003:33). Traditional learning takes place in an eye-to-eye environment (synchronously).

An innovative feature to improve learning is to use media with hi-tech visual images, enabling teachers to provide complex graphical illustrations, models or simulations to enhance and support the higher level of classroom learning and the growing demand for web-enhancement capabilities (Wingard, 2004:1; Hargreaves, 1994:75).

Emotional readiness of learners to learn new technology is required when communication between the instructional medium and the learner is reorganised and restructured to exploit and use the technology efficiently (Bates, 1995:58; Hirschbuhl *et al.*, 1998:38; Piskurich, 2003:100). Therefore, assessment of learners' readiness is a necessity for designing a program that will address all the various types of support required to provide a meaningful and effective e-learning experience (Piskurich, 2003:92, 258).

The first section of the questionnaire developed in chapter 4 aims to test the readiness of the VUT students for a blended e-learning environment.

E-learning allows a learner to study at his or her own pace. This approach to learning is characterised as asynchronous learning and refers to programs independent of time (Rosenberg, 2001:139). E-learning incorporates many elements that make learning new material more fun (Clarke, 2004:1; Piskurich, 2003:73). It also helps avoiding missed information from the instructor in the class.

The success of the learning process in an educational system depends on how well knowledge is presented to the learner in order to enrich him or herself

intellectually and individually in terms of complexity and learner progress (Naidu, 2003:55; Piskurich, 2003:257).

According to ACT Media (2009:1), e-learning is excellent for many types of learning, owing to the following reasons:

- E-learning offers the same learning content in many different ways, for example, by using images or adding sound and text to encourage better retention of the learning material.
- Making learning material interactive by clicking on links to activate animation of an object, switching between pages or dragging and dropping items to improve learning abilities.
- Using any interaction that will capture a person's attention, such as games, quizzes, or to allow the person to change an object on the computer screen. Active participation draws the attention towards the subject and that could lead to better understanding.
- Immediate feedback will allow better understanding and may improve the learning tempo. Each step of the learning content must build on the knowledge obtained in the previous step, and this may be possible through continued feedback.
- Encourages interaction between e-learners and the lecturer in chat rooms and other Internet communication methods, such as twitter, facebook and e-mail. Effective interactive communication may introduce a substitution for classroom discussions. According to ACT Media (2009:1), effective online communication has a strong influence on the success of online programs.

Learners learn in many different ways, and the learning potential of students can be improved by adjusting teaching styles to match learning styles. According to Holmes and Gardener (2006:102), e-learning supports many different learning styles, allowing the student and lecturer to expand their learning and teaching environment. At the VUT, it was decided to use e-learning material for the purpose of developing study material that would accommodate different students' learning styles.

Holmes and Gardener (2006:14) further argue that e-learning content is available on the Internet and may be accessed at any time from any place, worldwide. Research done by Porter (2004:14) indicates that on-line students feel more at ease, as they work well on their own.

When designing e-learning material, there are certain factors that must be kept in mind. Holmes and Gardener (2006:29) identified the following important factors to be considered:

- The instructional design of the material must be clear and consistent.
- The user interface should be easy to use and to navigate.
- Applications such as exercises and examples are necessary.
- Regular evaluation of student progress is required.
- Multimedia should be used to motivate learning.

There are certain advantages and disadvantages when e-learning is implemented. The most important advantages and disadvantages will be discussed from the work of Hartley (2001:25) and from the IOWA State University (2010:1).

Advantages of e- learning

- Learning can be scheduled to accommodate work and family.
- World Wide Web allows learners to study 24 hours a day, seven days a week from any place in the world through the Internet.
- One of the largest benefits of e-learning is that it eliminates the expense of getting the instructor and students together in the same place.
- Students have the opportunity of choosing learning content that will match their learning style.
- Learner centered modules allow students to work at their own pace.
- Flexibility to participate in discussions at any hour, or use chat rooms to communicate with classmates and lecturers.
- E-learning allows more interaction between students and lecturers than lectured courses.
- E-learning accommodates different learning styles through a variety of activities.

- Develop Internet and computers skills that will be of great value for learners in future.
- On-line courses build self-confidence and encourage students to assume liability for their learning.
- Learners have the opportunity to skip over known parts of learning material and concentrate on areas containing new information.

Disadvantages of e- learning

- Learners who are not motivated to study will fall behind.
- Learners will have to set up strict routine structures to stay on schedule with course activities and deadlines.
- Isolation from classmates and lecturer will cause tension.
- Help from the lecturer will not always be available when needed.
- Frustration may set in due to ineffective Internet connections.
- Entry-level learners who make use of on-line learning courses may have trouble to use and manage learning material.
- Practical sections of modules are difficult to simulate through on-line learning.

Blended e-learning is a combination of both traditional class lectures and e-learning on the Internet and will be discussed in the next section.

3.4.5 Blended E-learning

Blended e-learning is part of sub-objective 3.5, discussed in section 3.1. Much research has been done about blended e-learning, from primary school to university level. Blended e-learning is a parallel learning medium which combines traditional learning and e-learning (Littlejohn & Pegler, 2007:3). When a learning program involves a combination of classroom and online components, the learning is said to be blended (Carliner, 2004:36, 37). According to Tyson (2006:232), it allows the lecturer and students to have the best of both worlds. Kerres and De Witt (2003:112) explain blended learning as the mix of different didactic methods and delivery formats. Mason and Rennie (2008:26) use the term “distributed learning” to describe distance education and e-learning. With blended learning,

learners need not taking notes in class and therefore are tapping the verbal and the visual spatial working memory (Dutke & Rinck, 2006:528).

The term blended learning is described by Mayer (2001:1) as teaching with technology and has gained considerable preference in recent years. Mayer further states that learners understand an explanation better when presented in both words and pictures. Several researchers like Dugger *et al.* (2001:32), Perraton (2000:37) and Cheek & Walsh (1996:39) define this learning medium as all the methods and material that can be used to support the learning process. Jacobs *et al.* (2002:240) define blended learning as a medium that establishes conditions enabling the learner to acquire knowledge, skills and attributes.

The quality of blended e-learning depends on the design and the learners' engagement in the learning environment (Duffy & Kirkley, 2004:4). Learners have certain expectations about the quality of the blended e-learning material; if it does not comply with their expectations, it will affect their commitment.

Martin (2006:106) describes the Pygmalion effect which means that "what we expect about someone is what we get." The Pygmalion effect refers to learners' expectations of teachers' competence to provide learning material in e-based learning and the influence thereof on the learning outcomes (Fries *et al.*, 2006:340). According to Piskurich (2003:362), blended e-learning may be a more sophisticated learning tool than other forms of learning.

It is this type of learning method that gives the learner a variety of learning material to choose from. Normally, with blended e-learning the students have the opportunity of selecting learning material that will match their learning style preferences. The most important advantage of a blended e-learning methodology is that it is an instruction method that manages to address most students' learning preferences (Holmes & Gardner, 2006:66; Thorne, 2003:36).

The learning material in this research will cover only a section of the module Network Systems III. The section discusses the part that describes subnetting. Lecturers will explain the information during formal class periods, whereafter

students will have the opportunity to access additional information about subnetting through the Internet.

Figure 3.2 describes blended e-learning as a combination of traditional learning and e-learning. Traditional learning involves the lecturer in a classroom, explaining the learning content to students. E-learning involves the Internet, where the same learning content is available in other formats to accommodate learners with different learning styles.

Blended e-learning therefore is a combination of, and a parallel learning approach to e-learning and traditional learning. Traditional learning occurs according to a fixed time schedule a few times per week. E-learning, as discussed in section 3.4.4, can occur at any time and is not time-dependent, while students can actively use the e-learning content for as long, and as many times they want.

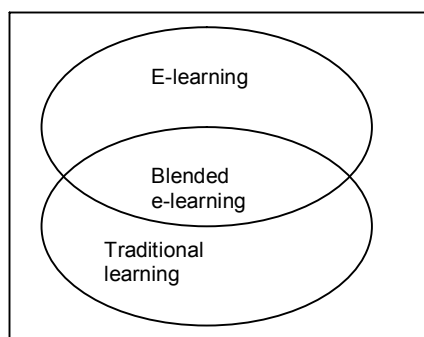


Figure 3.2 Blended e-learning

This learning process called blended e-learning is described in the next sections in terms of cognitive theory (section 3.4.5.1), the multimedia presentation principle, (section 3.4.5.2), the split-attention principle (section 3.4.5.3) and the individual differences principle (section 3.4.5.4). This discussion is part of sub-objective 3.6 in section 3.1.

3.4.5.1 Cognitive theory of blended e-learning

Blended e-learning technology, also called multimedia e-learning, allows instructional presentations involving animation and narration where both words and pictures are used (Moreno & Mayer, 2008:1).

Learning occurs when learners adapt how they learn from spoken words to the new advances in technology to promote meaningful education (Harskamp *et al.*, 2007:468; Rabinowitz *et al.*, 2004:31, 34).

The design of blended learning instruction should be based on a theory of how people learn (Rabinowitz *et al.*, 2004:37). Martin *et al.* (2008:1) discuss the following three important cognitive processes in multimedia learning:

- selection, is applied to verbal information to introduce text based information.
- organisation, is applied to word based information to create a verbal model of the content to be displayed. This is applied to create an image base of the system.
- integration, is when the learner builds verbal or visual connections between corresponding events.

Blended e-learning was discussed as a combination of classroom activities and online components. Blended e-learning allows the researcher to change e-learning content in such a way that it will make provision for almost all learning style preferences. This will have a very positive effect on this research project. The following principles of blended e-learning are discussed:

- Multimedia presentation principle.
- Split-attention principle.
- Individual differences principle.

3.4.5.2 Multimedia presentation principle

According to the multimedia presentation principle it is more beneficial to present an explanation through narration and animation (Rabinowitz *et al.*, 2004:40; Sears & Jaco, 2007:70). When narration is processed in the verbal information processing system, and animation is processed in the visual information processing system, cognitive learning takes place.

Cognitive learning encourages collaborative learning and is very important in a multidisciplinary field where researchers are surrounded by learning and teaching sciences with one principle to develop education. The most important aspect of analysing collaborative learning is to measure the value of interaction derived from the individual cognitive learning (Strijbos & Fisher, 2007:391).

This principle encouraged the team at the VUT to include videos in the e-learning material developed in objective 3 of this study (refer section 3.1).

3.4.5.3 Split-attention principle

When giving a multimedia explanation, words should be presented verbally rather than visually (Brunning *et al.*, 2003:32). Cognitive theory of multimedia learning states that on-screen text and animation can overload the visual information processing system.

Learners have the opportunity to select e-learning material according to the learning style that suits them best, and it may differ from time to time depending on the type of learning content.

3.4.5.4 Individual differences principle

According to Durso and Nickerson (1999:561), multimedia effects, contiguity effects and split-attention effects depend on individual learner differences. Learners with high prior knowledge may be able to generate their own mental images while listening to an animation or reading a verbal text. A contiguous visual presentation is therefore not needed.

International trends and variations in technologies should be investigated to ensure they are sufficient, acceptable and cost effective for any given audience (Perraton, 1999:1). Learners in classes with high goal clarity and coherence demonstrated a more intensive trend towards learning than learners with low goal clarity (Seidel *et al.*, 2005:540). It is clear that education systems have advanced to very high standards with even higher technological advances, which mean that there are

multiple ways of displaying information to learners in a very different and active manner.

A multidisciplinary learning system, such as multimedia learning and blended e-learning, will allow learners at the VUT to decide what type of learning content will enable them to deliver better academic results.

3.5 TEACHING STRATEGIES TO IMPROVE LEARNING

Teaching strategies are part of sub-objective 3.7, discussed in section 3.1, and involve various methods to enhance learning.

The primary purpose of teaching involves the transfer of instructional content from the teacher to the learner in such a manner that it enhances a learner's ability to think strategically (Sloan, 2006:33). Strategic teaching creates an environment for retaining information and encourages the cognitive requirements of learning (Forsyth *et al.*, 1999:55).

Van Zyl (1975:315) typifies teaching as the assistance of one's fellow man in the learning process.

Steyn (1988:161) regards the teacher's actions to be directed towards uplifting specific dispositions in preparing the student for his duties in society. Steyn (1988:162) further argued that in education, there are two persons involved, one in the role of teacher and the other in the role of learner, before an activity can properly be called teaching.

Lott (2008:1) described teaching as a contract between a student and a teacher. This implies that teachers and students have an agreement and some distinct obligations towards one another.

Effective teachers are those who design lessons, utilise appropriate teaching strategies and implement techniques to optimise learning for all students. (Killen, 2007:73). Teaching can occur with groups and individuals (Piskurich, 2003:257).

Teaching styles and learning styles are very similar; it is the compatibility of these styles that is important for learning to take place (Tesar, 2003:78).

According to Moon (1999:1), approaches to teaching and learning processes in a professional environment relate directly to learner behaviours, cognition and relationships. A useful aspect of learning is that it can be integrated into practical techniques and applications by using expression to enhance the learning achievement and belonging (Hoy, 2008:496).

Successful instruction is a matter of emphasising the key points of the lesson to maximise the probability that learning will occur and that every learner will receive specified instruction (Rabinowitz *et al.*, 2004:38; Muijs & Reynolds, 2005:30).

It is very important for the teacher to pay attention as to how he or she should introduce the subject to learning (Betoret, 2006:452). Learners with high-perceived self-perception and interest generate higher expectations and achieve better academic results.

Hoy highlighted the importance of teacher motivation as complex and evolving as the challenge of teaching itself (Hoy, 2008:493). It is important to understand the complex theoretical contributions of teachers to direct attention towards teaching motivation (Levin, 2003:11).

Many authors ((Hoy (2008), Lott (2008), Levin (2003), Killen (2007), Betoret (2006), Sloan (2006), Muijs and Reynolds (2005), Rabinowitz *et al.* (2004), Tesar (2003), Forsyth *et al.* (1999), Moon (1999), Steyn (1988) and Van Zyl (1975)) agree that learning is only successful when there is a carefully planned interaction between teacher and learner.

3.5.1 Strategies for teaching

A teacher must be sensitive to the potential variation in learning paradigms amongst learners. Healy (2004:1) describes teaching by the way of Thomas Kuhn's paradigms and paradigm shifts. Healy argues that teaching is the process

of encouraging learners to change their paradigms to a form more consistent with the commonly held paradigm of the day.

Healy (2004:1) further states that at the heart of lifelong learning lies curiosity. A teacher that presents information with preference of thinking that matters to the variety of disparity in learning will have huge successes.

E-Learning as a communication tool has obvious benefits for the teacher. It expands the possibilities of professional development. Building an e-learning community among teachers themselves, allow them to collaborate to improve learning habits (VIP Tone Inc, 2001:1).

A discussion on some of the most important factors influencing learning from a teaching perspective follows next. These factors are receptivity, learning and memory, cognitive thinking and personality function.

3.5.1.1 Receptivity

Simultaneous presentation in two sensory modalities, such as auditory and visual modalities, is important. Researchers also agree on the importance of interaction between teachers and pupils (Muijs & Reynolds, 2005:42).

It is necessary to vary receptivity, allowing what is acquired and then stored into memory is accessible by more than one memory trigger, furthermore, to consider what to present visually.

3.5.1.2 Learning and memory

This function focuses on what is to be learned and to provide sufficient aids to access or retrieve learned information from memory.

Thematic linkage is a strategy that can be used to reinforce what is learned between the previous lecture and the present one. By doing this, the educator triggers memory from the last presentation, which will become interactive with new

information. Feedback (lectures, sessions, tests, textbooks) is essential for learning to be successful.

Information is transformed into enormous variations, thus forming relevant meaningful units of knowledge for learners to store into memory. Memory or knowledge transformations are determined by any sensory modalities (auditory, visual or motor) a learner might favour.

3.5.1.3 Cognitive thinking

Educators need to pay attention to their own mental activities and thinking preferences. Their cognitive style and preferred ways of organising and processing information will have an effect on how learners will perceive the information. Riding and Rayner (2000:97) see cognitive thinking awareness as a way in which individuals may be encouraged to reflect on their own learning processes.

3.5.1.4 Personality function

Ryan and Cooper (2008:171) state that the teacher's personality is the most critical factor in successful teaching. However, despite a teacher's efforts to perform well, he or she will have little knowledge of a learner's attention, motivation, cultural values, expectations and time management. The educator as facilitator should differentiate instruction to reach individual learners and ensure successful learning (Heacox, 2002:10; Hayden, 2008:1).

3.5.2 Evaluation

One of the most important measurements of teaching is evaluation. Evaluation of learners through test and examination results will give a very prominent indication of the learner's ability to retain information (Forsyth *et al.*, 1999:117).

The method of measuring desired results in a blended e-learning environment is faster and more effective. It will also indicate whether the teaching technique was successful or not.

Kirkpatrick (1998:24) discusses the four-level model of evaluation; each evaluation level is built on information provided by the lower level. Evaluation should always begin with the lowest level and move to the next level until the last level is reached. Information from the first level serves as a base for the next level's evaluation. The following levels have to be evaluated in order to measure the standard of teaching and learning:

3.5.2.1 Reactions

The reaction level rates the perception of participants with regard to the training program. Every program should be evaluated at this level to provide for improvement.

3.5.2.2 Learning

This level assesses the amount of learning that has occurred and often uses tests before training (pretesting) and then again after training (post testing). This level attempts to determine the amount of learning that has occurred.

3.5.2.3 Transfer

This level measures the transfer of knowledge that has occurred in learners' behaviour as a result of the training program and represents the truest assessment of a program's effectiveness.

3.5.2.4 Results

This level measures the success of the program in terms of academic achievements, increased knowledge, improved quality of education, decreased costs, increased sales and higher returns on investment.

Evaluations were discussed as a strategic instrument to measure learning success through tests and examination results. Objective 5 in section 1.2 analyses the performance of students with regard to their test and examination results. This objective will be discussed in more detail in chapter 6.

3.6 CONCLUSION

This chapter enabled the researcher to investigate learning formalities, learning domains, different learning styles and other factors that may affect learning or improve learning achievement, therefore satisfying objectives 1 and 3 of section 1.2.

Sub-objective 1.1 gave a perspective of the initial diagnose phase of this action research which described learning through the views of other authors and came to the conclusion that learning is a process that causes a change in knowledge development in order to perform intellectually. Learning formations discussed different aspects of informal learning, formal learning and interconnected learning that contribute to knowledge development.

Sub-objective 1.2 in section 3.1 required a discussion of learning domains, dividing learning into categories where different instructional procedures can be addressed. The learning styles demonstrated different views about educating methods allowing students to learn. This is a very important aspect of this study and will have an impact on the direction in which this study will go.

Sub-objective 1.2 in section 3.1 also dealt with the characteristics of learning. It described different approaches and actions for learning to occur. Although sub-objective 1.2 made way for the direction of this study, sub-objective 1.3 allowed the researcher to select a specific approach for the study. The learning styles model of Felder and Silverman was selected for this research, as this model will have the biggest impact on the learners and also provides for a questionnaire to test the learning style preferences of learners.

Sub-objective 1.4 in section 3.1 addressed the model of Felder and Silverman in section 3.2.3.4. The remainder of the research will involve actions relating to the learner styles model and index of learning styles.

Sub-objective 3.3 in section 3.1 required a discussion on learning effectiveness with reference to the factors that have an effect on the learning practices of students. When developing the e-learning material, the researcher will take special

notice of these factors, thereby ensuring the improvement of learning achievements.

Sub-objective 3.4 in section 3.1 required a discussion of technology usage that will enable learners to visualise and understand certain complicated parts of learning material better through animation, simulation, personalised classrooms and e-learning. The most important aspect of modern technology for this research is the parallel learning approach, namely blended e-learning. Blended e-learning is the core approach that will be put into action for this research in an attempt to improve the learning experience of students at the VUT as stated in sub-objective 3.5 of section 3.1. Cognitive theory, multimedia presentation, split-attention and individual principles were described as the characteristic features to be presented when developing e-learning material as described in sub-objective 3.6 in section 3.1.

Sub-objective 3.7 in section 3.1 required a description of teaching strategies that could be helpful to improve learning and enhance the learner's ability to think strategically. Evaluation was discussed as a method to measure what was learned in order to evaluate the success of the learning experience.

Knowledge gathered from this literature study will enable the researcher to develop an interpretive questionnaire similar to the index of learning styles of Felder and Soloman. This interpretive questionnaire will contain closed and open-ended questions, addressing specific matters related to the learning styles of the Network Systems III module students at the VUT. It is aimed at determining their readiness and preferences with regard to multimedia learning material. The questionnaire and the analysis thereof are discussed in chapter 4.

The outcome of chapter 4, combined with the knowledge obtained in chapter 3 on learning, teaching and e-learning, will be used to develop e-learning material (reported on in chapter 5).

CHAPTER 4

PRESENTATION AND ANALYSIS OF INTERPRETIVE QUESTIONS

4.1 INTRODUCTION

This chapter is part of the first phase of the action research project as depicted in figure 4.1. The literature survey in chapter three formed the basis for the diagnosis phase. This chapter presents the analysis of the data on learning styles gathered from Network Systems III module students.

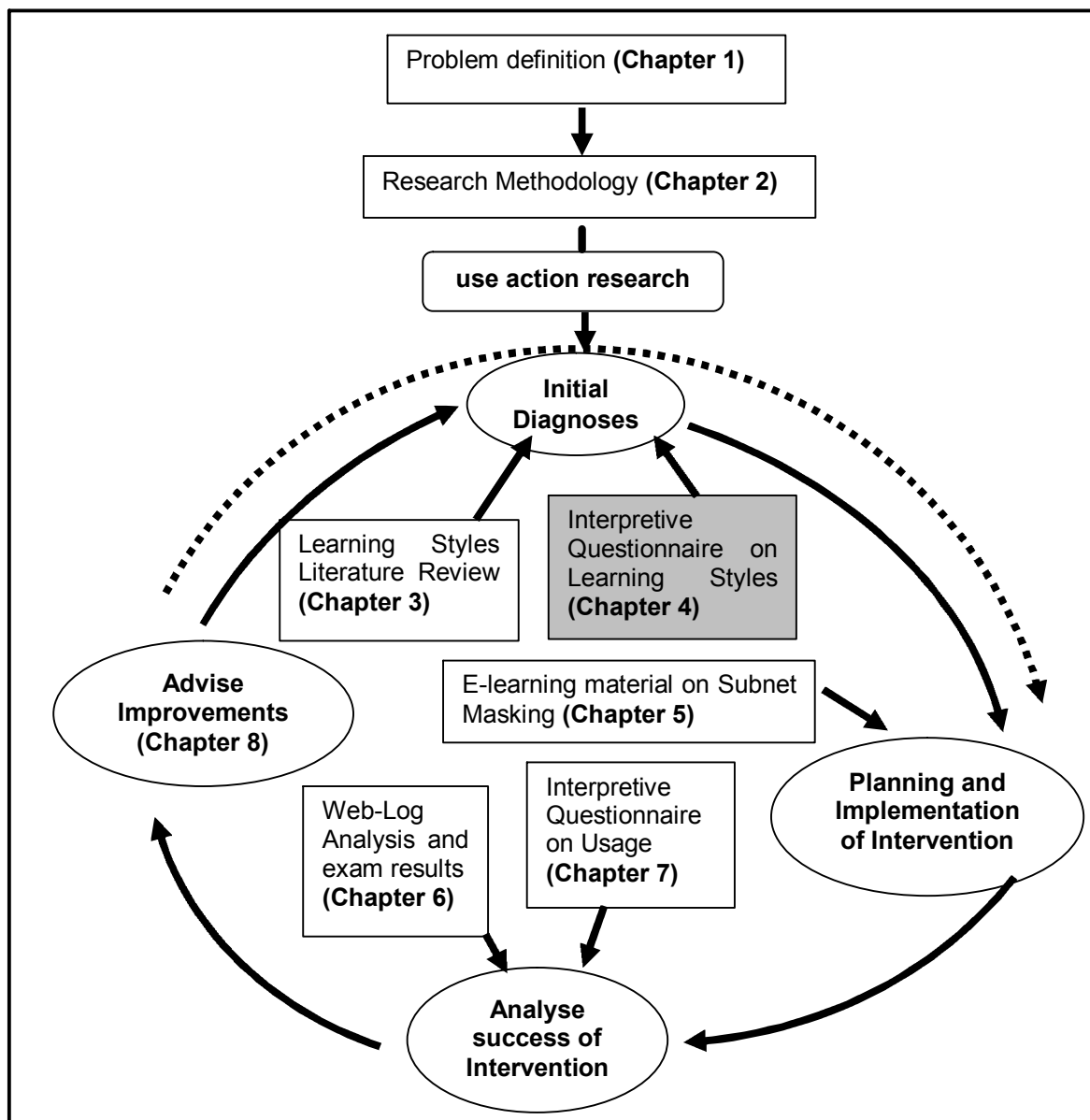


Figure 4.1 Schematic layout of this research

The intention of the diagnosis phase is to research and get acquainted with different learning styles, furthermore to identify the learning styles of students and develop e-learning material sensitive to various learning styles.

During the diagnosis phase, the learning styles of the students at the Vaal University of Technology are investigated. Answers given by the participants in the questionnaire, as discussed in this chapter, will be reconciled with the learning styles of chapter 3. The result of the reconciliation process will determine the structure of e-learning material in chapter 5.

The interpretive questions are presented and analysed as part of the diagnosis phase shown in figure 4.1 and described in objective 2 in section 1.2.

Objective 2: Understanding of learning styles of Network Systems III module students based on an interpretive survey, can be divided into the following sub-objectives:

- 2.1 Planning the data collection process of this research with reference to the participants, current research in learning styles and the questionnaire.
- 2.2 Analysis of data with specific references to the method of analysis and presentation of questionnaire results.
- 2.3 Understanding of learning styles of participants from the analysis of the questionnaire data.

Figure 4.2 shows the timeline of the entire research process and indicates most of the actions that took place. The first column indicates the semesters and the number of enrolled students in brackets, while column two indicates the months for each semester. Column three indicates the time taken, in months, to find the most suitable research project and also the time when discussions were held with lecturers. Column four indicates the time when research methodology was evaluated and an appropriate method was selected. Column 5 indicates the time when the research plan was developed, while column six indicates when the

literature study took place after which the questionnaire was developed, distributed and analysed as indicated in column seven.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sem.	Month	Write proposal	Research Methodology	Research plan	Literature review	Questionnaire	E-learning develop	Implement	1st Iteration	2nd Iteration	Evaluate	Final analysis	Write dissert.
2006_2	7												
	8												
	9												
	10												
	11												
	12												
2007_1 (189)	1												
	2												
	3												
	4												
	5												
	6												
2007_2 (153)	7												
	8												
	9												
	10												
	11												
	12												
2008_1 (114)	1												
	2												
	3												
	4												
	5												
	6												
2008_2	7												
	8												
	9												
	10												
	11												
	12												
2009_1	1												
	2												
	3												
	4												
	5												
	6												
2009_2	7												
	8												
	9												
	10												
	11												
	12												

Figure 4.2 Time line of the research project

Column 8 indicates when the e-learning material was developed and the duration time to complete it. Development of certain parts of the e-learning material was independent of the outcomes of the analysis of the questionnaires and was done in parallel to the analysis of the questionnaires. Column 9 indicates when the e-learning material was implemented on the Moodle LMS for students to start using it. Columns 10 and 11 show when the first and second iteration was done and column 12 indicates when each iteration was evaluated. Column 13 indicates when the final analysis was done, while column 14 indicates when the dissertation was written.

The next section (4.2) discusses data collection which includes participants, current research in learning styles and the questionnaire. Section 4.3 discusses data analysis, as well as the method of analysis and the presentation of questionnaire results for each question. This is followed by the conclusion (section 4.4).

4.2 DATA COLLECTION

4.2.1 Participants

The participants in this study are the 2007/2008 students enrolled for the module Network Systems III of the Computer Systems course at the Vaal University of Technology. As indicated on figure 4.2 this constitutes three groups of students (2007_1, 2007_2 and 2008_1).

The Computer Systems module is offered as part of the National Diploma qualification consisting of the following modules: Computer Skills, Digital Systems I, II, III, Programming I, II, III, Electronics I, II, III, Mathematics I, II, Electrical Engineering I, Communication Skills 1A, 1B, Network Systems II, III, System Analysis II, Design Project III, Communication Studies II, Logic Design II, Operating Systems III, Software Engineering III, Database Principles III, Operational Research III, Entrepreneurship II and Projects 1.

The learning styles used in these subjects are still the typical traditional styles where the lecturer explains text book material with the help of an overhead

projector, or by writing text on the blackboard. Some learners in the Engineering faculty are using the Moodle LMS, although still not widely applied.

The National Diploma is a three-year course, covering four academic semesters and a one year work-integrated learning period. Network Systems III is one of the senior phase modules in the fourth semester.

The text book was the only source used to expand learners' knowledge about subnetting. It was suggested by the lecturers that the possibility of making additional e-learning material available to all learners should be investigated. At the time this research was started, the VUT did not offer no e-learning material on this specific topic.

Learners at the VUT are mostly from previously disadvantaged groups. A high percentage of these learners do not have their own computers and therefore cannot access the Internet from home. However, the VUT has made sufficient provision for this shortcoming through student centres on campus where approximately 3000 computers with Internet facilities are at the students' disposal. These computer centres with free Internet access are open between 18 and 20 hours per day for 7 days a week. A card system allows the student to enter the computer centre by swiping his or her card to open the turn style gate. Students are not allowed to use the computer centre for playing games or watching movies, however, this happens from time to time.

The age of these students range between 18 and 22 and the majority of them are male.

4.2.2 Current research in learning styles

When originally started their research on learning styles, Felder and Silverman developed the learning styles model discussed in chapter 3, section 3.2.3.4. Preferences on four dimensions with two types of learning styles grouped together in each dimension were assessed (Felder, 2009:1). With this learning style approach, they tried to determine the learners' approach towards learning in order

to clarify the lecturer's teaching style for creating a match (Bastable, 2007:115). Felder and Soloman took the research further by developing the index of learning styles questionnaire specifically suitable for investigating learning styles of engineering students (Kalman, 2008:6).

Felder and Soloman's questionnaire consists of 44 questions. These questions are divided into four dimensions with 11 questions each. The dimensions are: active/reflective, sensing/intuitive, visual/verbal and sequential/global.

The above-mentioned dimensions were already described in section 3.2.3.4, but a short summary is given here. *Active* learners need to interact with others or apply knowledge in a practical situation, while *reflective* learners need quiet time to process information by themselves. *Sensing* learners prefer to learn real life facts, *intuitive* learners prefer theories. The preferences of *visual* and *verbal* learners are self-evident. *Sequential* learners need to process information in a clear order, while *global* learners need to have an overview of the learning material, or need to see the connections between different parts before they understand the whole picture.

4.2.3 The questionnaire

According to Bowling and Ebrahim (2005:394), structured questions are formulated beforehand for the participant to make a choice of which to answer. For this research, the participant has to make a tick opposite the answer he or she prefers, as shown in Table 4.0. (Table numbers correspond to the question numbers in the questionnaire and number 0 is used in examples).

In what language are you being lectured?

English	x
German	
Afrikaans	

Table 4.0 Example of option selection

Questions in this research were kept relatively simple ensuring that all participants could understand and answer by just indicating his or her option with an **x** or **✓**. As the students were all in the senior phase of their studies, no problems with

understanding the questionnaire were experienced as the researcher was present to address any misunderstandings.

Each question will be analysed separately, and the comments on the open-ended questions will be categorised through a content analysis process called coding. The principles of coding in this chapter is based on the open coding of the grounded theory discussed in section 2.2.4.2.

4.2.3.1 Origin of questions

The learning style model of Felder and Silverman contributed to the development of the Index of Learning Styles questionnaire, developed by Felder and Soloman (Felder, 2009:1). For this research, twenty four multiple, open-ended and closed questions were used of which ten (15 to 24) were taken directly from Felder and Soloman's index of learning styles (Felder, 2009:1). The questionnaire addresses the following dimensions of Felder and Silverman's learning style model: Active/Reflective, Visual/Verbal and Sequential/Global. Only one question addresses the Intuitive/Sensing learning style. Although this is a shortcoming of the questionnaire, the specific style is difficult to test with this kind of questionnaire and answers might not directly influence the design of the e-learning material.

The decision to use this learning style model was discussed in section 3.2.3.4.

The remainder of the questions were specifically developed for this research and focused on investigating whether students would benefit from extended e-learning and how material should be presented (See Annexure B).

4.2.3.2 Administrative Procedures

The questionnaire was distributed personally by the Network Systems III module lecturers at the VUT and was handed to all students present in this module for completion in February 2007. The return rate of questionnaires was very good, as the questionnaires were handed out during the class period and collected immediately thereafter. All questionnaires were returned.

The students had 30 minutes to complete the questionnaires during a one hour class period. Each question was explained to the students and they knew exactly what was expected from them. It was explained to them that they were allowed to write any comments on the dotted lines provided in many of the questions. The reason for the written comments was to see whether there would be any other interpretations or experiences they would want to share to make their learning experience easier.

It is important to analyse the interpretive questions in order to understand exactly what the participants' preferences are with regard to learning styles. The results obtained from this questionnaire will have an immediate effect on the approach adopted to develop the e-learning material for this research.

According to Gall *et al.* (1996:246), the type of questionnaire to be used, would depend on the purpose of the research. For this research, a questionnaire containing structured, interpretive questions with the opportunity to add comments, were used. It proved to be a cost-effective exercise, as the researcher made use of a self-administered questionnaire. According to Bourque (1995:3), a self-administered questionnaire is completed by a participant where the researcher is present.

4.2.3.3 The covering letter

Vermeulen (1998:68) and Gall *et al.* (1996:299) emphasised the necessity of a letter accompanying the questionnaire. A copy of this letter appears in Annexure A. The covering letter was aimed at orientating the participants, as well as assuring them of confidentiality and anonymity.

4.3 ANALYSIS OF DATA

In section 4.3.1, the method of analysis of questionnaires is discussed by categorising the questions in three different types. In section 4.3.2, all results are shown in chronological order.

4.3.1 Method of analysis

There are three types of questions, each of which will be indicated in brackets next to the question heading. Questions were explained to participants, see discussion in section 4.2.3.2. The three different types of questions are:

- select one option question (type one)
- select one option question with the opportunity to make a comment (type two)
- select more than one option question with a comment (type three)

The total number of participants who participated in this questionnaire is 102. The analysis of data is introduced by means of tables for each question. As shown in Table 4.0A, the number for each option appears in the first column. The second column for the closed questions (types one, two and three) shows the description of the options for each question. The third column indicates the number of participants who have chosen a particular answer, whereas the fourth column represents the percentage of participants who selected the option. The fifth column indicates the option's relationship to Felder and Silverman, while the last column gives a guideline or "wish list" for the e-learning material to be developed.

	Options	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Daily	71	69.6%	Sequential reading	Text in chronological steps

Table 4.0A Example of open-ended questions

The analysis of comments in each open-ended question (type two or three) is presented in tabular form and indicates the option selected by the participant, as well as the number of comments stemming from the same option. The themes detected during the coding process are presented in the third column. The fourth column contains a possible link to Felder's ILS. The last column explains what information is gained from this detected theme with a view to developing good e-learning material. An example of this is shown in Table 4.0B.

Option	Comments	Themes detected	Relate to Felder	E-learning guidelines
1	5	Organised methods of learning	Sequential	Include Internet and text.

Table 4.0B Open-ended question coding

It is important at this stage to note that column 5 (e-learning guidelines) was not part of the original questionnaire. The e-learning guidelines serve as a type of “wish list” for possible actions that need to be taken to enhance the traditional method of information transfer from the lecturer to the student. The e-learning guidelines allow the researcher to identify beforehand all possible actions to be taken in order to develop the e-learning material reported on in chapter 5.

When a question or analysis of a question refers to a computer, it means that a participant uses his or her own computer or a computer in the student centre. Any reference made to the Internet means a computer that can access the Internet either from home, or from the student centre.

An answer is considered to be void when the participant selected more than the specified number of options for a particular question. However, as this questionnaire is analysed from an interpretive perspective, void responses were considered to convey in some instances an identifiable message.

4.3.2 Presentation of questionnaire results per question

4.3.2.1 Question 1 (type one)

How often do you use a computer?

	Options	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Daily	71	69.6%	Non specific	Important to have a typical look and feel interface.
2	Few times per week	29	28.4%	Non specific	Important to have a typical look and feel interface.
3	Sometimes	2	2.0%	Non specific	Important to have a typical look and feel interface.
4	Never	0	0.0%	Non specific	None

Table 4.1 Data on how often a computer is used.

All participants completed this question and there were no void answers. According to Morley (2008:5), computers are an integral part of our lives. From table 4.1, it is clear that most of the students (69.6%) are using computers on a daily basis. There are 0% students who do not use a computer at all. It may be assumed that when learning material is presented on a computer, no additional restraints will be created.

It is very significant that more than 98% of the participants use a computer at least a few times per week. This shows that it is possible to incorporate e-learning material into the learning environment with good reason to believe that participants will use it.

4.3.2.2 Question 2 (type one)

How often do you play computer games?

	Options	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Never	28	27.5%	Non specific	None
2	Less than 4 hours per month on average	46	45.1%	Non specific	None
3	Between 1 and 5 hours per week on average	18	17.6%	Non specific	One could base material on a typical games interface.
4	More than 5 hours per week on average	10	9.8%	Non specific	One could base material on a typical games interface.

Table 4.2 Data on how often computers games are played.

All participants completed this question and there were no void answers. The aim of this question was to investigate whether the students are used to the typical games interfaces. As 27.5% and 45.1% (72.6%) of the students play less than 4 hours a month, one cannot assume that a games-like interface for the material should be followed.

Many students do not possess computers, and that might be a reason why they do not play computer games. They are not permitted to play games on computers at the student centre, although they might have played, had they have the opportunity to do so. The results obtained from this question are somewhat different from what was expected, suggesting that not all participants were familiar with the typical games user interface.

4.3.2.3 Question 3 (type one)

How often do you watch a movie on your computer?

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	More than once per week	16	15.7%	Visual	Include movies, videos.
2	Once per week	20	19.6%	Visual	Include movies, videos.
3	Sometimes	56	54.9%	Non specific	Include movies, videos.
4	Never	10	9.8%	Non specific	None

Table 4.3 Data on how often movies are watched on a computer.

All participants completed this question and there were no void answers. This question was another way of establishing whether or not students interact with computers. A total of 90.2% has experience of watching a movie on a computer.

This indicates that they are used to using computers for diverse purposes and therefore might be ready to use computers for tuition as well.

4.3.2.4 Question 4 (type two)

Do you like animation and sound in computer games?

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	I don't play games	26	26.57%	Non specific	Non specific.
2	Enjoy it very much	46	46.94%	Visual	Include animation and sound.
3	Never notice it	19	19.39%	Non specific	Draw specific attention to important aspects of information.
4	Other	7	7.1%	Non specific	Non specific.

Table 4.4A Animation and sound on computer games.

Option	Comments	Themes detected	Relate to Felder	Guideline for e-learning
1	1	Don't like animation and sound in computer games	Non specific	None
2	0	None	Non specific	None
3	0	None	Non specific	None
4	2	Sometimes if cool (1) Sometimes enjoy sound (1)	Reflective	Include functional sound clips.

Table 4.4B Comments on question 4

Four participants did not complete this question. Although previous questions indicated that computers were not often used for playing games, table 4.4A indicates that 46.94% of the students like the animation and sound of computer games. The 19.39% who selected option 3 is not as visual or sensitive and focuses on the main issue rather than the way information is presented. The 46.94% of participants enjoying animation and sound in computer games is indicative of the fact that they may have accepted multimedia with a possibility of interacting with the e-learning material. Computer games teach the player to interact with the computer in various ways.

The results obtained from this question comply very favourably with the results obtained from question 1. In question 1, 27.5% of the participants indicated that

they do not play computer games. In question 4, a total of 26.57% again indicated that they do not play computer games.

The three comments in table 4.4B did not provide additional information to the researcher.

4.3.2.5 Question 5 (type two)

What type of lecturing method do you prefer?

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Going to normal lecturing classes	72	74.23%	Active	Material should be interactive and associable to lectures.
2	Use a computer with sound and video to learn new concepts	20	20.64%	Visual	Include sound and video to e-material.
3	Doing self-study	4	4.13%	Reflective	E-material should be very comprehensive and detailed.
4	Other	1	1.0%	Non specific	None

Table 4.5A Data on preferred lecturing methods

Question 5 is a type two open-ended question. There were five comments on this question. One participant did not complete the open-ended question, while the other four selected more than the allowed number of options, thereby rendering their answers void.

It is worth mentioning here that none of the participants' other modules exposed them to e-learning material to the extent that they experienced a blended e-learning environment.

The majority of students (74.23%) still prefer normal lecturing classes. This motivates the choice of a blended e-learning environment where traditional lectures are still the main form of tuition.

However, fact of the matter is that in the past, traditional lectures revealed shortcomings. The current students might not see the reason for change, but if proved successful, the e-learning material on subnetting will help the academic staff to decide the further teaching combination for this and other modules.

The response to this question in favour of traditional classes also guided the development of e-learning material towards a structure similar to the traditional lectures.

The result obtained from this question clearly shows that 74.23% of the participants are auditory, as well as active participants preferring lecturing classes and interacting with others.

4.3.2.6 Question 6 (type two)

If available, would you make use of multimedia (voice, animation and video) to improve your learning skills?

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Yes	86	85.15%	Visual	E-material should contain voice, animation and video.
2	No	15	14.85%	Verbal	E-learning material should be associable with lectures.
If you want to, tell us more about your answer					

Table 4.6A Data on the usage of multimedia

Option	Comments	Themes detected	Relate to Felder	Guideline for e-learning
1	21	Prefer looking at text and pictures (13) Listen to lecture in class (3) Other class activities (5)	Visual Verbal Active	Include Multimedia and text. Listen to voice recordings. Include interactive activities.
2	2	Listen (1) Disturb concentration (1)	Verbal Non specific	Add to voice recordings. Use only functional animation and sound.

Table 4.6B Comments on question 6

One participant did not complete question six. There were no void answers. The results of table 4.6A are of great importance, as they revealed that 85.15% of the students would use multimedia if made available to them. There is a strong resemblance between two dimensions of the learning style model of Felder and Silverman. Most of the participants indicated that they are active participants, preferring both a visual and verbal style environment.

Comments pertaining to question six were analysed in table 4.6B. Of twenty three comments received, a majority of 91% indicated that they were in favour of a visual, verbal and active learning approach and indicated that they will make use of multimedia to improve their learning skills.

4.3.2.7 Question 7 (type three)

*Which of the following situations do you prefer when receiving new information?
(You may select more than one option)*

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Attending a lecture	83	81.37%	Active	E-material should be interactive and associable to lectures.
2	Studying a text book	57	55.88%	Reflective	Material should be comprehensive and detailed.
3	Watching a video over and over	39	38.24%	Sequential	Material should allow multiple sessions.

Table 4.7A Data on new information received.

There were no void answers to this question, as participants were allowed to choose more than one option. The majority of participants (81.37%) in table 4.7A indicated a preference for attending a lecture to receive new information. A possible motivation for this is that they haven't had much previous experience with multimedia teaching. More than 38% of the students preferred a lecture on video, and watching it repeatedly, while 55.88% of the participants preferred a text book for studying. This question indicates that participants prefer variation when learning new concepts, although attending a lecture is still their dominant learning style preference.

Option	Comments	Themes detected	Relate to Felder	Guideline for e-learning
1	20	Read textbook (3) Use text for self study (2) Listen to lecturer (3) Combine, lectures and read(5) Look at pictures (3) Interaction in class (4)	Verbal Reflective Active Visual Visual Active	Material should be associable with lectures, be comprehensive and detailed, include audio recordings of material with pictures and graphs and linked to other pages.
2	10	Read through textbook (1) Use text for self study (2) Listen to lecturer (2) Combine lectures and read (4) Interaction class activities (1)	Verbal Reflective Active Visual Active	Material should be associable with lectures, be comprehensive and detailed, include audio recordings of material with pictures and graphs and linked to other pages.
3	11	Read text book (1) Listen to lecturers (1) Combine, lectures and text (5) Like to see pictures (2) Interaction in class (2)	Verbal Active Active Visual Active	Material should be associable with lectures, be comprehensive and detailed, include audio recordings of material with pictures and graphs and linked to other pages.

Table 4.7B Comments on question 7

With regard to question 7, twenty one (21) comments were made. Participants were allowed to choose more than one option and also write a comment. Most of

the comments indicated their preference for a combination of lecturing, reading a textbook and looking at videos when receiving new information. As participants were allowed to select more than one answer, guidelines for all options in table 4.7B are more or less the same. The selection of all options represents active, reflective, visual and verbal learning preferences and gives a clear indication that participants may be susceptible to multimedia learning.

An interesting challenge arose in that students like interaction as experienced in the classroom environment. This can be met with chat groups on a web interface.

4.3.2.8 Question 8 (type three)

What do you do to understand difficult and new information? (You may select more than one option)

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Use your imagination to form images in your mind	44	43.14%	Visual	E-material should contain graphs and pictures.
2	Look at pictures and read more about the topic	60	58.82%	Visual	E-material should contain graphs and pictures.
3	Discuss the topic in class	57	55.88%	Active	Include e-mail connectivity.

Table 4.8A Data on difficult and new information understood.

There were no void answers to this question, as participants were allowed to choose more than one option. Although 55.88% of participants in table 4.8A wanted to discuss new information in class, 58.82% preferred looking at pictures and reading more about the topic.

Option	Comments	Themes detected	Relate to Felder	Guideline for e-learning
1	8	Discuss work with friends (2) Self study at home (1) Interact with other students (4) Read text from textbooks (1)	Active Reflective Active Verbal	Include interactive multimedia pages. The e-learning material should together with the textbook provide a reliable and complete source of the study content. Include interactive multimedia pages. Include text pages on screen.
2	8	Discuss problems (2) Study problems at home (2) Interact with friends (4)	Active Reflective Active	Include interactive multimedia pages. Access printable e-material through Internet. Include interactive multimedia pages.
3	10	Discuss problems in class (1) Interaction with students (8) Write and read text (1)	Active Active Reflective	Include interactive multimedia pages. Include e-mail connectivity. Include readable text on screen.

Table 4.8B Comments on question 8

The comments in table 4.8B were analysed and categorised to include multimedia, text, discussion forums and e-mail connections for participants who needed interaction with others and required Internet connectivity.

4.3.2.9 Question 9 (type three)

I learn best by: (You may select more than one option)

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Reading my textbook over and over	63	61.77%	Reflective	Include text material on screen.
2	Doing lots of exercises	72	70.59%	Reflective	Include exercises through e-learning.
3	Asking other people to re-explain the work	57	55.88%	Active	Include e-mail connectivity.

Table 4.9A Data on how people prefer to learn.

There were no void answers to this question, as participants were allowed to choose more than one option. According to table 4.9A, most participants (70.59%) indicated that learners learn best by doing many exercises, while 61.77% preferred to read their textbooks over and over. Felder and Silverman's reflective learning style features prominently, as 66.18% (135/204) of the selected answers confirm processing of information by either reading the textbook several times, or doing lots of exercises. The demand for many exercises can be addressed by accessing the Internet and printing them to work through at home.

Option	Comments	Themes detected	Relate to Felder	Guideline for e-learning
1	5	Like to do practical things (3) Interaction with others (2)	Reflective Active	Include interactive multimedia content, and text pages including user forums. Combine class and Internet actions with e-mail and discussion forums.
2	8	Do many exercises (4) Compare answers (3) Do exercises and talk about it (1)	Reflective Verbal Active	Include exercises through e-learning. Include e-mail and discussion forums. Combine class and Internet actions with e-mail and discussion forums.
3	8	Work in groups (3) Interaction with colleagues (2) Do exercises and read (1) Work alone and discuss work (2)	Active Active Visual Reflective	Combine class and Internet actions with e-mail and discussion forums. Include page interaction. Update e-learning material constantly and include text material.

Table 4.9B Comments on question 9

Table 4.9B contains the comments of twelve participants categorised as active, reflective, verbal and visual learners. Most of the participants who commented on this question, learned best by doing lots of exercises. This indicates that they are reflective and prefer the classroom (class - lecturer) environment. The strong preference for class related activities motivated the selection of a blended e-learning environment where traditional lectures are continued as previously, whilst complemented by e-learning material.

The response to this question, like that of question 5, suggests a careful introduction to e-learning material by the students' lecturers.

4.3.2.10 Question 10 (type two)

How do you react during an active class session?

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Take part in class activities	52	60.47%	Active	Include variation of screens with interaction.
2	Look and listen at class activities	24	27.90%	Active	Include variation of screens and audio.
3	Read through your text book	8	9.30%	Reflective	Include on screen text.
4	I am generally bored	2	2.33%	Non Specific	None
5	Other	0	0.00%	Non specific	None

Table 4.10A Data on how students react during an active class session.

In table 4.10A, more than half of the students (60.47%) indicated that they take part in class activities, while only 2.33% find active class activities boring. Results

obtained from this question revealed that participants prefer synchronous learning, that they are active, as well as visual/verbal participants, thus representing a combination of two dimensions of Felder and Soloman's index of learning styles.

Option	Comments	Themes detected	Relate to Felder	Guideline for e-learning
1	4	Listen to explanations (1) Write notes (1) Participate if understand (2)	Visual Verbal Active	Include text and video, animation. Make text available on screen. Include interactive screens.
2	3	Participate if understand (2) Write notes down (1)	Active Verbal	Include interactive screens. Make text available on screen.
3	3	Do exercises and examples (1) Write notes from lecture (1) Participate sometimes (1)	Verbal Verbal Active	Make text available on screen. Include interactive screens.
4	1	Write important information (1)	Visual	Non specific.
5	0	None	Non specific	Non specific.

Table 4.10B Comments on question 10

Five students commented but each of them selected more than one option. A total of eleven selections were recorded among these five students. Although these students did not answer the question as intended they did demonstrate their preferred learning styles.

Four of the five participants who wrote comments said that they like taking part in class activities. Again the researcher notices the overwhelming effect of the role of lecturers in the students' framework of reference of learning environments.

4.3.2.11 Question 11 (type two)

How do you prefer to study?

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Start from the beginning and work through the text book	52	59.1%	Sequential	Explain information in steps.
2	Learn the most difficult parts first and then the easier parts	16	18.2%	Global	Allow selection of different pages.
3	Learn the easier parts first and then the difficult parts	17	19.30%	Global	Allow selection of parts.
4	Don't study at home, just listen in class	3	3.40%	Active	Include video and audio text.
5	Other	0	0.0%	Non specific	None.

Table 4.11A Data on how students prefer to study.

Two participants did not complete this question while twelve participants selected more than one option, thereby rendering their answers void. It appears as if these 12 students use a combination of the provided options to study. According to table

4.11A, 59.1% of students study by starting from the beginning and working through the textbook. Only 3.4% do not study, they only listen to the lecture. The high percentage (59.1%) is evident of most participants being sequential, which is a dimension of Felder and Silverman's learning styles model. Learners who study in sequence can easily be addressed by means of e-learning material.

Option	Comments	Themes detected	Relate to Felder	Guideline for e-learning
1	2	Interact with students and text (1) Study on own (1)	Active Reflective	Include video and audio text. Include readable text on screen.
2	1	Study recent work first (1)	Sequential	Include sequential text on screen.
3	2	Interact with students and text (1) Study on own (1)	Active Reflective	Include video and audio text. Include readable text on screen.
4	0	Non specific	None	None
5	0	Non specific	None	None

Table 4.11B Comments on question 11

Comments in table 4.11B are too few to generalise the findings for the group as a whole. However, they clearly state that the learning style is reflective, as participants prefer studying in a sequential manner at home. They also like to go through all the work they have done during the day.

4.3.2.12 Question 12 (type two)

How would you improve your current marks?

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	By using current methods more effectively	27	27.3%	Sensing	Material should be associable to lectures.
2	To try and find new more effective methods to study	70	70.7%	Reflective	Introduce effective text explanations.
3	Other methods	2	2.0%	Non specific	None

Table 4.12A Data on how to improve marks.

All participants completed the question, but three selected more than one option, thus rendering their answers void. According to table 4.12A, most of the students (70.7%) agreed that to improve their marks, more effective study methods should be found. The majority of participants indicated that the traditional way of learning is not sufficient anymore and that the application of new and more effective study methods would contribute towards improving their current marks.

Option	Comments	Themes detected	Relate to Felder	Guideline for e-learning
1	4	Self study more attractive (3) Interaction with other students (1)	Reflective Active	Make e-learning material available through Internet. Include e-mail and discussion forums.
2	1	Prefer self study (1)	Reflective	E-learning material should be very comprehensive and detailed.
3	3	Study on their own (2) Interaction with others (1)	Reflective Active	E-learning material should be very comprehensive and detailed. Include e-mail and discussion forums.

Table 4.12B Comments on question 12

Comments received in table 4.12B, clearly underline the preferential learning styles as reflective and active. This is very much in line with e-learning material, as it allows students to study independently and at their own pace.

4.3.2.13 Question 13 (type one)

Which of the following would you use if they were available?

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Using multimedia aids on a computer	26	28.3%	Visual	Include video and voice and all other forms of multimedia.
2	Listening and looking at video recordings	35	38.0%	Visual	Include video and voice.
3	Collecting additional textual information	31	33.7%	Verbal	Together with the textbook the e-learning material should provide a reliable and complete source of the study content.

Table 4.13 Data on which teaching aid students would choose.

All participants completed the question, while ten selected more than the permitted number of options, thereby rendering their answers void. However, by selecting more than one option these ten students did convey a message to the researcher that they would appreciate more diverse teaching methods. As indicated in table 4.13, if available to them, 38% of students would use video recordings, while 28.3% preferred multimedia aids on a computer and 33.7% would use additional text material. The percentage of participants selecting a verbal learning style was 33.7%, while a total of 66.3% opted for a visual learning style. Written text, according to Felder and Silverman, is also considered to be verbal learning.

Although previous questions (such as question 5) indicated a preference for traditional lecturing, answers to this question were encouraging, as 66.3% of the

students (those who selected options 1 and 2) indicated that they would use other than traditional methods if available. The response in option 3 is a reminder to ensure that the text book combined with the e-learning material should provide a complete source of the learning material.

4.3.2.14 Question 14 (type one)

I understand something more effectively when I:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Do it myself	64	70.31%	Reflective	E-learning material should be comprehensive and detailed.
2	Think about it before I do it	21	23.1%	Reflective	Allow time to think about solutions.
3	Draw pictures about the topic	6	6.59%	Visual	Include pictures and diagrams.

Table 4.14 Data on self-understanding.

All participants answered the question, but eleven selected more than the permitted number of options, thereby rendering their answers void. However, these students did convey that they have a preference for a combination of methods. According to table 4.14, 70.31% of the students agreed that they understand something better when doing it on their own. Only 6.59% selected drawing pictures for better understanding. Most of the participants preferred a reflective learning style, which is part of the first dimension of Felder and Soloman's learning style index.

4.3.2.15 Question 15 (type one)

When I think about what I did yesterday, I am most likely to get:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	A picture	76	76.8%	Visual	Include video, pictures and diagrams.
2	Words	23	23.2%	Verbal	Include on screen text.

Table 4.15 Data on preferences of study aids.

Questions 15 to 24 were directly taken from the free version of Felder and Soloman's Index of Learning Styles (Felder, 2009:1), which is available on the Internet.

All participants answered the question, but three answers were rendered void. Once again these three students conveyed to a message of combination of styles.

According to table 4.14, only 6.59% of participants preferred drawing pictures to understand better. However, in table 4.15A most of them (76.8%) indicated that they recall best what they learned the previous day by visualising it as a picture. Only 23.2% remembered words during an explanation. There is a strong tendency (76.8%) towards visual learning when students recall what they did the previous day. Visualising is a very strong concept emanating from this question and is an indication that multimedia may be accepted as a learning instrument.

4.3.2.16 Question 16 (type one)

I tend to:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Understand details of a subject but may be fuzzy about its overall structure	47	46.08%	Sequential	Include sections of material that show smaller parts of the e-learning material.
2	Understand the overall structure but may be fuzzy about details	55	53.92%	Global	Include a picture or diagram that gives an overall impression of the entirety.

Table 4.16 Data on understanding learning material

All participants answered the question and there were no void answers. According to table 4.16, more students (53.92%) have to understand the overall structure before attempting the details of learning material. On the other hand, 46.08% of students have to understand the details of the learning material before they understand its overall structure. These participants hereby indicated their preference for a global style of learning.

4.3.2.17 Question 17 (type one)

I prefer to get new information in:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Pictures, diagrams, graphs or maps	36	36.74%	Visual	Include multimedia, pictures and animation.
2	Written directions or verbal information	62	63.26%	Verbal	Include voice and text.

Table 4.17 Data on information gathering

All participants answered the question but there were four void answers as a result of participants selecting more than one option. This may convey a message of combined styles, as these students found it difficult to choose only one option. According to table 4.17, most students (63.26%) indicated their preference for

verbal explanations when learning new concepts. Only 36.74% preferred pictures, diagrams, graphs or maps. The response to this question motivated the researcher to ensure that the written parts of the e-learning material are clear and complete when used in conjunction with the text book.

Written text is also seen as a verbal learning style as described and can be easily applied through a multimedia approach (section 3.2.3.4). It is possible to have interactive pages and links to pictures, video clips, text and animated objects, explaining the same topic differently.

4.3.2.18 Question 18 (type one)

Once I understand:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	All the parts, I understand the whole thing	50	49.5%	Sequential	Include smaller parts of section in sequential order.
2	The whole thing, I see how the parts fit	51	50.5%	Global	Include an overview of the whole in text or picture.

Table 4.18 Data on understanding of parts of learning material.

All participants answered the question but one selected more than one option thereby rendering the answer void. According to table 4.18, there is only a 1% difference between the preferences for learning material. As the global learning style has such a small advantage over sequential learning, it is clear that the material developed should cater for both styles. The global learning approach can be implemented by using a picture showing the whole layout of study material. Smaller pictures can facilitate smaller parts thereof. Both multimedia and the computer are perfectly positioned to indicate parts individually or globally, allowing the participant to choose any of these approaches as a preferred learning style.

4.3.2.19 Question 19 (type one)

In a book with lots of pictures and charts, I am likely to:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Look over the pictures and charts carefully	57	56.44%	Visual	Include pictures and charts.
2	Focus on the written text	44	43.56%	Verbal	Include text screens.

Table 4.19 Data on preferences of pictures and charts vs text.

All participants answered the question but as one selected more than one option, this particular answer was rendered void. When gathering the information of table 4.19, it was found that 56.44% of the students preferred looking at pictures and charts rather than focusing on the written text. The results of question 17 were about learning of new information, while question 19 specifically addresses the preference of participants when looking at pictures and charts. Most of them preferred visual learning, but as the percentage difference between visual and verbal learning is only 13%, both learning styles should be satisfied.

4.3.2.20 Question 20 (type one)

I like teachers:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Who put a lot of diagrams on the board	25	25.3%	Visual	Include video and pictures.
2	Who spend a lot of time explaining	74	74.7%	Verbal	Material should be associable to text and lectures.

Table 4.20 Data on lecturing preferences.

All participants answered the question but three selected more than one option thus rendering these answers void. Once again, void answers might convey a message that these students like both methods. The analysis of this question highlights the current situation at the VUT where traditional lectures are the norm. The overwhelming response with regard to explaining should be conveyed to lecturers in the blended e-learning environment. Their role in the success of students is emphasised here.

According to table 4.20, most of the students (74.7%) preferred the lecturer who would spend a lot of time explaining a topic before moving on to the next. Only 25.3% preferred the diagrams, which is an indication that participants opt for a verbal learning style rather than a visual one. Verbal learning as explained in section 3.2.3.4 may also be addressed through written text which is fully compatible with e-learning methods.

4.3.2.21 Question 21 (type one)

When I start a homework problem, I am more likely to:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Start working on the solution immediately	12	11.76%	Intuitive	Non-specific.
2	Try to fully understand the problem first	90	88.24%	Sensing	When introducing a new section of the module be sure to explain the need for the material carefully.

Table 4.21 Data on problem solving.

All participants answered this question, and no void answers were recorded. The response to this question relates to a dimension of the learning styles model of Felder and Silverman not addressed by the rest of this questionnaire. This dimension describes how students react to given material. Some students will react more intuitively, while others would react more sensitively. It is not clear at this stage how the structure of the material will be influenced by this dimension.

It is not easy to address the sensing/intuition learning style dimension in an e-learning environment. The most appropriate option was to give the student the opportunity of selecting the e-learning material most preferable and acceptable to him or her. However, in this blended e-learning environment, it will be possible to address the dimension in the traditional lecturing environment. The response to this question should be brought under the attention of the lecturers.

According to table 4.21, 88.24% of participants preferred to understand a problem first before starting on their homework, while only 11.76% would start doing their homework before understanding the problem. This result confirms the participants' preference for a sensing learning style.

From the analysis of this question it is clear that the specific context of new topics should be carefully discussed. Students need to understand the necessity of the new topic in terms of problems addressed by the new material before studying the detail of such material.

4.3.2.22 Question 22 (type one)

It is more important to me that an instructor:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Lay out the material in clear sequential steps	49	49%	Sequential	Allow sequential selection of learning material.
2	Give me an overall picture and relate the material to other subjects	51	51%	Global	Include diagram or picture to explain the whole of the section.

Table 4.22 Data on instruction explanation.

All participants answered the question but two selected more than one option, and these answers were rendered void. There is not much difference in data shown in table 4.22. Nevertheless, from this data it is evident that 51% of the students would wish the instructor to relate learning material to other subjects, rather than explaining the material in clear sequential steps. Both options should be catered for.

4.3.2.23 Question 23 (type one)

When I see a diagram or sketch in class, I am most likely to remember:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	The picture	22	22%	Visual	Include pictures, diagrams and video.
2	What the instructor said about it	78	78%	Verbal	Material should be associable to lectures.

Table 4.23 Data on remembering a picture or verbal explanation.

All participants answered the question but there were two who selected more than one option, thereby rendering their answers void. It might be possible that these students are using both options when they study.

Once again the response to this question should be understood within the relevant context. From the overwhelming response, it is clear that all new material should be associated with lectures, and as written text also addresses the verbal style, care should be taken to provide enough written explanations on the e-learning material.

According to table 4.23, 78% of the students will remember what the instructor said when seeing a diagram or sketch in class. An overwhelming number of participants selected a verbal learning style and preferred synchronous learning. E-learning

material should offer good explanations in aid of given diagrams. It is clear that it is impossible to improve the performance of these students without well planned lectures.

4.3.2.24 Question 24 (type one)

For entertainment, I would rather:

	Option	Answers	Percentage	Relate to Felder	E-learning guidelines
1	Watch television	68	69.39%	Visual	Include pictures, video.
2	Read a book	30	30.61%	Verbal	E-material should be comprehensive and detailed.

Table 4.24 Data on preferred entertainment.

All participants answered the questions but four selected more than one option, and their answers were rendered void. According to table 4.24, 69.39% of the participants would rather watch television for entertainment. Only 30.61% would read a book instead. This is encouraging, as it shows that the participants enjoyed the multiple sense stimulation of television.

4.4 LEARNING STYLE PREFERENCES

There is a growing realisation that learning style awareness contributes to the effectiveness of learning and teaching. This analysis gave a clear indication of the trend in learning styles of students in engineering at the VUT, enrolled for the Network Systems III module.

Dimensions	Learning Styles	Questions	Percentages	Guidelines for e-learning material
1	Active	5, 7, 8, 9, 10, 11	74.23%, 81.37%, 55.88%, 55.88%, 88.37%, 3.4%	Create interactive variations of module content on computer that are associable to lectures, have active Internet links, e-mail connectivity, audio, video and text.
	Reflective	5, 7, 9, 10, 12, 14	4.13%, 55.88%, 70.59% (at least), 9.3%, 70.7%, 93.4%	E-learning material should be associable to lectures. Create functional e-learning material with sound clips and text material that allows time for comprehensive and detailed explanations with exercises.
2	Sensing	12, 21	27.3%, 88.24%	When introducing a new section of the module be sure to explain the need for the material carefully.
	Intuitive	21	11.76%	Non-specific.
3	Visual	3, 4, 5, 6, 8, 13, 14, 15, 17, 19, 20, 23, 24	35.3%, 46.94%, 20.64%, 85.15%, 58.82%, (at least) 66.3%, 6.59%, 76.8%, 36.74%, 56.44%, 25.3%, 22%, 69.39%	Create e-learning material that includes multimedia explanations with the aid of movies, videos, pictures, charts, voice explanations, animation, graphs and text with and without sound.
	Verbal	6, 13, 15, 17, 19, 20, 23, 24	14.85%, 33.7%, 23.2%, 63.26%, 43.56%, 74.7%, 78%, 30.61%	Create e-learning material associable with lectures and includes comprehensive and detailed explanations through text pages on computer screens and voice explanations.

Dimensions	Learning Styles	Questions	Percentages	Guidelines for e-learning material
4	Sequential	7, 11, 16, 18, 22	38.24%, 59%, 46.08%, 49.5%, 49%	E-learning material explained in small chronological sections through selected pages and multiple sessions.
	Global	11, 16, 18, 22	37.5%, 53.92%, 50.5%, 51%	E-learning material with the ability to give an overall expression of the whole, or sections of the whole, through the help of pictures, diagrams or text, using a computer.

Table 4.25 Learning style preferences

Table 4.25 summarises the data in terms of the learning styles of Felder and Silverman. It also provides a summary of the e-learning material guidelines presented in the analysis of the individual questions. The data points to the fact that on the one hand, each participant has a preferred learning style, while on the other hand, the group of participants is representative of all learning styles. Subsequently, the e-learning material must cater for all learning styles tested, irrespective of the relative percentages of individual learning style preferences.

4.5 CONCLUSION

Sub-objective 2.1 in section 4.1 deals with the data collection process. A questionnaire was distributed to the Network Systems III module students to be completed. The questions were explained to the students. The questionnaire was based on the ILS questionnaire of Felder and Soloman, but adapted for the specific research purposes at the VUT.

The analysis of questions, both closed and open-ended, clearly indicated that participants had a variety of combinations with regard to learning styles. One of the most prominent observations featuring in the analysis was the fact that students were used to traditional lectures and would need guidance in the process of changing to a blended e-learning learning environment.

In order to use multimedia for study purposes, it has to be visual and should accommodate active learning style preferences to allow for learner interaction through discussion forums and e-mails. Learning material therefore should comprise of text with links to various other activities, such as pictures, videos, voice recordings and text examples. The participant should be in a position to work through the e-learning material sequentially and have the opportunity of assessing the bigger picture before working through its smaller parts. E-learning material should be structured in such a way to represent the same sequence that the lecturers followed with the module syllabus.

The learning environment at the VUT in this module is seen as blended learning with the lecturer presenting the learning material, while the student has the option of collecting additional information and refreshing his or her memory through multimedia presentations on the Internet. This chapter presented an analysis and interpretation of research results in this field as depicted in sub-objective 2.2 in section 4.1.

Results obtained from questions 1, 2, 3, 4 and 6 support the idea that learning material presented on a computer will not create additional restraints. During analysis of these questions, in particular question 6, it was clear that participants were comfortable with using computers for tuition.

From the overall analysis of data presented in section 4.4 (addressing sub-objective 2.4 in section 2.1), it is clear that participants were representative of all tested learning styles.

As a result e-learning material should cater for all the tested learning styles. E-learning material should be developed according to the following guidelines:

- Create interactive variations of module content on computer that are associable to lectures, have active Internet links, e-mail connectivity, audio, video and text.
- Create functional e-learning material with sound clips and text material that allows time for comprehensive and detailed explanations with exercises.

- When introducing a new section of the module, be sure to explain the need for the material carefully.
- Create e-learning material that includes multimedia explanations with the aid of movies, videos, pictures, charts, voice explanations, animation, graphs and text with and without sound.
- Create e-learning material associable with lectures and includes comprehensive and detailed explanations through text pages on computer screens and voice explanations.
- E-learning material explained in small chronological sections through selected pages and multiple sessions.
- E-learning material with the ability to give an overall expression of the whole, or sections of the whole, through the help of pictures, diagrams or text using a computer.

Chapter 5 represents the planning and implementation of intervention phase of the action research project and reports on the development of e-learning material for subnet masking.

CHAPTER 5

E-MATERIAL ON SUBNET MASKING

5.1 INTRODUCTION

This chapter represents the second phase of the action research cycle i.e. the planning and implementation of the intervention phase indicated in figure 5.1.

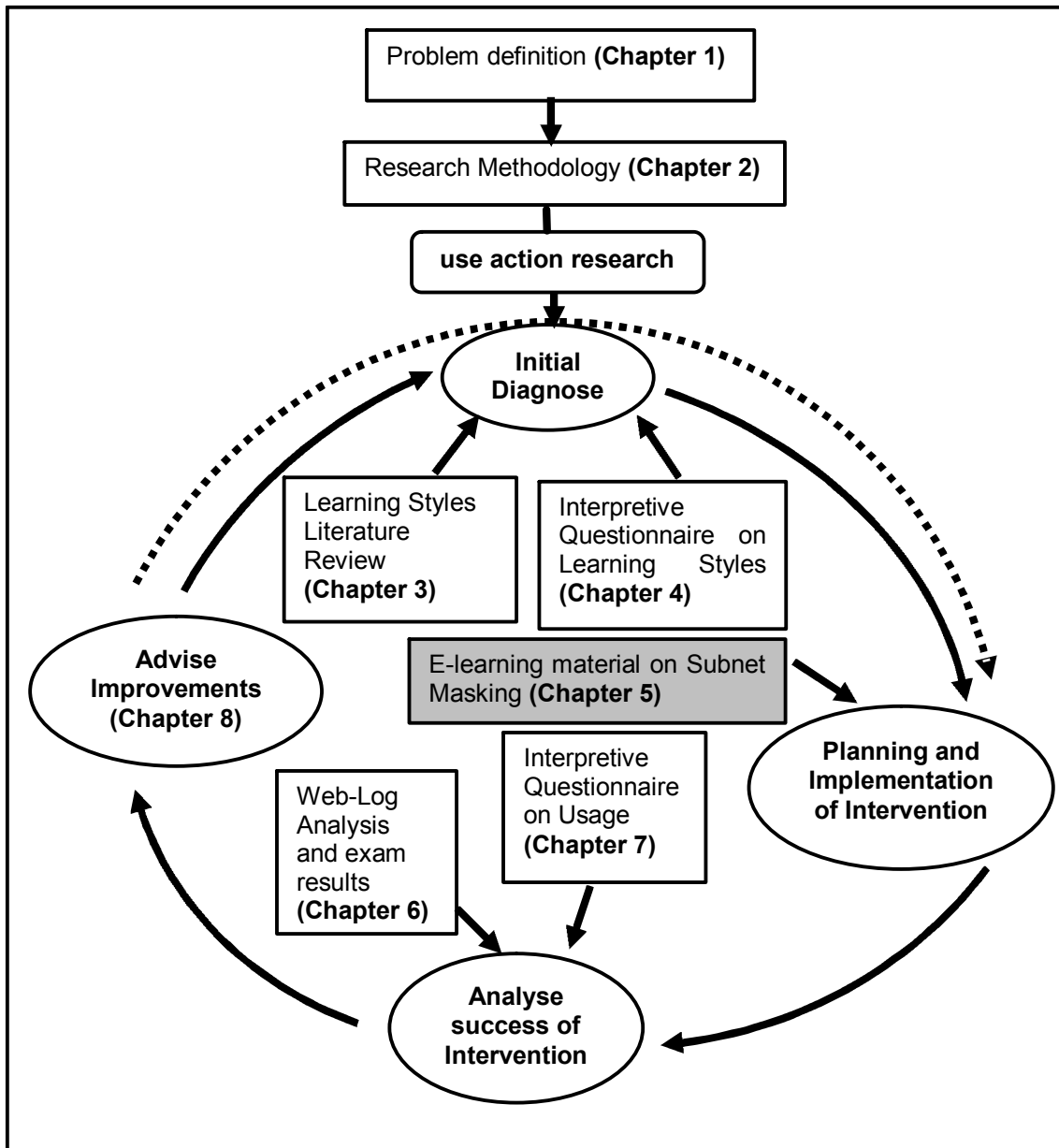


Figure 5.1 Schematic layout of this research

Textbook learning material will be reconciled with comprehensive and multidimensional e-learning material accessible to all learners at all time.

Preference will be given to the learning styles model of Felder and Silverman, discussed in section 3.2.3.4. In an attempt to improve student performance, the use of e-learning material as a parallel medium to support traditional teaching methods, will be applied to the findings obtained from the analyses of the questionnaires in chapter 4.

The development of e-learning material will be discussed in chapter 5 as part of the planning and implementation of intervention phase of action research as shown in figure 5.1. This chapter addresses objective 3, stated in section 1.2. The objective can be divided into sub-objectives to ease linkage between different sections of this chapter.

Objective 3: Creating of e-material accommodating different students' learning styles, was already described in chapter 3 (section 3.1) and will be further divided into the following sub-objectives:

- 3.8 Identifying a specific area of the Network Systems III module syllabus for which e-learning material will be developed.
- 3.9 Planning the e-learning material from the literature review on learning styles.
- 3.10 Planning the e-learning material from the analysis of the interpretive questionnaires on learning styles discussed in chapter 4.
- 3.11 Physically creating e-learning material related to the selected area of the Network Systems III module content.
- 3.12 Understanding the analysis capabilities of Learning Management Systems.

An action research project is a collaboration between the participants in the research project and the researcher in order to solve a specific problem. As stated in section 1.2, the aim of this study is to improve student performance in the Network Systems III module at the VUT. As a first phase (part of the diagnosis of the problem), a discussion was held to identify problematic areas of the learning material. This is expressed by objective 3.8 stated earlier in this section.

After a discussion with lecturers, the decision was made to develop e-learning material on the subnet masking section of the module's learning content. This decision was based on:

- Historically poor performance of students in sections of the final examination paper on subnet masking.
- Historically poor performance of students in semester tests on this section of the learning content.
- Views expressed by lecturers that from their experience, students have difficulty with understanding the learning content of subnet masking.
- It was decided to develop e-learning material on this content in order to create additional material that is always available to students.
- It became clear that students asked lecturers lots of questions on subnetting during and after formal lectures. This led to the decision to develop a multimedia environment where videos could be used to give verbal explanations along with additional text information.
- It was agreed that a study on learning styles might be advantageous before development of the material was finalised.
- Traditional lectures should still be continued as before.

Section 5.2 firstly describes the planned intervention as a result of the literature review in chapter 3 (sub-objective 3.9) and secondly, the intervention as a result of the interpretive questions in chapter 4 (sub-objective 3.10). Section 5.3 discusses subnetting which is the topic chosen for this research. Section 5.4 explains how the learning material was designed to address the main learning preferences of the learners obtained through the questionnaires (sub-objective 3.11). Section 5.5 discusses the learning management system used to distribute the adapted learning material for users (sub-objective 3.12).

The conclusion follows in Section 5.6.

5.2 PLANNED INTERVENTION

From the initial diagnoses it was decided to create e-learning material on the subnet masking section of the Network Systems III module.

The researcher investigated a learner management system (LMS) for distributing and managing the learning material and allowing learners to follow their own pace of learning at home or in the student centre through the Internet. Usage of the material does not form part of formal instruction and students, although encouraged to do so, should decide themselves to use the material.

The e-learning material has different approaches for the same topic and will attempt to make the learning content easier to understand. This approach makes teaching learner-centred and not teacher-centred (Weimer, 2002:187).

For the purpose of this study, the Moodle LMS is used as it is an open source (free to use) and allows students sufficient flexibility and autonomy with regard to the accessibility of information.

5.2.1 Mode of tuition prior to intervention

This module was traditionally taught in a classroom, using a black board, overhead projector and text books. At the time, no e-learning material was available. There are six classes with students varying from 28 to 40 per class. Each class has three two hour sessions per week.

The intervention resulting from a literature review presented in chapter 3 will be discussed next.

5.2.2 Planned intervention as a result of literature review

In chapter 3, the researcher investigated learning formalities, learning domains, different learning styles and factors that may affect learning or improve learning achievement. Insight into learning was gained. The principles of Rogers (1983) described in section 3.2, were instrumental in the planning of the material. Even aspects of informal learning, such as imprinting, influenced the development of the design of the material. The importance of learning domains for this study was discussed in section 3.2.2.4.

From the literature review, it became clear that different learners have different learning styles and that e-learning material therefore should accommodate most of the learners' preferences. Analysing the content of this literature enabled the researcher to develop a questionnaire for the investigation of learning styles. The questionnaire was developed for the learners at the VUT and contains open-ended, as well as multiple choice questions addressing specific matters related to their learning styles.

Many of the twenty rules of Wozniak (1999) could be applied in the development of this e-learning material as mentioned in section 3.3.2.1.

The literature review also indicated that dynamic, systematic and long-term professional development in technology is necessary. International trends and variations in technologies should be investigated to ensure that technology is efficient and acceptable to any given audience. There is a variety of ways in which information can be displayed to learners. It was decided to adopt a blended e-learning strategy, since it will be implemented as a parallel method of instruction to augment traditional teaching methods.

The next section addresses intervention as a result of the interpretive questionnaires.

5.2.3 Planned intervention as a result of analysis of interpretive questionnaires

The section summarises the analysis of interpretive questionnaires presented in chapter 4.

Intervention based on knowledge gained from learning style analysis, revealed the following:

- Students showed their willingness and ability to use computers for learning purposes.
- Many students demonstrated a preference for a visual learning style.

- Some students liked the active participation in a class environment.
- There were students preferring a quieter environment to study.
- Some students chose to receive their learning material in clear sequential steps.
- The preference of having knowledge of the whole before studying the smaller parts was demonstrated.
- Students demonstrated their preferences for verbal learning.
- Some students preferred to select certain parts of the learning material and study that first and then continue with the rest.

Intervention based on guidelines for e-learning material:

- Create interactive variations of module content on computer that are associable to lectures, have active Internet links, e-mail connectivity, audio, video and text.
- Create functional e-learning material with sound clips and text material that allows time for comprehensive and detailed explanations with exercises.
- When introducing new section of the module, be sure to explain the need for the material carefully.
- Create e-learning material that includes multimedia explanations with the aid of movies, videos, pictures, charts, voice explanations, animation, graphs and text with and without sound.
- Create e-learning material associable with lectures and includes comprehensive and detailed explanations through text pages on computer screens and voice explanations.
- E-learning material explained in small chronological sections through selected pages and multiple sessions.
- E-learning material with the ability to give an overall expression of the whole, or sections of the whole, through the help of pictures, diagrams or text using a computer.

The visual/verbal learning dimension of Felder and Soloman's LSI is a common learning style and very prominent as a learning dimension throughout this analysis. Most participants are still making use of the traditional learning styles, such as

verbal lectures in lecturing classes. Students are not used to e-learning material but are using technology in various other aspects of their lives.

Participants also felt that media play an important role in presenting lectures to accommodate teaching and learning styles. Students prefer a practical approach for studying new concepts; they want to experience the new information by looking at pictures, videos and do many exercises in order to understand,

A brief discussion of subnet masking is given in order to familiarise the reader with the specific nature of the subnet masking material.

5.3 SHORT DISCUSSION ON NETWORKS: SUBNETTING

This section introduces subnet masking (or subnetting) identified by the lecturers.

5.3.1 Subnetting

Subnetting involves taking an IP network and subdividing it into smaller logical networks through a process called subnet masking (Brandon, 1998:109; Fegan & Forouzan, 2000:109; Shanmugam *et al.*, 2002:247). A Subnet Mask, according to Shanmugam *et al.* (2002:251), is a 32-bit value used to extract the network number from an IP address by performing a binary AND operation between the IP address and the Subnet Mask. When subnetting a network, it is important to look at the requirements of the organisation with regard to the number of subnets and number of hosts needed on each subnet.

5.3.2 IP Address

The first part of an IP address is used as a network address, the last part as a host address. By using a 255.255.255.0 Subnet Mask, the network ID is 192.168.123.0 and the host address is 0.0.0.132. For example, taking 192.168.123.132 and dividing it into these two parts result in the following:

192.168.123Network.132Host

The network portion and subnet id in combination are called the extended network portion, indicated in figure 5.2.

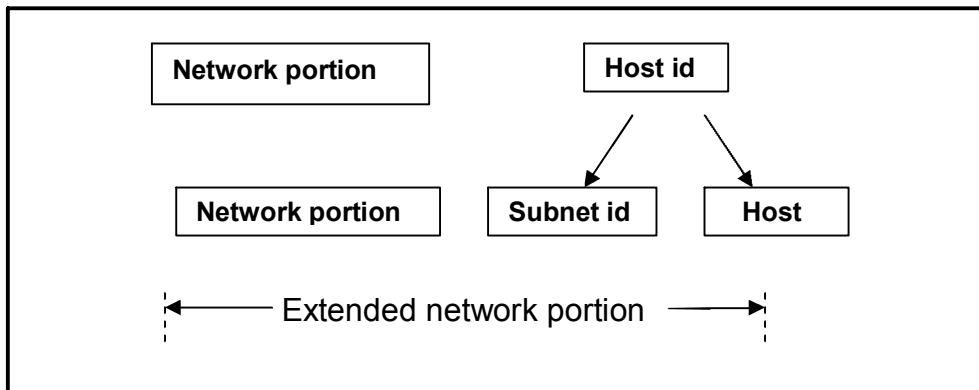


Figure 5.2 Analysis of IP address

5.3.3 Networks

Shanmugam *et al.* (2002:249) argue that there are three different classes of networks, namely A, B and C (table 5.1). The most significant bits in each base class define the network; A = 8 bits, B = 16 bits, C = 24 bits (Brandon, 1998:108). He further explains that the Subnet Mask depends on the number of bits used for the subnet number and the network class (A, B or C).

Class	Base Subnet Mask	Number of Networks	Number of Hosts
A	255.0.0.0	128	16 777 216
B	255.255.0.0	16 384	65 534
C	255.255.255.0	2 097 152	254

Table 5.1 Base Subnet Masks with hosts (Brandon, 1998:112)

In a class "A" network, a total of $2^{24} - 2$ hosts can be connected. For example: If an organisation requires 13 subnets from a class B address ($B = 32 - 16 = 16$), there are 16 bits that can be administered to create subnets and host numbers. The number of subnets required, is 13 subnets ($2^4 - 2 = 14$).

5.3.4 Path of network messages

According to VFX Technologies Inc (1998: 28) and Shanmugam *et al.* (2002:254), when a packet is transmitted on any network a deciphering key is used to examine the destination address, comparing it with the local 32-bit Subnet Mask to detect whether the address is on the local subnet. If both numbers of the source and the destination are the same, it is concluded that both computers belong to the same network. To determine the network number of the source computer, the binary

AND operation is performed on the source address and Subnet Mask as indicated in figure 5.3.

11000010	00100011	00110010	00000010 (address computer A)
11111111	11111111	11111111	00000000 (Subnet Mask)
11000010	00100011	00110010	00000000 (Result AND)
194	35	50	0 (dotted decimal notation)

Figure 5.3 Binary AND operation with decimal notation

The routing of an IP datagram involves the following three steps:

- Delivery to the site
- Delivery to the sub-network
- Delivery to the host

5.3.5 Special addresses in subnetting

According to the RFC 950 standard (RFC950 standard, 2009:1) the last octet of the following addresses 192.168.123.0 and 192.168.123.255 cannot be used meaning that the total number of available subnets is reduced by 2. The zero address specifies a network without specifying a host and the 255 address (all 1s) is used to broadcast a message to every host on a network.

5.3.6 Class Interdomain Routing (CIDR)

CIDR (Class Inter Domain Routing) is described as a “slash-n” network where “n” is the number of pre-assigned bits (VFX Technologies Inc, 1998:6; Shanmugam *et al.*, 2002:255). A CIDR network means that the IP address (192.168.1.1) with the Subnet Mask 255.255.255.0 can also be expressed as 192.168.1.1/24. The /24 indicates the network prefix length which is equal to the number of continuous one-bits in the Subnet Mask, indicated in figure 5.4.

192.168.1.1	11000000.10101000.00000001.00000001 (address computer A)
255.255.255.0	11111111.11111111.11111111.00000000 (Subnet Mask)
	AND operation Equals
192.168.1.0/24	11000000.10101000.00000001.00000000

Figure 5.4 AND operation

This concludes the short introduction to subnetting, more detailed information can be found in Annexure C to L.

5.4 DESIGN OF LEARNING MATERIAL

Participants indicated a preference for a wide variety of combinations in learning styles including visual, verbal, active and reflective approaches augmented with charts, figures and animation.

The following sections contain learning material developed to comply with the findings of the questionnaires in chapter 4.

5.4.1 Introduction

This section introduces the newly designed e-learning material. The restriction here is that it only shows screen shots of the animated e-learning material which is not a good indication of the real product. However, the software is protected by copyright of the academic institution and does not allow publication of the complete software in this dissertation.

5.4.1.1 Subnetting

Subnetting involves taking a network and subdividing it into smaller logical networks. The process of subdividing one large network into smaller networks is explained in figure 5.5, using an auditory animated picture to explain how subnetting works. The animated version of the text explanation is activated when the learner clicks on the link which forms part of the text.

The learning styles involved in this particular action are active; the learner is actively involved and clicks on the animated button to start the animation. The learning styles are also reflective; the learner activates this information at home or in the student centre and looks and listens to the explanation which may be repeated as many times as necessary. Furthermore, the styles are visual/verbal; the learner looks at the screen while listening to the voice explanation.

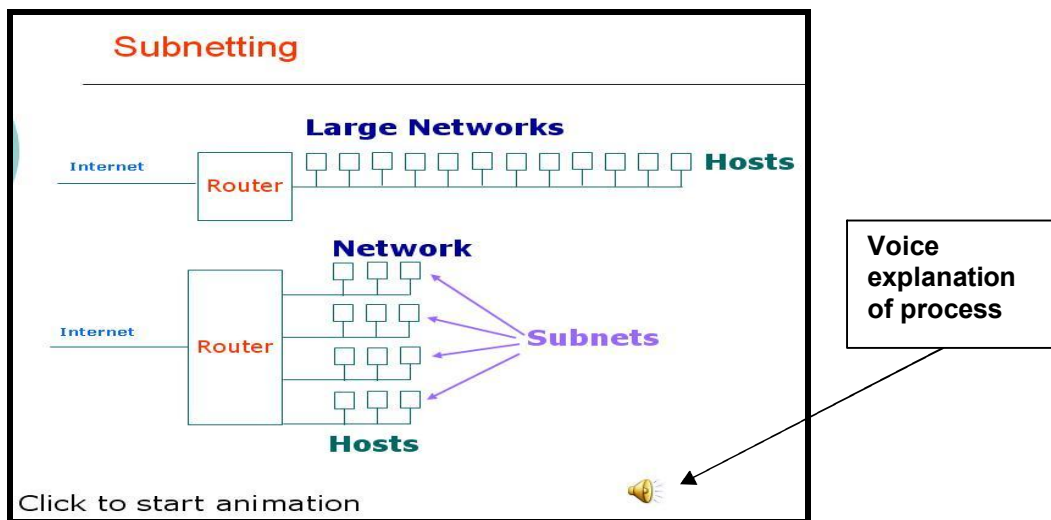


Figure 5.5 Screen shot of e-learning material on subnetting

5.4.1.2 IP Address

A Subnet Mask is a 32-bit value used to extract the network number from an IP address by performing a binary AND operation between the IP address and the Subnet Mask. A screenshot of the binary AND operation is illustrated in figure 5.6.

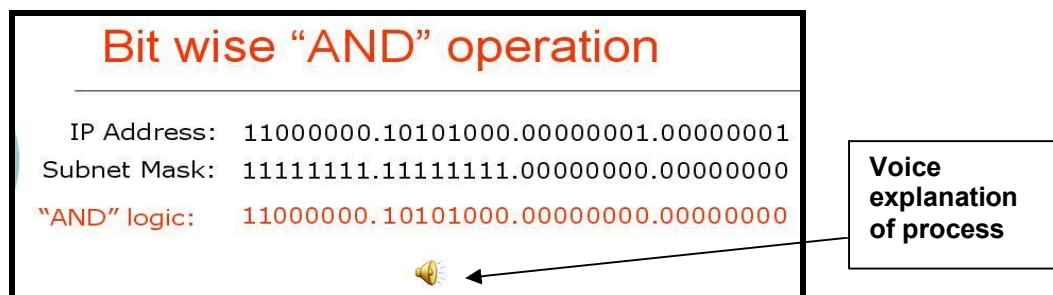


Figure 5.6 Binary AND operation

Learners found the concept of subnet masking and the AND logic operation in a 32 bit value difficult to understand. The animation shows that the “1” in the top row, above a “1” in the second row, will fall through to the last row. If there is a “1” in the top row above a “0” in the second row, the “1” will not fall through and the value in the last row will be “0”.

This type of explanation with regard to the LSI of Felder and Soloman is active, reflective, verbal, visual, sequential and global. The human-computer interaction allows the learner to be actively involved with the information and reflective in the

sense that the learner has the opportunity of processing this information on his/her own. Visual and verbal allow the learner the opportunity to see and read what happens when a logic AND operation is performed.

This operation has to be performed in a clear order to get the correct answer, which makes it easy for the sequential learner.

5.4.1.3 Networks

Shanmugam *et al.* (2002:249) argue that there are three different classes of networks, namely A, B and C (table 5.2). The most significant bits in each base class define the network. A = 8 bits, B = 16 bits and C = 24 bits (Brandon, 1998:108).

Class	Base Subnet Mask	Number of Networks
A	255.0.0.0	128
B	255.255.0.0	16 384
C	255.255.255.0	2 097 152

Table 5.2 Base Subnet Masks (Brandon, 1998:112)

This section of the learning content is described in clear sequential steps through text and video explanations with detailed examples. The e-learning material in this section accommodates mostly verbal learners through text and video explanations and sequential learners through linear representation, discussed in section 3.2.3.4.

5.4.1.4 Path of network messages

According to VFX Technologies Inc (1998:28, 7), when a packet is transmitted on any subnet, the routers determine, with the aid of the 32-bit Subnet Mask, on which network an address is located. If the packet's address matches the IP address, the packet is allowed to enter the network and a second custom Subnet Mask is used to determine to which sub-network the packet should go. Once in the correct sub-network, the packet is delivered to the correct host. The path of a packet through the network to its final destination is described in figure 5.7.

The routing of an IP datagram involves three steps:

- Delivery to the site

- Delivery to the sub-network
- Delivery to the host

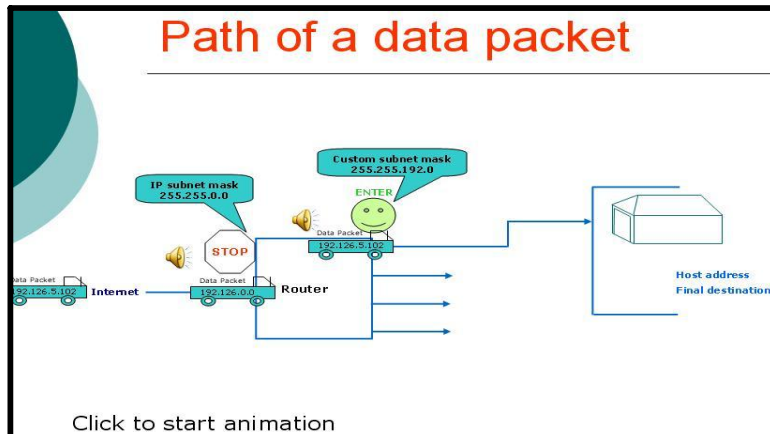


Figure 5.7 Path of a data packet

Figure 5.7 is a good example of a global learning style. The process starts with the data package arriving at the network through the Internet. The first action taking place is the Subnet Mask logic AND operation to determine the network to which the package should go. Each section in the package route is clearly indicated from the start to the end. Learning styles involved in this figure are active, reflective, sequential, verbal, visual and global.

Figure 5.7 is also divided into sub-text divisions where different parts of the figure are explained and indicated by a circle. This makes it easier for the learner to see the bigger picture and then study the part that is applicable to that page. The learner proceeds through the whole “path” of the data package and knows exactly where the package is and what is happening with it at each stage.

5.4.1.5 Special Addresses in subnetting

To determine the network number of the source computer, the binary AND operation is performed on the source address and subnet mask (figure 5.8).

11000000	10101000	00000001	00000001 (source address)
11111111	11111111	00000000	00000001 (subnet mask)
11000000	10101000	00000000	00000001 (AND Result)
192	168	0	0 (dotted decimal notation)

Figure 5.8 Example of binary AND operation with decimal notation

The part of the mask containing 1s defines the net-id or combination of net-id and subnet-id (Fegan & Forouzan, 2000:112).

Network or subnet base address

IP Address: 11000000.10101000.00000001.00000001
 Subnet Mask: 11111111.11111111.00000000.00000000
 Network Base Address: 11000000.10101000.00000000.00000000

IP Address: 11000000.10101000.11000000.00000001
 Subnet Mask: 11111111.11111111.11000000.00000000
 Subnet Base Address: 11000000.10101000.11000000.00000000

Click to start animation

Voice explanation of process

Figure 5.9 Network and Subnet Base address

To extract the network ID of the destination computer, the same operation has to be performed between the destination address and the Subnet Mask. When the network numbers of both the source and the destination computers are the same, it is concluded that they both belong to the same network.

Figure 5.9 explains the beginning, or first and second process in figure 5.7, where the Internet id and subnet id of the data package and network are determined and compared by using the Subnet Mask, ensuring that the package is at the correct address.

Binary versus dot Decimal notation

192 . 168 . 1 . 1
 ↓ ↓ ↓ ↓
 11000000 . 10101000 . 00000001 . 00000001

Voice explanation of process

Figure 5.10 Binary and dot Decimal notation

Figure 5.10 explains how to change the binary value of an IP address to a dot decimal notation by using an animated picture with audio.

Each of the figures in this section made use of various learning styles, the purpose being to accommodate as many as possible of the learning styles identified through the questionnaire. The animated e-learning material and audio recordings

also consist of text based learning material and video recordings thereof. Examples of the text based learning material are available in annexure C, D, E, F, G, H, I, J, K, and L.

5.4.1.6 Class Inter-domain Routing (CIDR)

A CIDR network means that the IP address (192.168.1.1) with the Subnet Mask 255.255.255.0 can also be expressed as 192.168.1.1/24. The /24 indicates the network prefix length, which is equal to the number of continuous 1-bits in the Subnet Mask.

This section is described in the e-learning content through text and video explanations. The text explanations also contain interactive links to other pages. Processing, input and understanding of Felder and Silverman's learning styles model are important dimensions for this section. Reflective learning is part of the processing dimension and allows learners to work in a quiet environment, while verbal learning occurs through textual learning content, which is part of the input dimension. Sequential learning addresses learning content in linear steps.

This concludes the discussion on e-material developed. Section 5.5 will cover the Moodle LMS.

5.5 USAGE OF MOODLE

There are many open source learner management systems in use around the world, all with the same collective purpose, to enhance learning opportunities (Golden, 2005:5; DiBona *et al.*, 1999:70). Bell *et al.* (2003:3, 4) explain that open source software must allow for modification and redistribution of the modified source code. Some of the most widely used LMS's are Moodle in Australia (Moodle, 2009:1), Wizdom in India (Wizdom, 2009:1), Atutor in Canada (Atutor, 2009:1).

In order to use a LMS, the computer must be connected to a network providing the correct learning platform structure for all components to work together, thus creating unity and facilitating communication with one another. Through this

network connectivity, it is possible to access the self-paced study content which may consist of detailed course notes and multimedia learning content. The e-learning approach enables learners, administrators and lecturers to access this information at all time, therefore not bound to normal class hours (Edmundson, 2006:27).

Moodle is accessible to a wide range of users. It continues to focus on improving its accessibility, usability, sustainability, security and pedagogical flexibility (Moodle, 2009:1).

As LMS is an open source with a web-based course delivery base, Moodle extends the classroom beyond the borders of the institution and allows students in this pedagogical environment to find a common place to search for learning material (Moodle, 2009:1). LMS has the resources to post news items, assign and collect assignments, post electronic journals while allowing lecturers to generate test assessments, messaging and notifications.

The course content of Moodle must adhere to the changing needs of its users and must constantly be adapted to ensure learning comfort. The next section describes specifics of Moodle.

5.5.1 Characteristics of Moodle

Moodle has the following complete set of attributes to create online learning opportunities:

5.5.1.1 Security

Moodle LMS is reliable and password protected, allowing learners to study in privacy. Only eligible learners may log onto the system to work through the course content at their own pace using all the available learning tools. The course content is organised and supported through the Internet, thus creating a feeling of coherence within the class group.

It allows the teacher to structure access to various modules according to the requirements of the course and the students' needs. Learners and lecturers are allowed to access various resources, communicate at any time, submit and collect assignments in order to satisfy all their requirements.

5.5.1.2 Support

Moodle provides features and functionalities to support learning tasks to a world wide community (Chao, 2009:191). The main purpose of Moodle is to facilitate collaborative learning within the student community.

5.5.1.3 Uploading files

File uploading via the web is restricted to one file at a time. Uploading more than one file is possible when using a zip program to compress many files into a single file. This provides for uploading a zipped file and then unzipping it on the server. Any type of file can be uploaded onto Moodle. It is important to ensure that appropriate software is available for accessing downloaded files (Cole & Foster, 2007:34).

5.5.1.4 Add activities

Assignments and resources such as modules containing learning material or important subject related information, accessible at any time, can be added to the Moodle LMS. Lecturers can also add quizzes or set quiz tests. After adding activities, they can be moved up and down in the course layout. A survey facility allows the lecturer to understand and evaluate the learners.

Within resources, activities can be added or certain items hidden. It is possible to compose a text or web page and add subject-oriented information to those pages. Linking a file or website, or adding a link to uploaded files is possible. Text, images, videos or many others may be inserted. It also allows for adding entire lessons to guide students based on their answers.

5.5.1.5 Audio and video

In order to activate audio, multimedia must be enabled by adding the sound file as a resource file, or add it as embedded sound to the module. The resource will then use the default media player (Real Player, Quicktime, Media Player, etc.). MP3 proves best for embedded sound.

Moodle supports QuickTime, Windows Media Player and Flash Player (Macromedia) for adding video to the classroom. A video can be uploaded as a separate resource, or it can be integrated into forums and other Moodle modules. The video file has the extension .wmv. For the video to play, learners would need the appropriate program and plug-ins. (Quicktime, Media Player or Flash). It is important to ensure that the module has enough capacity available and that Moodle administrator has provided sufficiently for video uploads.

The specific video material for the Network Systems III module subnetting learning material was created with the help of Camtasia software. However, it needed to be converted to a video flash file as it was too large (261Mb) to be uploaded onto the Moodle LMS software. Camtasia is a software package used to create short flash movies and to change the format of a movie to flash format. The video file was converted with Flashpoint v2.77 of 2007 (Mininova) to a shockwave file with extension .swf and played in Moodle with Flash 9. The most effective procedure for playing short video files on Moodle is to encode the files in .flv format.

5.5.1.6 Text based content with images

According to Mayer (2001:1), multimedia refers to the presentation of learner-centred material through two or more delivery devices, such as words and pictures, resulting in a meaningful learning outcome depending on the cognitive activity of the learner while learning.

The learning material is uploaded onto Moodle LMS through the Internet. This is done by the module supervisor who normally is the lecturer of the specific subject. Thereafter, the learning material is available instantaneously.

5.5.1.7 PowerPoint slides

Presentations featuring streaming video with synchronised PowerPoint slides, interact with Macromedia Flash based activities. When creating streaming video the video file format and the streaming format is important.

Various video file formats may be chosen from when creating video streams. The most viable formats are Windows Media (.wmv or .asf), RealMedia (.rm), Quicktime (.mov), MPEG-4 (.mp4) and Adobe Flash. Streaming media or streaming video server is a specialised application running on an Internet server. Streaming video is a term used to describe content sent in compressed form over the Internet and displayed by the viewer in real time (Adobe, 2009:1). This enables the web user to watch real time content, enabled through a continuous stream of data and played as it arrives.

HTTP streaming video is the simplest and cheapest way of streaming video from a website. It makes use of a host server which recognises common video type files. Live video streaming is not possible in HTTP as it works only with files stored on the server. To create a streaming video file, it is necessary to use a conversion utility for importing a video clip and exporting it to a different format.

Streaming allows the end user to start watching the file as it begins to download. True streaming must be delivered from a specialised streaming server. PowerPoint presentations must be converted into easy to share flash format in order to use it on Moodle. One of the products that may be used to convert PowerPoint to flash is Wondershare PPT2Flash Professional (Wondershare, 2009:1). Before any PowerPoint presentation can be distributed over the Internet for e-learning purposes, there are certain important aspects to be taken into consideration. Since Flash player is widely installed on computers and supported by most Web browsers, it is the best choice for distribution.

Advantages when converting PowerPoint presentations to Flash movies are the following:

- It keeps the original PowerPoint animations and transitions.

- It reduces up to 90% of the file size of PowerPoint.
- There is a password protection on the output Flash presentation which means that no one can edit it except the author.
- Embed the Flash conversion anywhere, hence creating rich-media Web pages easily.
- The small size file can easily be e-mailed to others.

5.5.1.8 Integration of multimedia components

According to Mayer (2001:5), understanding takes place when learners build meaningful connections between visual and verbal representations. This is the starting point of multimedia learning. Moodle has the capability of enabling all registered users to upload and use information as needed.

5.5.2 Moodle Logs

Moodle logs keep track of the usage of learning material by students, as well as the duration of their activities. For each module it collects data on the student's activities on different days and provides information to this effect. The overall idea of the clickstream analysis is to collect evidence on activities pertaining to the course material used. On a website, clickstream analysis is a process through which specific data is collected for the purpose of analysing it (Inbarani & Thangavel, 2009:9). The data contains the order in which it was selected by the visitor, as well as the duration of each session. It is used to keep track of what pages users linger on and what they put in or take out. By making use of clickstream analysis, large volumes of data can be gathered through many different areas of interest.

Clickstream analysis is considered to be most effective when used in conjunction with evaluation resources (Chen & Chau, 2004:313). Logging will typically contain statistics on the frequency with which each user has used a feature of the program and through which an analysis on patterns of use can be made.

Server logs provide a high level overview of the pages visited by a user and contain information about which document was requested at what time, whether it

was successfully delivered, how long it was accessed and the address the request came from. Clickstream logs on the usage of subnetting pages will be discussed in chapter 6.

5.6 CONCLUSION

The chapter began with a description of the process that led to the selection of subnet masking as a problem area to be improved, as stated in sub-objective 3.8 in section 5.1.

The planned intervention was discussed in terms of mode of tuition prior to intervention, knowledge gained from the literature review presented in chapter 3 (sub-objective 3.9) and the analysis of the interpretive questionnaires presented in chapter 4 (sub-objective 3.10). Knowledge gained from the learning style analysis in chapter 3 and the analysis of questionnaires in chapter 4 were summarised in section 5.2.3.

A short discussion of subnetting was given in section 5.3, dealing with sub-objective 3.11 in section 5.1, which gave a perspective on the specifics of subnet masking (subnetting). The design of the e-learning material was discussed in section 5.4. The usage of the Moodle LMS was covered in section 5.5 and addressed sub-objective 3.12 of section 5.1. It explained how the learner management system Moodle was used to introduce e-learning material to the students.

One of the easiest and most effective ways of using enhanced technology to promote blended e-learning is through a Learning Management System (LMS) (Bersin, 2004:209). It allows learners to work through all the e-learning material developed in order to extend the current learning environment to a blended e-learning environment. This learning content was uploaded onto the Moodle LMS for use by VUT students.

Time spent on each module is logged into the system, enabling the researcher to see exactly what time any specific student devoted to each module and hence to the total content.

Clickstream logs of all users of the module Network Systems III e-learning material will be analysed in chapter 6.

CHAPTER 6

WEB LOG ANALYSIS AND EXAMINATION RESULTS

6.1 INTRODUCTION

This chapter is part of the “analyse success of intervention” phase in the action research methodology and will compare the usage of e-learning material to the students’ results as shown in figure 6.1.

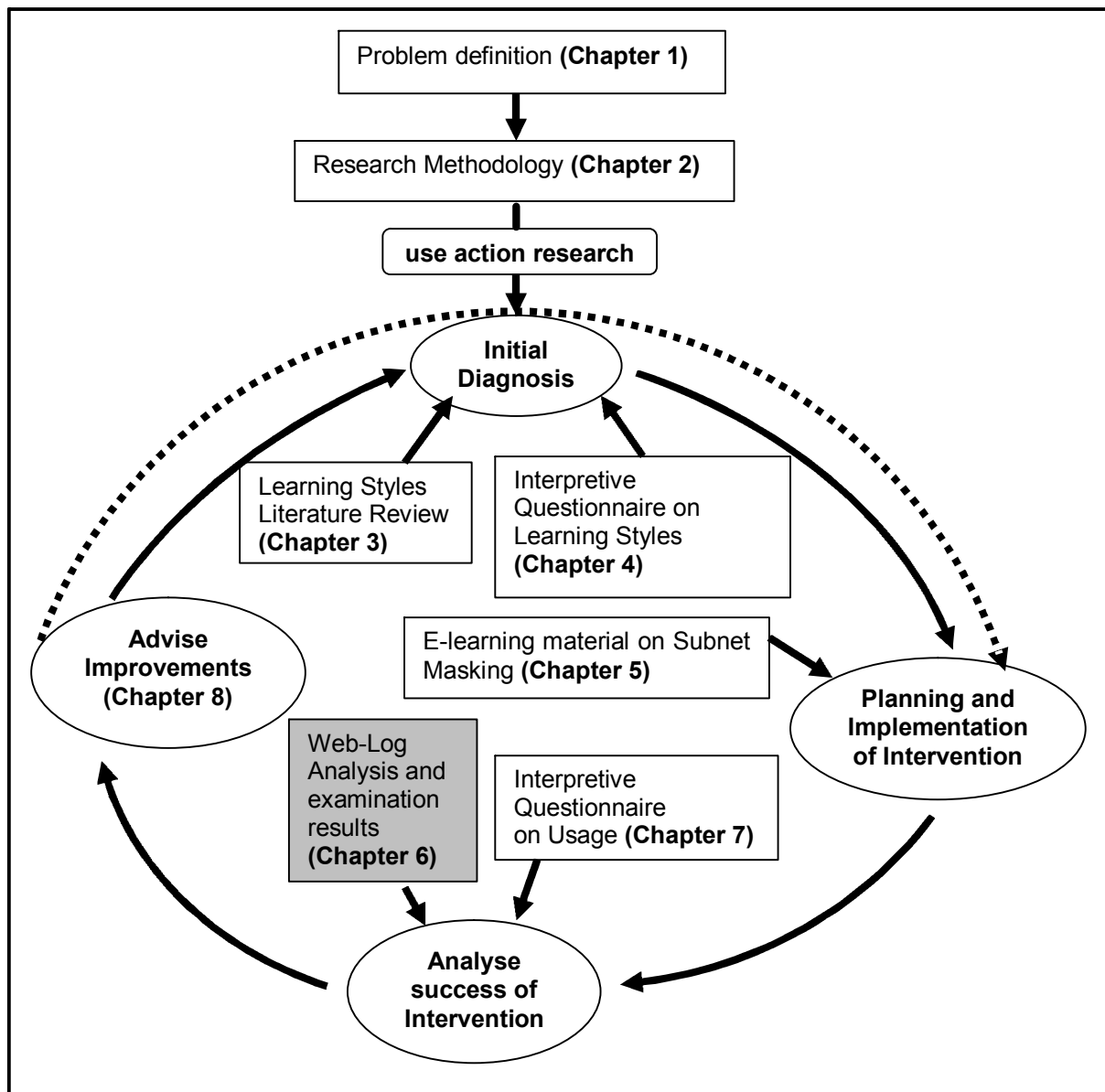


Figure 6.1 Schematic layout of this research

Web logs, representing the usage of the e-learning material and examination results will be analysed in order to determine the success of the e-learning material. As stated in section 1.2, the aim of the study is to improve student performance in the Network Systems III module at the VUT.

This aim was divided into objectives (section 1.2) of which objectives 4, 5 and 6 are addressed in this chapter. These are divided into smaller parts to guide the research process.

Objective 4: Analysing the usage of the e-learning material by means of web logs created with the Moodle LMS, can be divided into:

- 4.1 Identifying the Moodle log activities to determine the usage of the e-learning material presented in section 6.2.
- 4.2 General analysis of the usage of e-learning material presented in section 6.2.2.

Objective 5: Analysing the performance of students in terms of examination results and e-learning usage, can be divided into:

- 5.1 Explaining the examination results of each of the groups studied in this research in general, presented in section 6.3.2.
- 5.2 Comparing the examination success of the e-learning material users to that of non-users of the e-learning material. This is done irrespective of the amount of time spent by the users using the e-learning material. These results are presented in section 6.3.3.
- 5.3 Analysing the amount of time spent on the e-learning material and the examination success of these students. These results are presented in section 6.3.4.
- 5.4 Analysing the number of sessions spent on the e-learning material and the examination success of these students. These results are presented in section 6.3.5.

Objective 6: Applying statistical methods to the results of objectives 4 and 5 to establish the presence of a meaningful correlation, if any, can be divided into:

- 6.1 Determining whether there is a meaningful correlation between the usage of the e-learning material and the results of the students in tests and examinations. To do this, Pearson correlations were used and this analysis is presented in sections 6.3.6.3 and 6.3.6.5.
- 6.2 Determining whether students who used the e-learning material performed better in tests and the examination than students who did not use it. To do this, t-tests were used and this analysis is presented in sections 6.3.6.4 and 6.3.6.6.

The following section presents the analysis required by objective 4.1 as stated above.

6.2 MOODLE DATA COLLECTION

Data was collected from participants enrolled for the module Network Systems III, described in section 4.2.1. The data collection process was done through the Moodle log report facility.

Accounts were opened, enabling students to log into the Moodle LMS. Once logged in, their activities were recorded with a tracking tool called logs. A log is a list of records showing how many users visited a page, when they visited the page and time they stayed on it. It is possible to see the actions for single and multiple visits. When a single student's log record is generated, it shows all the activities and visits for the selected period.

Students' activities were collected by generating their Moodle log records for any given period in time. The main source of data in this chapter is the Moodle log reports of student activities within the content of the e-learning modules. These reports show daily information in a fixed format on course level, as well as user and activity levels for any specific number of days, or for all days

6.2.1 Data format

Reports on user activities are presented in a fixed format. Data is described in the sequence it appears on the log report from left to right, as follows:

1. Date of activity
2. Starting time of activity
3. Student number
4. Name of user
5. Action of user
6. Information viewed

Each line in the log report represents a single activity of a specific user. An example of raw data can be seen in table 6.1.

Date of activity	Starting time of activity	Student Number	Name of user	Action of user	Information viewed
08 Aug. 2007	07:37:51 AM	2304568	Chauke F. H.	Course view	Network Systems III
08 Aug. 2007	07:38:47 AM	2304568	Chauke F. H.	Resource view	Introduction to Binary
14 Aug. 2007	08:38:47 AM	2304556	Tsolo K. J.	Resource view	Introduction to Binary
19 Sept. 2007	12:27:16 PM	2304568	Chauke F. H.	Course view	Network Systems III

Table 6.1 Moodle log activities of raw data

In table 6.1, the first column indicates the raw data of each activity. In this case, data is captured in date sequence and the information of a single student is scattered through the data.

Date of activity	Starting time of activity	Student Number	Name of user	Action of user	Information viewed
08 Aug. 2007	07:37:51 AM	2304568	Chauke F. H.	Course view	Network Systems III
08 Aug. 2007	07:38:47 AM	2304568	Chauke F. H.	Resource view	Introduction to Binary
19 Sept. 2007	12:27:16 PM	2304568	Chauke F. H.	Course view	Network Systems III
14 Aug. 2007	08:38:47 AM	2304556	Tsolo K. J.	Resource view	Introduction to Binary

Table 6.2 Moodle log activities of sorted data

In table 6.2, raw data is sorted to allow for students' activities in date and time sequence. Each student's total activities for the semester are shown. The next

column indicates the starting time of a session (a new session coincides with a changed date in the first column). The duration of each activity is calculated by subtracting the starting time of the first activity from the starting time of the next activity. The third column indicates the student number, in this case a fictitious number. The fourth column indicates the name of the student. The fifth column shows the action of the student and whether he or she looked at specific learning content or general information. The last column shows specific sections of the learning content accessed by the student during a specific activity.

It was not possible to calculate the duration of the last log entry of a student, which means that students who use only a single log entry with the e-learning material, as well as students spending multiple sessions will be affected when time duration is calculated. To determine the time duration of the first log entry, there has to be a starting time for the next log entry for the same date.

6.2.2 General analysis of the Moodle data

As described in section 4.1, this study involves three semesters' students at the VUT. These are firstly, students in the first semester of 2007 (referred to as 2007_1), who did not use any e-learning material, secondly, students in the second semester of 2007 (referred to as 2007_2), who were the first to use the e-learning material and thirdly, students in the first semester of 2008 (referred to as 2008_1).

It is worth repeating here that the VUT offers all modules in this course every semester, a new group therefore starts the Network Systems III module every six months. In 2007_2 and 2008_1, the e-learning material on subnet masking was used in combination with lectures in a blended e-learning environment. No changes were made in the lecturing format in terms of number of sessions during the periods 2007_1 to 2008_1 (three semesters).

During 2007_2, 104 students used the e-learning material, according to the web logs. A total of 153 students were enrolled for the module. Of the 104 who used the material, 24 were not enrolled for the module and came from other departments of the VUT. Only 80 students enrolled for the Network Systems III module, used the

e-learning material. There were 1549 log entries on the Moodle LMS, representing the total number of visits and usage of the e-learning material.

Analysis of the test and examination results in 2007_2 was done and compared with the information in the Moodle logs. This analysis is presented in section 6.3 along with the data of 2008_1 for ease of comparison. The comparison of the performance of users versus non-users indicated that users of the e-learning material performed much better in the examination questions about subnet masking than non-users. Detail of the 2007_2 analysis is presented in section 6.3.6.4.

In discussions after 2007_2 on the success of the intervention with all stakeholders (lecturers, head of department and research team), it was decided that the usage in 2007_2 was unsatisfactory. However, as the examination results of the users in comparison to the non-users were very encouraging, it was decided to use the e-learning material unchanged in 2008_1.

From the action research project's perspective, this constitutes a second iteration. As the e-learning material was not going to be changed, it was not necessary to investigate the learning styles of the 2008_1 group of students. Supporting this decision is the fact that analysis of the 2007_1 group showed that almost every learning style was used by some or other student in the group, therefore, the group as a whole was considered representative of all tested learning styles. The e-learning material developed in 2007_1 made provision for all types of learning styles tested.

An important change was made in respect of the second iteration. It was decided that lecturers need to refer to the available e-learning material frequently during classes and that students need to be encouraged to use the e-learning material. The lecturers would point out to students exactly what explanations and additional examples with exercises are available when discussing subnet masking in class.

At the end of 2008_1, the logs were again analysed, and the intervention of lecturers were found successful as many more students used the e-learning material.

During 2008_1, 155 students used the e-learning material, 101 of whom were enrolled for this module. As there were 114 students enrolled for this module in 2008_1, the increase in usage was from $80/153 = 52.3\%$ to $101/114 = 88.6\%$ of the total number of students enrolled for this module.

It should be noted that not all students who used the e-learning material qualified for the examination. Specific details on numbers of students who wrote the examination and who used the e-learning material are given in section 6.3.3.

After 2008_1, it was decided that the results of the usage analysis in 2008_1 combined with the examination results, were indeed representative of the success of the e-learning material, as 88.6% of students used the material at some time or another during the semester.

6.3 DETAILED ANALYSIS OF DATA

In this section, the main data analysis of the usage of the e-learning material and the examination results of the students are presented. As indicated in objectives 5 and 6, the analysis is done in terms of:

- Student performance in 2007_1, 2007_2 and 2008_1. Examination results are presented in section 6.3.2.
- Comparison of examination success of users and non-users of the e-learning material (presented in section 6.3.3).
- Analysis of the amount of time spent on the e-learning material and the examination success (presented in section 6.3.4).
- Analysis of the number of sessions spent on the e-learning material and the examination success (presented in section 6.3.5).
- Statistical analysis using Pearson correlation and t-tests (presented in section 6.3.6).

Section 6.3.1 starts with a short discussion on the specifics of the examination marks used in this study.

6.3.1 Examination marks used in this analysis

The aim of the study, as stated in section 1.2, is to improve student performance in the Network Systems III module at the VUT. Educators agree that there are two ways of looking at student performance in a module (i.e. module success).

Either examination pass rate or throughput can be examined. In the first instance, pass rates are computed as a percentage of students who passed the examination in terms of students who wrote the examination. This approach do not take into account how many students left the course, commonly referred to as drop-outs.

In the second approach, the pass rate is determined by computing the percentage of students who passed the examination in terms of the number of students who enrolled for the module. This approach is more widely used, as it is a better indication of the overall success of the module.

In this research, a similar decision needed to be taken. It was decided to concentrate on the first approach where the success is measured in terms of students who wrote the examination.

The motivation for this is that the main intervention is on the subnet masking section of the module. This section is presented in the second part of the semester when some of the drop-outs already occurred.

The research team accepts that there are shortcomings in this approach, but it was decided that the success of the e-learning material can better be investigated when the analysis is done on the performance of students who did attend the section on subnet masking and wrote the examination.

The difference between the number of students enrolled and the number of students who wrote the examination represents two groups of students. Firstly,

there are students who left the module and secondly, there are those who did not qualify to write the examination. The qualification mark comprises the evaluation marks on all sections of the module. Some students could have failed their first test badly, while achieving better marks in the evaluations on subnet masking. The assumption was made that all students who wrote the examination did complete the section on sub-netting. There is not enough information available to determine who of the other students attended the section on sub-netting. They were therefore omitted from the study.

To measure the usage of e-learning material, it is necessary to look at the time and number of sessions a student spends on it. Time duration is derived from the starting and finishing time of each session during which e-learning material was used.

When comparing examination standards of the three semesters, the following should be taken into consideration: All test and examination questions and the content of the Network Systems III module in general have to comply with standards set up by the HEQC (HEQC, 2010:1) and ECSA (ECSA, 2010:1). These two bodies have to ensure that the qualification complies with the quality promotion and quality assurance standards according to the Higher Education Act of 1997 (Act 101 of 1997) and the Engineering Profession Act of 2000 (Act 46 of 2000).

The standard of the examination paper for the three semesters is assumed to be the same. It is also worth mentioning that the same lecturers presented this module in 2007_1, 2007_2 and 2008_2.

6.3.2 Examination success rate

Data was collected for comparing the students' pass rate for three semesters. The first semester of 2007 was used as a standard, or starting point to which the results of the next two semesters (2007_2 and 2008_1) could be compared.

The e-learning material was not implemented for semester 1 of 2007. The following statistics were recorded:

- Number of students enrolled for the semester
- Drop-out number
- Drop-out percentage
- Students who repeat the semester
- Percentage of repeating students
- Students permitted to write examination
- Students passing the examination
- Pass rate percentage for the examination
- Module throughput percentage of enrolled students.

Semester	Students enrolled	Drop-outs		Repeaters		Examination			
		N	%	N	%	Write	Pass	Pass rate %	Through- put %
2007_1	189	38	20.11%	70	37%	151	102	67.6%	53.9%
2007_2	153	11	7.12%	26	17%	142	86	60.6%	56.2%
2008_1	114	40	35.09%	4	3.50%	74	68	91.9%	59.6%

Table 6.3 Semester pass rate comparison

A very important fact that should be mentioned is the number of drop-outs. According to table 6.3, the drop-out percentage in 2007_1 was 20.11%. During 2007_1, it decreased to 7.12% and increased again to 35.09% in 2008_1. There are many factors that may contribute to the fact that students drop out of the module, such as financial matters, ill health and other reasons. It falls outside the scope of this research to investigate the reason for student drop-outs. However, despite the number of student drop-outs, there were definite signs of a steady increase in student examination throughput percentage from 53.9% in 2007_1 to 56.2% in 2007_2 and 59.6% in 2008_1. As discussed in section 6.3.1, examination pass rate is considered more representative of the success of the e-learning material than throughput.

6.3.2.1 Semester 1 of 2007

From table 6.3, it can be seen that 189 students were registered for 2007_1 with 70 repeating the module. This was before implementing e-learning material on the Moodle LMS.

Test results showed either very good marks or poor marks, with few students obtaining results around the average of 50%. Thirty eight drop-outs, i.e. students not qualifying to write the examination or who left the module, were recorded. Of the 151 remaining students, 49 failed and 102 passed. This means that the pass rate percentage of students who wrote the examination in this semester was 67.6%. This figure favourably compares to historic statistics for this module.

6.3.2.2 Semester 2 of 2007

The e-learning material was implemented and made available to Moodle users at the beginning of the second semester of 2007. Only 52.3% of the students used the e-learning material.

Records from this semester, as shown in table 6.3, indicated that there were 153 students enrolled for the Network Systems III module. The number of students repeating this module was 26.

The number of drop-outs was 11, not allowed to write the examination. Of the 142 remaining students, 56 failed and 86 passed. This means that the pass rate percentage of the students who wrote the examination was 60.6%.

6.3.2.3 Semester 1 of 2008

With reference to table 6.3, in semester 2008_1, 114 students were enrolled for the module Network Systems III. The number of students who repeated this module was 4, while 88.6% of the enrolled students used the e-learning material.

The number of drop-outs was 40. Of the 74 remaining students, 6 failed and 68 passed. This means that the pass rate percentage of students writing the examination was 91.9%.

6.3.2.4 Conclusions from examination success rate

As an effort was made not to change any aspects other than those reported, it may be concluded that when e-learning material was used in a blended e-learning environment, the pass rate of students who were allowed to write the examination,

accelerated from 67.6% in semester 2007_1 to 91.9% in semester 2008_1. From table 6.3, it is clear that drop-out numbers for semesters 2007_1 and 2008_1 increased by 14.98%. The reader is reminded that drop-outs occurred throughout the semester, some of which before the section on subnet masking was done.

These results are encouraging, although further research must be focused on the relatively high drop-out number for this module.

The issue of causality is still not resolved. One can still investigate whether students did better because they used the e-learning material, or whether other factors were involved? The following section further investigates the examination performance of users, as opposed to non-users of the e-learning material.

6.3.3 Examination success of users versus non-users

Table 6.4 presents information on the examination success of students who used the e-learning material compared to students who did not use it.

	2007_2			2008_1		
	E-learning material			E-learning material		
Students	Non-users	Users	Total	Non-users	Users	Total
Total enrolled	73	80	153	13	101	114
Total to write examination	70	72	142	9	65	74
Drop-outs	3	8	11	4	36	40
Fail	34	22	56	1	5	6
Pass	36	50	86	8	60	68
% e-learning usage		72/142 = 50.7%			65/74 = 87.8%	
Pass rate percentage	36/70 = 51.4%	50/72 = 69.4%		8/9 = 88.9%	60/65 = 92.3%	

Table 6.4 E-learning material usage and pass rates

This information is subsequently discussed for each semester.

6.3.3.1 Semester 2 of 2007

According to table 6.4, the number of students not using e-learning at all was 73 (47.7%). There were 15 students who used the e-learning material for 1 session only. Time spent by those students could not be recorded for the reason explained in section 6.2.1.

Eighty students (52.3% of the total students enrolled) used the e-learning material on the Moodle LMS during this period.

Percentage of students who used e-learning material and passed the examination is 69.4% (50 out of 72). The examination pass rate of users (69.4%) is substantially higher than that of non-users (51.4%)

6.3.3.2 Semester 1 of 2008

During 2008_1, 101 students made use of the e-learning material, representing 88.6% of the total number of students enrolled for the module. Sixty of these passed. Thirteen students used the material for one session only.

Percentages of students enrolled, but not using the e-learning material were 47.7% in 2007_2 and 11.4% (13 out of 114) in 2008_1. Percentage of students who used the e-learning material and passed the examination is 92.3% (60 out of 65), compared to the 88.9% of non-users.

6.3.3.3 Conclusions from using e-learning material

The usage of e-learning material content increased immensely from 52.3% in semester 2007_2 to 88.6% in semester 2008_1.

The pass rate of students permitted to write the examination in 2007_2 who used the e-learning material was also notably higher than the pass rate of non-users (69.4% vs 51.4%). It appears as if the increased usage of e-learning material had a positive impact on the students' results.

The higher frequency of usage and pass rate percentage in table 6.4 is clearly visible for semester 2008_1.

The pass rate percentage of e-learners increased from 69.4% in semester 2007_2 to 92.3% in semester 2008_1, an increase of 22.9% (92.3% - 69.4%) between the two semesters. This may be attributed to the efforts of lecturers to align the available e-learning material with the context of their lectures. These efforts might also have influenced the results of the non-users in 2008_1 positively.

Once again the issue of causality should be raised. Did the students who used the e-learning material do better because they used the e-learning material, or did they do better because they spent more time on the module? One might argue in favour of the e-learning material in as far as the availability of the e-learning material and the motivation from the lecturers to use it, increased the total time spent on the module content, thereby improving their performance. This question is partially addressed in chapter 7.

Up to this point, students were grouped into users and non-users. The following section analyses the amount of time spent on e-learning material by users and the effect thereof on their examination pass rate.

6.3.4 Comparison of time spent on e-learning material

Time spent on e-learning content will be compared with pass rate for each semester to find a relationship between this and pass rates. Efforts by lecturers to promote e-learning material improved the usage of it on the Moodle LMS. This in turn led to better pass rates.

Semester	Enrolled students	Using e-learning	Total time spent on e-learning material	Average time for each student	Examination pass rate of users
2007_2	153	72	31:00:52	00:25:51	69.4%
2008_1	114	65	48:16:57	00:44:34	92.3%

Table 6.5 Pass rate vs time spent on e-learning material

From table 6.5, there seems to be a relationship between time spent on e-learning material and examination pass rates. The average time spent by a student on e-

learning material for 2008_1 was more than that for students in 2007_2. The examination pass rate for 2008_1 was considerably higher than that for 2007_2.

A time duration layout for different time slots and pass rate percentage in each time slot will be given in section 6.3.4.1 and section 6.3.4.2 for 2007_2 and 2008_1 respectively. It should be noted that students who used the e-learning material only once could not be considered, as the duration of the final session of each student could not be computed as described in section 6.2.1.1.

6.3.4.1 Semester 2007_2

Results in table 6.6 indicate that pass rate percentages of students in the two time slots (30 minutes to 59 minutes and 59 minutes to 1½ hour) are both 83.3%. These two time slots also have the highest pass rate percentage for semester 2007_2.

There is a steady growth in the pass rate percentage from the lowest time slot (0-59 seconds) with a pass rate percentage of 55.5% to 77.7% in time slot (10 minutes to 30 minutes). However, the pass rate percentage in time slot (1½ hours to 3 hours) is 33.3%.

The best results, according to table 6.6, occurred between 30 minutes and 1½ hours.

	0-59 sec.	60 sec – 10 min.	10–30 min.	30–59 min.	59 min. - 1½ hr	1½-3 hr	3–5 hr	5–10 hr	Total
Enrolled	11	26	20	13	6	3	0	1	80
Drop-outs	2	2	2	1	0	0	0	1	8
Examination	9	24	18	12	6	3	0	0	72
Pass	5	15	14	10	5	1	0	0	50
Failed	4	9	4	2	1	2	0	0	22
Pass rate %	55.5%	62.5%	77.7%	83.3%	83.3%	33.3%			69.4%

Table 6.6 Time layout of e-learning material usage for 2007_2

6.3.4.2 Semester 2008_1

Results in table 6.7 indicate that most of the students spent between 1 minute and 59 minutes on the e-learning material. The pass rate percentage for time slot (60 seconds to 10 minutes) is 94.4% and the pass rate percentage for time slot (10 minutes to 30 minutes) is 88.8%.

Time slot (30 minutes to 59 minutes) has a pass rate percentage of 100%, while time slot (59 minutes to 1½ hours) has the same pass rate percentage (83.3%) as the corresponding time slot in 2007_2. All students who spent more than 1½ hours on the e-learning material in 2008_1 passed the module.

	0-59 sec.	60 sec – 10 min.	10–30 min.	30–59 min.	59 min. - 1½ hr	1½-3 hr	3–5 hr	5–10 hr	Total
Enrolled	8	29	32	16	7	6	2	1	101
Drop-outs	5	11	14	4	1	1	0	0	36
Examination	3	18	18	12	6	5	2	1	65
Pass	2	17	16	12	5	5	2	1	60
Failed	1	1	2	0	1	0	0	0	5
Pass rate %	66.6%	94.4%	88.8%	100%	83.3%	100%	100%	100%	92.3%

Table 6.7 Time layout of e-learning material usage for 2008_1

6.3.4.3 Conclusion of time spent on using e-learning material

It may be concluded that, when comparing the two semesters (2007_2 and 2008_1), there is a relationship between time spent on e-learning material and the pass rate percentage.

The pass rate compared to time spent on e-learning material may be a result of students studying harder, or the fact that they found e-learning material helpful.

Although the relationship between usage and pass rate is somewhat unexpected, it is worth noting that the material can be printed. Students with short periods of logged time may have printed the material and used it off-line. Uncertainties about the exact usage of the material motivated the research team to distribute interpretive questionnaires to understand the value of e-learning material from the students' perspective. These questionnaires and the analysis thereof are reported on in chapter 7.

The following section analyses the number of sessions spent on e-learning material by users and the effect thereof on their pass rate percentage.

6.3.5 Comparison of sessions spent on e-learning material

The number of sessions spent on e-learning content will be compared with the pass rate for each semester to find a relationship between them. As noted in

section 6.3.4, efforts by lecturers to promote e-learning material improved the usage of it on the Moodle LMS, which in turn leads to better pass rates.

Semester	Enrolled students	Using e-learning	Total sessions spent on e-learning material	Average sessions for each student	Examination pass rate of users
2007_2	153	72	199	2.8	69.4%
2008_1	114	65	292	4.5	92.3%

Table 6.8 Pass rate versus sessions spent on e-learning material

From table 6.8, there seems to be a relationship between the number of sessions spent on e-learning material and examination pass rates. The average number of sessions spent by a student on e-learning material for 2008_1 was more than that for students in 2007_2. The examination pass rate for users in 2008_1 was considerably higher than that for 2007_2. Non-users also performed better in 2008_1. This is discussed in section 6.3.6.7 as part of the conclusions.

A session layout for different sessions and the pass rate percentage of students in each session slot will be given in section 6.3.5.1 and section 6.3.5.2 for 2007_2 and 2008_1 respectively.

6.3.5.1 Semester 2007_2

Results in table 6.9 indicate that there is a steady growth in pass rate percentage from 63.6% of students who spent 1-2 sessions on the e-learning material to a 100% pass rate percentage of students who spent 7-10 sessions on the e-learning material. Table 6.9 indicates that students who spent more sessions on the e-learning material have a better pass rate percentage.

	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	Total
Enrolled	50	17	8	3	2	0	0	0	80
Drop-outs	6	2	0	0	0	0	0	0	8
Examination	44	15	8	3	2	0	0	0	72
Pass	28	10	7	3	2	0	0	0	50
Failed	16	5	1	0	0	0	0	0	22
Pass rate %	63.6%	66.6%	87.5%	100%	100%				69.4%

Table 6.9 Session layout of e-learning material usage for 2007_2

6.3.5.2 Semester 2008_1

There is a clear indication in table 6.10 that better results are obtained when more sessions are spent on the e-learning material.

One student, who spent between 13 and 14 sessions on the e-learning material failed the module. It is not clear why. It is also interesting to note that students who hardly viewed the material (session 1-2) passed the examination. It is worthwhile to note that the material can be printed, and these students may have printed it during their first session.

	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	Total
Enrolled	34	26	24	11	3	1	1	1	101
Drop-outs	14	9	9	3	1	0	0	0	36
Examination	20	17	15	8	2	1	1	1	65
Pass	17	16	15	8	2	1	0	1	60
Failed	3	1	0	0	0	0	1	0	5
Pass rate %	85%	94.1%	100%	100%	100%	100%	0%	100%	92.3%

Table 6.10 Session layout of e-learning material usage for 2008_1

6.3.5.3 Conclusion of number of sessions spent on using e-learning material

It may be concluded that, when examining the two semesters (2007_2 and 2008_1), there is a relationship between the number of sessions spent on e-learning material and the pass rate percentage.

The pass rate compared to the number of sessions spent on e-learning material may be a result of students studying harder, or the fact that they found e-learning material helpful. However, from the results in sections 6.3.5.1 and 6.3.5.2 it is clear that the pass rate percentage improved when more than 4 sessions were spent on e-learning content.

The analysis of the data in section 6.3.6 is conducted statistically using the Pearson correlation and t-tests on the data.

6.3.6 Statistical analysis of time spent on e-learning material

Professor H.S. Steyn, from the statistical consultation service of the North-West University in Potchefstroom, assist with the analysis of the data for this section. Firstly, an explanation of the most important terms used for this analysis will be given (section 6.3.6.1), followed by an explanation of the different variables used (section 6.3.6.2). Results of the analysis will be shown from section 6.3.6.3 onwards.

6.3.6.1 Discussion of statistical terms

This section provides short explanations of statistical terms on samples used in this study.

The term *mean of n numbers* is the sum of the values divided by n (Yang & Miller, 2007:378).

When there are two variables, for example, time taken to study and result obtained in the examination, *correlation* means the relationship between these two values (Urdan, 2005:75). When there is a positive correlation, it means that the more a person studies, the higher the results will be. Positive correlation means that both variables move in the same direction. A negative correlation means that the more a person studies, the lower his/her results will be. Negative correlation thus means that the two variables move in opposite directions. According to Urdan (2005:79), the *Pearson correlation coefficient* is powerful in that it allows a researcher to determine whether the values of one variable can be linearly related to values of another variable.

Urdan (2005:90) explained that the t-test is used to compare two groups with one another with regard to the means of two independent samples. The results of t-tests are used to generalise results from the sample to the population of which the sample was taken.

The term *meaningful* means that the result of a statistical calculation has a significant value and meaning for the researcher (Gravetter & Wallnau, 2008:249).

According to Altman (1991:168) and Freund (1993:33), the probability value, denoted by the symbol p , shows the probability that something will occur. In the context of the statistical hypothesis testing to be used, p is the probability of wrongly rejecting the null-hypothesis of no difference in means or no correlation. When p is below 0.05, the result is “statistically significant”. When it is lower than 0.01, it is “highly significant”, but if p is higher than 0.05, it is “not significant”.

The results of the total population (entire class of Network Systems students) were analysed in this study.

6.3.6.2 Description of data and variables in this section

Students doing the Network Systems III module at the VUT undergo formative and summative evaluation. In the formative evaluation, students write various tests to improve their understanding of the module content in smaller sections. For summative evaluation at the end of the semester, students' knowledge of the total learning content is tested.

Every question in the evaluations can be associated with a specific section of the module content. Thus, one is able to analyse the marks obtained by students according to specific content of the module.

Lecturers kept track of specific marks obtained by each student for every question of each formative evaluation, as well as for the final examination.

In 2007_2 and 2008_1, two of the tests written during the semester addressed amongst others, subnet masking. For the purpose of this study, they are referred to as test 1 and test 2. There are three sets of marks for 2007_2 and three sets of marks for 2008_1, comprising marks for the two tests and for the examination. Evaluations are divided into two marks, the first being the mark for questions addressing subnet masking and the second mark for the complete evaluation.

The following variables are used in the statistical analysis of the data:

- Q1 is the mark obtained for the question about sub-netting in test 1
- T1 is the total mark obtained for test 1
- Q2 is the mark obtained for the question about sub-netting in test 2
- T2 is the total mark obtained for test 2
- QE is the mark obtained for the examination question about sub-netting
- E is the total mark obtained in the examination
- N is the number of sessions for e-learning

The results of the analysis is presented firstly for 2007_2 in terms of objectives 6.1 and 6.2 respectively and then again for 2008_2 in terms of the same objectives.

6.3.6.3 Correlation between usage and student performance for 2007_2

Usage is studied in terms of number of sessions, as well as minutes spent using the e-learning material. In order to achieve this, the Pearson correlation was used, and the results of this analysis are presented in table 6.11

Variables	Correlations) Number of students = 72 (Casewise deletion of missing data) Include condition: Users=1	
	Time (minutes)	Sessions
Q1	-.0005 p=.997	-.0450 p=.707
T1	-.0164 p=.891	.0150 p=.900
Q2	-.1145 p=.338	-.0110 p=.927
T2	-.217 p=.066	.0501 p=.676
QE	.2801* p=.017	.0936 p=.434
E	-.0604 p=.614	.1339 p=.262

*correlations are significant at $p < .05$

Table 6.11 Pearson correlations 2007_2: users

It can be seen that there is no meaningful correlation between the number of sessions for e-learning (N) and the results obtained in the test questions on subnet masking (Q1, Q2 in section 6.3.6.2), or the total mark obtained in the tests (T1, T2 in section 6.3.6.2). There is also no meaningful correlation between the number of sessions for e-learning (N) and the results obtained in the question asked in the examination (QE), or the total mark obtained in the examination (E).

There is also no meaningful correlation between time spent on e-learning and the results of test questions Q1 and Q2 and the total marks T1, T2 and E, obtained for test one, test two and the examination.

In table 6.11, there is a meaningful correlation ($p < .05$) between:

- The mark obtained for the specific examination question on work related to the content of e-learning material (QE in section 6.3.6.2) and time spent on the e-learning material, (0.2801, $p=.017$).

It may be concluded that time spent on e-learning material had a positive influence on the students' examination results with regard to work covered by the e-learning material.

6.3.6.4 Statistical analysis of users versus non-users in 2007_2

The aim of this section is to determine whether users of the e-learning material performed better in the tests and examination than non-users of the e-learning material. In order to do this, the t-tests were used. Results of this analysis for 2007_2 are presented in table 6.12.

Non-users are represented by columns with a 0 in the column heading, while users are represented by columns with a 1 in the heading. For example, the denotation *mean 0* is the average mark of students not using the e-learning material and *mean 1* is the average mark of students using the e-learning material.

In table 6.12, the first column of the t-test contains the variables discussed in section 6.3.6.2. The second column (*Valid N 0*) is the number of participants in group 0. The third column (*Valid N 1*) is the number of participants in group 1. In column four, the *Mean 0* is the mean value of group 0. Column five indicates *Mean 1* as the mean value for group 1. Column six shows the *Std.Dev 0*, which is the standard deviation from the mean of group 0. In column seven, Std.Dev 1 is the standard deviation from the mean of group 1. Column eight shows the p value of each variable.

Variables	T-tests; Group 1: non-users Group 2: users						
	Valid N 0	Valid N 1	Mean 0	Mean 1	Std. Dev 0	Std. Dev 1	p
Q1	73	80	55.43275	56.88920	36.79145	36.01646	0.805023
T1	73	80	52.35616	54.46250	15.23690	15.80594	0.403602
Q2	73	80	73.39145	82.20013	30.32890	22.40649	0.041593
T2	73	80	63.94099	72.80288	21.20892	20.91842	0.010247
QE	70	72	47.82609	65.06410	19.15465	20.89495	0.000001
E	70	72	44.50000	52.77778	13.20600	13.84239	0.000377

Table 6.12 Student t-test for unequal variance 2007_2

Mean 0 for the related question in test 2 is 73, while for the same question, *mean 1* is 82. The *mean 0* value for the second test (T2, all questions) is 63 and the *mean 1* value is 72 with a p value of 0.01. The *mean 0* value for the related question in the examination is 47 and the *mean 1* for the same question is 65 with a p value smaller than 0.01. The *mean 0* value for the total examination (E, all questions) is 44 and the *mean 1* value is 52 with a p value smaller than 0.01.

From table 6.12, it can be seen that students who used the e-learning material performed better in the question in the second test and overall results for the second test, as well as the examination question and total results for the examination than those not using the e-learning material.

6.3.6.5 Correlation between usage and student performance for 2008_1

The aim of this section is to determine whether there exists a meaningful correlation between the usage of the e-learning material and the student's performance. In order to do this, the Pearson correlation was used. Results of this analysis for 2008_1 are presented in table 6.13.

Variables	Correlations N=65 (Casewise deletion of missing data) Include condition: Users=1	
	Time (minutes)	Sessions
Q1	.1317 p=.296	.0957 p=.448
T1	.0802 p=.525	.0469 p=.710
Q2	-.0795 p=.529	.0168 p=.894
T2	-.0508 p=.688	.1508 p=.231
QE	.0674 p=.594	-.0586 p=.643
E	-.1245 p=.323	-.1662 p=.186

Table 6.13 Pearson correlations 2008_1: users

It shows no meaningful correlations between the number of sessions for e-learning and marks obtained for test questions or examination question (Q1, Q2 and QE) and for test marks or examination in total (T1, T2 and E).

There are also no meaningful correlations between time spent on e-learning material and marks obtained for test questions or the examination question on

subnet masking (Q1, Q2 and QE), or for test marks and examination marks in total (T1, T2 and E). These results differ from the results in 2007_2 and will be discussed in section 6.3.6.7.

6.3.6.6 Statistical analysis of users versus non-users in 2008_1

In 2008, unlike 2007, comparing results (p-values) of the group using the e-learning material to those not using it, revealed no significant difference in marks obtained for the tests and examination (table 6.14). From the Mean column in table 6.14 it is evident that users performed better in questions on subnetting in the examination than non-users (50.82% vs 67.90%). This difference should be analysed taking the size of the standard deviation into consideration. Table 6.14 has the same column layout as explained in section 6.3.6.4.

Variable	T-tests; Grouping: Group 1: Non-users Group 2: Users						
	Valid N 0	Valid N 1	Mean 0	Mean 1	Std. Dev 0	Std. Dev 1	p
Q1	13	101	56.04396	57.79349	40.28028	42.43195	0.888378
T1	13	101	54.77855	52.71527	25.41247	26.14795	0.788737
Q2	13	101	67.38462	70.12286	27.63934	27.03769	0.768053
T2	13	101	5.11111	11.54137	16.50019	16.05310	0.786422
QE	9	65	50.82540	67.90350	29.87404	25.50145	0.069126
E	9	65	58.11111	59.38462	10.25237	11.00950	0.744120

Table 6.14 Student t-test for unequal variance 2008_1

6.3.6.7 Conclusion of statistical analysis of time spent on e-learning material

In section 6.3.6.3, seven variables were analysed to find possible statistical correlations among them. Correlation was found in 2007_2, between time spent on using the e-learning material and the examination question on subnet masking (table 6.11).

The t-test for unequal variance in semester 2 of 2007 (table 6.12) indicated that students using the e-learning material obtained a better result for questions in the examination on subnet masking than those not using it.

The Pearson results for 2008_1 indicated that there was no meaningful correlation between the examination question on subnet masking and time spent on e-learning material (table 6.13). There were also no correlations found in the t-test for 2008_1.

All the students performed better in 2008_1. Most of them (88.6%) used the material online, the remaining 11.4% also performed well. It might be that they used printed copies of the material or that all the references to the material in class (by the lecturers as part of the intervention after the first iteration) motivated them to pay more attention to the section about subnet masking.

These results were surprising and led to the decision to conduct interpretive questionnaires with students in order to understand their attitude towards the e-learning material. These are reported on in chapter 7.

6.4 CONCLUSION

The aim of this chapter was to determine the success of intervention, or in this instance, the success of e-learning material on subnet masking. Objects 4, 5 and 6 were further developed in section 6.1.

A general analysis of the web logs indicated that only 52.3% of students used the e-learning material in 2007_2. These students performed better than other students in the examination questions on subnet masking, as indicated in section 6.3.6.4. This prompted the decision to keep the e-learning material unchanged and encouraged students to use it more effectively in 2008_1.

In 2008_1, 88.6% of the students used the e-learning material. There was however, no correlation between the usage of the e-learning material in 2008_1 and the performance of students according to the Pearson correlation. The pass rate of students using the e-learning material was 92.3%. All the students performed much better in 2008_1.

From the above, it may be concluded that the intervention made as part of this research, did have a positive influence on the success of the Network Systems III module students.

A few observations should be made to qualify the apparent success of the e-learning material:

- Subnet masking is only part of the module content and although 92.3% of users of the e-learning material passed in 2008_1, they must have performed well in the other sections as well.
- Students using the e-learning material spent more time on the module than they would have done, had the e-learning material not been available. This is not necessarily a negative aspect of the study, as the availability of the e-learning material encouraged them to spend more time on the module content.
- The e-learning material was printable, but the number of hours spent on reading printouts off-line is unknown.

In 2007_2, users had better examination marks in the question on subnet masking than non-users. As a result of this observation, it was decided by the lecturers to encourage students to use the e-learning material more consistently.

In 2008_1, the same analysis as in 2007_2 were conducted (Pearson and t-tests). This was done for the sake of uniformity. There was, however, no correlation between the two groups. The lecturers succeeded in convincing most of the students to use the e-learning material, resulting in an improvement of the pass rate percentage in this semester.

It may be argued that the 2008_1 group was academically stronger than that of 2007_2, but it is also clear that the number of students who left the module (drop-outs) was higher in 2008_1 than in 2007_2. With this in mind it cannot convincingly be declared that the 2008_1 group was academically stronger than the 2007_2 group. As a result of the unexpected results of the 2008_1 group, it was decided to test the attitude of students by means of an interpretive questionnaire, which will be discussed in chapter 7.

CHAPTER 7

PRESENTATION AND ANALYSIS OF INTERPRETIVE QUESTIONS ON USAGE

7.1 INTRODUCTION

This chapter is part of the “analyse success of intervention” phase of the action research project as depicted in figure 7.1. It presents the analysis of information on the usage of e-learning material gathered from students who completed the Network Systems III module. This chapter addresses objective 7, discussed in section 1.2.

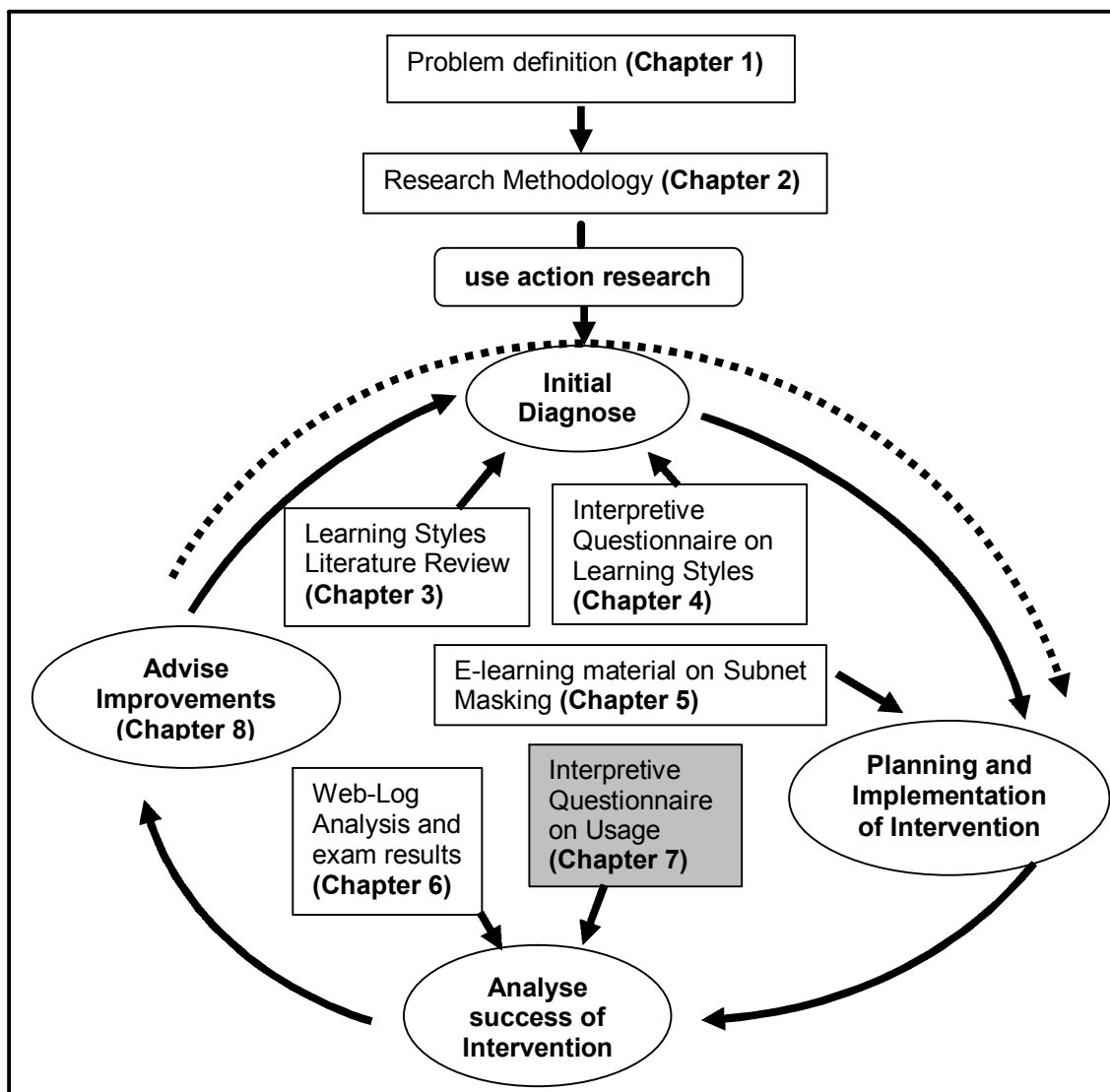


Figure 7.1 Schematic layout of this research

Objective 7: Conducting an interpretive survey in order to understand the students' attitude towards e-learning material, can be sub-divided into the following sub-objectives:

- 7.1 Understanding the data collection process of this research with regard to the usage of e-learning material.
- 7.2 Analysis of data with reference to participant preferences.

In an action research project, the aim for the researcher is to work together with stakeholders in a problem area to find a solution to a specific problem, in this instance, the poor performance of Network Systems III students at the VUT.

As reported in chapter 5, a discussion was held with the lecturing and managerial staff at the VUT to develop a strategy to address this problem.

It was decided to develop additional e-learning material for the section on subnet masking of the syllabus. This material should cater for students with different learning styles. In order to do that, the learning styles of the students were investigated (reported in chapter 4). E-learning material was developed and implemented (reported in chapter 5), and a statistical analysis of the success of this material was done (reported in chapter 6).

From the statistical analysis, it became clear that students using the material performed better than those not using it. There were, however, students who passed the module without using the material (refer section 6.3.3.2).

The analysis in chapter 6 highlighted the issue of causality. Did students perform better as a result of the e-learning material, or did they perform better because more time was spent on module content? From a pragmatic point of view, it does not really matter, since their performance improved. However, from a managerial point of view, a decision needs to be taken as to whether the e-learning material should be extended to cover other sections of the syllabus as well.

It was decided in a meeting with all stakeholders after the 2008_1 analysis, to ask the students how they experienced the e-learning material.

A problem confronted the research team in that neither the 2007_2, nor the 2008_1 groups of students were available on the campus anymore. As discussed in section 4.2, students doing the National Diploma leave the campus of the VUT after 4 academic semesters to undergo a one year work-integrated learning period. This is done in industry all over the country and students leave the campus for this purpose. The Network Systems III module is presented in the fourth semester, with students leaving immediately after completion of the examination.

The decision was made to distribute a questionnaire to all students who previously used the e-learning material in 2007_2 and 2008_1 and could still be reached. A small number of these students were still on campus, as they were repeating previously failed modules, or requiring a module to complete the academic part of their study.

From a research perspective, the value of this information is to gain understanding of the attitude of those students who could be reached.

As some of these students attended the Network Systems III module in 2007_2 and others in 2008_1, no attempt was made to link the answers to the specific usage of these students as recorded in the Moodle logs.

The purpose of the questionnaire was merely to get some informal feedback from the students. This feedback will be critically evaluated and might be of value in future iterations of the research process.

The first section (7.2) discusses data collection which includes a description of the participants, usage of e-learning material and the questionnaire. Section 7.3 covers data analysis in terms of the method of analysis and the presentation of questionnaire results for each question. The analysis of the data is summarised in section 7.4. This is followed by the conclusion (section 7.5).

7.2 DATA COLLECTION

7.2.1 Participants

Participants in this study are the students enrolled for the module Network Systems III of the Computer Systems course at the Vaal University of Technology. A description of this qualification concerning the modules and duration of the course was given in section 4.2.1.

A total number of 16 participants completed the questionnaire. The information obtained is therefore not viewed as representative of the entire group using the system. However, since students also made useful suggestions, it was decided to include this analysis in the discussion.

7.2.2 Usage of e-learning material

When developing e-learning material, such as in chapter 5, there should be a method of obtaining a general opinion on the usage of this material. E-learning material not user friendly should be identified to ensure improvement for further usage. This questionnaire will be used to investigate the attitude of students towards the e-learning material.

7.2.3 The questionnaire

For this research, the participant has to make a tick opposite the answer he or she prefers, as shown in table 7.A. The questionnaire was developed in such a way as to understand the overall attitude of students towards the e-learning material.

Did you make use of the Networking Systems III e-learning material on Moodle?

Yes	X
No	

Table 7.A Example of option selection

As explained in section 4.2.3, the questions in this research were kept relatively simple, ensuring that all participants could easily indicate their options with an x or ✓.

Each question will be analysed separately, and comments related to the open-ended questions will be categorised by means of content analysis.

7.2.3.1 Composition of questions

Twenty two multiple option, closed and open-ended questions were used to determine the usage of the e-learning material.

The questions were specifically developed for this research and focused on whether students benefit from blended e-learning and how the material should be presented to them (See Annexure N).

7.2.3.2 Administrative procedures

The questionnaire was distributed to the students by the Network Systems III module lecturers at the VUT. Participation in this survey was voluntary. A total of 100 questionnaires were distributed, 16 were returned.

The questionnaire was distributed by e-mail to some of the students and handed out to others in the class.

7.2.3.3 The covering letter

A covering letter aimed at orientating the participants, as well as assuring them of confidentiality and anonymity, was issued. For a copy of this letter, refer Annexure M.

7.3 ANALYSIS OF DATA

In section 7.3.1, the method of analysis of questionnaires is discussed by categorising the questions in two different types. In section 7.3.2, all results are shown in chronological order.

7.3.1 Method of analysis

There are two types of questions, each of which will be indicated in brackets next to the question heading. The two different types are:

- yes or no questions (type one)
- open-ended questions (type two)

The analysis of data is introduced by means of tables for each question. As shown in table 7.B, the number for each option appears in the first column. The second column shows the description of every option for each particular question. The third column indicates the number of participants who have chosen a particular option, and the fourth column represents the percentage selection for that particular option. The table is typically used for closed (type one) questions.

	Options	Answers	Percentage
1	Yes	71	69.6%

Table 7.B Example of closed questions

The analysis of comments in open-ended questions (type two) is presented in tabular form and indicates the option selected by the participant, as well as the number of comments stemming from that option.

Option	Comments	Themes detected
1	5	Organised methods of learning

Table 7.C Open-ended question coding

The themes detected during the coding process are presented in the third column. An example of this is shown in table 7.C.

7.3.2 Presentation of questionnaire results per question

Each question will be analysed individually, and the results will be recorded in this section.

7.3.2.1 Question 1 (type one)

Did you make use of the Network Systems III e-learning material on Moodle?

	Options	Answers	Percentage
1	Yes	16	100%
2	No	0	0%

Table 7.1 Usage of material

All participants completed this question and there were no void answers. From table 7.1, it is clear that all of the participating students (100%) used the e-learning material on Moodle. It may be assumed that the e-learning material was accessible through the Internet and that Moodle allowed the participants to browse through all the sections of the material.

7.3.2.2 Question 2 (type one)

If you answered NO in question 1, explain why?

	Options	Answers	Percentage
1	N.A.	N.A.	N.A.
2	N.A.	N.A.	N.A.

Table 7.2 Non-users of e-material

All the participants in the previous question answered “yes”, therefore no data for table 7.2.

7.3.2.3 Question 3 (type one)

How many hours did you spend on the Moodle learning material?

	Option	Answers	Percentage
1	1 and 3 hours	7	47%
2	3 and 7 hours	4	27%
3	7 and 16 hours	2	13%
4	More than 16 hours	2	13%

Table 7.3 Hours spent on e-learning material

Only 15 participants answered the question and percentages were calculated accordingly. The usage varied as indicated in table 7.3.

7.3.2.4 Question 4 (type one)

Did you print the e-learning material on Moodle?

	Option	Answers	Percentage
1	Yes	2	12%
2	No	14	88%

Table 7.4 Printing of e-learning material

Lecturers reported on students who brought printed copies of e-learning material to the classroom. Two participants printed e-learning material. It is possible that these students, as indicated in table 7.4, distributed the material to their friends, or used it to explain the more difficult concepts to students not using the facilities.

7.3.2.5 Question 5 (type one)

If you answered YES in question 4, did you lend it to your friends?

	Option	Answers	Percentage
1	Yes	1	20%
2	No	4	80%

Table 7.5 Material lent to friends

Only 5 participants answered the question and percentages were calculated accordingly. This is surprising as only 2 of the students answered yes to the previous question and 5 answered this question. One participant indicated that he or she lent the printed e-learning material to a friend (table 7.5). This concurred with the reports of lecturers discussed in section 6.3.4.3, that not all of the participants using the e-learning material were recorded on the Moodle LMS logs. Those using hard copies instead of the electronic version were impossible to trace. The reader is reminded that the group who responded was too small to be representative of the whole.

7.3.2.6 Question 5a (type one)

Are there other subjects that support learners with e-learning material?

	Option	Answers	Percentage
1	Yes	10	63%
2	No	6	37%

Table 7.6 Other modules supporting e-learning

In table 7.6, most of the participants (63%) indicated that there are other modules supporting learners with e-learning material. Only 37% of the participants answered in the negative. The use of Moodle by lecturers at the VUT increased substantially between 2007_1 and 2008_2.

7.3.2.7 Question 6 (type one)

Do you want other subjects to do the same?

	Option	Answers	Percentage
1	Yes	15	94%
2	No	1	6%

Table 7.7 E-learning for other modules

A majority of participants (94%) indicated that they would like other modules to do the same (table 7.7). From this it is clear that participants would welcome the opportunity of accessing study material via the Internet.

7.3.2.8 Question 7 (type two)

How can we improve the e-learning material?

Themes detected	Answers	Percentage
Make use of examples and explanations	4	27%
Make sure to use multimedia environment	5	33%
Make it class related	1	7%
Put examination papers on Moodle and make discussion short	3	20%
Summarise topics from class	2	13%

Table 7.8 Methods to improve e-learning material

Only 15 participants answered and percentages calculated accordingly. Most of the participants (33%) indicated that they would prefer a multimedia interface (table 7.8). This includes animation, videos, pictures, voice and many more. One participant wanted the e-learning material to be class related, while two others preferred a summary of class lectures, which make a lot of sense. The rest wanted proposed answers to previous questions, also more examples and explanations. It is not always the majority having an impact, but the smallest contribution will also affect the overall performance.

7.3.2.9 Question 8 (type one)

Was the e-learning material helpful?

	Option	Answers	Percentage
1	Yes	15	94%
2	No	1	6%

Table 7.9 E-learning material

There was an overwhelming majority of 94% responding positively to the e-learning material (table 7.9). It was clear that participants were using the e-learning material and that they will continue doing so.

7.3.2.10 Question 9 (type one)

Will you recommend this e-learning material to other students?

	Option	Answers	Percentage
1	Yes	15	94%
2	No	1	6%

Table 7.10 Recommend e-learning material

The positive outlook on e-learning material is evident as table 7.10 shows 94% of participants willing to recommend the e-learning material to other students.

7.3.2.11 Question 10 (type two)

What will you change about the present content of this e-learning material?

Themes detected	Answers	Percentage
No, nothing or none	5	33%
Relate e-learning to class and chapters with good index	5	33%
Use smaller portions of chapter, summarise material	4	25%
Explain examples in the book	1	9%

Table 7.11 Changes to e-learning material

Fifteen participants answered the question and percentages calculated accordingly. Although 33% of the participants indicated that they will not change anything, the same percentage preferred the e-learning material to be class and text (chapter) related (table 7.11). Something worth taking into consideration is the request for smaller portions of work. The participants also wanted the examples in the book explained to them.

7.3.2.12 Question 11 (type two)

What do you think was the best part about the e-learning content?

Themes detected	Answers	Percentage
Discussion about topic and explanations	5	39%
Videos, pictures and subnetting	6	46%
Work through examples	1	7.5%
No	1	7.5%

Table 7.12 Best part about e-learning content

Only 13 participants answered the question and percentages calculated accordingly. In table 7.12, a total of 46% of the participants preferred the multimedia approach to learning, especially in e-learning material. There are still

participants wanting to have discussions and explanations when not understanding.

7.3.2.13 Question 12 (type two)

What explanation was the worst?

Themes detected	Answers	Percentage
None	5	71%
Not seeing the clips	1	14.5%
Hosts	1	14.5%

Table 7.13 Worst explanation

Only 7 participants answered the question and percentages calculated accordingly. As indicated in table 7.13, 71% of the participants did not think there was a bad explanation. One participant did not see the clips and another believed the explanation of hosts was the worst. The section concerning worst explanation should be re-visited by the developer.

7.3.2.14 Question 13 (type two)

What will you do to make the e-learning material more acceptable?

Themes detected	Answers	Percentage
Use more explanations	4	25%
Use multimedia such as videos, pictures	5	31%
Synchronise e-learning with traditional class activities	4	25%
Shorter time, tell a friend and feedback	3	6%

Table 7.14 Make e-learning more acceptable

As indicated in table 7.14, participants want more explanations, more multimedia presentations, and they want the e-learning material to be synchronised with text and class activities.

7.3.2.15 Question 14 (type one)

What was your best score in tests or examination papers in Network Systems III?

	Option	Average	Percentage
1	Below average	3	50%
2	Above average	3	50%

Table 7.15 Best scores before and after e-learning.

Only 6 participants indicated their scores and those figures were taken into consideration for calculation purposes. All marks were added up and divided by the number of participants for obtaining the average. Table 7.15 shows percentages above and below average. The results indicated that students across the spectrum benefit from using the e-material.

7.3.2.16 Question 15 (type one)

Are you repeating the subject?

	Option	Answers	Percentage
1	Yes	1	7%
2	No	14	93%

Table 7.16 Module repeated

One participant did not answer the question, calculations therefore reflecting on 15 participants only. According to table 7.16, 93% of participants are not repeating the module.

7.3.2.17 Question 16 (type two)

If you answered yes in Question 15, what is the reason?

	Option	Answers	Percentage
1	N.A.	N.A.	N.A.
2	N.A.	N.A.	N.A.

Table 7.17 Reason for repeating subject

This question is not relevant as the majority of participants are not repeating the subject (table 7.17). The participant repeating the subject gave no explanation for it.

7.3.2.18 Question 17 (type one)

Do you have a computer at home?

	Option	Answers	Percentage
1	Yes	11	69%
2	No	5	31%

Table 7.18 Use of computer at home

Most of the participants (69%) have their own computers at home. These participants may be more confident with using a computer. This answer surprised the researcher as this information differs from what was observed in chapter 4. It

may be that only a few students took part in this survey or the situation has changed, as the research project started approximately 16 months earlier.

7.3.2.19 Question 18 (type two)

Do you have any access to a computer?

	Option	Answers	Percentage
1	Yes	16	100%
2	No	0	0%

Table 7.19 Access to computers

Themes detected	Answers	Percentage
Home	6	37.5%
Campus	7	44%
Both places	3	18.5%

Table 7.19A Place to access computers

As indicated in table 7.19, all participants have access to a computer. Table 7.19a indicates where the computers are used. Many participants (44%) use computers on campus, while 37.5% use their computers at home. The rest use computers on campus and at home.

7.3.2.20 Question 18a (type two)

Do you think the e-learning material helped you to score higher marks?

	Option	Answers	Percentage
1	Yes	14	87.5%
2	No	2	12.5%

Table 7.20 Usability of e-learning

Themes detected	Answers	Percentage
More explanations	3	25%
Multimedia: Pictures, videos	3	25%
Understand better	3	25%
It has information and examples to work through	2	17%
Did not know it was there	1	8%

Table 7.20A Usage of e-learning

Table 7.20 covers the answers of participants, as to whether the e-learning material helped them to obtain higher marks, or not. The different themes in table 7.20a address the comments submitted by participants. The majority of them (87.5%) indicated that the e-material helped them to score higher marks. Their

comments clearly stated that they want more explanations (25%), more multimedia (25%), while understanding better when using the e-learning material presented to them (25%).

7.3.2.21 Question 19 (type one)

Do you want us to extend the material?

	Option	Answers	Percentage
1	Yes	15	94%
2	No	1	6%

Table 7.21 Extend e-learning material

The response to this question was overwhelmingly positive, as 94% of the participants in table 7.21 indicated that they want the e-learning material to be extended. That is also a clear indication that they will continue to use it.

7.3.2.22 Question 20 (type two)

How will you explain the section about subnetting to students?

	Themes detected	Answers	Percentage
1	Difficult and challenging	8	50%
2	Easy if you understand when using examples to improve marks	4	25%
3	Have idea what's it about	4	25%

Table 7.22 Explain subnetting

Table 7.22 confirms strong agreement (50%) that the section on subnetting is difficult. A number of participants (25%) indicated that subnetting is easy and that marks will improve if better understood.

7.4 DATA ANALYSIS SUMMARY

The analysis of questions, both closed and open-ended, clearly indicated the participants' preference for combinations when using e-learning material. One of the prominent combinations is multimedia and more explanations.

To use multimedia for study purposes, it has to be visual and should accommodate active learning style preferences, allowing for learner interaction. Learning material therefore should comprise of text with links to various others, such as pictures,

videos, voice recordings and text examples. The student should be in a position to work through learning material sequentially and also have the opportunity of assessing the bigger picture before working through its smaller parts.

The interactive component should enable students to go to any part of their study material with the click of a mouse. Learners are used to attending classes, and learning material should be structured in such a way as to represent the same sequence followed by the lecturer.

Results obtained from questions 1 and 3 indicated that the e-learning material was used. The results from questions 4 and 5 indicated that some of it was printed and might have been distributed to other students as well. Questions 5a and 6 indicated the need for more modules to follow. Questions 7, 8, 9, 10, 11, 12 and 13 addressed possible improvements. Usage of the material was addressed in questions 14, 15, 16, 17, 18, 18a, 19 and 20.

7.5 CHAPTER CONCLUSION

This chapter presented the analysis of an interpretive survey conducted to understand the students' attitude towards e-learning material. Although only a few students participated in this survey, the researcher considered their answers a valuable contribution to this study.

When discussed by the group of stakeholders, these results motivated them to continue using the e-learning material in 2008_2 and thereafter. It was also decided to start a process of identifying other problematic aspects of the Network Systems III module syllabus, suitable for further development of e-learning material.

The students were positive towards the e-learning material. It was widely used and students gave constructive feedback in terms of improvements. They indicated that more examples and exercises would be helpful. Students enjoyed the videos and pictures and requested that the material be extended to cover other sections of the syllabus.

Chapter 8 is the conclusion of this study.

CHAPTER 8

SUMMARY, FINDINGS AND RECOMMENDATIONS

8.1 INTRODUCTION

This chapter represents the last part of the action research study, i.e. the “advise improvements” phase. It also serves as a summary and conclusion of the research reported in this dissertation. Figure 8.1 shows a summary of the research project as described in the previous chapters.

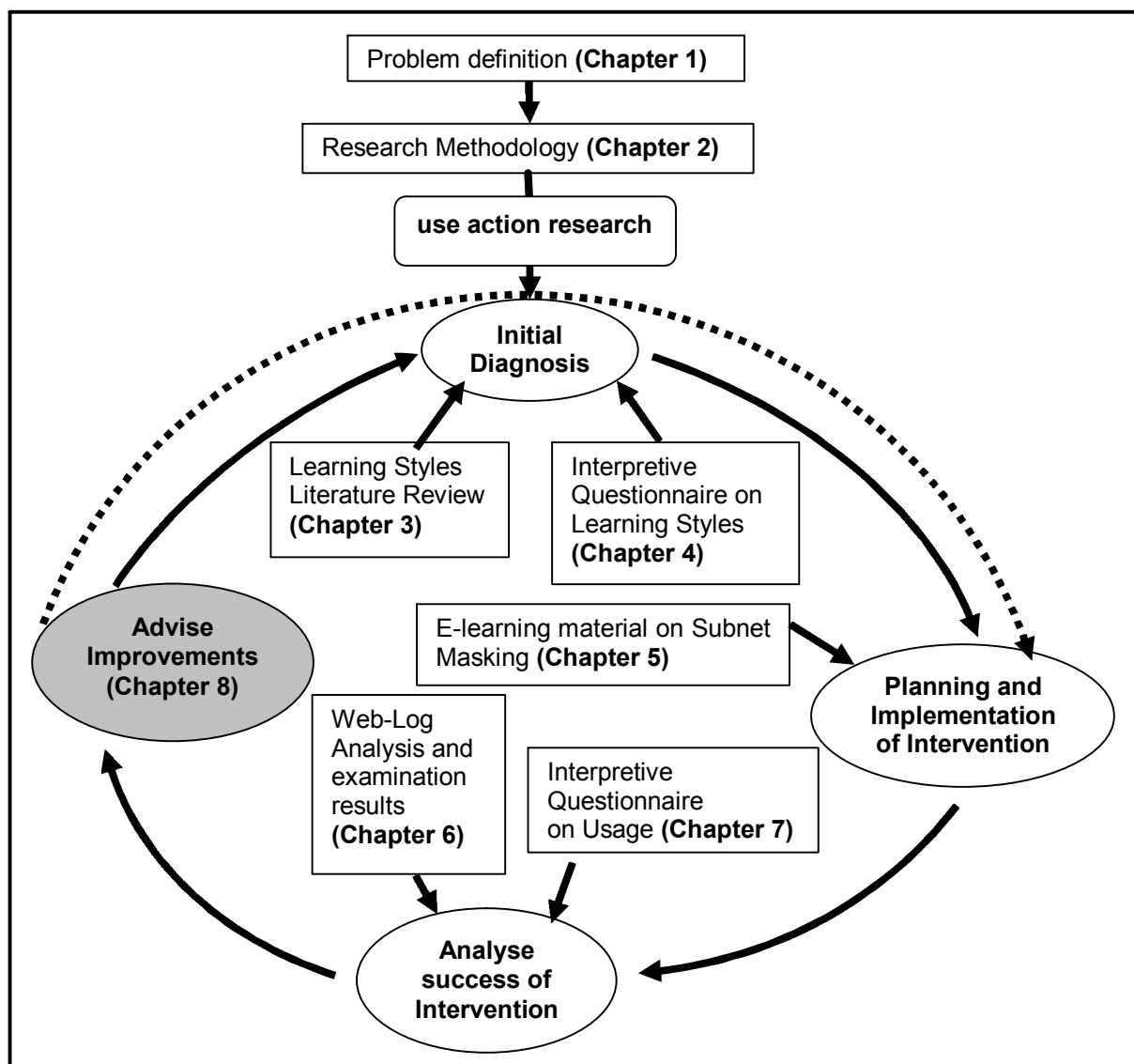


Figure 8.1 Schematic layout of this research

The aim of this study was to improve performance in the Network Systems III module at the VUT.

Eight objectives were identified to guide the research in order to achieve this aim:

1. Understanding of learning styles based on a literature review.
2. Understanding of learning styles of Network Systems III module students based on an interpretive survey.
3. Creating of e-material accommodating different students' learning styles.
4. Analysing the usage of the e-learning material by means of web logs created with the learning management system (Moodle).
5. Analysing performance of students in terms of examination results and e-learning material usage.
6. Applying statistical methods to the results of objectives 4 and 5 to establish the presence of a meaningful correlation if any.
7. Conducting an interpretive survey in order to understand the students' attitude towards the e-material.
8. Make recommendations to the stakeholders in order to sustain and further improve the student performance in the Network Systems III module at the VUT.

Objective 8: Provide recommendations to the stakeholders in order to sustain and further improve the student performance in the Network Systems III module at the VUT, can be divided into the following sub-objectives:

Provide a summary of the action research process followed (described in section 8.2).

- 8.2 Provide a summary of the findings of the previous phases of the action research process (described in section 8.3).
- 8.3 Make recommendations based on these findings on the future teaching environment of the Network Systems III module at the VUT (described in section 8.4).

As this chapter also serves as the conclusion of the dissertation, section 8.5 describes the value of the action research project from a research perspective. Section 8.6 provides a discussion of future research and section 8.7 is the conclusion of the chapter.

Section 8.2 provides a summary of the action research process.

8.2 SUMMARY OF ACTION RESEARCH PROCESS

Chapter one outlined the aim of the study and presented eight objectives of the research. The following questions were asked in section 1.3:

- How can we establish more appropriate learning and teaching combinations for the Network Systems III module class in terms of the accommodation of students with different learning styles?
- How can we develop e-learning material to be used in the blended e-learning environment that accommodates student learning styles?
- How can we determine whether a student actually makes use of the additional e-learning material?
- What effect will additional multimedia study material have on the test and examination results of students? What is the relationship between the time spent on additional e-learning material and test and examination results?

In order to answer these research questions, an action research project was designed as depicted in figure 8.1 and sub-objectives were developed for the objectives stated in section 1.2 (repeated in section 8.1). The action research model comprises of the four stages (outlined in section 1.4), i.e. Initial diagnosis, Planning and implementation of intervention, Analyse success of intervention and Advise improvements. A brief summary of each of the phases follows.

8.2.1 Phase 1: Initial diagnosis

Action research started with the initial diagnose phase which consisted of three sub-phases addressing the following:

- Discussions with lecturers (reported in section 5.1, also part of objective 3.8).
- Literature review of learning styles (chapter 3).
- Understanding of learning styles of students by means of interpretive questionnaires (chapter 4).

Objectives 1 and 2 of the study guided this phase and were divided into sub-objectives. Objective 1 (Understanding of learning styles based on a literature review), was sub-divided into the following parts:

- 1.1 Understanding learning by means of a literature review on learning and learning formations (presented in section 3.2.1).
- 1.2 Understanding learning styles in general by means of a literature review on learning styles based on a review on learning domains, learning modalities and multiple intelligence (presented in section 3.2.2 and 3.2.3).
- 1.3 Summarising different learning style models in terms of specific models, learning dimensions and a description (presented in section 3.2.3).
- 1.4 Understanding the model of Felder and Silverman (2009:1) used in this study (presented in section 3.2.4).

Objective 2 (Understanding of learning styles of Network Systems III module students based on an interpretive survey) was further divided into sub-objectives:

- 2.1 Planning the data collection process of this research with reference to the participants, current research in learning styles and the questionnaire (presented in section 4.2).
- 2.2 Analysis of data with specific references to the method of analysis and presentation of questionnaire results (presented in section 4.3).
- 2.3 Understanding of learning styles of participants from the analysis of the questionnaire data (presented in section 4.3.2).

This phase provided an understanding of the learning styles of the students and guided the next phase.

8.2.2 Phase 2: Planning and implementation of intervention

The second phase, Planning and implementation of intervention, was reported on in chapter 5. The process was guided by objective 3. Objective 3 (Creating of e-material accommodating different students' learning styles) was divided into the following sub-objectives:

- 3.1 A literature review on learning styles (accomplished in objective 1 and presented in section 3.2).
- 3.2 An understanding of the learning styles of the VUT students (accomplished in objective 2 and presented in chapter 4).
- 3.3 A literature review on learning effectiveness to ensure the development of effective material (presented in section 3.3).
- 3.4 A literature review on learning and technology usage to ensure that the special aspects of using modern technology are taken into account in the development of e-learning. This review should focus on e-learning (presented in section 3.4.1 to 3.4.4).
- 3.5 A literature review on blended e-learning as this is the preferred model chosen in this study (presented in section 3.4.5).
- 3.6 Identify specific characteristic features that the e-learning material should contain in order to support any learning style (presented in section 3.4.6 to 3.4.8).
- 3.7 Teaching strategies to improve learning and the method to measure the learning success of learners was identified (presented in section 3.5).
- 3.8 Identifying a specific area of the Network Systems III module syllabus for which e-learning material will be developed (discussed in section 5.1).
- 3.9 Planning the e-learning material from the literature review on learning styles (discussed in section 5.2.2).

- 3.10 Planning the e-learning material from the analysis of the interpretive questionnaires on learning styles discussed in chapter 4 (discussed in section 5.2.3).
- 3.11 Physically creating e-learning material related to the selected area of the Network Systems III module content.
- 3.12 Understanding the analysis capabilities of Learning Management Systems (discussed in section 5.3).

The result of this phase was e-learning material on subnet masking implemented on the Moodle LMS. The material was developed with effective learning and teaching strategies in mind, catering for the learning styles tested of the Networking Systems III students at the VUT.

8.2.3 Phase 3: Analyse success of intervention

The third phase, Analyse success of intervention, consisted of two sub-phases:

- Analyse the success of intervention on learning material through web log analysis and test and examination results of learners (chapter 6).
- Analyse the success of the intervention through the development and analysis of an interpretive questionnaire on the usage of the e-learning material on the Moodle LMS (chapter 7).

The first sub-phase was guided by objectives 4, 5 and 6 and the second one by objective 7 stated in section 1.2.

Objective 4: Analysing the usage of the e-learning material by means of web logs created with the Moodle LMS was divided into:

- 4.1 Identifying the Moodle log activities to determine the usage of the e-learning material (presented in section 6.2).
- 4.2 General analysis of the usage of e-learning material (presented in section 6.2.2).

Objective 5: Analysing the performance of students in terms of examination results and e-learning usage was divided into:

- 5.1 Explaining the examination results of each of the groups studied in this research in general (presented in section 6.3.2).
- 5.2 Comparing the examination success of the e-learning material users to that of non-users of the e-learning material. This is done irrespective of the amount of time spent by the users using the e-learning material (presented in section 6.3.3).
- 5.3 Analysing the amount of time spent on the e-learning material and the examination success of these students presented in section 6.3.4).
- 5.4 Analysing the number of sessions spent on the e-learning material and the examination success of these students presented in section 6.3.5).

Objective 6: Applying statistical methods to the results of objectives 4 and 5 to establish the presence of a meaningful correlation if any, was divided into:

- 6.3 Determining whether there is a meaningful correlation between the usage of the e-learning material and the results of the students in tests and examinations. To do this, Pearson correlations were used (presented in sections 6.3.6.3 and 6.3.6.5).
- 6.4 Determining whether students who used the e-learning material performed better in tests and the examination than students who did not use it. To do this, t-tests were used (presented in sections 6.3.6.4 and 6.3.6.6)

Sub-phase 2 was reported on in chapter 7. Objective 7 was divided into the following sub-objectives:

- 7.1 Understanding the data collection process of this research with regard to the usage of e-learning material (presented in section 7.2).
- 7.2 Analysis of data with reference to participant preferences (presented in section 7.3).

This phase provided an understanding of the usage of the e-learning material by the students as well as insight into the impact of the usage of the e-learning material on the performance of the students. The attitude of available students towards the material was investigated.

8.2.4 Phase 4: Advise improvements

The last phase, Advise improvements, evaluates and analyses the results of previous phases to determine whether any further actions are necessary to improve results which are guided by objective 8 stated in section 1.2.

Objective 8: Provide recommendations to the stakeholders in order to sustain and further improve the student performance in the Network Systems III module at the VUT can be divided into the following sub-objectives:

- 8.1 Provide a summary of the action research process followed (presented in section 8.2).
- 8.2 Provide a summary of the findings of the previous phases of the action research process (follows in section 8.3).
- 8.3 Make recommendations based on these findings on the future teaching environment of the Networking Systems III module at the VUT (follows in section 8.4).

This phase provides recommendations to guide the future teaching environment of this module at the VUT. In order to achieve this objective a summary of findings of the previous phases of the action research process is provided in section 8.3

8.3 FINDINGS ON THE FIRST THREE PHASES OF THE ACTION RESEARCH PROJECT

In this section, the sequence of findings with regard to the action research process will be given. This section presents only information on each phase that had a direct influence on the next phase.

8.3.1 Findings on phase 1: Initial diagnosis

After a discussion with lecturers, the decision was made to develop e-learning material on the subnet masking section of the module's learning content. This decision was based on:

- Historically poor performance of students in sections of the final examination paper on subnet masking.
- Historically poor performance of students in semester tests on this section of the learning content.
- Views expressed by lecturers that from their experience, students have difficulty with understanding the learning content of subnet masking.
- It was decided to develop e-learning material on this content in order to create additional material that is always available to students.
- It became clear that students asked lecturers lots of questions on subnetting during and after formal lectures. This led to the decision to develop a multimedia environment where videos could be used to give verbal explanations along with additional text information.
- It was agreed that a study on learning styles might be advantageous before development of the material was finalised.
- Traditional lectures should still be continued as before.

The literature review on learning and learning styles led to the selection of the learning style model of Felder and Silverman, discussed in more detail in section 3.2.3.4 for use in this research project.

The learning style model of Felder and Silverman was developed specifically for engineering students. This model is widely used in research on learning styles by authors, such as Graf *et al.* (2007) at the Massey university in New Zealand and Vienna university of technology in Austria, Visser *et al.* (2006) at the North-West university in South Africa and Glasgow Caledonian university, Zywno (2003) at the Ryerson university in Toronto, Canada and Litzinger *et al.* (2007) at the Pennsylvania state university with students in engineering, liberal arts and education.

As students of the VUT are also engineering students, this model appeared to be suitable for this research. The model also contained an interpretive questionnaire, called the Index of Learning Styles, developed by Felder and Soloman, which was adapted for use in this study.

The analysis of questions, both closed and open-ended, clearly indicated that participants had a variety of combinations with regard to learning styles. One of the most prominent observations featuring in the analysis was the fact that students were used to traditional lectures and needed guidance in the process of changing to a blended e-learning environment.

Analysis of the data pointed to the fact that on the one hand, each participant had a preferred learning style while on the other hand, the group of participants was representative of all learning styles. Subsequently, the e-learning material catered for all learning styles tested, irrespective of the relative percentages of individual learning style preferences. It was decided that e-learning material should be developed according to the following guidelines:

- Create interactive variations of module content on computer that are associable to lectures, have active Internet links, e-mail connectivity, audio, video and text.
- Create functional e-learning material with sound clips and text material that allows time for comprehensive and detailed explanations with exercises.
- When introducing a new section of the module, be sure to explain the need for the material carefully.
- Create e-learning material that includes multimedia explanations with the aid of movies, videos, pictures, charts, voice explanations, animation, graphs and text with and without sound.
- Create e-learning material associable with lectures and includes comprehensive and detailed explanations through text pages on computer screens and voice explanations.
- E-learning material explained in small chronological sections through selected pages and multiple sessions.

- E-learning material with the ability to give an overall expression of the whole, or sections of the whole, through the help of pictures, diagrams or text using a computer.

8.3.2 Findings on phase 2: Planning and implementation of intervention

The result of this phase was e-learning material on subnet masking implemented on the Moodle LMS. The material was developed with effective learning and teaching strategies in mind catering for the tested learning styles of the Networking Systems III students at the VUT.

8.3.3 Findings on phase 3: Analyse success of intervention

As described in section 4.1, this study involved three semesters' students at the VUT. Firstly, students in the first semester of 2007 (referred to as 2007_1) who did not use any e-learning material, secondly, students of the second semester of 2007 (referred to as 2007_2) who were the first to use the e-learning material and thirdly, students of the first semester of 2008 (referred to as 2008_1). Two iterations of the action research were done. The success of the intervention in 2007_2 will be discussed before that of 2008_1. The section concludes with a summary of findings of the interpretive questionnaire that was developed and analysed.

8.3.3.1 Findings of phase 3: Analyse success of intervention of 2007_2

During 2007_2, only 52% of the students enrolled for the Network Systems III module used the e-learning material.

Analysis of test and examination results in 2007_2 was done and compared with the information in the Moodle logs. Results of t-tests to determine the performance of users versus non-users indicated that users of the e-learning material performed much better in the examination questions about subnet masking than non-users. Detail of the analysis was presented in section 6.3.6.4 and 6.3.6.6.

In discussions after 2007_2 on the success of the intervention with all stakeholders (lecturers, head of department and research team), it was decided that the usage in 2007_2 was unsatisfactory. However, as the results of users were very encouraging, it was decided to use the e-learning material unchanged in 2008_1.

8.3.3.2 Findings of phase 3: Analyse success of intervention of 2008_1

In 2008_1, 89% of the students used the e-learning material, demonstrating the success of the intervention by lecturers after 2007_2. There was however no meaningful correlation between time spent using e-learning material and marks obtained in the examination questions on subnet masking. The pass rate of the students using the e-learning material was 92%. This result is encouraging when interpreting the success of e-learning material.

A few observations should be made to qualify the apparent success of the e-learning material:

- Subnet masking is only a part of the module content and although 92% of users of the e-learning material passed in 2008_1, these students must have performed well in the other sections as well.
- Students using the e-learning material spent more time on the module than they would have done if the e-learning material was not available. This is not necessarily a negative aspect of the study, as the availability of the e-learning material encouraged them to spend more time on the module content.
- The e-learning material was printable, however, the number of hours spent on reading printouts off-line is unknown.

In order to find answers to these uncertainties, interpretive questionnaires were developed and analysed. This process was discussed in chapter 7 and findings are presented in the following section.

8.3.3.3 Findings of phase 3: Analyse success of intervention from the interpretive questionnaire

The analysis of the previous sections highlighted the issue of causality. Did students perform better as a result of the e-learning material, or did they perform better because more time was spent on module content? It was decided in a meeting with all stakeholders after the 2008_1 analysis, to ask the students how they experienced the e-learning material.

As discussed in section 7.1, many of the students who participated in the study were no longer available. The decision was made to distribute a questionnaire to all students who previously used the e-learning material in 2007_2 and 2008_1 and could still be reached. From a research perspective, the value of this information would be to gain understanding of the attitude of those students who could be reached.

The students were positive towards the e-learning material. It was widely used and students gave constructive feedback in terms of improvements. They indicated that more examples and exercises would be helpful. Students enjoyed the videos and pictures and requested that the material be extended to cover other sections of the syllabus.

The following section represents phase 4 of the action research project, namely advise improvements.

8.4 PHASE 4: ADVISE IMPROVEMENTS

The aim of any action research project is to achieve positive change through a joint effort by the researcher and stakeholders in the problem situation. An action research project is iterative in nature and the researcher and stakeholders should decide together whether further iterations would be required to solve the initial problem.

In this instance, the e-learning material was used the first time in 2007_2 after which the stakeholders decided to do a second iteration, as discussed in section 8.3.3.1. A discussion of the analysis of the 2008_1 data led to the development

and distribution of interpretive questionnaires, discussed in section 8.3.3.3. When the results of the analysis of the questionnaire were discussed by the group of stakeholders, they decided to continue using the e-learning material in 2008_2 and thereafter.

It was also decided to start a process of identifying other problematic aspects of the Network Systems III module syllabus, suitable for further development of e-learning material. The analysis of the questionnaires (presented in chapter 7) again highlighted the need to link e-learning material with lectures.

The scope of this dissertation does not cover this follow-up project. However, the project will keep on evolving as new technology becomes available and more thought is given to how learner management systems can be used to further sound pedagogical principles.

From an educational perspective, the blended e-learning environment can be restructured in such a way that students are expected to work on their own through the e-learning material in preparation for their formal lectures. Such an approach would have the advantage that students become more independent. The e-learning material would have to be restructured and the lecturers would have to facilitate the process, but since this module is on a final academic level for these students, such independence should be encouraged.

From a technical perspective, one may extend the interaction between students, fellow-students and lecturers. One may even extend some parts of the e-learning material to be used on mobile devices. Learner management systems provide many opportunities not yet used in this module to facilitate the educational environment. As this study indicated that students who used the e-learning material found it helpful, it serves as a motivation to extend the use of the LMS in this and other modules at the VUT.

8.5 CONTRIBUTION OF STUDY

The contribution of this study is twofold. From a content perspective, it shows how e-learning material can be developed to cater for the learning styles of different students. An LMS should be seen as a vehicle to further pedagogical principles rather than a document repository. It also demonstrates how usage of such material can be analysed through web logs, generated by the LMS.

From a research point of view, the study is a demonstration of a critical social research project using both quantitative and qualitative data, analysed respectively from a positivistic and interpretive perspective. The interpretive data analysis of chapters 4 and 7 served to gain an understanding of specific characteristics of the problem situation. In contrast, the positivistic measurements and analysis aimed at establishing the presence of a meaningful correlation between the usage of the e-learning material and the performance of the students. This project showed how a mixed methods strategy can benefit the participants in a problem situation.

8.6 FUTURE RESEARCH

The e-learning environment should be enhanced to include course content as a whole and not just part of it.

Furthermore, action to synchronise and improve the use of e-learning in conjunction with class lectures should be investigated. The usability of other types of e-learning material still remains to be fully investigated.

It is hoped that findings of this study will help providing teachers and learners with more information as to how their teaching and learning strategies can be applied more effectively, thus allowing learners to benefit from understanding the information presented to them, whether traditionally and through blended e-learning.

In view of possible limitations in this research, the following suggestions for further research are made:

- Research should be conducted and courses developed to train teachers in using the learning style of learners to their advantage.
- Web logs that will measure the time of single sessions, as well as the last session of multiple sessions.

Ideas for future research will involve the use of interactive multimedia screens, promoting interaction between the computer and the student. For example, if the student does something correctly, the computer will award him/her by responding positively to the action taken.

E-learning material should be made attractive to work with, similar to the present-day computer games. This will encourage students, rather than forcing them to make use of e-learning material.

8.7 CONCLUSIONS

The aim of this research, referred to in section 1.2, was to improve the performance of the Network Systems III students at the VUT. This was done by considering the different learning styles of these students. The diversity of the students in terms of language, culture, ability and learning styles makes the usability of e-learning material currently used, imperative.

There is no doubt that blended e-learning can provide significant results with regard to the improvement of learning. The e-learning material was accepted positively by students participating in the research. The growing need for blended e-learning could be seen in the increasing number of students using the e-learning material during the semesters of 2007-2 and 2008_1.

Other results obtained with e-learning material were very useful, and it is possible that students can learn more if the method of teaching is synchronised with their learning styles. A favourable outcome of e-learning is the fact that many dimensions of learning styles are integrated into one central learning system.

This research method is pluralistic in the sense of all three paradigms, i.e. positivism, interpretivism and constructivism, being used individually in different phases of the research.

The critical social theory came to the fore very strongly, as there were many sub-phases in this action research project concerning improvement of the human's situation. The most rewarding aspect was the opportunity of intervention to improve student learning conditions.

This study demonstrated an innovative way of achieving teaching-learning excellence.

ANNEXURE A

THE PURPOSE OF THIS QUESTIONNAIRE IS TO GET A PERCEPTIVE IDEA WITH REGARD TO STUDY STYLES

To all participants

I, C van Aardt am currently conducting research on the perspectives of **learners and educators** on the advantages and disadvantages of teaching and learning styles as currently in use at the Vaal University of Technology in the Process Control and Digital Systems Department. We need your support and contribution to be able to complete this study. Your participation is **voluntary** and information will be handled anonymously and with **confidentiality**. The numbers on the questionnaire are solely for administrative purposes and will not be used for identification.

Please read the following questionnaire and complete the questions asked. It will not take more than 16 minutes of your time. Please make sure you answer **all** the questions. There are no right or wrong answers.

We trust that the research will benefit you in future courses.

Thank you for your co-operation and support.

Mr. C van Aardt

Study Leader:

Dr R. Goede

NorthWest University (Potchefstroom)

ANNEXURE B

Network Systems III subject

This questionnaire is for research in the subject to find ways to improve or change teaching methods to make difficult parts of the subject more understandable for students. The outcome of this research should be visible through the results obtained in semester tests and the exam. Some of these questions were obtained from the "Index of Learning Styles Questionnaire" from Barbara A. Solomon.

Questions

1. **How often do you use a computer?**
 - ☐ Daily
 - ☐ Few times per week
 - ☐ Sometimes
 - ☐ Never
2. **How often do you play computer games?**
 - ☐ Never
 - ☐ Less than 4 hours per month on average
 - ☐ Between 1 and 5 hours per week on average
 - ☐ More than 5 hours per week on average
3. **How often do you watch a movie on your computer?**
 - ☐ More than once per week
 - ☐ Once per week
 - ☐ Sometimes
 - ☐ Never
4. **Do you like animation and sound in computer games?**
 - ☐ I don't play games
 - ☐ Enjoy it very much
 - ☐ Never notice it
 - ☐ Other:
5. **What type of lecturing method do you prefer?**
 - ☐ Going to normal lecturing classes
 - ☐ Use a computer with sound and video to learn new concepts
 - ☐ Doing selfstudy
 - ☐ Other:.....
6. **If available would you make use of multimedia, (voice, animation, video) to improve your learning skills?**
 - ☐ Yes
 - ☐ No

If you want to, tell us more about your answer:.....

7. **Which of the following situations do you prefer when receiving new information? (You may select more than one option)**
- ☐ Attending a lecture
- ☐ Studying a text book
- ☐ Watching a video over and over
- If you want to, tell us more about your answer:.....
8. **What do you do to understand difficult and new information? (You may select more than one option)**
- ☐ Use your imagination to form images in your mind
- ☐ Look at pictures and read more about the topic
- ☐ Discuss the topic in class
- If you want to, tell us more about your answer:.....
9. **I learn best by: (You may select more than one option)**
- ☐ Reading my textbook over and over
- ☐ Doing lots of exercises
- ☐ Asking other people to re-explain the work
- If you want to, tell us more about your answer:.....
10. **How do you react during an active class session?**
- ☐ Take part in class activities
- ☐ Look and listen at class activities
- ☐ Read through your text book
- ☐ I am generally bored
- Other:.....
11. **How do you prefer to study?**
- ☐ Start from the beginning and work through the text book
- ☐ Learn the most difficult parts first and then the easier parts
- ☐ Learn the easier parts first and then the difficult parts
- ☐ Don't study at home, just listen in class
- Other:.....
12. **How would you improve your current marks?**
- ☐ By using current methods more effectively
- ☐ To try and find new more effective methods to study
- ☐ Other methods:.....
13. **Which of the following would you use if they were available?**
- ☐ Using multimedia aids on a computer
- ☐ Listening and looking at video recordings
- ☐ Collecting additional textual information

14. **I understand something more effectively when I:**
- ☐ Do it myself
 - ☐ Think about it before I do it
 - ☐ Draw pictures about the topic
15. **When I think about what I did yesterday, I am most likely to get**
- ☐ a picture.
 - ☐ words.
16. **I tend to**
- ☐ understand details of a subject but may be fuzzy about its overall structure.
 - ☐ understand the overall structure but may be fuzzy about details.
17. **I prefer to get new information in**
- ☐ pictures, diagrams, graphs, or maps.
 - ☐ written directions or verbal information.
18. **Once I understand**
- ☐ all the parts, I understand the whole thing.
 - ☐ the whole thing, I see how the parts fit.
19. **In a book with lots of pictures and charts, I am likely to**
- ☐ look over the pictures and charts carefully.
 - ☐ focus on the written text.
20. **I like teachers**
- ☐ who put a lot of diagrams on the board
 - ☐ who spend a lot of time explaining.
21. **When I start a homework problem, I am more likely to**
- ☐ start working on the solution immediately.
 - ☐ try to fully understand the problem first.
22. **It is more important to me that an instructor**
- ☐ lay out the material in clear sequential steps.
 - ☐ give me an overall picture and relate the material to other subjects.
23. **When I see a diagram or sketch in class, I am most likely to remember**
- ☐ the picture.
 - ☐ what the instructor said about it.
24. **For entertainment, I would rather**
- ☐ watch television.
 - ☐ read a book.

ANNEXURE C

This annexure contains text information relating to binary values.

C.1 Introduction to Binary

A major stumbling block to binary calculations is the lack of understanding the underlying binary mathematics. The methodology discussed hereunder allows anyone with the necessary capabilities to successfully carry out all the binary essentials.

Look at Table C.1. Memorise this table and make sure that you understand it before you go further. Table C.2 contains different combinations of binary values.

One Octet = 8 Bits									
Explanation		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Binary Bits		1	1	1	1	1	1	1	1
Decimal value of each bit (Total value = 255)		128	64	32	16	8	4	2	1
2^x (Combinations of bits)	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Result of 2^x	256	128	64	32	16	8	4	2	1

Table C.1

Explanation Combinations of Binary Bits

Take for instance Bit 3 which has 2^3 combinations. This means that there are 3 bits and ($2^3 = 8$) combinations. The bit combinations are:

0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

Decimal Value of Bit combinations

8 Combinations

Table C.2 Combinations of binary values

128	64	32	16	8	4	2	1	Decimal Answer
1	0	1	1	0	0	0	0	176
0	0	1	1	1	1	0	0	60
1	1	0	0	0	0	0	1	193
0	0	0	0	1	1	1	1	15
1	1	1	1	0	0	0	0	240

Add only the values together where a 1 is visible.

Table C.3 How to interpret binary values within an octet

Table C.3 explains how to interpret the 1s and 0s in a binary value. Make sure that you are familiar with the calculation concept to get the decimal answer of a binary value and visa versa.

ANNEXURE D

This annexure contains text information concerning the arrival of a data packet at the router. It may also contain links to voice or animation material.

D.1 Path of Data Packets through the network

If you want to send a package to any destination through the post office, you have to indicate the exact address of the person to whom it should be sent. This address should at least contain the name of the town, the name of the suburb, the street name and house number of the addressee.

Networks and data packets work in exactly the same way. Any destination has a specific IP address where the data should be sent. When data arrives at this destination, a router, acting like a policeman, will decide whether this packet will be allowed to enter the network or not. The only way to verify whether this packet is at the correct destination is to use the IP Subnet Mask on the IP address. The Subnet Mask enables the router to divide the IP address into a network portion and a host portion. If the network portion of this data packet is correct, the router will allow it to enter the network. After allowing the data packet through, the router must decide where to send the data packet. To accomplish this, the router needs another Subnet Mask, called a custom Subnet Mask. To determine which subnet and host the data should be sent to, see figure D.1, displaying a description of the path of a data packet.

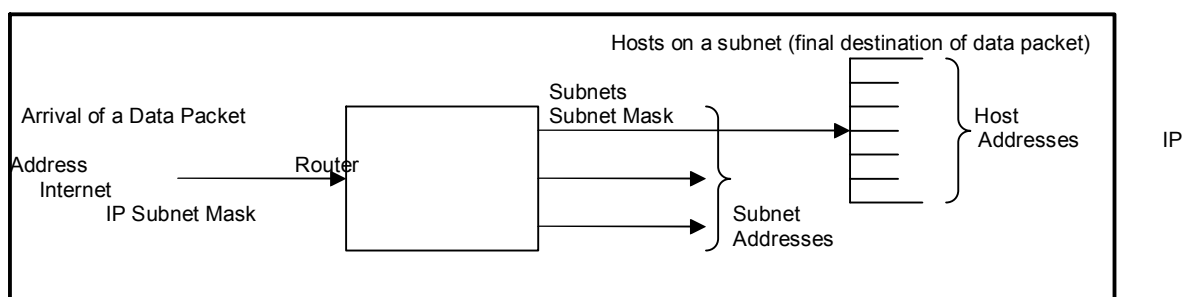


Figure D.1 Path of a data packet from start to finish

All sections in the data path will be discussed individually. [Click here](#) for an animated voice overview of Figure D.1.

ANNEXURE E

This annexure contains text information concerning the arrival of a data packet at the router. It may contain links to voice or animation material.

E.1 Discussion of the arrival of a data packet at the router

The data packet contains an IP address and arrives at the router through the Internet. This part is indicated by the circle in Figure E.1.

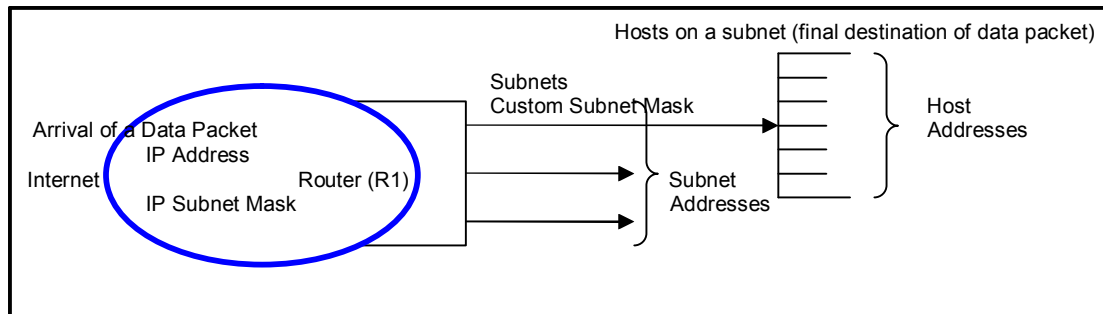


Figure E.1 Path of a data packet from start to finish

E.2 IP Address

The IP address is a unique official “public” network address your organisation has obtained from your Internet Service Provider (ISP) for use on the Internet. The most common network addressing we use, is IPv4, made up of 32 bits (4 octets of 8 bits each, refer Figure E.2).

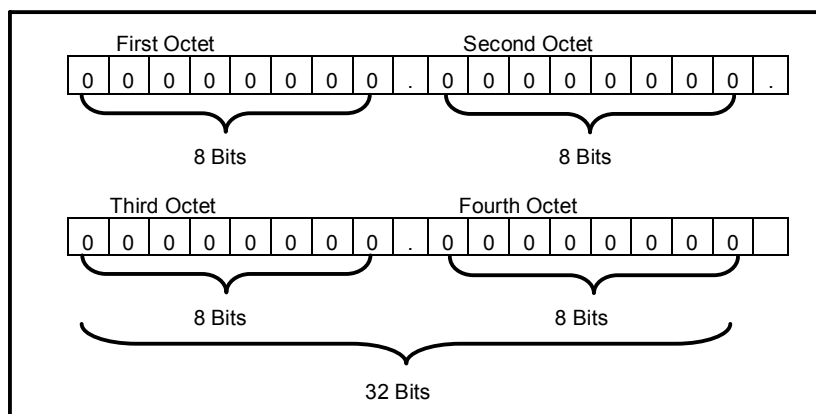


Figure E.2 32 Bit IP Address

The IP address allows you to communicate with other devices on the network also having their own unique IP addresses. An IP address can be expressed in binary notation or in dot-decimal notation (Table E.1).

First Octet									Second Octet								
1	1	0	0	0	0	0	0	.	0	1	1	1	1	1	1	0	.
192								.	126								.

First Octet									Second Octet								
0	0	0	0	0	1	0	1	.	0	1	1	0	0	1	1	0	.
5								.	102								.

Table E.1 Binary and dot-decimal expression of address 192.126.5.102

Dot-decimal notation means that you take the decimal value of the total binary number of each octet and put a point (.) between each octet value. It is also important to remember that the octet 00000000 in binary becomes 0 in dotted decimal notation and the octet 11111111 in binary becomes 255 in dotted decimal notation.

There are 3 classes of IP addresses which can be used for an IP network (Table E.2). The value of the leftmost octet of an IP address defines the network class to which it belongs.

Class	Leading Bits	IP Address range		CIDR Notation	Subnet Mask
		Start	End		
A	00	1.0.0.0	127.255.255.255	/8	255.0.0.0
B	10	128.0.0.0	191.255.255.255	/16	255.255.0.0
C	110	192.0.0.0	223.255.255.255	/24	255.255.255.0
D	1110	224.0.0.0	239.255.255.255		Multitasking
E	1111	240.0.0.0	255.255.255.0		Reserved

Table E.2 IP Address class range

Class A range 1 – 127 with default Subnet Mask of 255.0 .0 .0

Class B range 128 – 191 with default Subnet Mask of 255.255.0 .0

Class C range 192 – 223 with default Subnet Mask of 255.255.255.0

Another very important purpose of an IP Address is to identify the network portion and host portion of the network. This is accomplished by dividing the 32-bit IP address into two parts: an initial network ID portion identifying the individual network and a host ID portion identifying individual hosts on the network (Figure E.3).

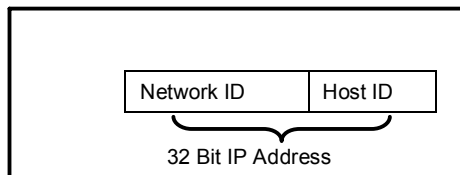


Figure E.3 Address Portions

Since the network ID is always the leading part of an IP address and the host ID always the trailing (last) part, we will use a simple masking scheme to identify these two portions

E.3 IP Subnet Mask

An IP Subnet Mask always accompanies the IP address and indicates which portion is the network ID and which portion is the host ID. The Subnet Mask consists of a series of uninterrupted “1”- bits followed by a series of uninterrupted “0” bits. The uninterrupted “1”- bits represent the network ID part and the uninterrupted “0”- bits the host ID part. In IP subnet masking, we perform a binary “AND” operation on a 32-bit IP address at the bit level, using another 32- bit number called the mask. The bits in the mask are related to the corresponding bits in the IP address.

Before the binary “AND” operation can be performed on the IP address, it is critical to know which of the three network classes the IP address belongs to. Each network class has its own unique IP Subnet Mask. This unique IP Subnet Mask identifies the network class in which the IP address resides by using the number of the first octet in the IP address (Table E.2).

Despite the fact that Subnet Masks and IP addresses are often represented in dot-decimal form, their use becomes clearer in binary. To get the network or host address, we must apply the binary “AND” operation on the IP addresses and mask as indicated in example 1. A Subnet Mask quickly and efficiently filters out anything not meant for our private network.

Example 1

IP address: 135.120.23.45, the first octet contains the number 135 which fits into the range of Class B (128 – 191). The Subnet Mask will be: 255.255.0.0

135.120.23.45	10000111.01111000.00010111.00101101
Subnet Mask, Class B	11111111.11111111.00000000.00000000
Network Portion	10000111.01111000. (binary-and result)
Host Portion	.00000000.00000000

However, Subnet Masks do not have to fill a given octet. Subnet Masks can also be expressed in a shorter form, known as Classless Inter-Domain Routing (CIDR), Subnet Mask notation. This gives the network address, followed by a slash (“/”) and the number of “1” bits in the binary notation of the net mask as shown in example 2.

Example 2

IP address: 192.168.5.0/25 indicates an IP address where the first 25 bits are used as the network address. (Subnet Mask is 255.255.255.128)

192.168.5.0/25	11000000.10101000.00000101.00000000
Subnet Mask /25, Class C	11111111.11111111.11111111.10000000
Network Portion	11000000.10101000.00000101.1 (binary-and result)
Host Portion	.- 00000000

The same rules apply to CIDR. The 1s in the Subnet Mask will always have the original IP address value as a result. The 0s in the Subnet Mask will have an end result of 0s, even if there were 1s in the IP address. This is just a measure to make sure that the network portion of the IP address always stays the same.

E.4 Router

The router is an integral part of the network. When an IP packet arrives at the network, routers ignore the host bits. They only need to match the network bits to find a route to the network. The router uses a combination of the network “base” address and “Subnet Mask” to determine whether this packet is at the correct destination. If the network address is not correct, the data packet will not be allowed to enter the network. However, if this network portion of the IP address is correct, the router will allow the data packet to enter. After allowing the data packet, the router must decide where to send this data packet. The destination address is extracted by examining the first two or three octets of the IP address.

For this the custom Subnet Mask is used. Once the address class has been determined, it is broken down into network and host bits (Figure E.4).

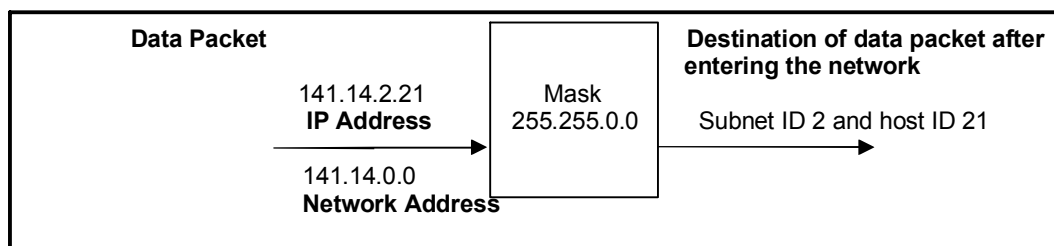


Figure E.4 IP address and IP Subnet Mask result

When the data packet destined for 141.14.2.21 arrives at the router, it knows that the network 141.14 is physically divided into three sub-networks. It also knows that the last two octets define the subnet ID and the host ID. Therefore, 2.21 must be interpreted as subnet ID 2 and host ID 21. The router uses the first two octets (141.14) as the network ID, the third octet (2) as the subnet ID and the fourth octet (21) as the host ID (Figure E.5).

First Octet	Second Octet	Third Octet	Fourth Octet
141	14	2	21
Network Address	Network Address	Subnet Address	Host Address

Figure E.5 Data packet octet explanation

Once a packet reaches its target network, its host field is examined for final delivery. The Subnet Mask is used with the network address to determine where the sub-network address is and where the host resides. Masking is the process used by routers to extract the physical network address from an IP address. If we have not sub-netted the network, masking extracts the network address from the IP address. If we have sub-netted, masking extracts the sub-network address from the IP address.

ANNEXURE F

This annexure contains text information concerned with a data packet entering the network. It may contain links to voice or animated material.

F.1 Data Packet entering the network

The router applied the Subnet Mask on the IP address and determined that the data packet is at the correct network. This data packet will now be allowed to enter the network as indicated by the circle in Figure F.1.

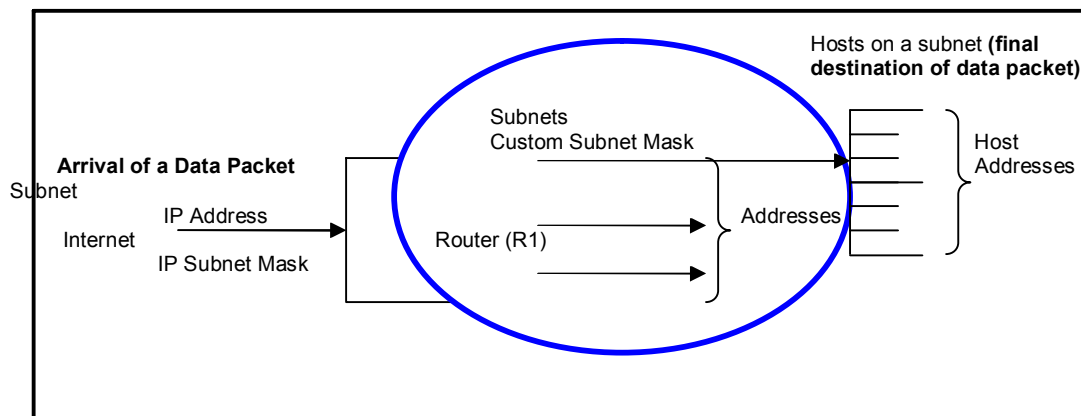


Figure F.1 Path of a data packet from start to finish

F.2 Router

We have already discussed the data packet's arrival at the router and the way the router deals with it. We now continue from where the router allowed the data packet to enter the network.

After allowing the data packet to enter the network, the router must decide where to send this data packet. The destination address is extracted by examining the first two or three octets of the IP address, using the custom Subnet Mask. Once the address class has been determined, it is broken down into network and host bits.

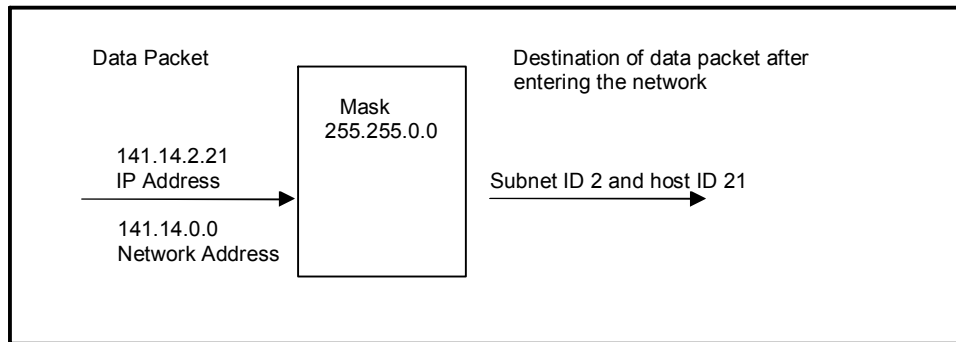


Figure F.2 IP address and IP Subnet Mask result

When the data packet destined for 141.14.2.21 arrives at the router, it knows that the network 141.14 is physically divided into three sub-networks (figure F.2). It also knows that the last two octets define the subnet ID and the host ID. Therefore, 2.21 must be interpreted as subnet ID 2 and host ID 21. The router uses the first two octets (141.14) as the network ID, the third octet (2) as the subnet ID and the fourth octet (21) as the host ID.

The subnet mask is used with the network address to determine where the sub-network address is and where the host resides.

Masking is the process routers use to extract the address of the physical network from an IP address. Masking can be done whether we have subnetting or not. If we have not sub-netted the network, masking extracts the network address from the IP address. If we have sub-netted, masking extracts the sub-network address from the IP address.

F.3 Subnetting

The purpose of subnetting is to enhance network performance by splitting large networks into separate subnets, each with its own number of hosts. The first step in understanding how to subnet, is to understand an IP address and Subnet Mask.

The explanation of IP address classes and the two forms of subnet notations, i.e. standard notation and CIDR (Classless Inter-Domain Routing) notation, makes it

easier to determine where the host ID part of the IP address resides. Both notations use a base address (or network address) to define the starting point of the network. It was mentioned earlier on that a 32-bit address can be subdivided into a network ID portion and a host ID portion. Now we have to add a subnet ID portion.

An IP address already accommodates a network ID and a host ID; all that is required is some way of creating the subnet ID field. We cannot expand the size of the IP address therefore we must “borrow” some bits from the existing address to use for the subnet ID. We have to borrow bits from the existing host ID field to create the subnet ID. The process of borrowing bits from the host ID field to form a new subnet ID field is known as subnetting.

F.4 Subnet

A subnet is exactly what the name suggests. It is part (smaller than the whole) of a larger network which can be identified in specific terms. A subnet contains a range of IP addresses and through the use of Subnet Masks and a network address, each subnet can be identified.

When dividing a network into sub-networks, the rest of the Internet is not aware of it. The sub-network still appears as a single network. To segment or divide the original network (IP Address), an addressing scheme able to identify each sub-network within the larger (original) network, must be devised. For this purpose an additional subnet ID, along with the original network ID and host ID, is required. A given host address is then uniquely identified through the combination of:

- 1) A network ID that uniquely specifies the network on which the host resides
- 2) A subnet ID that uniquely specifies the sub-network
- 3) A host ID that uniquely specifies the host on the sub-network

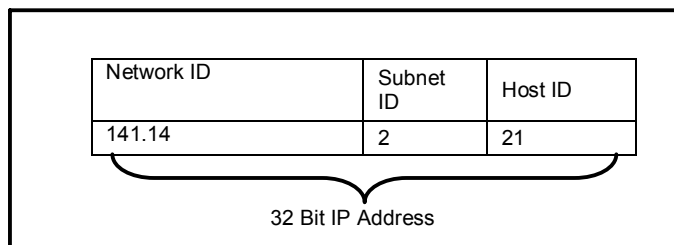


Figure F.3 Add a subnet ID

To divide the network into subnets, we need to “borrow” bits from the host ID (figure F.3). When borrowing bits from the host ID to create the subnet ID, the most critical issue is to accurately determine the number of subnets needed. The number of subnets can be calculated using the formula 2^n where n equals the number of bits to be borrowed from the host ID.

Example 1:

Say for instance we have an IP address: 192.138.50.0 and IP Subnet Mask: 255.255.255.0
If we need 5 subnets, the minimum number of bits that we have to “borrow” is 3.

To calculate the subnets we use $2^3 = 8$.

In Example 1, we borrowed three bits from the original host ID portion. This allowed us to split a single network portion into 8 smaller network portions.

Another formula to calculate the number of bits to be borrowed from the host ID is:

$$n = \frac{\log s}{\log 2} \quad \text{where } s \text{ is the number of subnets needed for the network and } n \text{ the number of bits to be borrowed, (Example 2).}$$

Example 2:

Using the values of example 1, we get the following:

$$\frac{\log 5}{\log 2} = 2.33 \text{ (If answer is 2.33, take the next integer which is 3)}$$

The bits we borrowed from the host ID portion will now become the subnet bits. Since we borrowed bits from the host ID, the original Subnet Mask is no longer accurate. We need to create a custom Subnet Mask to identify the subnet portion of the IP address.

F.5 Custom Subnet Mask

We saw in section 3.3 that the IP Subnet Mask is no longer valid because we added an additional portion to the IP address. As a result of the new subnet ID portion, we need to create a new custom Subnet Mask for the subnets. This is done by using the subnet bits in conjunction with the default Subnet Mask.

In example 1, three subnet bits were needed to create 8 subnets. To generate the new custom Subnet Mask, add up the binary bit values of all the 1- bits in the subnet portion (Figure F.4). A total value of 224 (128 + 64 + 32) is obtained. The custom Subnet Mask will be 192.138.50.224.

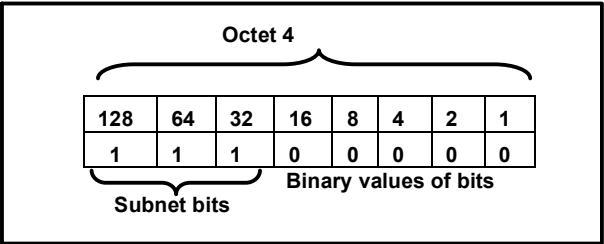


Figure F.4 Decimal value of octet 4

The IP Subnet Mask and custom Subnet Mask will be used by the router to send a data package to its final destination (Figure F.5).

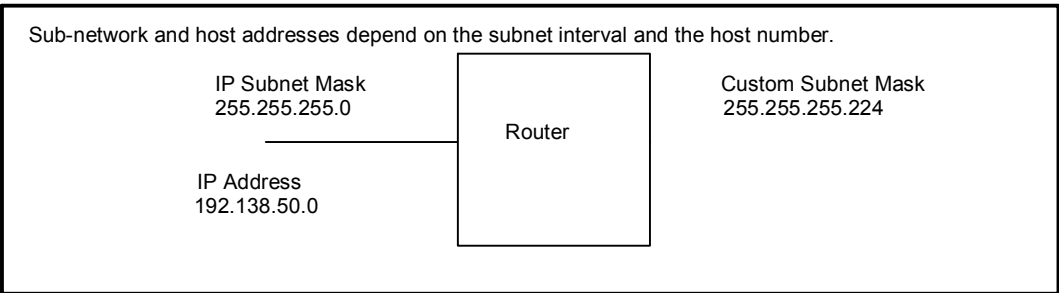


Figure F.5 Create Custom Subnet Mask with subnetting

F.5.1 Custom Subnet Mask in more than one octet

Consider an IP address 192.38.252.0 with an IP Subnet Mask of 255.255.252.0: We have to subnet this address in order to build 8 new subnets with 126 hosts on each sub-network. Three bits are needed for the 8 subnets. To achieve this, we use the last two bits of the third octet and the first bit of the fourth octet for the subnet portion of our IP address.

We know that we have to create a new custom Subnet Mask every time we create new subnets. The new Subnet Mask address (custom Subnet Mask) will look like

this: 255.255.255.128. We have added the value of three (3) to the third octet's value of 252, obtained from the 2 subnet bits in the third octet (Figure F.6), and we use the binary bit value of 128 from the fourth octet.

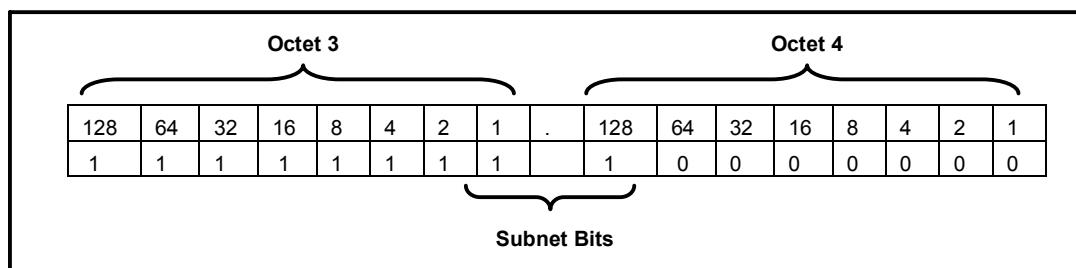


Figure F.6 Custom Subnet Mask stretching over two octets

F.5.2 Subnet Address

When determining the address for each sub-network, the previous address (network address) should be considered. If the subnet bits reside in the same octet than the network address, it must be added to the network address for that particular octet. Herewith the subnet address is determined. Looking at Table F.1, the subnet addresses will be determined as follows:

Firstly, the 8 combinations of the three subnet bits in octets 3 and 4 will be determined. Thereafter, we will add the values of the 1- bits to their respective octets to get the decimal value of that IP address.

Octet 1	Octet 2	Octet 3			Octet 4		
		2	1	Dec. Value	128	Dec. Value	Subnet addresses
192	38	0	0	252	0	0	192.38.252.0
192	38	0	0	252	1	128	192.38.252.128
192	38	0	1	253	0	0	192.38.253.0
192	38	0	1	253	1	128	192.38.253.128
192	38	1	0	254	0	0	192.38.254.0
192	38	1	0	254	1	128	192.38.254.128
192	38	1	1	255	0	0	192.38.255.0
192	38	1	1	255	1	128	192.38.255.128

Table F.1 Network address: 192.38.252.0

It can be seen that, although the network value of the third octet was 252, we added the values of the subnet bits to the network address in the third octet (the value in this octet being 252, the added subnet bits values (3) resulted in a value of 255). The new value for octet 3 will be 255. The same was done for the fourth

octet; we add 128 where the bit value was a 1. Together they form the new address for the sub-network.

If all the subnet bits reside in one octet only, the subnet intervals for each subnet are determined by looking at the lowest value of the subnet bits from the right of the octet in which the subnet bits are being “borrowed” (Figure F.7). The subnet interval in Figure F.7 is 32.

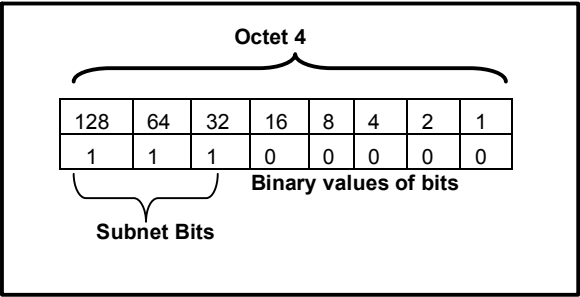


Figure F.7 Subnet Interval

The increment value of subnets is determined by using the first subnet binary value from the right in the octet where the subnet values reside as shown in Table F.2.

128	64	32	16	8	4	2	1	
N	N	s	S	s	H	h	h	This increment value is 8
N	s	s	S	h	H	h	h	This increment value is 16
s	s	h	H	h	H	h	h	This increment value is 64

Table F.2 Increment values

N = network bits
s = subnet bits
h = host bits

ANNEXURE G

This annexure contains information for determining the final destination. It may also contain links to voice or animated material.

G.1 Determine the final destination

In the previous section we discussed the entry of a data packet into the network. In this section, its final destination will be explained (Figure G.1).

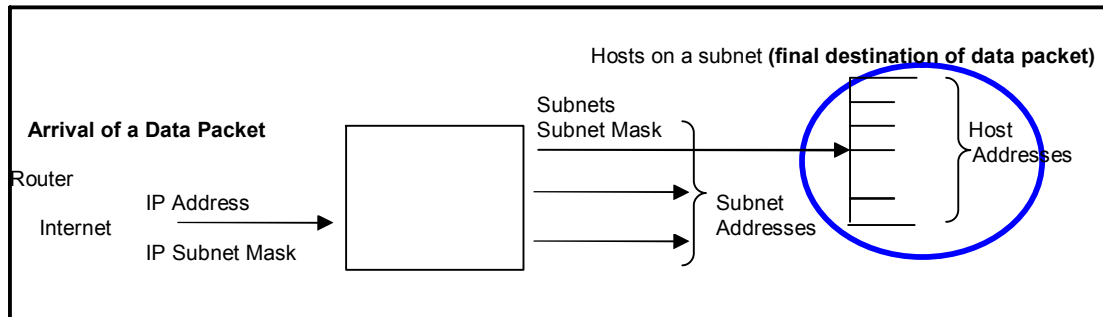


Figure G.1 Final destination of a data packet

As a result of the new subnet ID portion, we added a new custom Subnet Mask for the subnets by using the subnet bits in combination with the default Subnet Mask. The IP Subnet Mask and custom Subnet Mask will be used by the router to send the data package to its final host destination.

G.2 Host

A host is a device which is connected to the sub-network and has its own individual address. It can be a printer, other computers or any other device using an IP address. All the remaining bits after the subnet bits are used for hosts. The formula, $h = 2^n - 2$, is used to calculate how many hosts there are for each subnet, with n the number of bits used for the host portion of the address. The reason we subtract 2 is because all 0 - values and all 1 - values are reserved for the network ID and broadcast address.

For instance, if the Subnet Mask consist of 27 bits (this include octet 1, 2 and octet 3), it leaves 5 bits for the host addresses ($32 - 27 = 5$). This allows us to use 30 hosts on each subnet ($2^5 - 2 = 32 - 2 = 30$).

G.3 Host Address

Every host on a network has a unique address to identify itself and to receive and send data packets. The host address is very important as it ensures that there will be no clashes with regard to the destination of information over the Internet. The router compares each and every host address with the address of the data packet, thereby ensuring that the information reaches the correct final destination.

Host addresses are shown in Table G.1. Octets 1, 2 and 3 are excluded, as all the subnet and host bits are in the fourth octet.

Octet 4								Subnet Value	Host range
128	64	32	16	8	4	2	1		
0	0	0	0	0	0	0	1	0	1 - 31
0	0	1	0	0	0	1	0	32	32 - 63
0	1	0	0	0	0	1	1	64	64 - 95
0	1	1	0	0	1	0	0	96	96 - 127
1	0	0	0	0	1	0	1	128	128 – 159
1	0	1	0	0	1	1	0	160	160 – 191
1	1	0	0	0	1	1	1	192	192 – 223
1	1	1	0	1	0	0	0	224	224 – 254

Table G.1 Host addresses

ANNEXURE H

This annexure contains a text example on subnetting.

Example 1:

IP address: 135.105.0.0 registered for company ABC, Inc. The company needs 5 subnets and the maximum quantity of hosts.

Step 1:

Determine the address class of the IP address by matching it to the different ranges of each network class. We found it to be a Class B address as the leftmost octet is between the ranges 128 – 191.

The table below shows the standard number of host ID bits for each of the three major address classes A, B and C. To determine the address class of a network ID, look at the first octet in dotted decimal notation as indicated in Table H.1.

Address Class	Starting Octet for network ID	Network ID bits in Standard Subnet Mask	Host ID bits in standard Subnet Mask
A	1 - 127	8	24
B	128 - 191	16	16
C	192 - 223	24	8

Table H.1 Table of network classes

Step 2:

Determine the default Subnet Mask. The Subnet Mask has a default value for each address class. The default Subnet Mask for Class B is 255.255.0.0

Step 3:

Using the answer in step 2, determine how many bits of the Subnet Mask are set to 1s starting from the left.

IP Address: 135.105.0.0
Subnet Mask Class B: 255.255.0.0 (255 represents "11111111")
How many 1s: 8 8 - - = 16 ones

Step 4:

The answer from step 3 will also tell how many bits are dedicated to the network portion of the IP address. The network portion in this case has 16 bits, equal to 2 octets. This leaves the other 16 bits for the host ID portion of the address.

Step 5:

Draw a line separating the network ID portion of the IP address from the host ID portion:

135.105.|0.0

Using n to represent the network bits and h for the host bits, the address will look like this:

nnnnnnnn.nnnnnnnn.|hhhhhhhh.hhhhhhhh

With this in mind, let us determine the amount of hosts we can have on the network of 135.105.0.0. There is only one formula to calculate the amount of hosts, and that is $2^n - 2$, where n is the number of bits. There are 16 bits dedicated to the host address which gives us $2^{16} - 2 = 65534$ possible hosts.

Step 6:

Now ABC has grown and the company would like to split their LAN into separate independent networks. This is done through subnetting. To define separate subnets, we need to play with the Subnet Mask of the Class B address, already indicated as 255.255.0.0

To start the subnetting process, one will “borrow” bits from the host portion of the IP address and dedicate them to the subnet. How many bits to borrow depend on the number of subnets, or the number of hosts per subnet required.

ABC needs to split up their LAN into 5 subnets. The nearest amount of bits that will give 5 subnets is 3, which will give $2^3 = 8$ subnets. We therefore have to “borrow” 3 bits from the leftmost zero octet which leave us with 5 remaining bits for that octet.

It is safer to make sure that the subnets are comfortably large before increasing the hosts.

The IP address will look like this:

nnnnnnnn.nnnnnnnn.ssshhhh.hhhhhhhh

We use an “s” to indicate the subnet bits “borrowed” from the host portion.

Step 7:

The IP address will look like this:

nnnnnnnn.nnnnnnnn.ssshhhh.hhhhhhhh

Look at the remaining h (host bits) in the IP address. Thirteen bits remain to be used for the host, giving us the total of $2^{13} - 2 = 8190$ hosts per subnet. The TCP/IP standards determine that a host ID cannot be all 0s (current host) or all 1s (broadcast address). The formula for finding the number of bits needed for the host IDs is $2^n - 2$, where n is the bits available or needed for the host ID portion of the IP address.

Step 8:

Since we have determined the values of the subnets and hosts, we need to create a new Subnet Mask for the subnets. Look at the leftmost zero octet where we borrowed the bits for the subnets and where the host bits start (Table H.2). When evaluating that octet, we see the following:

s	s	s	h	h	h	h	h
128	64	32					

Table H.2 Leftmost zero octet

The decimal equivalent of the three subnet bits in the leftmost zero octet is 224 (Table H.2), which means that we have added them (128 + 64 + 32). This value will be used for the third octet in the new Subnet Mask. The new Subnet Mask will look as follows:

255.255.224.0

Now one has to determine the address that will be used for each subnet in the third octet. There are two options:

- a) Take the rightmost “s” and find its decimal value, which is 32
- OR
- b) Take 256 and subtract the Subnet Mask of 224, which is $256 - 224 = 32$

The 32 presents the range increment (R.I.) for the subnets. Take the 3 bits and determine the subnets:

135.105.0.0
135.105.32.0
135.105.64.0
135.105.96.0
135.105.128.0
135.105.160.0
135.105.192.0
135.105.224.0

We will extend the network ID portion of the default Subnet Mask by replacing its leftmost zero octet with a new value as indicated in table H.3.

Address Class	Default Subnet Mask	Leftmost Zero Octet
A	255.0.0.0	255.0.0.0
B	255.255.0.0	255.255.0.0
C	255.255.255.0	255.255.255.0

Table H.3 Class, default Subnet Mask and leftmost zero octet

Step 9:

Finally, we need to determine the address to be assigned to the hosts.

nnnnnnnn.nnnnnnnn.ssshhhhh.hhhhhhhh

For this, we work with s and h. Starting with 0s for the ss and with 1 for the hs, we get a 00000000.00000001 in binary which is 0.1 in decimal. This will be the first host address.

Now we make all the ss a 1 and all the hs a 1, except for the last h which must stay a 0. We have added one to the starting numbers of all 0s and subtracted 1 from all

1s of the last number in the range. The last host address will be 11111111.11111110. This is because we cannot use all 0s and all 1s. The all 0s is the network address and the all 1s is the broadcast address.

Step 10:

The last step is to take the original IP address (first two octets) and put it in front of these subnets.

ANNEXURE I

This annexure contains the text information of an example.

Slide 1

In example 1 we have an IP Address of 172.16.255.254 and want to know how many subnets can be created with at least 7000 users each.

We also have to determine the broadcast address and address ranges for each subnet.

Specific steps for finding the solution to this problem will be followed and explained in the next slides.

Slide 2 (Step 1)

In step 1, we have to make sure that we know what type of IP address it is. The type of IP address is very important, as it will give us an indication of the Subnet Mask this IP address belongs to.

There are two ways of writing an IP address: The first is the normal way, such as 172.16.255.245. The second way is to include a forward slash sign with a number after the last octet of the IP address. This type of IP address is called a CIDR address. The number after the forward slash sign means that we have to include that many 1s in the binary notation of the Subnet Mask from left to right.

In this example, we have an IP address without the forward slash sign. We have to determine to which address class this IP address belongs. In order to do so, we compare the first octet of our IP address, which is 172, with the address ranges. It fits in the range 128 to 191. That means that we have a Class B address with a Subnet Mask of 255.255.0.0, which concludes step 1.

Slide 3 (Step 2)

In step 2 we want to separate the network portion of the IP address from the host portion of the IP address.

To do this, we need to take the dot-decimal value of the IP address and the Subnet Mask and convert it to binary.

After converting the values to binary, we need to do a “AND” logic operation on the IP address and the Subnet Mask. The result of these two values is the network portion of the IP address. The ns and hs indicate which part of the IP address belongs to the network portion and which part to the host portion.

Slide 4 (Step 3)

In step 3, we already know how many bits of the IP address belong to its host portion. From here on, we are only working with the host bits. The network bits will never change.

We know from the problem statement that as many subnets as possible, each with at least 7000 hosts, are needed.

Firstly, we determine how many bits are needed to have at least 7000 hosts. For calculating the hosts, we use the formula, two to the power b minus 2 equals h, where b equals the number of bits needed for the hosts.

Looking at the table, we see that two to the power 10 minus two equals 1022, which is less than 7000. Likewise, two to the power 12 minus 2 equals 4094, is still short of 7000. However, two to the power 13 minus 2 equals 8190, which is more than sufficient.

If we substitute the hs in the IP address, there are only three bits left for the subnets. The formula to calculate the subnets is two to the power b, and in this case b equals three as there are only three bits left for the subnets. Therefore, two to the power 3 equals eight subnets. The letter “s” in the IP address is used to indicate the subnets. The number of subnets we have is eight, and each subnet will have 8190 hosts.

Slide 5 (Step 4)

In step four, we will determine the new custom Subnet Mask, as well as the interval for each subnet.

To create the custom Subnet Mask, we look at the octet in which the subnet bit or bits reside. In this case, it is octet three. We take the binary values of the subnet bits which are 128, 64 and 32 and add them up to get the total value of 224.

This value is placed in the third octet to get a new custom Subnet Mask of 172.16.224.0. The three subnet bits will be part of the new network address. The ss are substituted for ns in the new custom Subnet Mask.

We also have to determine the size of each subnet by determining the interval for each subnet. The easiest way of doing this is to find the first subnet bit from the right, in this case 32. This value 32 indicates the interval for each subnet.

To conclude step four, we know that we have eight subnets, each with an interval of 32 and 8190 hosts.

Slide 6 (Step 5)

In step 5, we will write down the subnet address range of each subnet. The first subnet range starts with a zero and ends with one number less than the interval, the first subnet therefore ending with 31. The second interval starts with the interval value of 32 and ends with one number less than the interval, which is the value of 63.

There are eight subnets, each with an interval value of 32. The table displays the values of the other subnets.

Slide 7 (Step 6)

In step six, we need to make sure that we know exactly how to write down the host addresses.

The following principles should be considered:

The host address range will always start with zero plus one and end with maximum minus one. The hosts in this case will start with one and end with 254.

The zeros and ones are used for network and broadcast addresses, this being the reason why they cannot be used for host addresses.

Slide 8 (Step 7)

The last step of this example is to apply what has been discussed in step six.

In the host address, we use the network portion of the IP address first, followed by the subnet portion, and then start with a one. The last address of the range will have the same sequence of the start host address, but the last value will be the maximum value minus one.

The broadcast address will always have the network portion of the IP address, the highest value of the subnet range and the highest host address plus one.

ANNEXURE J

This annexure contains the text information of a video version of annexure H and is concerned with subnetting examples.

Video 1

Problem

You are given the following IP address: 172.16.255.254. How many subnets with 7000 users each can you create? What Subnet Mask is required on each subnet? Determine the address ranges and broadcast address for each subnet.

Step 1

The CIDR notation is not used in this case. We therefore have to determine the address class of this IP address in order to get the corresponding Subnet Mask. The first octet (172) is in the interval 128 – 191, putting this IP address in network class B. The Subnet Mask is 255.255.0.0.

Step 2

By doing an “AND” logic arithmetic operation (Figure J.1), we can determine how many bits of the IP address (172.16.255.254) is part of the network address.

IP address:	172.16.255.245	in binary:	10101100.00010000.11111111.11111110
Subnet Mask (class B)	255.255.0.0	in binary:	11111111.11111111.00000000.00000000
binary “AND”	172.16. 0.0	in binary:	10101100.00010000.00000000.00000000

Figure J.1 Results of a binary AND operation

Step 3

We know from step 2 that 16 bits are dedicated to the network portion of the IP address and 16 bit to the host ID portion. The IP address can be written as follows:

nnnnnnnn.nnnnnnnn.hhhhhhhh.hhhhhhhh

n = network bits of the IP address

h = host bits of the IP address

Step 4

To create subnets, we have to “borrow” from the original host ID portion of the IP address. The formula to determine subnets is $s = 2^x$ and for hosts it is $h = 2^x - 2$, where x is the number of bits needed. We first want to determine how many bits are needed for the 7000 hosts of each subnet.

$$\begin{aligned}h &= 2^n - 2 \\&= 2^{13} - 2 \\&= 8192 - 2 \\&= 8190 \text{ hosts}\end{aligned}$$

We need 13 bits for the hosts to ensure that there are at least 7000 host per subnet. Thus, we had 16 bits available for the host ID portion. Subtracting the 13 bits from the 16 bits ($16 - 13 = 3$), leaves us with 3 bits for the subnets. This means that we have to “borrow” three (3) bits from the host ID bits.

If we write the network address again, this time with the host bit and subnet bits, it will look like this:

nnnnnnnn.nnnnnnnn.ssshhhh.hhhhhhhh
s = subnet bits of the IP address

To determine how many subnets we have, the following formula applies:

$$\begin{aligned}s &= 2^n \\&= 2^3 \\&= 8 \text{ subnets}\end{aligned}$$

Step 5

In this step, we have to determine the interval of each subnet. Look at the explanation of the IP address:

nnnnnnnn.nnnnnnnn.ssshhhh.hhhhhhhh

s	S	S	h	h	h	h	h
1	1	1	0	0	0	0	0
128	64	32					

Table J.1 Determine interval

From the above, we see that the first “1” bit value of the subnet in octet three, counting from the right is 32, as shown in Table J.1. This will be the interval (width) of each subnet.

The new Subnet Mask, called the custom Subnet Mask for the subnets, will be 255.255.224.0. The value of 224 in the third octet is determined by adding up the binary values for all the subnet bits.

Step 6

Since the number of subnets and their intervals are known to us, we can proceed with writing down the range of each interval. In octet 3, the subnet will start with 0 and increase with 32 in every subnet thereafter, as indicated in Table J.2.

	Start	End
Subnet 1	172.16.0.0	172.16.31.0
Subnet 2	172.16.32.0	172.16.63.0
Subnet 3	172.16.64.0	172.16.95.0
Subnet 4	172.16.96.0	172.16.127.0
Subnet 5	172.16.128.0	172.16.159.0
Subnet 6	172.16.160.0	172.16.191.0
Subnet 7	172.16.192.0	172.16.223.0
Subnet 8	172.16.224.0	172.16.255.0

Table J.2 Range of intervals

Bear in mind that all 0s (zeros) and all 1s (ones) are network and broadcast addresses and cannot be used in the addresses of any hosts.

Step 7

The Broadcast addresses for each host address can be determined by making all the bits in each subnet 1s. In Table J.3 (step 8) the broadcast addresses for each subnet are shown.

Step 8

The subnet addresses have been created, but the range of host addresses must still be done. The host address will always start with a 1 (one) and end with the highest number less 1 (Table J.3).

Subnet Addresses	Custom subnet Mask	Host Size	Host Range	Broadcast Address
172.16.0.0	255.255.224.0	8190	172.16.0.1 to 172.16.31.254	172.16.31.255
172.16.32.0	255.255.224.0	8190	172.16.32.1 to 172.16.63.254	172.16.63.255
172.16.64.0	255.255.224.0	8190	172.16.64.1 to 172.16.95.254	172.16.95.255
172.16.96.0	255.255.224.0	8190	172.16.96.1 to 172.16.127.254	172.16.127.255
172.16.128.0	255.255.224.0	8190	172.16.128.1 to 172.16.159.254	172.16.159.255
172.16.160.0	255.255.224.0	8190	172.16.160.1 to 172.16.191.254	172.16.191.255
172.16.192.0	255.255.224.0	8190	172.16.192.1 to 172.16.223.254	172.16.223.255
172.16.224.0	255.255.224.0	8190	172.16.224.1 to 172.16.255.254	172.16.255.255

Table J.3 Subnet addresses

ANNEXURE K

This annexure contains the text information of a video version of subnetting examples.

Video 2

Problem

Given the IP address 172.16.30.0/24, you are required to create the following four networks: Network one with 100 users, network two with 50 users and networks three and four with 25 users each. Determine the Subnet Mask to be used on each subnet. What is the base network ID on each subnet? Determine the address ranges and broadcast address for each subnet.

Step 1

The CIDR notation is used in this case. The “/24” means that we have to use 24 bits for the Subnet Mask which gives us a 255.255.255.0 Subnet Mask. Remember that 255 means all the bits in an octet are 1s (ones).

Step 2

By doing an “AND” logic arithmetic operation (Figure K.1), we can determine how many bits of the IP address (172.16.30.0/24) is part of the network address.

IP address:	172.16.30.0 in binary:	10101100.00010000.00011110.00000000
Subnet Mask (class B)	255.255.0.0 in binary:	11111111.11111111.11111111.00000000
“AND” operation	172.16.30.0 in binary:	10101100.00010000.00011110.00000000

Figure K.1 Example of binary AND operation

Step 3

We know from step 2 that 24 bits are dedicated to the network portion of the IP address and 8 bits to its host ID portion. The IP address can be written as follows:

nnnnnnnn.nnnnnnnn.nnnnnnnn.hhhhhhhh
n = network bits of the IP address
h = host bits of the IP address

Step 4

To create subnets, we have to “borrow” from the original host ID portion of the IP address. The formula to determine subnets is $s = 2^x$ and for hosts, $h = 2^x - 2$, where x is the number of bits needed. We first want to determine how many bits are needed for 100 hosts.

$$\begin{aligned}h &= 2^n - 2 \\&= 2^7 - 2 \\&= 128 - 2 \\&= 126 \text{ hosts}\end{aligned}$$

Seven bits for the hosts are needed to ensure that there are at least 100 hosts per subnet. Thus, we have 8 bits available for the host ID portion. Subtracting the 7 bits from the 8 bits ($8 - 7 = 1$), leaves us with 1 bit for the subnets. This means that we have to “borrow” one (1) bit from the host ID bits.

If we write the network address again, this time with the host bit and subnet bits, it will look as follows:

nnnnnnnn.nnnnnnnn.nnnnnnnn.shhhhhhh

s = subnet bits of the IP address

To determine how many subnets we have, the following formula is used:

$$\begin{aligned}s &= 2^n \\&= 2^1 \\&= 2 \text{ subnets}\end{aligned}$$

Step 5

In this step we have to determine the interval of each subnet. Look at the explanation of the IP address:

nnnnnnnn.nnnnnnnn.nnnnnnnn.shhhhhhh

s	H	h	h	h	h	h	H
128							

Table K.1 Interval of subnet

From the above, we see that the first value of the subnet in octet three, counting from the right, is 128, as shown in Table I.1. This will be the interval (width) of each subnet.

The new Subnet Mask, called the custom Subnet Mask for the subnets, will be 255.255.225.128. The value of 128 in the third octet is determined by adding up the binary values for all the subnet bits.

Step 6

Since the number of subnets and their intervals are known to us, we can proceed with writing down the range of each interval. The subnet will start in octet 3 with 0 and increase with 128 in every subnet thereafter.

	Start	End
Subnet 1	172.16.30.0	172.16.30.127
Subnet 2	172.16.30.128	172.16.30.254

Table KI.2 Interval of the subnet

All 0s (zeros) and all 1s (ones) are network and broadcast addresses and cannot be used in the addresses of any hosts.

Step 6 a

Two subnets with 50 hosts each are needed, as we have to subnet the second one again in order to get the second and third subnets. Starting from step 1 again, we proceed as follows:

Step 6.a1

The CIDR notation is used in this case. The net mask is now “/25”, as we already have 1 subnet bit giving us a 255.255.255.128 Subnet Mask. Remember that 255 means all the bits in an octet are 1s (ones).

Step 6.a2

By doing an “AND” logic arithmetic operation (Figure K.2), we can determine how many bits of the IP address (172.16.30.128/25) are part of the network address.

IP address: 172.16. 30. 128 in binary: 10101100.00010000.00011110.10000000
Mask (class B) 255.255.255.128 in binary: 11111111.11111111.11111111.10000000
binary “AND” 172.16. 30. 128 in binary: 10101100.00010000.00011110.10000000

Figure K.2 Example of binary AND operation

Step 6.a3

We know from step 2 that 25 bits are dedicated to the network portion of the IP address and 7 bits to its host ID portion. We can write the IP address as follows:

nnnnnnnn.nnnnnnnn.nnnnnnnn.nhhhhhhh

n = network bits of the IP address

h = host bits of the IP address

Step 6.a4

To create subnets, we have to “borrow” from the original host ID portion of the IP address. The formula to determine subnets is $s = 2^x$ and for hosts, $h = 2^x - 2$, where x is the number of bits needed. We first want to determine how many bits we need for 50 hosts.

$$\begin{aligned} h &= 2^n - 2 \\ &= 2^6 - 2 \\ &= 64 - 2 \\ &= 62 \text{ hosts} \end{aligned}$$

Six bits are needed for the hosts to ensure that there are at least 50 hosts per subnet. Thus, we have 7 bits available for the host ID portion. Subtracting the 6 bits from the 7 bits ($7 - 6 = 1$) leaves us with 1 bit for the subnets. This means that we have to “borrow” a one (1) bit from the host ID bits.

Writing the network address again, this time with the host bit and subnet bits, it will look as follows:

nnnnnnnn.nnnnnnnn.nnnnnnnn.nshhhhhh

s = subnet bits of the IP address

To determine how many subnets we have, the following formula is used:

$$\begin{aligned} s &= 2^n \\ &= 2^1 \\ &= 2 \text{ subnets} \end{aligned}$$

Step 6.a5

In this step we have to determine the interval of each subnet. Look at the explanation of the IP address:

nnnnnnnnn.nnnnnnnnnn.nnnnnnnnn.nshhhhhh

n	S	h	h	h	h	h	h
128	64						

Table K.3 Indicate the binary value of “s”

From the above, we see that the first value of the subnet in octet three, counting from the right, is 64, as indicated by Table K.3. This will be the interval (width) off each subnet.

The new Subnet Mask, called the custom Subnet Mask for the subnets, will be 255.255.225.192. The value of 192 in the third octet is determined by adding up the binary values (1s) for all the subnet bits.

Step 6 b

We need two subnets with 25 hosts each, therefore we have to subnet the third subnet again to get the third and fourth subnets. We start once more from step 1.

Step 6.b1

The CIDR notation is used in this case. The net mask is now “/26”, as we already have 1 subnet bit which gives us a 255.255.255.192 Subnet Mask. Be reminded that 255 means all the bits in an octet are 1s (ones).

Step 6.b2

By doing an “AND” logic arithmetic operation (Figure K.3), we can determine how many bits of the IP address (172.16.30.192/26) are part of the network address.

IP address:	172.16.	30.192	in binary:	10101100.00010000.00011110.11000000
Mask (class B)	255.255.255.192		in binary:	11111111.11111111.11111111.11000000
binary "AND"	172.16.	30.192	in binary:	10101100.00010000.00011110.11000000

Figure K.3 Example of binary AND operation

Step 6.b3

From step 2 it is known that 26 bits are dedicated to the network portion of the IP address and 6 bits to its host ID portion. The IP address is written as follows:

nnnnnnnn.nnnnnnnn.nnnnnnnn.nnhhhhhh

n = network bits of the IP address

h = host bits of the IP address

Step 6.b4

To create subnets, we have to “borrow” from the original host ID portion of the IP address. The formula for determining subnets is $s = 2^x$ and for hosts, $h = 2^x - 2$, where x is the number of bits needed. We first want to determine how many bits we need for 25 hosts.

$$\begin{aligned}
 h &= 2^n - 2 \\
 &= 2^5 - 2 \\
 &= 32 - 2 \\
 &= 30 \text{ hosts}
 \end{aligned}$$

Five bits for the hosts are needed to ensure that we have at least 25 hosts per subnet. Thus, we have 6 bits available for the host ID portion. Subtracting the 5 bits from the 6 bits ($6 - 5 = 1$), we are left with 1 bit for the subnets. This means that we have to “borrow” one (1) bit from the host ID bits.

Writing the network address again, this time with the host bit and subnet bits, it will look as follows:

nnnnnnnn.nnnnnnnn.nnnnnnnn.nnshhhhh

s = subnet bits of the IP address

To determine the number of subnets we have, the following formula is used:

$$\begin{aligned} s &= 2^n \\ &= 2^1 \\ &= 2 \text{ subnets} \end{aligned}$$

Step 6.b5

In this step, we have to determine the interval of each subnet. Look at the explanation of the IP address:

nnnnnnnnn.nnnnnnnnnn.nnnnnnnnnn.nnshhhhh

n	N	s	h	H	h	H	h
128	64	32					

Table K.4 Interval of the subnet

From the above, we see that the first value of the subnet in octet three, counting from the right, is 32, as indicated in Table K.4. This will be the interval (width) of each subnet.

The new Subnet Mask, called the custom Subnet Mask for the subnets, will be 255.255.225.224. The value of 224 in the third octet is determined by adding up the binary values for all the subnet bits (128, 64 and 32).

	Start	End
Subnet 1	172.16.30.0	172.16.30.127
Subnet 2	172.16.30.128	172.16.30.191
Subnet 3	172.16.30.192	172.16.30.223
Subnet 4	172.16.30.224	172.16.30.255

Table K.5 Interval of each subnet

Step 7

The Broadcast address for each host address can be determined by making all the bits in each subnet 1s. In Table K.6 (step 8) the broadcast addresses for each subnet are shown.

Step 8

Having created the subnet addresses, we need to show the range of host addresses as indicated in Table K.6. The host address will always start with a 1 (one) and end with the highest number less 1. The network is shown in Figure K.4.

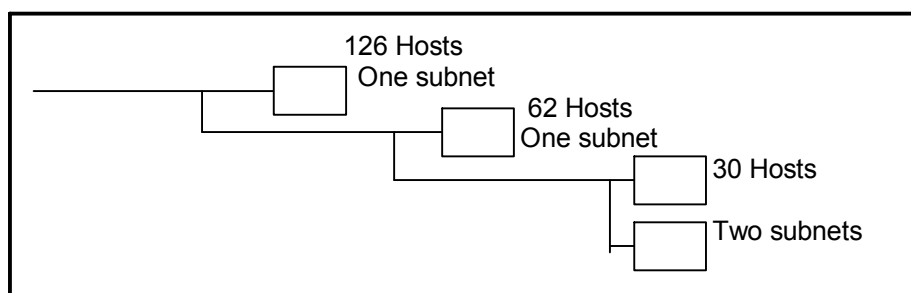


Figure K.4 Network lay-out

Subnet Addresses	Custom Subnet Mask	Host Size	Host Range	Broadcast Address
172.16.30.0	255.255.255.128	126	172.16.30.1 to 172.16.30.126	172.16.30.127
172.16.30.128	255.255.255.192	62	172.16.30.129 to 172.16.30.191	172.16.30.192
172.16.30.192	255.255.255.224	30	172.16.30.193 to 172.16.30.223	172.16.32.224
172.16.30.224	255.255.255.224	30	172.16.30.225 to 172.16.30.254	172.16.32.255

Table K.6 Sub-network addresses

ANNEXURE L

This annexure contains the text information of a video example of subnetting.

Video 3

Problem

You are the network administrator of the company. The IT manager, concerned with address reduction, gave you the task to subnet the IP address 172.16.0.0. The default gateway address is already assigned as 172.16.0.1. Two thousand, four hundred (2400) hosts should be provided for. Show in table form the address range of your subnets, as well as the address range for your hosts on each subnet. 1-bit subnets are allowed. Also show the address that will be used for broadcast purposes.

Step 1

The CIDR notation is not used in this case. We have to determine which Subnet Mask to use for this IP address. The value of the first octet is within the interval 128 – 192, which makes this a class B IP address with a Subnet Mask address of 255.255.0.0. It should be borne in mind that 255 means all the bits in an octet are 1s (ones).

Step 2

By doing an “AND” logic arithmetic operation (Figure L.1), we can determine how many bits of the IP address (172.16.0.0) are part of the network address.

IP address:	172.	16.0.0	in binary:	10101100.00010000.00000000.00000000
Mask (class B)	255.255.0.0	in binary:	11111111.11111111.00000000.00000000	
binary “AND”	172.	16.0.0	in binary:	10101100.00010000.00000000.00000000

Figure L.1 Example of binary AND operation

Step 3

From step 2, we know that 16 bits are dedicated to the network portion of the IP address and 16 bits to its host ID portion. The IP address can be written as follows:

nnnnnnnn.nnnnnnnn.hhhhhhhh.hhhhhhhh

n = network bits of the IP address
h = host bits of the IP address

Step 4

To create subnets, we have to “borrow” from the original host ID portion of the IP address. The formula for determining subnets is $s = 2^x$ and for hosts, $h = 2^x - 2$, where x is the number of bits needed. We first want to determine how many bits are needed for 2400 hosts.

$$\begin{aligned} h &= 2^n - 2 \\ &= 2^{12} - 2 \\ &= 4096 - 2 \\ &= 4094 \text{ hosts} \end{aligned}$$

Twelve (12) bits for the hosts are needed to ensure that we have at least 2400 hosts per subnet. Thus, we have 16 bits available for the host ID portion. Subtracting the 12 bits from the 16 bits ($16 - 12 = 4$), leaves us with 4 bits for the subnets. This means that we have to “borrow” four (4) bits from the host ID bits.

The network address with the host bit and subnet bits will look as follows:

nnnnnnnn.nnnnnnnn.sssshhhh.hhhhhhhh

s = subnet bits of the IP address

To determine the number of subnets, the following formula is used:

$$\begin{aligned} s &= 2^n \\ &= 2^4 \\ &= 16 \text{ subnets} \end{aligned}$$

Step 5

In this step, we have to determine the interval of each subnet. Look at the explanation of the IP address:

nnnnnnnn.nnnnnnnn.sssshhhh.hhhhhhhh

S	s	s	S	h	h	H	h
128	64	32	16				

Table L.1 New Subnet Mask

From the above, we see that the first value of the subnet in octet three, counting from the right, is 16 (Table L.1). This will be the interval (width) of each subnet.

The new Subnet Mask, called the custom Subnet Mask for the subnets, will be 255.255.225.240. The value of 240 in the third octet is determined by adding up the binary values for all the subnet bits (128, 64, 32, and 16).

Step 6

Since the number of subnets and their intervals are known to us, we can proceed with writing down the range of each interval. The subnet will start in octet 3 with 0 and increase with 16 in every subnet thereafter, as shown in Table L.2.

	Start	End
Subnet 1	172.16.0.0	172.16.15.0
Subnet 2	172.16.16.0	172.16.31.0
Subnet 3	172.16.32.0	172.16.47.0
Subnet 4	172.16.48.0	172.16.63.0
Subnet 5	172.16.64.0	172.16.79.0
Subnet 6	172.16.80.0	172.16.95.0
Subnet 7	172.16.96.0	172.16.111.0
Subnet 8	172.16.112.0	172.16.127.0
Subnet 9	172.16.128.0	172.16.143.0
Subnet 10	172.16.144.0	172.16.159.0
Subnet 11	172.16.160.0	172.16.175.0
Subnet 12	172.16.176.0	172.16.191.0
Subnet 13	172.16.192.0	172.16.207.0
Subnet 14	172.16.208.0	172.16.223.0
Subnet 15	172.16.224.0	172.16.239.0
Subnet 16	172.16.240.0	172.16.255.0

Table L.2 Intervals of the 16 sub networks

All 0s (zeros) and all 1s (ones) are the network and broadcast addresses and cannot be used in the addresses of any hosts.

Step 7

The Broadcast addresses for each host address can be determined by making all the bits in each subnet 1s. In Table L.3 (step 8), the broadcast addresses for each subnet are included.

Step 8

Having created the subnet addresses, the range of host addresses need to be shown. The host address will always start with a 1 (one) and end with the highest number less 1, as indicated in Table L.3.

Subnet Address	Subnet Mask	Subnet Size	Host Range	Broadcast
172.16.0.0	255.255.240.0	4094	172.16.0.1 to 172.16.15.254	172.16.15.255
172.16.16.0	255.255.240.0	4094	172.16.16.1 to 172.16.31.254	172.16.31.255
172.16.32.0	255.255.240.0	4094	172.16.32.1 to 172.16.47.254	172.16.47.255
172.16.48.0	255.255.240.0	4094	172.16.48.1 to 172.16.63.254	172.16.63.255
172.16.64.0	255.255.240.0	4094	172.16.64.1 to 172.16.79.254	172.16.79.255
172.16.80.0	255.255.240.0	4094	172.16.80.1 to 172.16.95.254	172.16.95.255
172.16.96.0	255.255.240.0	4094	172.16.96.1 to 172.16.111.254	172.16.111.255
172.16.112.0	255.255.240.0	4094	172.16.112.1 to 172.16.127.254	172.16.127.255
172.16.128.0	255.255.240.0	4094	172.16.128.1 to 172.16.143.254	172.16.143.255
172.16.144.0	255.255.240.0	4094	172.16.144.1 to 172.16.159.254	172.16.159.255
172.16.160.0	255.255.240.0	4094	172.16.160.1 to 172.16.175.254	172.16.175.255
172.16.176.0	255.255.240.0	4094	172.16.176.1 to 172.16.191.254	172.16.191.255
172.16.192.0	255.255.240.0	4094	172.16.192.1 to 172.16.207.254	172.16.207.255
172.16.208.0	255.255.240.0	4094	172.16.208.1 to 172.16.223.254	172.16.223.255
172.16.224.0	255.255.240.0	4094	172.16.224.1 to 172.16.239.254	172.16.239.255
172.16.240.0	255.255.240.0	4094	172.16.240.1 to 172.16.255.254	172.16.255.255

Table L.3 Range of host addresses

ANNEXURE M

THE PURPOSE OF THIS INTERPRETIVE QUESTIONNAIRE IS TO GET A PERCEPTIVE IDEA ON THE USAGE OF THE E-MATERIAL

To all participants

I, C van Aardt am currently conducting research on the perspectives of **learners and educators** with regard to the usage of the e-learning material placed on the learner management system, Moodle at the Vaal University of Technology in the Process Control and Digital Systems Department. We need your support and contribution to be able to complete this study. Your participation is **voluntary** and information will be handled anonymously and with **confidentiality**. The numbers on the questionnaire are solely for administrative purposes and will not be used for identification.

Please read the following questionnaire and complete the questions asked. It will not take more than 12 minutes of your time. Please make sure you answer **all** the questions. There are no right or wrong answers.

We trust that this research will benefit you in future courses.

Thank you for your co-operation and support.

Mr. C van Aardt

Study Leader:

Dr R. Goede

NorthWest University (Potchefstroom)

ANNEXURE N

Network Systems III subject

This questionnaire is to research the usage, receptiveness and experience of the learners with regard to the adapted blended e-learning material with reference to the changed teaching methods to make difficult parts of the subject more understandable for students.

Questions

1. Did you make use of the Networking Systems III e-learning material on Moodle?

Yes	No
-----	----

2. If you answered NO in question 1, explain why?

3. How many hours did you spend on the Moodle learning material?

4. Did you print the e-learning material on Moodle?

Yes	No
-----	----

5. If you answered YES in question 4, did you lend it to your friends?

Yes	No
-----	----

- 5a. Are there other subjects that support learners with e-learning material?

Yes	No
-----	----

6. Do you want other subjects to do the same?

Yes	No
-----	----

7. How can we improve the e-learning material?

8. Was the e-learning material helpful?

Yes	No
-----	----

9. Will you recommend this e-learning material to other students?

Yes	No
-----	----

10. What will you change about the present content of this e-learning material?

11. What do you think was the best part about the e-learning content?

12. What explanation was the worst?

13. What will you do to make the e-learning material more acceptable?

14. What was your best score in tests or exam papers in Network Systems III?

Before e-learning After e-learning

15. Are you repeating the subject?

Yes	No
-----	----

16. If you answered yes in Question 15, what is the reason?

17. Do you have a computer at home?

Yes	No
-----	----

18. Do you have any access to a computer?
☐ Yes ☐ No Where?
- 18a. Do you think the e-learning material helped you to score higher marks?
☐ Yes ☐ No Why?.....
19. Do you want us to extend the material?
☐ Yes ☐ No
20. How will you explain the section about subnetting to students?
.....
.....
.....

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