Enhancing individualised learning and interaction in online learning environments.

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ENHANCING INDIVIDUALISED LEARNING AND INTERACTION IN ONLINE LEARNING ENVIRONMENTS

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LIST OF TERMS

Accommodator: Term used to describe students who prefer to learn from concrete experiences and active experimentations.

Ask Tutor tool: A tool designed for synchronous or semi-synchronous one-to-one based communication tools between students and teachers.

Assimilator: Term used to describe students who prefer to learn from abstract conceptualisations and reflective observations.

Chat room tool: A tool designed for any form of synchronous conferencing - for communicating by sending text messages to people in the same chat-room, and in real-time.

Converger: Term used to describe students who prefer to learn from abstract conceptualisations and active experimentations.

Course sequencing protocol: A prototype web-based learning management system, designed for sequencing the learning objects used in an online course.

Discussion forum tool: A web application for holding discussions and posting user generated content.

Diverger: Term used to describe students who prefer to learn from concrete experiences and reflective observations.

General public licence (GPL): Copyright license grants the recipients of a computer programme the rights to the free software definition and uses the copyleft to ensure the freedoms are preserved, even when the work is changed or added to.

Individualised learning: A learning model that places the student (learner) in the centre of the learning process. In Individualised learning, students are active participants in their learning; they learn at their own pace and use their own learning styles.

Interaction: The engagement and collaborative processes within/between/amongst students, teachers, course designers, course content and other learning supporters in an online learning course.

Interaction tools: Tools designed for implementing and facilitating interactions in online learning courses. In this study these include: Ask Tutor tools, chat room tools, discussion forum tools and messaging tools.

Interactive learning: A learning model that uses a range of interactions to contribute to the student learning process.

Internet protocol (IP): A protocol used for communicating data across a packet-switched internetwork.

Learning activities: Student learning processes or procedures found in the course sequencing protocol.

Learning experience: The cognitive and socio-cultural experience derived from a diverse range of interactions and level of satisfaction gained from a learning situation.

Learning management system: A system that is used to create, store, assemble and deliver personalised online learning content in the form of learning objects.

Learning objects: Small pieces of instruction that can be assembled into some larger instructional structure.

Learning object repository: A central database in which learning content is stored and managed.

Learning style: The composition of cognitive, affective, and physiological learning preferences that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment.

Learning style inventory (LSI): Self-perception questionnaires designed to help students discover their particular learning style.

Log: A computer programme automatically record events in a certain scope.

Meta tag: The process of describing data.

Messaging tool: A tool based on typed text which is designed for synchronous or semi-synchronous communication between two or more students.

Operating system: Software designed to control the hardware of a specific data-processing system which allows users and application programmes to make use of it.

PHP: A server-side reflective programming language designed for producing dynamic web pages.

Semi-synchronous: Term used to describe the automatic alerts appearing when students log into the course sequencing protocol, which notify them of incoming private messages.

Server: A computer that processes requests for documents that are components of web pages.

Web browser: A computer programme used to view web pages.

ABSTRACT

The quality of the student learning experience in an online learning course has raised many debates in educational studies. Evidence found in current literature indicates that individualised learning and interactive learning do contribute to the student learning experience in online learning courses. However, there is little evidence of any major studies that have tried to explore the impact of both individualised learning and interactive learning on the students' experience.

Drawing on the constructivist "student-centred" learning perspective, this study aims to match instructional methods to the students' individual learning pace, learning styles and individualised course content in a technology-enhanced learning environment. The study was carried out in China with fourth year undergraduate computing science students enrolled on a Cisco CCNA course.

The study was carried out using a mixed methods research approach. Qualitative data were analysed using content analysis and quantitative data were analysed using SPSS.

The findings of this study suggest that students taking an online course in which the contents/materials are individualised based on: learning style, learning pace and prior knowledge structure, and supported with relevant interactions and learning objects technology, have an improved quality of learning and a better learning experience than the normal 'one-size-fits-all text/graphic based format' online course or the online course with only individualised features or interaction tools. Results from this study found significant statistical difference in both the level of students' achievement and learning experience.

This study confirmed that synergies could be formed by combining individualised learning and interactive learning within an online learning environment. It also demonstrated that students with different learning styles interact more effectively in online learning courses. An interaction model has been designed to guide the design and implementation of effective learning in online situations through a diverse range of interactions.

The findings of this study may be impacted upon by the cultural norm of 'strict compliance to rules and regulations' within the Chinese educational system. The study proposes educational principles to support the transferability of individualised and interactive learning to other cultures and disciplines.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Over the last decade, the rapid evolution of Internet technology has led to the growth and expansion of online learning. Learning online offers a flexible and convenient mode of learning both in terms of time and of location, and allows people to study courses at any time or place, so long as they have a personal computer (PC) and Internet access.

In 2006, the Ministry of Education of China, reported that "seven million people enrolled in formal distance and online learning courses in China ... However, the report highlights that the quality of distance and online learning still needs to be enhanced" (Ministry of Education of China 2006). In the western world, several authors point out that there is a high drop-out rate from online learning courses, indicating that the students are not satisfied with some of these online courses (Dutton and Perry 2002; Garrison and Anderson 2003; Shute and Towle 2003; Mungania 2004; Bouhnik and Marcus 2006; Liaw 2004, 2008).

The key reasons highlighted by the above authors for the students' dissatisfaction and the high drop out rates were associated with the lack of:

- individualised course content to meet the students' learning needs.
- high quality interactions between students, teachers and course content.
- a robust framework which encourages, motivates and supports students to learn.

The reasons identified for the high drop out rate in online education led the researcher to the question: How can the quality of learning and the student's learning experience be enhanced in online courses? This study attempts to resolve the issues identified as key reasons for high drop out rate in online learning through a pedagogical approach by providing an online learning platform that offers the student an individualised learning environment which functionalities that promote relevant interactions and interactivity and learner support. The idea for this study stems from the Constructivists' student-centred learning theory, which is reviewed in Chapter 2 of the thesis.

A number of authors argue that individuals differ in how they prefer to learn. Therefore, the designing of pedagogies is a major concern for effective learning (Kolb 1984; Blackmore 1996; Shepherd 1999; Hobbs 2002; Shute and Towle 2003). Honebein, Duffy and Fishman (1993) emphasise that successful instructional design should be based not only on the learning outcome, but also on the motivational, cognitive and volitional aspects of learning, as seen from the students' perspective. The recognition of individual learning preferences has become an increasingly important consideration when designing and delivering courses. (McLoughlin 1999; Brickell 1999; Blackmore 1996). Obviously, there are different types of students within any online learning course, so, in order to suit everyone's learning style, an individualised learning environment is essential.

Computer software manufacturers make claims to individualise learning by simply referring to the identification of the user by the input of username (UFIDA Inc. 2008). Recent development and interest in Web 2.0 technologies also make very large claims about personalising the learning environment (Anderson 2007). According to the National University of Singapore (2007), "Web 2.0, at its core, distinguishes between the generally unidirectional character of the old web (read-only) and the flurry of new online applications and services which allowed for user input and interaction (read/write)". It is clear that web 2.0 is a technology to support individualised learning rather than directly providing an individualised learning environment. In educational studies, 'personalising or individualising learning' involves focusing on pace of learning, learning styles, content, etc. (Department of Employment, Education Training and Youth Affairs 1996).

Fieldwork conducted in the area of individualised learning within the online learning environment has shown that an individualised learning strategy enhances the learning experiences for students of online courses (Conlan, Wade, Bruen and Gargan 2002; Shute and Towle 2003; Cheng, *et al.* 2006). Theories on individualised learning are reviewed in Chapter 2 of the thesis.

Other authors, (Moore 1989; Chen 1998; Garrison and Anderson 2003; Juwah 2003; Hirumi 2006) have argued that interactions play an important role in the students' learning process including those which:

- promote active and participative learning through social dialogue;
- allow learner input to the learning process in order to allow students to take control of their learning;
- enable the development of enhanced learning skills and abilities, e.g. critical thinking, problem solving, judgement, decision-making skills, and reflection;
- provide effective feedback to inform on the whole teaching and learning process, and to enhance the quality of the learning

experience (Garrison and Anderson 2003; Fahy 2003; Fahy 2001; Juwah 2003).

From the debate and findings in the literature, it is clear that interaction is a crucial component in designing e-learning courses and shows that students benefit from the implementation of interactive online courses. Many studies have demonstrated that the use of interactive learning technology within an online learning course has a positive effect and enhances the quality of online learning. (Thorpe 2008; Rourke and Anderson 2002; Zhang, Luo, Jiang, Liu and Zhang 2004). Theories on interactions are reviewed in Chapter 2 of the thesis.

The study finds that current literature and research work in the online individualised learning field has mainly been done from a course design perspective. Research work into online interactive learning mainly comes from an online collaboration perspective. There was a clear gap between interactive learning and individualised learning. Hirumi (2006) examined individualised learning from an interaction perspective and identified a Level One interaction type called *student-self interaction*. Hirumi's description of *student-self interaction* states that, "it consists of the cognitive operations that constitute learning and the meta-cognitive processes that help individuals monitor and regulate learning." (p.49). Hirumi's theory bridges the gap between the individualised learning and interactive learning, and this study will offer a direct examination of the student-self interaction theory.

There is a lack of research into the blending of individualised learning and interactive learning into one learning platform. By mixing individualised learning and interactive learning into one learning platform, would students get an enhanced learning environment in terms of enhanced qualities of learning experiences? This study will examine this question.

According to Myers-Briggs (1962) and Kolb (1984), students with different learning styles prefer to use different learning methods. Previous work shows that, in classroom training, team collaborations among students with different learning styles produce better results than do those teams with the same learning styles (Halstead and Martin 2002; Kayes 2001). It is argued that a synergy develops within the team with different learning styles. Research shows that in current literature and studies, there is a scarcity of research looking at the synergy which develops between online learning students with different learning styles. This study will explore whether this synergy can be formed within an online learning environment and the development process of this synergy.

In interactive learning, two interaction models have been created to guide the designing and implementation of the online interactions (Anderson 2004, Hirumi 2006). Anderson's (2004) model covered six types of interactions, including those between students, teachers and content. However, the design process of the interactions, and the cognitive process of the individual were not covered in Anderson's model. Hirumi's (2006) model covered both the design and implementation process of the interactions. However, her approach is from a student centred position and lacks the study of the interactions between teachers and content. In this study, a new interaction model is proposed which will provide a robust framework on which online students will be encouraged, motivated and supported to learn.

1.2 RESEARCH QUESTION AND RESEARCH AIMS

The research question for this study is: Will students find that an online course in which the content/material is individualised, based on their learning style, learning pace and prior knowledge (supported with relevant interactions and learning objects technology) provides an improved quality of learning and a better learning experience in comparison with a normal "one size fits all text/graphic based format" online course or the online course with only individualised features or only interaction features?

The research aims are to:

- find out whether bringing individualised learning and interactive learning together in an online learning context can develop any synergies.
- identify the nature of individualised learning and interactive learning to enable them to be merged into one applicable model.
- develop an interaction model by modifying Hirumi's (2006) and Anderson's (2004) interaction models, which will inform and guide the design and implementation of effective online interactions.

1.3 RESEARCH DESIGN

In order to address the research question, the study designed a course sequencing protocol which can simulate various learning environments such as:

- individualised learning environment with interaction tools
- individualised learning environment without interaction tools
- "one-size fits all" mode learning environment with interaction tools
- "one-size fits all" mode learning environment without interaction tools

It is intended that the study will attempt to address the research question and research aims by examining and comparing student learning experiences and learning activities throughout the learning process within different learning environments. This study will identify the nature of individualised and interactive learning and propose an interaction model.

1.4 ORIGINAL CONTRIBUTION

Original contributions from this study to the knowledge, design and practice of online learning will be to:

- develop a prototype course sequencing protocol, which can provide an individualised and interactive learning environment.
- use different types of interactions to inform and underpin individualised learning in a technology-enhanced learning environment and to identify students' behaviours on using the course sequencing protocol.
- develop an interaction model, which is able to cover all identified interactions and guide the designing and implementation of the interactions in online learning.
- identify the nature of individualised and interactive learning in an online learning environment and to identify whether synergies exist

between the students with different learning styles in an online learning context, and the synergies forming process.

CHAPTER 2

LITERATURE REVIEW

This literature review gives a broad view of what is known, what has been done and what has not been done, within the field of individualised and interactive learning. Theories in course design, educational database technology, learning objects and course management systems are also reviewed, as they compose the theoretical foundation for building the course sequencing protocol used in this study.

2.1 THEORETICAL FOUNDATION OF INDIVIDUALISED LEARNING AND INTERACTIVE LEARNING

In today's modern educational environment, the challenge faced by many institutions is the lack of the quality of the student learning experience (Garrison and Anderson 2003; Conlan, Wade, Bruen and Gargan 2002). Many educational institutions now realise that there is a real need for students to fully understand educational materials and to put these learning materials to optimal use during the learning process. Therefore, the main question which must be answered by academia is how to improve the quality of the student learning experience.

The theory of constructivism suggests that individuals do not gain knowledge by going through predefined scientific methods and processes. Instead, when acquiring scientific knowledge, an individual will generate his or her own ideas and philosophies. This is in direct contrast to positivism which suggests that rigid scientific methodologies need to be followed in order to acquire scientific knowledge (Clark 2008). In today's modern educational environment, constructivism is seen as an effective way of learning in both formal and informal settings (Kim 2005). Constructivism proposes that the best way for individuals to learn in an educational environment is to participate fully throughout the learning process (Clark 2008).

Constructivism can be traced back to John Dewey. In his famous work *Experience and Education* (Dewey 1938) he argued that people learn from experience. He highlighted two principles of the experience. The first is "continuity" - where all single experiences can be formed into a process. The second is "interaction" – through which knowledge is built. Garrison and Anderson (2003) argue that "interaction", in an educational environment, has a dual purpose helping both to build the individuals' knowledge and also support the knowledge base within a learning community.

Dewey (1938) believed that students should be encouraged to participate directly in the learning process rather than just following a strict learning framework which involves repetitive activities and memorisation. He further addressed individualities in education by stating, "an individual is no longer just a particular, a part without meaning save in an inclusive whole, but is a subject, self, a distinctive centre of desire, thinking and aspiration" (Dewey 1958 p. 216). This statement underlines the student-centred approach.

Based on Dewey's theory and other constructivism theories and educational theories, Kolb developed his experiential learning theory (Kolb 1984). Kolb contends that there is a four-part learning cycle which includes:

- concrete experience;
- testing in new scenarios;
- observation;
- the construction of abstract concepts and ideas.

He further investigated previous research on individuality, and argued that each individual has his or her own unique 'possibility-processing' structures during the learning process.

Addressing individuality in learning is a revolution in education. Interestingly, a similar revolution happened in China more than two thousand years ago when Confucius addressed the importance of teaching students in accordance with their aptitude in his famous work *The Analects* (Confucius and Dawson 2000).

Authors also believe that there is the need for a 'community of enquiry'. The interactive learning process would not be successful without it (Lipman 1991). According to Lipman, a "community of enquiry is one that is organised and overseen by teachers where students are able to interact freely with each other." It consists of a learning environment where students are able to exchange ideas, challenge each other and develop new ideas through a constructivist collaborative approach. Such learning environments can be especially effective when they are organised within online learning (Garrison and Anderson 2003).

Both Lipman (1991) and Garrison and Anderson (2003) studies highlight that constructivism student-centred learning theory addresses the process of learning from the perspectives of individualised learning (students' individualities) and interactive learning (constructivist collaboration).

Constructivism is a social theory of learning in which the acquisition of knowledge involves social/cultural interactions (e.g. dialogue, negotiation, meaning making, etc.) and construction of new knowledge (Doolittle and Camp, 1999).

The process of learning is characterised by being: active, cognitive, adaptive and subjective. The principles of constructivist learning are based on the premise that:

- Learning should take place in authentic and real-world environments.
- Learning should involve social negotiation and mediation.
- Content and skills should be made relevant to the learner.
- Content and skills should be understood within the framework of the learner's prior knowledge.
- Students should be assessed formatively, serving to inform future learning experiences.
- Students should be encouraged to become self-regulatory, self-mediated, and self-aware.
- Teachers serve primarily as guides and facilitators of learning, not instructors.
- Teachers should provide for and encourage multiple perspectives and representations of content. (Doolittle and Camp 1999)

Kim (2006) also summarised the social constructivism approach to education from four perspectives as:

- Cognitive tools perspective: Cognitive tools perspective focuses on the learning of cognitive skills and strategies. Students engage in those social learning activities that involve hands-on project-based methods and utilization of discipline-based cognitive tools.
- Idea-based social constructivism: Idea-based social constructivism sets education's priority on important concepts in the various disciplines.
- Pragmatic or emergent approach: Authors for this approach argue that knowledge, meaning, and understanding of the world can be addressed through the learning process from both the view of the individual learner and the collective view of the learners' group.
- Transactional or situated cognitive perspectives: This perspective focuses on the fact that knowledge and meaning is constructed via interactions between individuals and their environment.

From the above, it is clear that social constructivism theory focuses on both individualised learning and interactive learning.

This study reviews the theories and practices of individualised learning and interactive learning in the subsequent sections of this chapter.

2.2 INDIVIDUALISED LEARNING

The following section reviews the theories of and practices in individualised learning.

2.2.1 Definition of individualised learning

Although, a variety of authors, non-profit organisations and trading bodies provide definitions for individualised learning, the differences between them are minimal.

The National Centre for Research on Teacher Learning defined individualised learning as:

> *"Individualised learning, is a learning model that places the student (learner) in the centre of the learning process. In individualised learning, students are active participants in their learning; they learn at their own pace and use their own strategies; they are more intrinsically than extrinsically motivated; learning is more individualized than standardized. Individualised learning develops learning-how-to-learn skills such as problem solving, critical thinking, and reflective thinking. Individualised learning accounts for and adapts to different learning*

styles of students." (National Centre for Research on Teacher Learning 2002)

This definition is a typical constructivist view on individualised learning and demonstrates the constructivist "student-centred" approach. The definition implies individualised learning and does not necessarily mean independent working. Rather, it is the involvement of each student with learning plans that are designed to meet individual needs, interests and abilities. Normally, there are thought to be three elements of individualised learning which are the:

- Pace of learning;
- Style of learning;
- Learning activities or materials;

(Department of Employment, Education Training and Youth Affairs 1996)

The three elements that are highlighted in the above definition have been discussed in a wide range of literature (Kolb 1984; Sullivan 2003; German Institute for Adult Education 2000; Sampson 2003; McLaughlin 1999; Beishuizen and Stoutjesdijk 1999).

2.2.2 Pace of learning

Each one of us has his or her individual pace of learning. There are a variety of reasons for this, some of which are thought to be the result of their life history, educational history and personal characteristics (German Institute for Adult Education, 2000).

Individualised learning tries to adapt to each student's learning pace. This means that each learner can benefit in the following ways, by being able to:

- learn information and skills when they need them
- be independent of the structure and pace established by the teacher
- have more control of the learning process, which is highly motivating for many students.
- be active rather than passive, and assume greater responsibility for their own learning
- have more efficient use of training time and resources
- organise learning activities sequentially
- provide teachers with the time to focus more on the students who need assistance (Sullivan 2003; German Institute for Adult Education 2000; Beishuizen and Stoutjesdijk 1999).

On the other hand, the limitations of self-pace learning have also been identified. These limitations mainly concern the skills each student has in time management or study planning. Sullivan (2003) argues that students can lack the necessary motivation to self-pace their learning. Therefore, it is essential to help them to improve the quality of the learning experience, because student motivation in the learning process is fundamental to the learning experience.

2.2.3 Learning style

The effect of individual differences on the learning process has been widely discussed in the educational world for a long time (Kolb 1984; Honey and Mumford 1992; Rasmussen 1998; Riding and Grimley 1999; Hobbs 2002). Areas of individual differences, which have been explored relate to differences in learning style, learning strategies and concepts (McLoughlin 1999; Rasmussen 1998; Riding and Grimley 1999). "Such differences present a profound challenge for instructional designers and research has shown that the quality of learning material is enhanced when it is designed to take into account the learners' individual learning styles" (McLoughlin 1999).

What is learning style? Keefe (1979) defines learning style as "the composition of cognitive, affective, and physiological learning preferences that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment". This definition highlights the cognitive processes within students' minds and the interaction processes between students and environments.

2.2.3.1 Models of Learning Style

This study examines five of the most cited learning style models to have been used effectively in current educational practice (Kolb 1984; Myers-Briggs 1962; Herrmann 1990; Felder 1993; Honey and Mumford 1992).

2.2.3.1.1 Kolb's Learning Style Model

The core of the Kolb's theory of experiential learning is that learner's progress through using a learning cycle where experience leads to observation and reflection, and which then leads to concept formation (Kolb 1984; Hartman 1995; Carithers 2003). See figure 2.1a for the stages of the learning cycle.

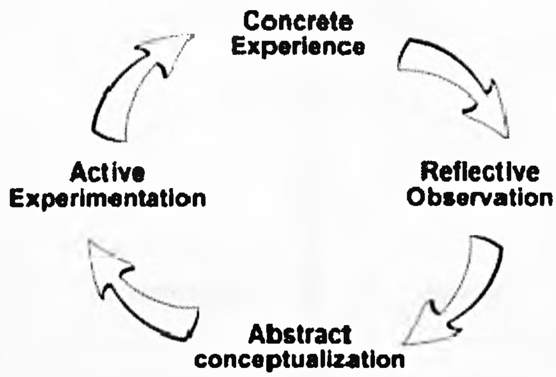


Figure 2.1a: Stages of the learning cycle according to Kolb (1984)

This learning cycle model "classifies students as having a preference for (1) concrete experience or abstract conceptualization (how they take information in), and (2) active experimentation or reflective observation (how they internalise information)." (Felder 1996 p. 19) The four types of learners in this classification scheme are shown in Figure 2.1b. Felder (1996) also summarised the characteristics of the four types of learners as:

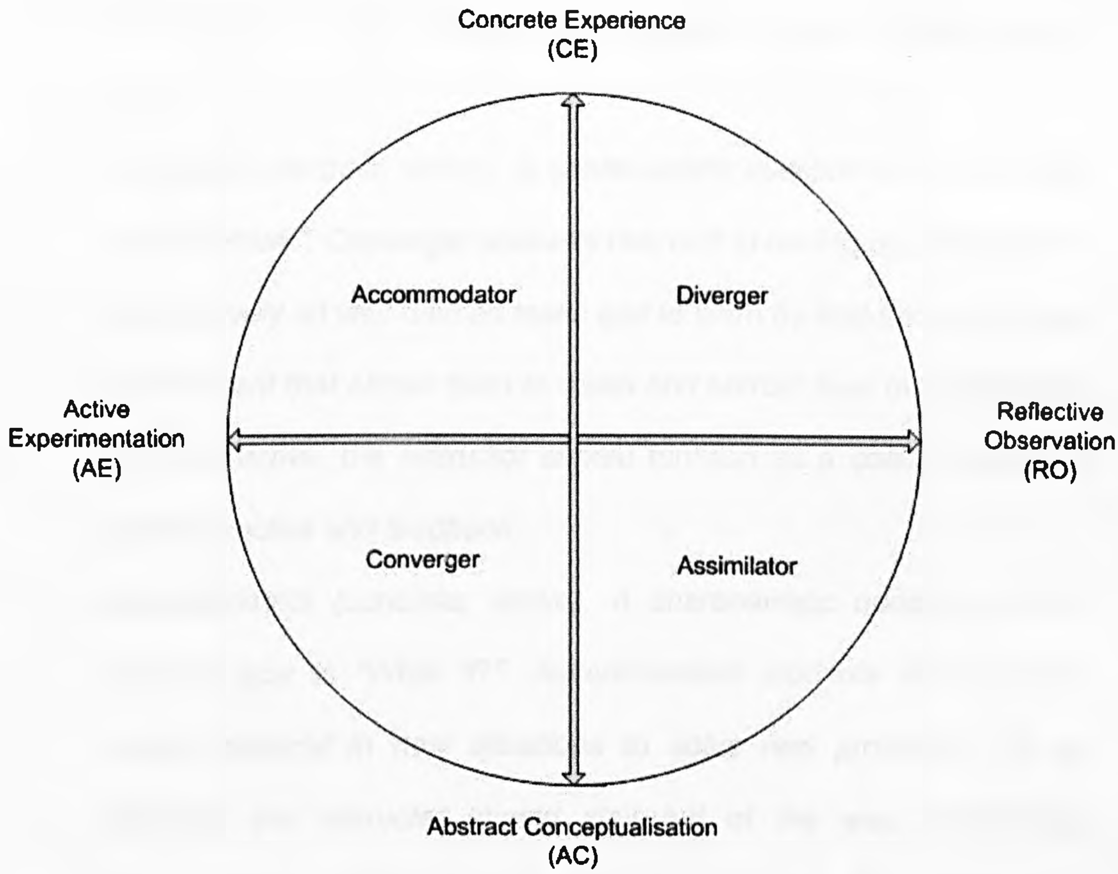


Figure 2.1b: Learning classification according to Kolb (1984)

- "*Diverger (concrete, reflective). A characteristic question of this learning type is "Why?". Diverger students respond well to explanations of how course material relates to their experience, their interests, and their future careers. To be effective with Type 1 students, the instructor should function as a motivator.*
- *Assimilator (abstract, reflective). A characteristic question of this learning type is "What?". Assimilator students respond to information presented in an organised, logical fashion and benefit if they have time*

for reflection. To be effective, the instructor should function as an expert.

- *Converger (abstract, active). A characteristic question of this learning type is "How?". Converger students respond to having opportunities to work actively on well-defined tasks and to learn by trial-and-error in an environment that allows them to make and correct their own mistakes. To be effective, the instructor should function as a coach, providing guided practice and feedback.*
- *Accommodator (concrete, active). A characteristic question of this learning type is "What if?". Accommodator students like applying course material in new situations to solve real problems. To be effective, the instructor should stay out of the way, maximising opportunities for the students to discover things for themselves."* (Felder 1996 p.19)

2.2.3.1.2 The Myers-Briggs Type Indicator

The MBTI model classifies students according to their preferences on scales derived from Carl Jung's theory of psychological types (Myers-Briggs 1962; Felder 1996). There are four separate preference scales; Extraversion-Introversion, Sensing-Intuition, Thinking-Feeling and Judging-Perceiving.

2.2.3.1.3 Herrmann Brain Dominance Instrument

Herrmann Brain Dominance Instrument classifies students according to their relative preferences for thinking based on the task-specialised functioning of the physical brain (Herrmann 1990; Felder 1996). The four modes or quadrants in this classification scheme are:

- "*Quadrant A (left brain, cerebral). Logical, analytical, quantitative, factual, critical;*
- *Quadrant B (left brain, limbic). Sequential, organised, planned, detailed, structured;*
- *Quadrant C (right brain, limbic). Emotional, interpersonal, sensory, kinaesthetic, symbolic;*
- *Quadrant D (right brain, cerebral). Visual, holistic, innovative.*" (Felder 1996 p. 20)

2.2.3.1.4 Felder-Silverman Learning Style Model

In this model (Felder 1993, 1996) classifies students as:

- *"Sensing learners (concrete, practical, oriented towards facts and procedures) or Intuitive learners (conceptual, innovative, oriented towards theories and meanings);*
- *Visual learners (prefer visual representations of presented material--pictures, diagrams, flow charts) or Verbal learners (prefer written and spoken explanations);*
- *Inductive learners (prefer presentations that proceed from the specific to the general) or Deductive learners (prefer presentations that go from the general to the specific);*
- *Active learners (learn by trying things out, working with others) or Reflective learners (learn by thinking things through, working alone);*
- *Sequential learners (linear, orderly, learn in small incremental steps) or Global learners (holistic, systems thinkers, learn in large leaps)."* (Felder 1996 p. 20)

2.2.3.1.5 Honey and Mumford Learning Style Model

This model (Honey and Mumford 1992; Shepherd 1999) classifies students as:

- *"Activists – people who love novelty, and will 'try anything once';*
- *Reflectors - people who like to 'look before they leap'. They prefer to*

observe rather than take the lead;

- *Theorists - people who live in a world of ideas. They are not happy until they have got to the bottom of things and explained their observations in terms of basic principles;*
- *Pragmatists - people who are also keen on ideas but want to try them out to see if they work."* (Shepherd 1999)

This thesis summaries the theoretical foundation, the validity, the pedagogical implications and the limitations for each learning style model. (See Table 2.1a)

Table 2.1a Comparison of Learning Styles

	Kolb's Learning Style Model	The Myers-Briggs Type Indicator	Herrmann Brain Dominance Instrument	Felder-Silverman Learning Style Model	Honey and Mumford Learning Style Model
Theoretical Foundation	The core of the Kolb's theory of experiential learning is that learner's progress through using a learning cycle where experience leads to observation and reflection, and which then leads to concept formation (Kolb 1984; Hartman	The MBTI model classifies students according to their preferences on scales derived from Carl Jung's theory of psychological types (Myers-Briggs 1962; Felder 1996).	Herrmann Brain Dominance Instrument classifies students according to their relative preferences for thinking based on the task-specialised functioning of the physical brain (Herrmann 1990; Felder 1996).	Felder-Silverman Model classifies students based on how student perceive information (sensing/intuitive, visual/verbal, inductive/deductive, active/reflective, and sequential/global) (Felder 1996)	Based on Kolb's model, with new terms for style preferences which are aligned to the four stages in the learning cycle.

	1995; Carithers 2003).				
Learners Classification	This learning cycle model "classifies students as having a preference for (1) concrete experience or abstract conceptualization (how they take information in), and (2) active experimentation or reflective observation (how they internalise information)." (Felder	There are four separate preference scales; Extraversion-Introversion, Sensing-Intuition, Thinking-Feeling and Judging-Perceiving. By combining the preferences, this produces a possible 16 types of learner indicator.	The four modes or quadrants in this classification scheme are: Quadrant A (left brain, cerebral). Logical, analytical, quantitative, factual, critical; Quadrant B (left brain, limbic). Sequential, organised, planned, detailed, structured;	10 classifications	Activists Reflectors Theorists Pragmatists

	1996 p. 19) There are four types of learners in this classification scheme.		Quadrant C (right brain, limbic). Emotional, interpersonal, sensory, kinaesthetic, symbolic; Quadrant D (right brain, cerebral). Visual, holistic, innovative." (Felder 1996 p. 20)		
Validity	A recent literature review by Hickox found that, "83.3 per cent of the studies analysed provided	Face validity of MBTI is generally accepted (Coffield, Moseley, Hall and Ecclestone 2004)	Internal evidence suggests that the HBDI is psychometrically sound (Coffield,	Found no evidence to support validity of this model.	Face validity is claimed by authors (Coffield, Moseley, Hall and Ecclestone 2004)

	support for the validity of Experiential Learning Theory and the Learning Style Inventory." (cited by HayGroup 2002 p. 70)		Moseley, Hall and Ecclestone 2004)		
Pedagogical Implication	The theory provides a framework for the design and management of all learning experiences. Teachers and students may be	The use of MBTI Indicator in career counseling is widespread and has been used to steer students into 'appropriate' areas of study. (Coffield, Moseley, Hall and	Herrmann provides rich accounts of how people think and learn, value diversity and argue for mutual understanding. Teachers, students, managers and	Teach students according to their learning style. (Felder 1993)	To help managers/ employees to devise personal development plans. To inform managers how to help their staff learn. (Shepherd 1999;

	stimulated to examine and refine their theories of learning; through dialogue, teachers may become more empathetic with students. Instruction can be individualised with the help of IT. (Kolb 1984; HayGroup 2002)	Ecclestone 2004)	workers may be stimulated to examine and refine their ideas about communication and learning. (Herrmann 1990; Coffield, Moseley, Hall and Ecclestone 2004)		Coffield, Moseley, Hall and Ecclestone 2004)
Limitations for each learning style model	None	The MBTI provides a view of the whole personality,	Although well established in the business world, the	Not widely used, still in developing stage. Not available in the	Validity not assessed by authors. More

		however, it does not focus on learning.	use of the HBDI has yet to be extensively validated in education.	market.	evidence is needed before LSQ is widely acceptable.

2.2.3.2 Learning style inventory

All the models reviewed in section 2.2.3.1 have designed self-perception inventories in order to help people find out which type dominates in their particular case. The learning style inventory is a standardised choice-based questionnaire. Students determine their learning styles by answering questions contained in the self-scoring inventory and interpretation leaflet.

For this study, the individual's learning style is determined using Kolb's standardised and validated Learning Style Inventory (LSI). Kolb's learning style inventory is the only LSI this study can find with an official Chinese translation. This was the main reason for choosing Kolb's LSI in this research. Table 2.1b summarises the choice of Kolb's Learning Style Inventory for this study.

Table 2.1b: Evaluation of Learning Style Inventory

	Kolb's Learning Style Model	The Myers-Briggs Type Indicator (MBTI)	Herrmann Brain Dominance Instrument (HBDI)	Felder-Silverman Learning Style Model	Honey and Mumford Learning Style Model
Availability on market	YES	YES	YES	NO	YES
Cost	£15/test	unknown	unknown	unknown	$25/test
Questionnaires length	12	88*	120	unknown	80/40
In Chinese language	YES	NO	NO	NO	NO

*European English edition

"It is commonly believed that most people favour some particular method of interacting with, taking in, and processing stimuli or information." (Wikipedia Foundation Inc 2008). Debates on learning styles are mostly based on the validity and reliability of a learning style inventory (Coffield, Moseley, Hall and Ecclestone 2004).

Kolb's learning style inventory is an industry recognized learning styles inventory. The inventory has been used in the academic and professional training for over 35 years. (Kolb and Kolb 2005)

Mainemelis, Boyatzis and Kolb (2002) cite two case studies to prove the validity and reliability of the Kolb's learning style inventory. The first one analysed 81 studies and concluded that "overall 61.7 per cent of the studies supported the Experiential Learning Theory (ELT), 16.1 per cent showed mixed support and 22.2 per cent did not support ELT" (cited by Mainemelis, Boyatzis and Kolb 2002 p.12). The second case study found that "49 studies showed strong support for the LSI, 40 showed mixed support and 12 studies showed no support" (cited by Mainemelis, Boyatzis and Kolb 2002 p.12).

On the other hand, the Kolb's learning style inventory has also come under criticism. Coffield, Moseley, Hall, Ecclestone (2004) published a famous critical review on learning styles. The review criticised the reliability, validity and empirical evidence of Kolb's learning style inventory. There are 121 citations of this article by other authors writing on learning styles (Google 2008).

<u>Reliability</u> The eight studies cited in the review all used a "test-retest" methodology to examine the reliability of Kolb's learning style inventory. The "test-retest" was designed to measure the stability of students' learning styles (Coffield, Moseley, Hall, Ecclestone 2004).

This study does not agree with the "test-retest" methodology since it ignores the fact that people are continually changing. Kolb also responded to the criticism stating, "cross-sectional studies suggest that learning style does change as a function of career path and life experience" (cited by Delahoussaye 2002).

Validity The review challenged the validity of Kolb's learning style theory by questioning the theory of experimental learning theory. (Coffield, Moseley, Hall, Ecclestone 2004).

However, HayGroup (2002 p. 70), states that, "hundreds of studies have tested the validity and applicability of the validity of the experiential learning theory". A more recent literature review by Hickox found that, "83.3 per cent of the studies analysed provided support for the validity of Experiential Learning Theory and the Learning Style Inventory." (cited by HayGroup 2002 p. 70).

Empirical evidence The review concludes that "there is no evidence that 'matching' the learning style and teaching style improves academic performance in further education." (Coffield, Moseley, Hall, Ecclestone 2004 p. 70) based on five studies reviewed.

This study does not agree with their conclusions. Firstly, the study questions the scope of their review. There is empirical evidence, which shows that the student learning experience can be enhanced by matching the learning style and teaching style (Kayes 2001; Cook and Smith 2006; Sharp 2006). Secondly, the study questions the methodology used in the review. The studies cited in the review are all used experimental group and control group methodologies and then compared both group results (Coffield, Moseley, Hall, Ecclestone 2004). By using this method, a single student was not able to compare his/her own learning experience in a "one-size fit all" format and in an individualised format suited to their learning style. Therefore, the study found that the methodologies could not sufficiently compare the student learning experiences.

Hence, this study concludes that Kolb's experiential learning theory and the learning style inventory (Kolb 1984) are suitable for the study in terms of reliability, validity and applicability.

2.2.4 Learning activities or materials and prior knowledge structure

The third element of individualised learning highlighted by the Department of Employment, Education Training and Youth Affairs (1996) is the learning material or activities. This approach is from a course content perspective and emphasises that course content should meet individual needs.

Individualised course content is a very broad concept. However, this study suggests the field should take into account the prior knowledge structure of the student, before he/she commences an individualised online course. From a common sense perspective, knowledge is built step by step, for example, it is not wise to let a student study calculus without having a foundation in primary mathematics. The above is the reason why this section of the study highlights the prior knowledge structure. This is a view supported by a number of authors (Shute and Towle 2007; Cao, Li, Chi and Wu 2004).

2.2.5 Rationale for applying individualised learning strategy into course design

A successful course design will be based not only on the learning outcome, but also on the motivational, cognitive and volitional views of learning from the learners' perspective (McLoughlin 1999). Honebein, Duffy and Fishman (1993) emphasise the learner context when designing courses:

> *"Stated simply, the context is not just an external context imposed by somebody else. It is also an internal context- the frame of reference or point of application that the learner*

generates (envisions). The learners (or readers) bring their own framework to the task. They have real world problems they are trying to solve and they read the text with those problems in mind. Hence the reader is cognitively problem solving in the area of application while reading the text. What information is attended to, how the information is organised and what personal knowledge is combined with the information all revolves around.... those contexts of application the reader imposes" (Honebein, Duffy and Fishman 1993 p. 89).

The recognition of individual learning styles is becoming an increasingly important consideration when designing and delivering courses (McLoughlin 1999; Brickell 1999; Blackmore 1996). Boles (1999) highlights two main points to consider when designing courses to fit preferred learning styles. Firstly, the manner in which the course is formatted, in order to allow easy understanding of the topics and information presented. Secondly, how the individual will process the information.

Obviously, there are different types of students within any online learning course so, in order to suit different learning styles, an individualised learning environment is essential.

2.2.6 Implications for course design based on Kolb's learning style theory

One of the main functions of researches into learning styles is to establish the students' learning profile, so that this can be incorporated into the design process. This study has examined research conducted by Kolb (1984) Ellsworth (1995), Collis (1998), Riding (1991) and HayGroup (2002). Table 2.2 summarises the preferred learning strengths and learning situations for students with different learning styles.

Table 2.2: Summary of the learning strengths and situations for students with different learning styles

Learning style	Learning strengths and learning situations
Diverger **CE and RO**	• receiving many examples • self-diagnostic activities • identifying problems and gathering information • imaginative and innovative activities. • student may enjoy independent study
Assimilator **AC and RO**	• creating conceptual models • problem solving • considering alternative solutions • reading • abstract ideas and concepts • student may enjoy a systematic approach of study

Converger **AC and AE**	• hands-on activities • trial and error • learn from real world • being given clear objectives with a logical sequence to activities. • finding practical uses for ideas and theories • self study • student does not do as well in interpersonal situations
Accommodator **CE and AE**	• hands-on experience • trial and error • group study • sharing information with others • active learning • student works well with others and or serving as a leader.

Abstract Conceptualization (AC)

Active Experimentation (AE)

Concrete Experience (CE)

Reflective Observation (RO)

2.2.7 Fieldwork in applying individualised learning strategy into online learning course

Much fieldwork has been carried out on the application of individualised learning strategy into online courses (Conlan, Wade, Bruen and Gargan 2002;

Shute and Towle 2003). The following section of this thesis will review two widely cited studies of online individualised learning

Shute and Towle (2003) have conducted fieldwork on adaptive online learning. According to their definition, adaptive learning is, "delivering the right content, to the right person, at the proper time, in the most appropriate way—any time, any place, any path, any pace" (p. 108). It is clear that adaptive learning and individualised learning do not differ, according to the definition of individualised learning.

They used a course sequencing protocol called 'Adaptive Engine' to organise the different learning objects for individual students, in line with the students' prior knowledge and learning methods. The sample population consisted of 300 paid high school graduates. The students were divided into two groups in order to compare the results between the individualised course and the normal one-size-fits-all course. The results of four exams were evaluated at the end of the research. This research supported the effectiveness of the Adaptive Engine and also showed that the current state of e-learning is, "often little more than online lectures, where educators have created electronic versions of traditional printed student manuals, articles, tip sheets, and reference guides" (p. 113).

Their findings confirmed the effectiveness of individualised learning in an online learning environment.

Conlan, Wade, Bruen and Gargan (2002) conducted a major EU research trial on individualised learning in Trinity College, Dublin. In total, eighty students participated in the research and the course content was organised according to the students' individual needs. This was firstly based on prior knowledge and learning objectives, and secondly, on pedagogical considerations by a course sequencing protocol called Personalized Learning Service. The results were evaluated using follow-up evaluation questionnaires and results showed that, "the students were satisfied with the personalised courses generated by the PLS, although some comments on the evaluation questionnaires indicated that some students wanted a more exact level of content control than what is offered through the online instrument" (p. 110).

Their research also confirmed the effectiveness of individualised learning in an online learning environment. However, their conclusion noted that there were some comments on the control of learning and that the individual control of learning given to a student is a very important part of individualised learning.

Although Conlan, Wade, Bruen and Gargan's (2002) research shows the effectiveness of individualised learning in an online learning context, their research only addressed some of the requirements of this form of learning.

This study will investigate individualised learning further by addressing all three requirements of individualised learning identified by the Department of Employment, Education Training and Youth Affairs (1996): the pace of learning, the style of learning and the learning activities or materials.

2.3 INTERACTIVE LEARNING

The following section reviews the theories of and practices in interactive learning.

2.3.1 Taxonomies of interaction

There is plenty of literature, which discusses the various types of interactions in the field of online learning.

Sims (2002) offers a classification of 10 types of interactions based on a developer's viewpoint. These are: object interaction, linear interaction, support interaction, update interaction, construct interaction, reflective interaction, simulation interaction, hyperlinked interaction, non-immersive contextual interaction and immersive virtual interaction.

Sims' classification is taken from a designer's perspective - all the above interactivities are based on human-machine communication. Spitzer (1998) argues that the lack of social communication is the reason why distance education organisations have gone out of business. In addition, Hooper (2003) and Berge (1999) emphasise the importance of social communication in their studies.

Further studies began to address different types of interactions based on both the design and the social perspectives. Hirumi (2002) reviewed literature about interactions and categorised interactions as: "communications-based"; "roles of the instructor"; "purposed based"; "use of telecommunication tools" and "activity based". However, categorising interactions from multiple perspectives makes the classification of interactions more complicated. The field needs a taxonomy of interactions, which comes from one perspective but is able to cover all other the interactions identified.

Moore (1989) identified three types of interactions; student-content, student-teacher, and student-student. Kearsley (1995) gives a thorough review of these three types of interaction which he believes they "provides a basis for analysing the relative significance of different types of interaction in a distance education program. Each type of interaction could have different effects on learners or the effectiveness of a course." The three interaction types have been accepted by academia (Hirumi 2002; Anderson 2004).

Student-content interaction occurs when students access course content (Moore 1989). Hirumi (2006) and Anderson (2004) describe content as "learning objects" such as text, image and video. The Learning Technology Standards Committee of the Institute of Electrical and Electronics Engineers defines a learning object as "any entity, digital or non-digital, that may be used for learning, education or training" (Learning Technology Standards Committee 2002 p. 45).

Student-teacher interaction refers to interactions between students and teachers before, during and after the instruction process (Moore 1989). The student-teacher interaction has long been discussed since Dewey (1933). Many works have examined the student-teacher interaction in an online learning context (Garrison and Anderson 2003; Thach and Murphy 1995). Hirumi (2006) cited Thach and Murphy's research and summarised seven usages of student-teacher interaction in distance learning:

1. Establishing learning outcomes/objectives;

2. Providing timely and appropriate feedback;
3. Facilitating information presentation;
4. Monitoring and evaluating student performance;
5. Providing (facilitate) learning activities;
6. Initiating, maintaining and facilitating discussions;
7. Determining learning needs and preferences.

Student-student interaction is defined as the interaction "between one learner and another learner, alone or in a group setting, with or without the real-time presence of an instructor" (Moore 1989 p.4). Authors have examined the student-student interaction from different approaches, Juwah (2006) examined the student-student interaction from the discussion perspective, Garrison and Anderson (2003) examined it from the group collaboration approach. They showed that group collaboration increased the learning quality and learning experiences of students. Their approach was on a general group collaboration basis without considering individual student's learning style. However, studies have shown that team collaborations among students with different learning styles get better results in a classroom teaching basis (Halstead and Martin 2002; Kayes 2001).

This study will investigate the collaboration between students with different learning styles in an online learning context.

In addition, a fourth type of interaction is claimed to have been identified by educators. This is student-interface interaction, which occurs when a learner uses intervening technologies to communicate with the content, to gain understanding and to validate knowledge with teachers and other students Such interaction allows students to use the system to participate in the learning processes. The interface acts as the medium of interaction between learners and content, teachers, and other learners (Hillman *et al.* 1994).

However, this study argues there is not a fourth type of interaction, because according to the Learning Technology Standards Committee's definition, interfaces are a kind of 'learning object' (Learning Technology Standards Committee 2002). Moreover, for the sake of simplification, the student-content interaction is enough to incorporate the so-called student-interface interaction.

Furthermore, Anderson (2002) identified three other types of interaction which are: teacher-teacher interaction, teacher-content interaction; and content-content interaction.

Teacher-teacher interaction, according to Anderson (2004) is defined as creating "the opportunity for professional development and support that sustains teachers through communities of like-minded colleagues" (p. 48). His approach to examine teacher-teacher interactions is from a development and support perspective. However, in today's online learning field, online courses with multiple teachers teaching the same course are increasing, for example, the online GRE training course offered by New Oriental (New Oriental 2008). Anderson's definition lacks the scheduling and planning process between teachers. The scheduling and planning process is important for effective cooperation between teachers who are teaching on one course.

Teacher-content interaction was defined by Anderson (2004) as focusing "on the creation of content and learning activities by teachers" (p. 45). Anderson's definition of teacher-content interaction limits the interaction to content design. However, in practice, instructional design is also concerned with content, and instructional design can guide content design. (Honebein, Duffy and Fishman 1993). Therefore, it is argued that the teacher-content definition needs to be re-examined.

Content-content interaction refers to a situation where "content is programmed to interact with other automated information sources, so as to refresh itself constantly" (Anderson 2004 p.45). This type of interaction is widely used in the designing of computer games and dynamic websites. Content-content interaction is essential for an individualised learning environment, because the different modules behind interfaces of an individualised learning environment need to interact with each other to perform the individualisation process.

Further research in the field of interaction includes that of Hirumi (2006) who identified three more interaction types. These are student-environment interaction, student-self interaction and student-instruction interaction.

Hirumi (2006) defined student-environment as the interaction, which occurs "when learners visit locations or work with resources outside the computer environment" (p. 52). In an online learning context, this type of interaction is important because common sense dictates that if a student's computer has technical problems, he/she will have to interact with an engineer to solve the computer problem. This study treats the student-environment interaction as a support-type interaction, which supports a student in his/her online learning process. It need to be highlighted here, in this study, the interaction between student/teacher with learning environment is considered as student/teacher environment interaction since the learning environment support the student during the learning process. Teacher-environment interaction should be considered as well, because teachers also need support.

Student-self interaction was defined by Hirumi (2006) as "the cognitive operations that constitute learning and the meta-cognitive processes that help individuals monitor and regulate learning" (p. 49). This study argues that the identification of the student-self interaction was a major achievement of Hirumi in the interactive learning field. By identifying the student-self interaction, students' individuality was considered. Thus, the gap between individualised learning and interactive learning was bridged.

Student-instruction interaction is defined as "a meta-level that transcends, and is used to guide, the design and sequencing of interactions" (Hirumi 2006 p. 53). This definition highlights the design process of interactions from the perspective of instructional strategy. Compared with Anderson's (2004) teacher-content interaction, Hirumi's definition is preferable. This study believes that, by applying the student-instruction interaction into the course design, the student centred approach is more prominent. However, the term of "teacher-content interaction" is still kept within this study. The study addresses the teacher-content interaction from a different perspective other than the Anderson's approach (refer to page 52).

2.3.2 Defining interaction

There is a great deal of literature about interaction being an important component in students' learning process (Garrison and Anderson 2003; Hirumi 2002; Moore 1989; Sims 1999; Sutton 2001). Yet, within the literature reviewed, it is extremely difficult to find a universally accepted definition of interaction.

In popular culture, interaction describes everything from computer games to gym training; even a text book may claim that it is interactive. This can add further to the difficulty of finding a precise definition.

Garrison and Anderson (2003) cited Dewey's reference to interaction as "the defining component of the educational process that occurs when the student transforms the inert information passed to them from another and constructs it into knowledge with personal application and value" (p. 41).

Contemporary educators define "interaction" from many perspectives. Sims (1999) offers a definition of interaction as "the facilities provided by a computer-based application to provide the user with both control of the process and communication with content. This communication involves both the user initiating an action and the computer responding to that action". This definition is based on a bi-modal transaction between users and machine; he excludes the interactions between users and with the computer software.

Lipman (1991), in his book "Thinking in Education", shares a definition which focuses on group interaction as well as social constructivist models of learning. He states that "interaction is fundamental in creating and sustaining learning communities and communities of practice respectively" (p. 67).

Some authors, such as Damarin (1982), define interaction from the behaviour perspective. Damarin (1982) identifies a series of interactive options, which includes watching, finding, doing, using, constructing and creating. Similarly, Ambron and Hooper (1988) describe interaction as a state in which users are able to browse, annotate, link and elaborate within a rich, non-linear database. The above definition only focuses on the single user's behaviour; it disregards the fact that an interaction could take place between students, or between students and teachers on an online learning course.

Clearly, the contemporary definitions of interaction in an educational context often fail to address interactions, which happen without any student involvement. In the online learning context, the study tries to give a definition of interactions as: The engagements, collaborations process within/between/amongst students, teachers, course designers, course content and other learning supporters in an online learning course.

2.3.3 Models of interaction

A model of interaction is essential for instructional designers and course content designers. Anderson (2004) and Hirumi (2006) designed two models to sequence, illustrate and explain interactions. The following section examines the strength and limitations of the two models of interaction.

2.3.3.1 Anderson's model of interaction

Anderson's (2004) model of interaction is illustrated in Figure 2.2.

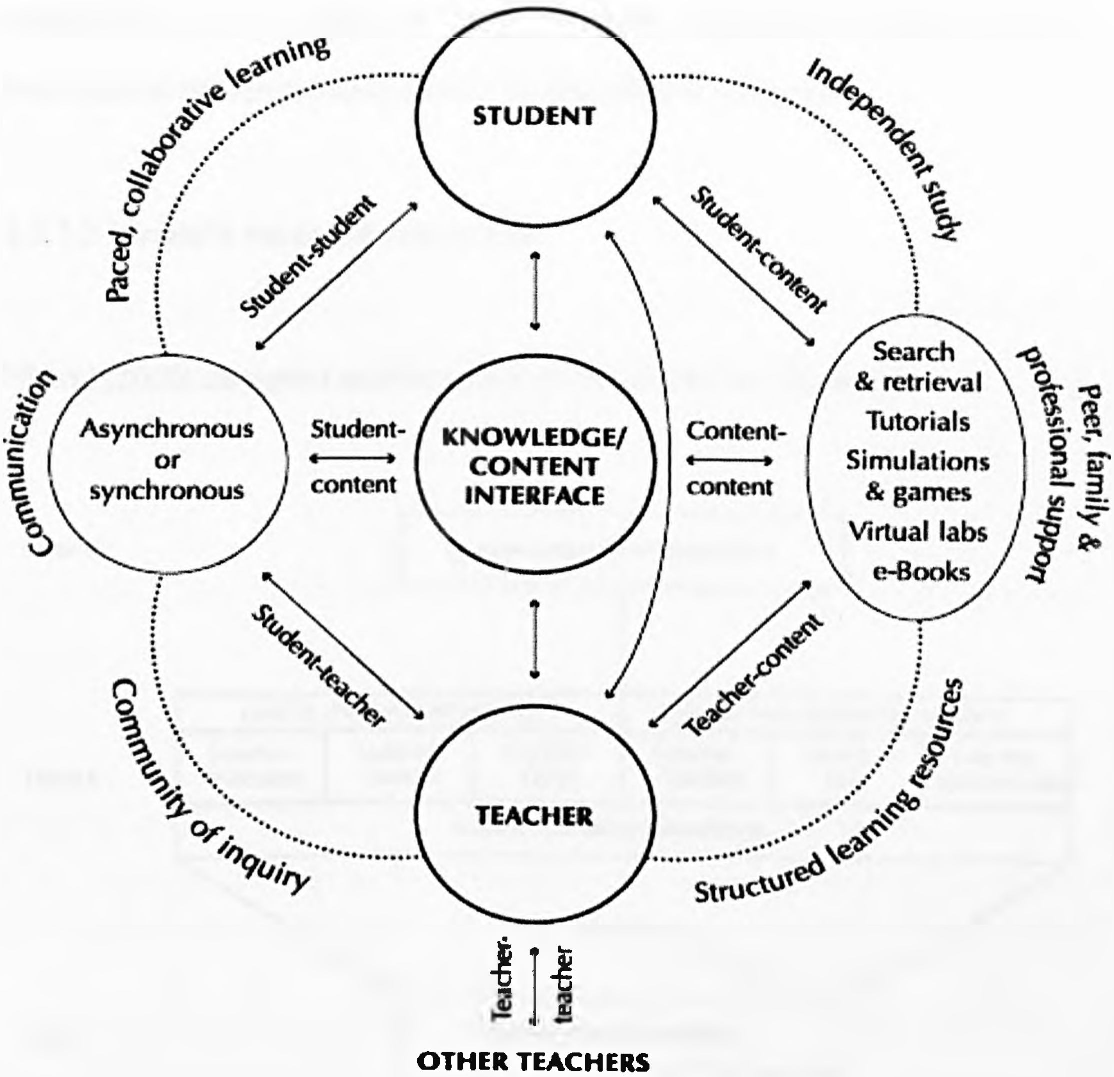


Figure 2.2: Anderson's model of interaction (Anderson 2004 p.49)

In this model, Anderson shows student-student interaction, student-teacher interaction, student-content interaction, teacher-teacher interaction, teacher-content interaction and content-content interaction. However, in his model all interactions are parallel based. The model lacks student-environment interaction and it does not cover student individuality. Moreover, the instructional design process cannot be identified in his model.

2.3.3.2 Hirumi's model of interaction

Hirumi (2006) designed an interaction model shown in Figure 2.3:

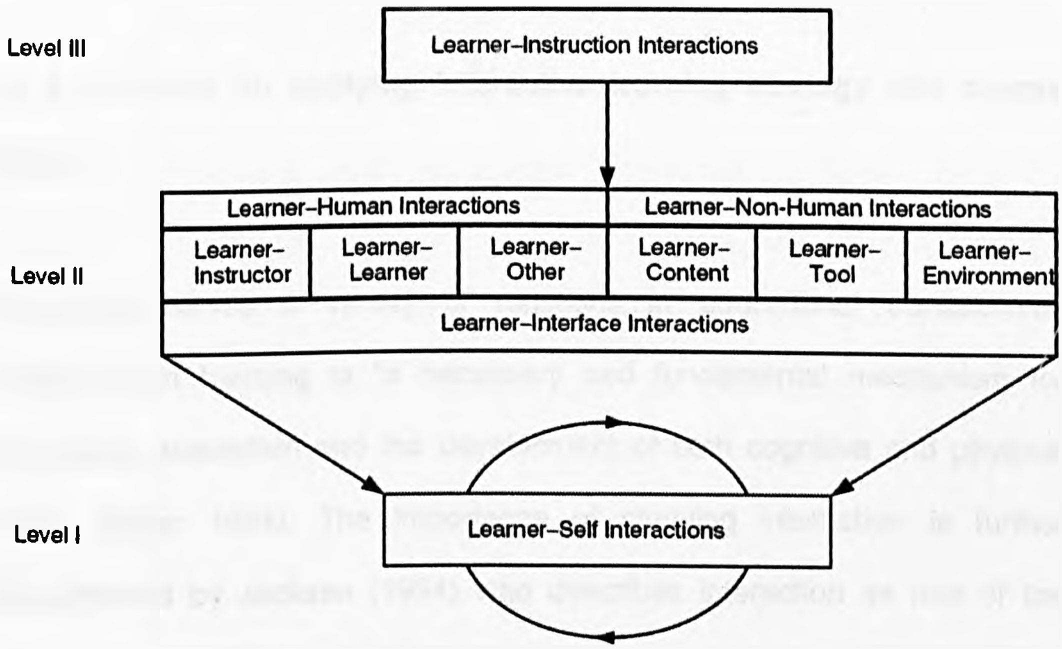


Figure 2.3: Hirumi's model of interaction (Hirumi 2006 p. 49)

In Hirumi's (2006) model, all identified student interactions are shown. The model also highlights two important interactions concerning students' individuality as student-self interaction and student-instruction interaction. However, in his model interactions which do not concern students are not considered. Teacher-teacher interaction, teacher-content interaction and content-content interaction are also needed to enhance students' learning quality and learning experience.

Therefore, this study argues that a new model of interaction is needed for the theory and practice of online learning which covers all identified interactions and which will guide the designing and implementation of online interaction.

2.3.4 Rationale for applying interactive learning strategy into course design

Interaction serves a variety of functions in educational transactions. Interaction in learning is "a necessary and fundamental mechanism for knowledge acquisition and the development of both cognitive and physical skills" (Baker 1994). The importance of studying interaction is further strengthened by Jackson (1994) who describes interaction as one of the central issues of distance education today.

Milheim (1996) identifies six benefits of having interaction in online classes. These include:

- Increased student interest;

- Higher cognitive processing;
- Development of co-operative learning skills;
- Teacher involvement;
- Curriculum integration;
- Teacher/student collaboration

Most technology-based learning environments claim to offer an interactive learning environment. Unfortunately Spitzer's (1998) astute observations depict how distance education organisations have gone out of business because they failed to create an effective online communication system for students. Wang (2004), a chief course developer at an e-learning company, pointed out that most e-learning courses lack interaction and they are a straight cut and paste job of content onto the web pages. The lack of interaction on an e-learning course results in a failure of e-learning companies.

2.3.5 Fieldwork applying interactive learning strategy to online learning courses

This study has reviewed the literature and fieldwork concerning interactive learning in an online learning context. However, there are no known studies on interactive learning which systematically employ all identified interaction types reviewed in this thesis on a single platform. One of the research aims of this study is to examine all identified interactions on a single platform and to build a model of interaction (refer to page 10).

Although there are no known studies, which employ all identified interactions on one learning platform, the studies that have examined one or multiple interactions on one platform do represent an interactive learning strategy. In this section the research reviews two typical studies.

Thorpe (2008) conducted research on interactive learning in an online learning context. The sample population was of 450 undergraduates per year, studying at the Open University in the UK. The course used in the study was U316: The Environmental Web. The research compared the completion rate with the faculty average and compared the students' course experience scores on the Environmental Web course with the students' average course experience scores on all courses offered by the university. The course tutors' interview results were also taken into consideration.

The study directly identified the following interactions on the course as: student-content interaction, student-teacher interaction, student-student interaction and student-environment interaction. In addition, the research implied teacher-teacher interaction also existed in the course, because there were multiple teachers involved. The teacher-content interaction should also have been considered because it is common sense that a teacher creates the course content. It is difficult to identify content-content interaction and student-self interaction in the course in this study.

The results of the research show that, in comparison with other courses, students on the Environmental Web course received a more enhanced learning experience.

Since this study is being carried out in China, it is necessary to examine a Chinese case. Zhang, Luo, Jiang, Liu and Zhang (2004) conducted research on online interactive learning involving 150 undergraduate students from Tsinghua University. A course sequencing protocol called WBCLE was used to sequence the course but the subject matter of the course was not specified in their paper. The research was evaluated using follow-up interviews.

The study identified the following interaction types on the course as: student-content interaction, student-teacher interaction, student-student interaction and teacher-content interaction. No other interaction types were identified.

The results of the research show that the students received an enhanced learning experience and, in the following year 89% of the students registered for the other course using WBCLE that was offered.

The above studies suggest the effectiveness of interactive learning in an online learning context.

2.4 INTERACTION IN INDIVIDUALISED LEARNING

An individualised learning environment should provide the following elements:

- Pace of learning;
- Style of learning;
- Learning activities or materials;

(Department of Employment, Education Training and Youth Affairs 1996)

Therefore, applying interaction theory to the design of an individualised learning environment can meet the demands of an individualised learning environment form a theory perspective (Hirumi 2006). Yet after a comprehensive literature review, there is no empirical evidence of interactive learning strategy being applied to online individualised learning environment design.

Hence, this study's research question is:

Will students find that an online course in which the content/material is individualised, based on their learning style, learning pace and prior knowledge (supported with relevant interactions and learning objects technology) provides an improved quality of learning and a better learning experience in comparison with a normal "one size fits all text/graphic based format" online course or the online course with only individualised features or only interaction features?

2.5 COURSE DESIGN

Hirumi (2002) argues that educators often fail to base their designs on research and theory. She provides a five step design model (Hirumi 2006) for designing interactive courses:

- *Step 1 – Select a grounded instructional strategy based on specified objectives, learner characteristics, context and students' epistemological beliefs;*

- *Step 2 – Operationalise each event, embedding essential experiences and describing how the selected strategy will be applied during instruction;*
- *Step 3 – Determine the type of interaction(s) that will be used to facilitate each event;*
- *Step 4 – Select the telecommunication tool(s) (e.g. chat, email, bulletin board system) that will be used to facilitate each event based on the nature of the interaction.*
- *Step 5 – Analyse materials to determine frequency and quality of planned e-learning interactions and revise as necessary* (p. 55).

It is critical, when designing a course, to constructively align the learner's needs, teaching and assessment methods and to take into account socio-cultural factors. For example, the learner's attributes, prior knowledge, learning preference or learning styles, technological issues and economics. This will ensure efficiency and cost effectiveness (Boud 1999).

The above theoretical approach to course design places great focus on the need and context of each individual learner. Therefore, in order to design an individualised learning environment with an emphasis on interaction, a database should be used.

2.5.1 Database technology in online learning

Online teaching and learning is a fast developing area of information and communication technologies. "The Web was originally designed for presenting static hypertext documents, but during the past few years the Web is used more and more as a vehicle for interaction with a myriad of applications that have more functionality than just hypertext documents" (Hiddink 2001 p. 301). These web based interactive softwares can be written in script language, such as PHP (Perl or Hypertext Preprocessor) and databases can be used to provide a more dynamic and interactive environment and make interaction design easier.

An education database, which functions together with script languages, allows the user to control, view, re-use, edit, etc. the educational data (Elmasri and Navathe 1989; Adjeroh and Nwosu1997). Database technology is a useful tool for designing interaction and individualised learning environments.

2.5.2 Learning object

"Traditionally, online learning course content is developed for a complete course. However, driven by the movement of learning technology standards and by teaching practice, databases are now been employed. We now see more content developed specifically to be deployed as learning 'objects' (smaller content units capable of being reused in different courses and contexts). " (Wiley 2000) A "learning object" is usually stored in a database.

The IEEE Learning Technology Standards Committee (LTSC) defines a learning object as "any entity, digital or non-digital, that may be used for learning, education or training" (Learning Technology Standards Committee 2002 p. 45). The above definition defines learning objects from a general perspective. IP, Young and Morrison (2002) give a more detailed definition of a learning object which focuses on interaction as "A computer mediated or delivered module or unit, that stands by itself that provides a meaningful learning experience in a planned learning context". The emphasis on "learning experience" is to take into account the different types of interaction a learner may have with the "learning object" (p. 315). A widely cited metaphor for describing learning objects is the LEGO metaphor. This conveys the notion of "small pieces of instruction (the LEGO blocks) that can be assembled (stacked together) into some larger instructional structure (castle or spaceship)" (Wiley 1999).

To effectively use learning objects, it is essential to tag the learning objects, just as books in libraries have catalogues. In online learning context, metadata is used to describe and catalogue learning objects. There are various metadata tagging standards for learning objects, such as IEEE, IMS, SCORM and Dublin Core. This study used PAR 1484.12.1: IEEE Standard for Learning Object Metadata (Institute of Electrical and Electronics Engineers 2002) as the default metadata standard for the following reasons:

- IEEE's learning objects metadata standards is valid and widely used. It is able to describe the learning objects in this study.
- The field work was carried in China. About 72.7% of Chinese online learning LOs use IEEE Standard for Learning Object Metadata as tagging standard (Online Education Newsletter, 2003).

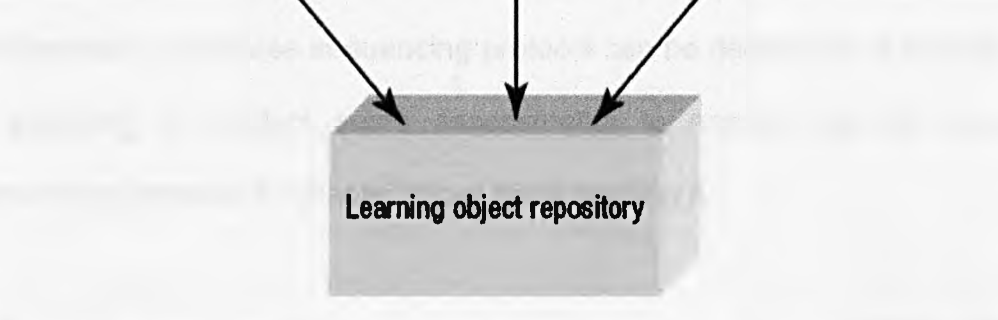
In order to sequence and manage these small pieces of instructional tuition, a learning management system should be employed.

2.5.3 Learning management system

Lennox (2001) identifies three key components for an e-learning system; infrastructure, services and content.

- **Infrastructure** is the software that allows learning to be created, managed, delivered and measured. It can be divided into: a Learning Management System (LMS).
- **Services** involve the planning, customisation, integration and management of the e-learning application.
- **Content** can be categorised according to subject, preferred format, student's progress and language requirements (Jesshope, 2002).

IDC (2001) defines a learning content management system as "a system that is used to create, store, assemble and deliver personalised e-learning content in the form of learning objects" (see Figure 2.4).



Source: IDC, 2001

Figure 2.4: A Learning Content Management System

Here, "The Learning Object Repository is a central database in which learning content is stored and managed. The Automated Authoring Application is used to create the reusable learning objects that are accessible in the repository. The purpose of the Dynamic Delivery Interface is to deliver a learning object which is based on learner profiles, pre-tests and/or user queries where a dynamic delivery interface is required. The Administrative Application is used to manage student records, launch e-learning courses from course catalogues, track and report student progress, and provide other basic administrative functions." (IDC 2001)

2.5.4 Test prototype learning management system

A prototype of a learning management system called 'course sequencing protocol' will be used in this study. This is a tool used to sequence learning and teaching activities. From a technical perspective, in an online learning environment, the course sequencing protocol can be deemed as a website. It is essential to conduct some assessments to ensure that the course sequencing protocol is reliable before implementing it.

Authors from different disciplines focus on different tests (W3C 2004; Paessler Inc 2005). However the research can be summarised into two main groups used in the testing of a web-based learning management system - the technical test and the usability test.

Technical tests refer to testing the servers which host a learning management system. This test is designed to measure whether the server is able to handle the users' request. (Paessler Inc 2005)

Usability tests refer to the testing of a learning management system from a user perspective and cover the following questions (W3C 2004):

- Does the website connection speed meet the users' requirements?
- Is the learning management system able to function under different operating systems and web browsers?
- Does the learning management system have bad links?
- Is the learning management system navigation system easy to use?
- Are the learning objects in the learning management system able to be displayed?
- Are the learning tools in the learning management system able to function?
- Does the font of the learning management system meet the users' requirements?

CHAPTER 3

METHODOLOGY AND METHODS

In this study, a two-stage approach was used to address the research question and to achieve the aims of the research. In stage one, a prototype course sequencing protocol was developed to provide an individualised and interactive learning environment. Stage two applied the course sequencing protocol in practice within an online course in order to obtain feedback from the students.

Considering the various aspects of design, testing, implementation and the range of learning scenarios involved with the study, a single research design approach will not suffice. Therefore, a mixed methods approach was adopted.

"A mixed methods study involves the collection or analysis of both quantitative and or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority and involve the integration of the data at one or more stages in the process of research" (Cresswell cited in Tashakkorri and Teddlie 2003 p.212).

This research approach will enable the gathering of a range of relevant and robust data.

For this study, data was collected via:

- Questionnaire: A survey questionnaire was used to gather responses regarding the range of variables/functionalities.
- Interviews: Interviews were used to follow up on and to explore and elaborate on some responses to the questionnaire.
- Computer Generated Log: The computer generated log was used to record and gather data on the students' behaviours (e.g. logging in patterns, interactions, etc.) within the individualised and interactive learning environment.
- Researcher Observation: The researcher observed and gathered data on students' behaviours within the training room.

Figure 3.1 illustrates the conceptual framework for the study.

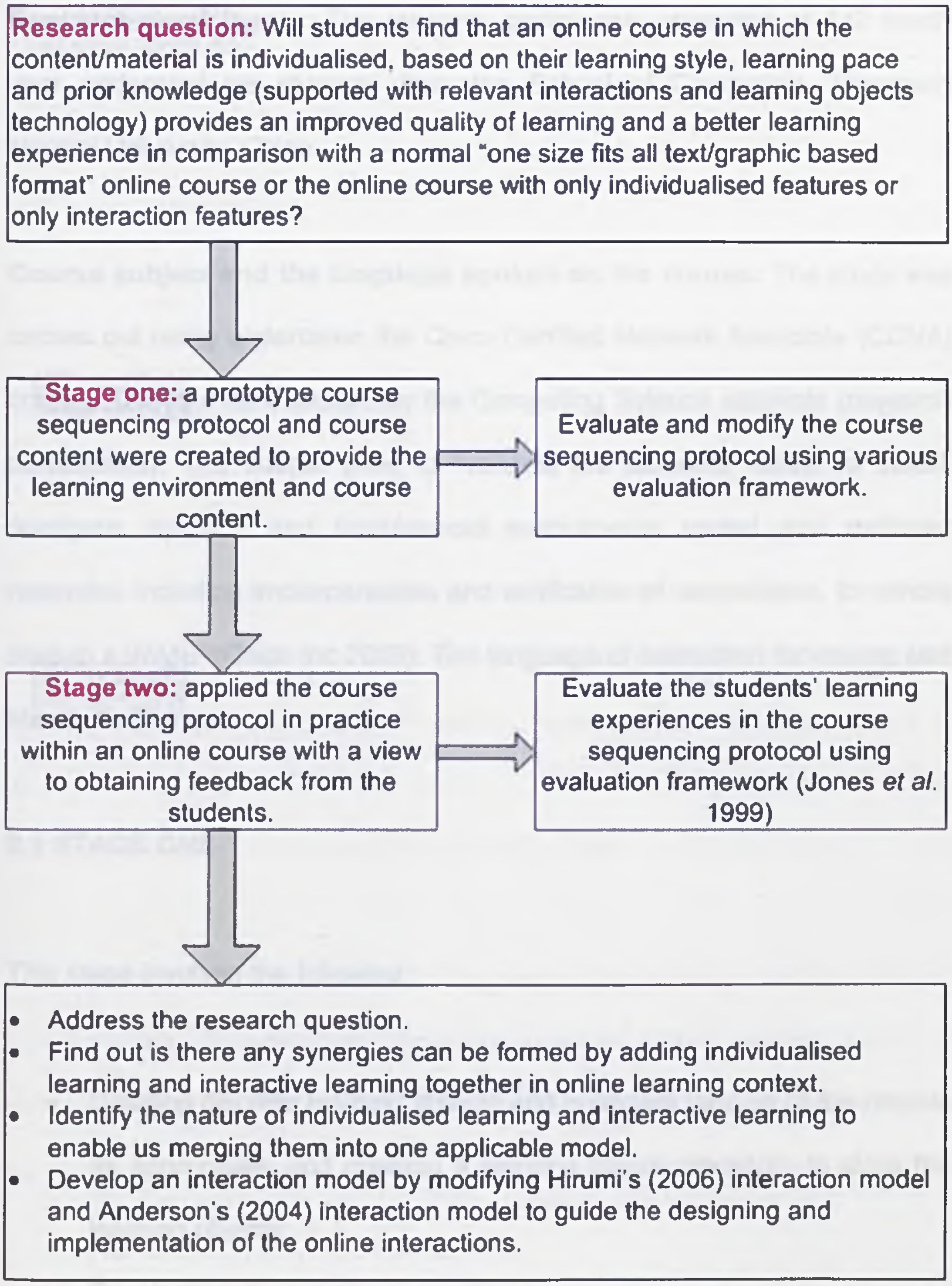


Figure 3.1: Conceptual framework for the Study

Research participants: The research participants consisted of 112 fourth year undergraduate students from the School of Computing, Shenyang Normal University, China.

Course subject and the language spoken on the course: The study was carried out using undertaken the Cisco Certified Network Associate (CCNA) course. This is a core course for the Computing Science students (research participants). The course aims to "validate the students' ability to install, configure, operate, and troubleshoot medium-size routed and switched networks, including implementation and verification of connections, to remote sites in a WAN." (Cisco Inc 2003). The language of instruction for course was Mandarin Chinese.

3.1 STAGE ONE

This stage involved the following:

- Creating discrete learning objects and metadata tagging of the objects, as appropriate, and creating a learning object repository to store the learning objects;
- Developing a prototype course sequencing protocol to simulate various learning environments;

- Training the research participants;
- Evaluating the efficacy of the course sequencing protocol;
- Applying the knowledge gained from the educational principles, and the data collected from the pilot tests, to modify the course sequencing protocol and enable it to function properly.

3.1.1 Learning Object Development

One thousand, four hundred and ninety one (1491) learning objects were created for a Cisco CCNA course. These objects were clearly metadata tagged using IEEE LOS as the tagging standard (Institute of Electrical and Electronics Engineers, 2002). A learning object repository was created to store the learning objects. The learning object metadata was stored in an XML file in order to manage all the learning objects used in the study.

The raw learning objects used in the study were in text, graphics, sound, video and animation formats. The study converted all the learning objects to a flash file format using FlashPaper™ (Adobe System Inc 2005) for higher visual satisfaction.

3.1.2 Learning Object Meta Tagging

All the learning objects used in this study were tagged, based on the IEEE Standard for Learning Object Metadata, IEEE 1484.12.1-2002 (Institute of Electrical and Electronics Engineers 2002). The metadata standard is reviewed in the literature review of the thesis (refer to page 68).

According to the specific need of the study, information relating to the learning objects was categorised into the following major groups:

1. **General Information**: This describes the basic information of the learning objects, such as identifier, title, language, and keywords.
2. **Technical Information**: This provides information related to format, size, location, duration, and software needed.
3. **Educational Information**: This provides the key pedagogical information pertaining to types of interactivity, intended end user role, learning style type, and context. It is the most important category of the metadata in this study. The learning object repository returned the specific learning objects to different students according to their different learning styles and asynchronous learning progress.
4. **Copyright Information**: This information relates to copyright.

The study also developed a Learning Object Management Tool (LOMT), which was key to the construction of the learning objects metadata (see Figure 3.2 for a LOMT screen shot).

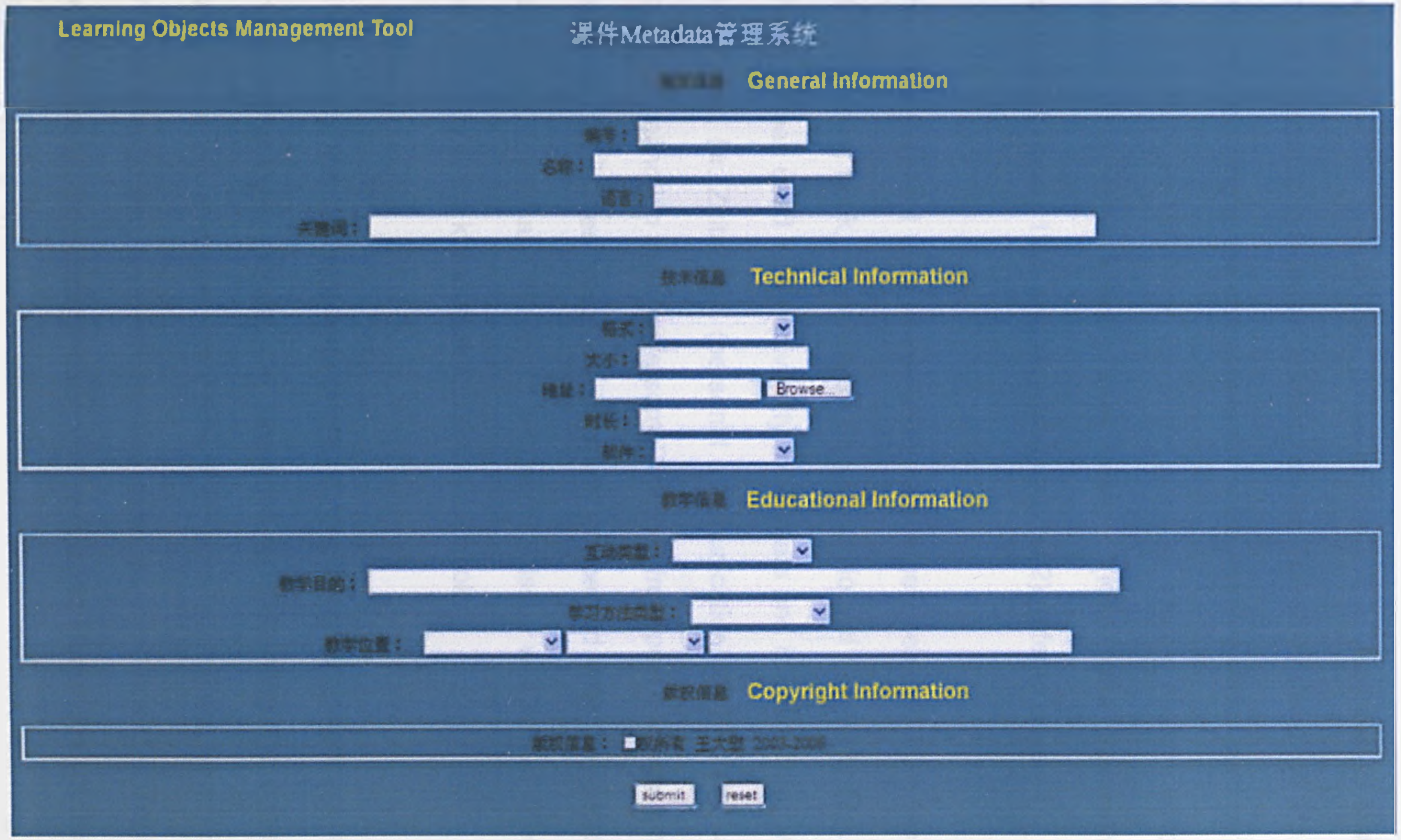


Figure 3.2: LOMT screen shot

3.1.3 Course Content Development

Individuals differ in how they prefer to learn, it is essential to match the course content to individuals' learning styles. The study designed the course content according to the characteristics of the learning styles summarised by David Kolb (Kolb 1984) and the implications for training designs which were discovered in Kolb's learning style research (Kolb 1984; Ellsworth 1995; Collis 1998; Riding 1991 and HayGroup inc 2002) (refer to page 43).

The course content used in this study was largely selected from the official CCNA training book, published by Shenyang Normal University (Xu, 1998). This has been used in the university for 4 years and is accredited by Cisco. The author, Dr. Zhitao Xu, (personal communication, 28 September 2004) notes that, although there were some critiques from past students who used the book, the issues raised were mainly concerned with the presentation sequences, layout and quality of pictures. No issue was raised concerning the accuracy of the knowledge content in the book.

In this study, the students were offered different course content according to their learning styles. Firstly, the sequence for presenting the content and guidance in the chapters was different for each participant based on their prior knowledge and preferred learning styles as summarised in Table 3.1a. Secondly, in addition to the sequence of presenting knowledge, students with different learning styles were offered different individualised learning objects as summarised below in Table 3.1b. The accuracy of the new course content in terms of technical knowledge was checked and verified by Dr. Zhitao Xu. Other sources of materials related to the CCNA study were not used because of licence issues.

Table 3.1a: Sequence for presenting the content and guidance in the chapters for students with different learning styles

Converger	Assimilator	Accommodator	Diverger
• At the beginning of each chapter, a figure, which illustrated the logical sequence of the knowledge content within the chapter, was given to the students. • The original course objectives for each chapter were enhanced. • The knowledge points in the chapter were numbered to reflect the figure at the beginning of the chapter. • The sequence of presenting knowledge was changed to allow	• At the beginning of each chapter, a figure which illustrated the logical sequence of knowledge in the chapter, was given to students. • At the beginning of every knowledge point, detailed directions were given to the students. • The sequence of presenting knowledge was changed so it was more focused on the logical sequence than the original sequence of the official CCNA	• The sequence of presenting knowledge stayed the same as that in the official CCNA training book. • From the beginning of the study, the students role-played as a real life network engineer.	• The sequence for presenting knowledge stayed the same as in the official CCNA training book. • Between every knowledge point, imagination pages were inserted to allow students to do creative and innovative activities. On the imagination pages between the knowledge points, there was question-based guidance to guide the students' creative activities.

it to be more focused on the logical sequence than on the original sequence of the official CCNA training book.	training book.		

Table 3.1b: Individualised learning objects for students with different learning styles

Converger	Assimilator	Accommodator	Diverger
• Routers and switches simulations. This was a Flash™ based routers and switches simulator, which was able to simulate real routers and switches. Routers and switches simulations appeared every time the students encountered a knowledge point which had routers or switches. • Mock test trial and errors. The test at the end of each chapter of the course. This tested each	• Further reading of the network technology. During the course, every knowledge point was expanded on for the student. • Further mock test. The mock tests for students were extended. • Mock online theoretical network project. The student was asked to design appropriate network solutions according to the chapter objectives on the Flash™ based network simulator	• Routers and switches simulations. This was a Flash™ based routers and switches simulator which was able to simulate real routers and switches. Routers and switches simulations appeared every time the student encountered a knowledge point which had routers or switches. • Mock test trial and errors. The test at the end of each chapter of the course. This tested each	• Brain storming session. The student was required to brain storm at the end of each chapter's study, on the following issues: knowledge of the chapter, exam questions, student-student interaction methods and teaching methods. The student was requested to write down ideas. Selected ideas were posted to the forum by the teacher for other students to consult.

knowledge point in the chapter. The chapter title would stay red if the student had not provided the correct answer to every question. The browser would revert back to the knowledge point if the student had provided a wrong answer to a question in the test. • Simulations of real world LAN/WAN network problems. This was a Flash™ based network simulator, which was able to simulate real LAN/WAN network problems. The student was required to identify and solve the problems.	and to specify the theory behind the design in a design report. Selected design reports were posted to the forum by the teacher for other students to consult. • Summarisation of each chapter's knowledge and conceptual model designing. The student was required to summarise each chapter's knowledge and design each chapter's conceptual model. The student was asked to specify them in a report. Selected reports were posted to the forum by the teacher for	knowledge point in the chapter. The chapter title would stay red if the student had not provided the correct answer to every question. The browser would revert back to the knowledge point if the student had provided a wrong answer to a question in the test. • Group mock online hands-on network project. The student was required to design the appropriate network solutions on a group basis according to the stated objectives on the Flash™ based network simulator. Selected design reports were	• Mock online network project. A network project objective was given to the student, who was required to design solutions as much as he/she could. Selected design reports were posted to the forum by the teacher for other students to consult. • Further examples of CCNA knowledge. As well as the examples of knowledge within the course, further examples were given to the students. • Self-diagnostic activities. The student was required to perform

• <u>Mock online hands-on network project</u>. The student was required to design appropriate network solutions according to the chapter objectives on the Flash™ based network simulator. Selected design reports were posted to the forum by the teacher for other students to consult.	other students to consult.	posted to the forum by the teacher for other students to consult. • <u>Tutorial</u>. The teacher forwarded Ask Tutor questions from other students to the student's learning management interface. The student was asked to answer these questions and send the answers back to the teacher. Selected questions and answers were posted to the forum by the teacher for other students to consult.	a self-diagnostic session after studying each chapter and to identify the strengths and areas of weaknesses found during the study and to present these information in a report. Selected reports were posted to the forum by the teacher for other students to consult.

3.1.4 Course Sequencing Protocol Development

A Course Sequencing Protocol was developed using PHP/MySQL technology and 3 pieces of GPL (General Public License) license software. The course sequencing protocol aims to provide various learning environments such as:

- Individualised learning environment with interaction tools
- Individualised learning environment without interaction tools
- "One-size fits all" mode learning environment with interaction tools
- "One-size fits all" mode learning environment without interaction tools

The research question and research aims can be addressed by comparing the students' learning experience and behaviours during the learning process within different learning environments.

The course sequencing protocol included two main processes: the individualisation process and the interaction process. These processes can be switched on and off in the control panel of the course sequencing protocol.

The aim of the individualisation process was to provide students with an individualised learning environment. Kolb's learning style inventory was used to determine the students' learning style and to build the Student Profile Database (SPD). The learning style inventory process, student process, content process, and teacher process have been designed to serve the individual's needs in the study.

The interaction process provides students and teachers with synchronous and asynchronous communication tools and was also designed to serve the student/teacher-environment interaction needs. The communication tools in the interaction process included a private messaging system, a chat room, an Ask Tutor system, and a discussion forum. The learning activities record tool was designed to collect information and data about the student learning activities during the course.

Details about the development of the course sequencing protocol are available in the course sequencing protocol section of this thesis (refer to page 105).

3.1.5 Training of the research participants

A 10 day face-to-face training session was delivered to the students who participated in the study. The course material was the adapted CCNA content provided by the Shenyang Normal University (Xu 2002). The 10 day session enabled the students to complete the first half of the CCNA course as well as familiarising them with the knowledge of basic router/switch technology. In addition, the students were given a tutorial session on how to use the course sequencing protocol. A total of 112 students participated in the training.

3.1.6 Course Sequencing Protocol Evaluation

A series of tests: a server stress test, an operating system and web browser test, a legal self-diagnostic session, a pilot study and a learning activities record tools test were used to evaluate the efficiency of the course sequencing protocol. These tests were done to assess the performance and reliability of the course sequencing protocol and to guarantee its dependability. The evaluation theories and the model are reviewed in the literature review of the thesis (refer to page 71)

3.1.6.1 Server stress test

For the evaluation of the course sequencing protocol, the Webserver Stress Tool 6.16 (Paessler Inc 2005) was used to conduct the computer test. The course sequencing protocol was designed for handling multiple users at the same time. This technical reliability test was designed to measure whether the programme could handle the expected number of users and for determining the precise point at which the product could fail as the number of users increased or their behaviours changed. The Webserver Load Performance Stress Test was carried out under the following condition: 150 simultaneous users - 5 seconds between clicks for ten minutes.

3.1.6.2 Operating system and web browser test

The course sequencing protocol was tested using Windows 2000 and Windows XP operating systems and Internet Explorer and Netscape browsers. This was to ensure that the course sequencing protocol was able to function under a variety of operating systems and web browsers.

3.1.6.3 Legal self-diagnostic session

A legal self-diagnostic test was required to comply with the Chinese government's initiative to prevent the uploading of illegal content to the web. The test was carried out in accordance with the protocol as detailed within the guide for the prevention of illegal web content produced by the Ministry of Information Industry of the People's Republic of China (2005).

3.1.6.4 Pilot study

The pilot study of the course sequencing protocol was carried out using a survey questionnaire and followed by face-to-face or telephone interviews. The questionnaire was based on a combination of structured and unstructured questions (See Appendix 1 for the survey questionnaire).

The questions were multiple choice and the students had to evaluate the usability of the prototype course sequencing tools using a scoring of "Very

Good", "Good", "Fair" and "Poor" to rate the various technical features, which could affect their functionalities and usage.

Also, the students were also asked to give their contact details - to be used with the follow up interviews. The purpose of the interview was to find out the reason(s) why some of the students rated some of the questions "Fair" or "Poor".

Students who rated any question in the questionnaire "Fair" or "Poor" were invited to a face-to-face or a telephone interview.

3.1.6.5 Learning activities record tools test

This test was designed to measure the function of the learning activities record tool. During the test, the students were asked to perform the following actions:

- Log in/Log out of the course sequencing protocol three times.
- Log in/Log out the course content three times (by performing logging in/logging out of Chapter 1 of the CCNA course).
- Log in/Log out of the chat room three times.
- Log in/Log out of the discussion forum three times, posting one thread and replying to one thread each time.
- Sending three messages to Ask Tutor facility.
- Sending three private messages to a designated recipient.

- Completing a report note and handing back the report note.

3.1.7 Course Sequencing Protocol Modification

Following feedback from the technical reliability test, the pilot study and the learning activities record tools test, some of the features of the course sequencing protocol was modified to suit students' needs. Further training was given to any students who were not clear on how to use the course sequencing protocol.

The detailed modifications to the course sequencing protocol are presented in the results chapter of this thesis (refer to page 127).

3.2 STAGE TWO

This stage of the study involved:

- Delivering the course through the course sequencing protocol.
- Using a survey questionnaire, semi-structured interviews, logs which were generated by the course sequencing protocol and the observations of the researcher who carried out this study, to evaluate the course in order to establish:

    1. the suitability and relevancy of the course sequencing protocol and course content in meeting the different respondents'

learning styles and the user-friendliness of the learning programme and the learning environment;

2. the differences (if any) between the courses, based on the different learning environments in the developed course sequencing protocol.
3. the model of interaction in the technology-enhanced learning environment.

- Evaluating the impact of the course sequencing protocol in the delivered courses in terms of quality of learning and the students' learning experience.

3.2.1 Course format and course delivery

The adapted Cisco Certified Network Associate (CCNA) course used for this study was divided into 10 chapters. The course duration was 10 days with 6 hours of learning each day and consisted of self-study with teacher support. The course was delivered in three training rooms at Shenyang Normal University. This stage of the course is referred to as the "training room sessions" in this research.

Upon finishing the course, students were informed that the course sequencing protocol was still available for them to access from any Internet Protocol (IP) range within the Shenyang Normal University campus before their formal CCNA exam. Four teachers involved in the training.

3.2.2 Sampling method

In order to address the research question and research aims, student feedback and comments on the course and the individualised and interactive learning environments are important. To facilitate the gathering of the relevant information and data for the study, the sampling process was divided into two main sessions as training room sessions and post-training room sessions.

3.2.2.1 Training room sessions

In the sessions, the course was delivered to the students in three training rooms in the School of Computing, Shenyang Normal University. The purposes of the sessions were to identify the difference (if any) between students who attended courses using different learning environments.

Step One. Chapters 1 to 5 of the adapted CCNA course were delivered to the students according to their learning styles. The individualisation system was switched on and the individualised course content was delivered to the students, but the interaction features were switched off so that the students could not use the communication tools. The students were randomly assigned to three training rooms.

Step Two. The students were evenly divided into three groups according to their learning styles. Each group of students was assigned to one training room. Chapters 6 to 10 of the CCNA course were delivered to the students as described in Table 3.2.

Table 3.2a: Group course delivery format for Chapters 6 to 10

Group 1	Group 2	Group 3
• Both the individualisation system and the interaction system of the course sequencing protocol were switched on.	• The individualisation system was switched off. • The course was delivered to all the students in the same mode regardless of their learning styles. The course content used was that provided in the official CCNA training book without individualised features. • The interaction system of the course sequencing protocol was switched on.	• Both the individualisation system and the interaction system of the course sequencing protocol were switched off. • The course was delivered to all the students in the same mode regardless of their learning styles. The course content used was that provided in the official CCNA training book without individualised features.

By offering the students different learning environments in the learning sessions of chapters 1-5 and chapters 6-10, the study was able to compare the students' learning experiences and learning behaviours within various learning environments. So, the learning environment, which contributed most to the students' learning experience, was able to be ascertained. See Table 3.2b for more details.

Table 3.2b: Comparison of Learning Environments

Individualised Learning environment without interaction tools vs. "One size fit all" learning environment without interaction tools	"One size fit all" learning environment with interaction tools vs. "One size fit all" learning environment without interaction tools.	Individualised Learning environment with interaction tools vs. Individualised Learning environment without interaction tools	Individualised Learning environment with interaction tools vs. "One size fit all" learning environment with interaction tools	Individualised Learning environment without interaction tools vs. "One size fit all" learning environment with interaction tools
Compare Group 3's learning experiences and learning behaviours in chapters 1-5 and chapters 6-10.	Compare Group 2's and Group 3's learning experiences and learning behaviours in chapters 6-10.	Compare Group 1's and Group 2's learning experiences and learning behaviours in chapters 6-10.	Compare Group 1's learning experiences and learning behaviours in chapters 1-5 and chapters 6-10.	Compare Group 2's learning experiences and learning behaviours in chapters 1-5 and chapters 6-10.

Table 3.3 represents the amount of the students in each group with their preferred learning styles (LS).

Table 3.3: Number of students in each group with their preferred learning styles

	Converger	Assimilator	Accommodator	Diverger	Total
Group 1	16	11	7	4	38
Group 2	16	10	8	3	37
Group 3	16	10	8	3	37
Total	48	31	23	10	112

Step Three. On finishing the training room sessions, the three groups of students were invited to complete the course evaluation questionnaires. The students were requested to complete every question in the questionnaire carefully and confidentially. The purpose of the questionnaire was to gather their feedback on the course itself and on the course delivery methods. The questionnaire was completed at the end of the last training room sessions. This was to obtain immediate feedback from the students about the course. (See Appendix 2 for the course evaluation questionnaire)

3.2.2.2 Post-training room sessions

During the 30 day gap between the date of the last training room sessions and the formal examination date for the CCNA course, all the students were granted access to the course sequencing protocol (with the individualised and the interaction system switched on) from the IP within the campus of Shenyang Normal University. In addition, the students had access to online tutor support. The purposes of the sessions were to examine the students' learning experiences and learning behaviours in an individualised course sequencing protocol supported by relevant interactions.

3.2.3 Data collection

For this study, data was collected from multiple sources. These included: survey questionnaires, interviews, logs and researcher observations.

Survey Questionnaire: The purpose of the questionnaire was to gather students' feedback on the course and course delivery methods. The questionnaire consisted of a combination of structured and unstructured questions. The structured section was based on a Likert scale response format and the unstructured part was based on free text responses. The students were requested to complete the survey questionnaire at the end of the training room session.

Interviews: Semi-structured interviews were carried out with all students who participated in the course. The face-to-face interviews were held within three days of the students completing the CCNA exam. The interviews conducted in groups of eleven (11) were intended to gather feedback on the students' experience of: the course sequencing protocol, the course itself and the course delivery methods. The interviews were digitally audio recorded and the responses were transcribed.

Logs: Users' logs were generated by the course sequencing protocol. The data collated within the logs were categorised as: general logs, interactions logs, and individualisation logs. An interaction index was built into the course sequencing protocol system to measure the students' interaction activities.

Researcher Observation: This involved the researcher observing the students' behaviours during the training room sessions. The researcher spent a total of thirty minutes within each training room: ten minutes at the beginning, middle and at the end of sessions. The data and comments/remarks on the students' behaviours were recorded using pen and paper.

3.2.4 Data analysis

The responses and data collected from the questionnaire and interviews were analysed using descriptive statistics and correlation analysis. Interviews were digitally audio recorded, transcribed and analysed using content analysis methods (Berelson 1990).

SPSS and Microsoft Excel were used for data analyses. This test was based on a one-tailed t-test. The inclusion criterion for this group was that students attended the CCNA teaching sessions in February 2004 and passed the official semester 1 test. The exclusion criterion was that students did not attend the above sessions and failed to pass the semester 1 test. A total of 112 students met the inclusion criteria.

3.2.5 Evaluation of the study

Jones *et al.* (1999) developed a framework for evaluating computer assisted learning programmes. The framework has been used effectively at the Open University, UK and other educational institutions worldwide. The framework intends to evaluate online learning programmes from context, interaction and outcomes perspectives. In the framework, evaluation from context perspective intends to address why particular learning programmes are adopted in the first place, i.e. the underlying rationale for its development and use. Interactions examine students' interactions with learning programmes in order to better understand students' learning process. Outcomes are used to evaluate the effectiveness of learning programmes. The evaluation framework is straight forward, and the incorporation of the above three aspects enhances the effectiveness of evaluations.

Using the CIAO! framework both formative and summative assessment approaches. (Jones, *et al.* 1999), this study will be evaluated from the following perspectives:

Context: This will involve evaluating the students' experiences in various learning environments in order to address the underlying rationale for the course sequencing protocol with both individualised and interactive learning features.

Interactions: This will involve evaluating the students' learning processes and behaviours in various learning environments.

Outcomes: The students' performances based on both formative and summative assessments will be used to evaluate the effectiveness of the course sequencing protocol.

3.2.6 Research Ethics

The study was carried out within the University's approved ethical guidelines. Also, to ensure that no students were disadvantaged, all students were offered the same training and development albeit at different times.

CHAPTER 4

COURSE SEQUENCING PROTOCOL

This chapter describes in detail the development and functionality of the course sequencing protocol. The course sequencing protocol is a prototype web-based learning environment. It was designed for sequencing the learning objects used in this study. It includes two main processes, the individualisation process and the interaction process. Both processes are able to be switched on/off in order to simulate multiple types of learning environments.

4.1 DEVELOPMENT OF THE COURSE SEQUENCING PROTOCOL

The course sequencing protocol was developed using PHP/MySQL database technology and 3 pieces of GPL (General Public License) license software.

Table 4.1 presents a summary of the evaluation of the interactive and database technology, which provided the basis for the choice and suitability of the preferred technology.

Table 4.1: Evaluation of Interactive and Database Technology

	PHP/MySQL	JSP/MySQL	ASP.Net
Cross Platform	YES	YES	NO, Windows Only, The study will use UNIX as the operating Platform
Cost	FREE	FREE	CHARGE
Client Software	NO	YES	NO
Integration with other software used in the study	YES	NO	NO
Suitable for the study	**YES**	**NO**	**NO**

4.2 INDIVIDUALISATION SYSTEM

The individualisation system was designed to serve the individualisation needs of the study. The system consists of: the learning style inventory process; the student process; the contents process and the teacher process. Kolb's LSI was used to inform and build the Student Profile Database (SPD). Figure 4.1 illustrates the framework of the individualisation system used in this study.

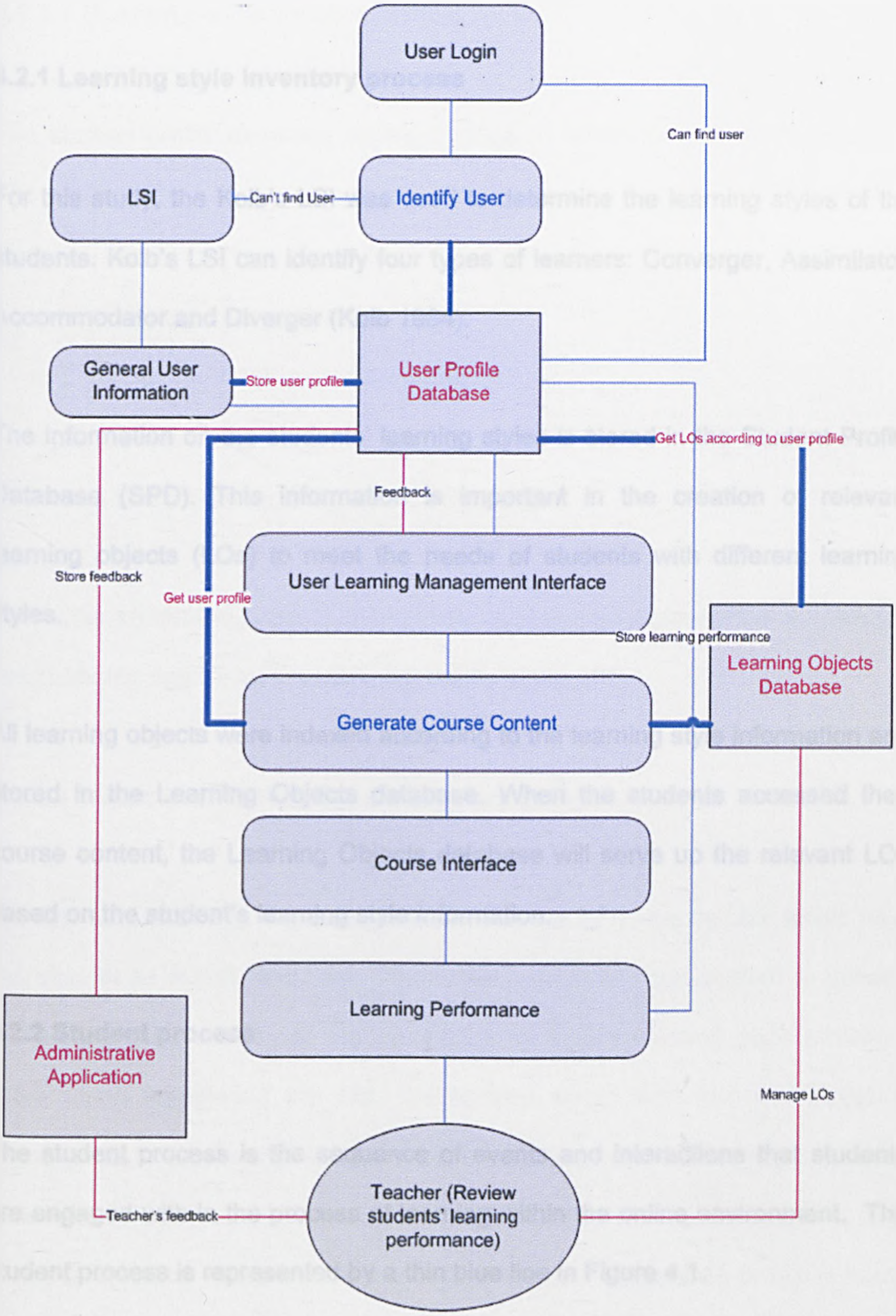


Figure 4.1: Individualisation System Design

4.2.1 Learning style inventory process

For this study, the Kolb's LSI was used to determine the learning styles of the students. Kolb's LSI can identify four types of learners: Converger, Assimilator, Accommodator and Diverger (Kolb 1984).

The information on the students' learning styles is stored in the Student Profile Database (SPD). This information is important in the creation of relevant learning objects (LOs) to meet the needs of students with different learning styles.

All learning objects were indexed according to the learning style information and stored in the Learning Objects database. When the students accessed their course content, the Learning Objects database will serve up the relevant LOs based on the student's learning style information.

4.2.2 Student process

The student process is the sequence of events and interactions that students are engaged with in the process of learning within the online environment. The student process is represented by a thin blue line in Figure 4.1.

4.2.2.1 Student profile database (SPD)

The student profile database stores a range of information about the student. These include:

- the student's learning style;
- information on their prior knowledge;
- the learning log;
- the interaction log and general information.

When the student logs on to the course sequencing protocol, the system will automatically search for the student's profile in the SPD.

4.2.2.2 Student authentication and student profile formation

If a student's profile is not found or located in the SPD, the system would treat the student as a first time user. The system would ask the student to provide his/her personal details via the completion of Kolb's learning style inventory (LSI). Upon completing the LSI, the system would work out the student's learning style according to the Kolb's learning style inventory's scoring instruction (HayGroup 2002). As described in 4.2.2.1, the student's general user profile information was stored in the SPD. Whenever a student's profile is found within the SPD, the system would direct the student to his or her individualised learning management interface (LMI).

The LMI is the portal for all the learning activities. Here, students could access the discussion forum, the messaging tool, Ask Tutor tools and the course content. They could also receive individualised feedback from teachers, which include amongst other things, system wide and group wide communications. The LMI enables the student to manage his or her pace of learning and learning activities. The system is able to alert the student to any unfinished course assignments and automatically show the finished and unfinished activities within the various chapters. Students are able to configure and customise alerts from the control panel in the LMI (see Figure 4.2 for LMI screen shot).

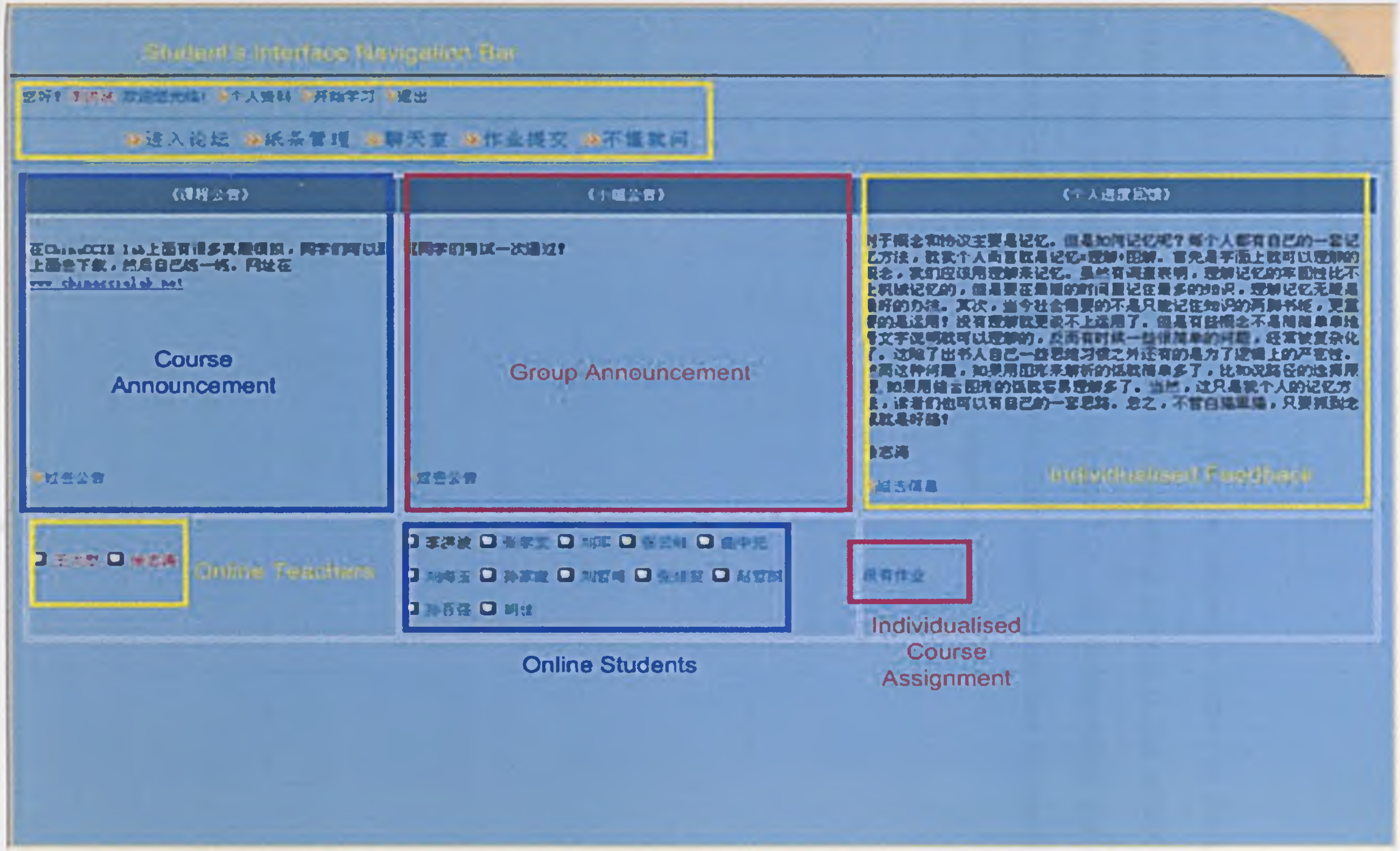


Figure 4.2: LMI Screen Shot

4.2.2.3 Student learning process

Students can access the course content by clicking a button in the LMI. The course content consists of a mixture of learning objects (LOs), which includes text, video and flash interaction objects. LOs are delivered to the students according to their learning styles and other learning activities log (refer to page 114). See Figure 4.3 for the course interface.

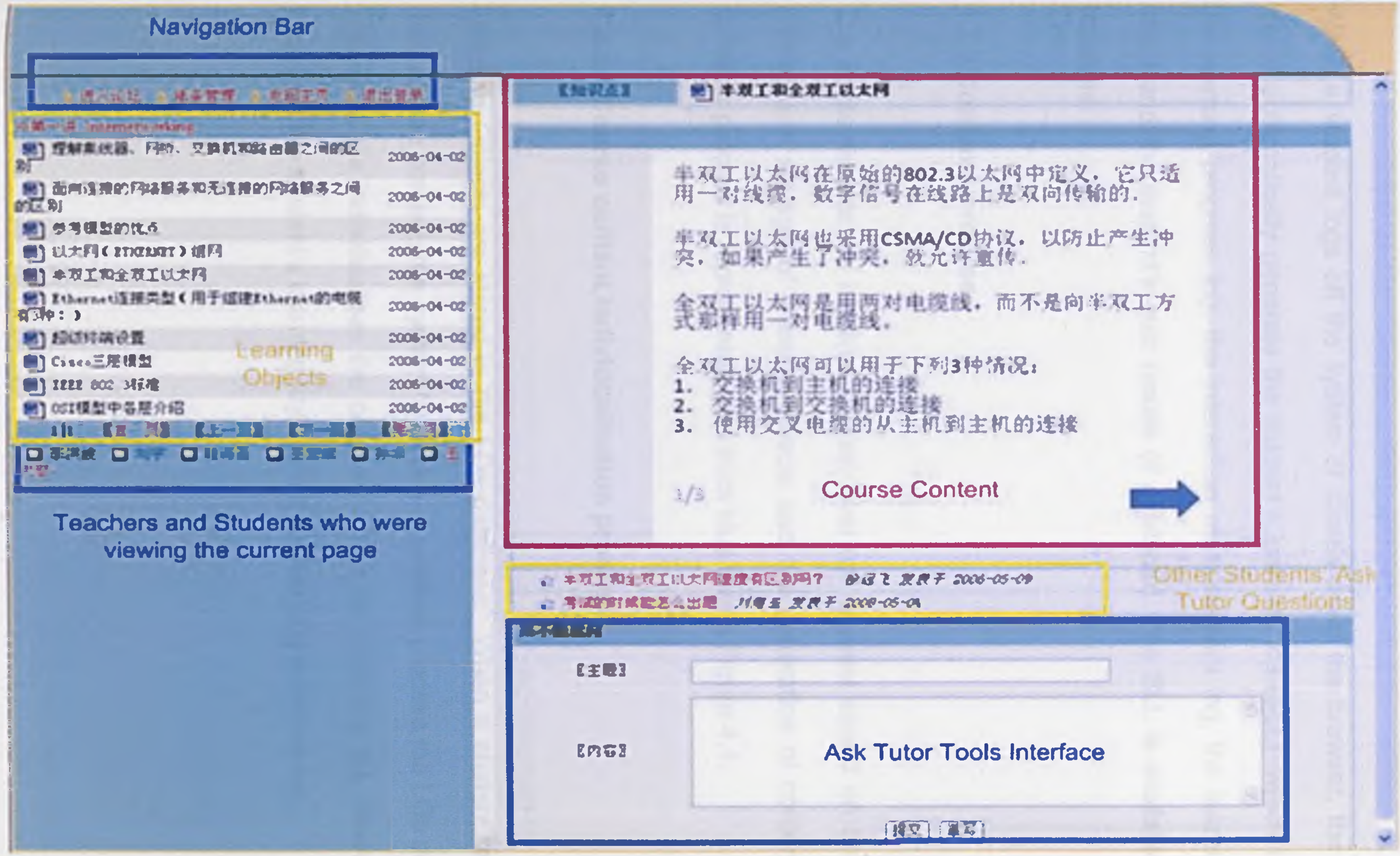


Figure 4.3: Course Interface

When a student logs off the system or closes down the browser, the system would automatically generate the student's learning log (SLL), which includes the learning progress log, the interaction measurement log, the learning time count and the student's quiz results (if available). The SLL is available to the teachers.

4.2.3 Contents process

The contents process involves the retrieval (on request based on the user's profile) and storage of learning objects and the generation of content. The contents process is represented by a thick blue line in Figure 4.1.

4.2.3.1 Course content individualisation process

Learning Objects are stored in the LOs database. When a student accesses their course content, the system triggers a requisition process the LOs database. The database individualises the course content by retrieving the relevant LOs based on the student's learning style and their learning activities log.

4.2.4 Teacher process

The teacher process is described as the range and sequence of events and interactions that the teacher is engaged with in order to promote effective learning within the online environment. The teacher fulfils both support and administration roles. The teacher process is represented by a red line in Figure 4.1.

The teacher provides support for students' learning by giving individualised feedback, answering the "Ask Tutor" questions and viewing the student's learning activities log. The teacher's administration role is mainly concerned with general database management and learning environment settings. The teacher manages his/her roles via the teacher management interface as shown in Figure 4.4.

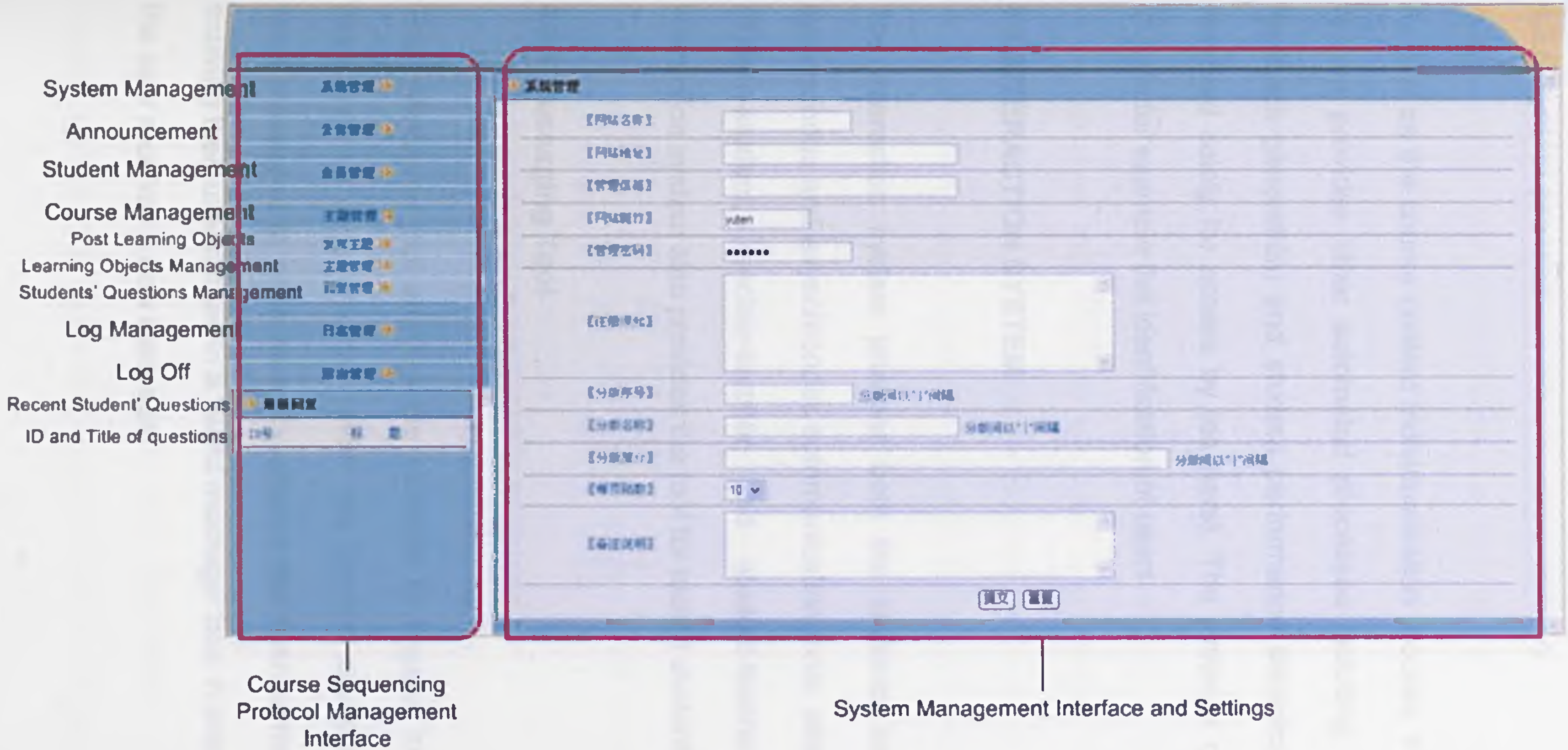


Figure 4.4: Teacher Management Interface

4.2.5 System process

As well as the course content individualisation process, the course sequencing system provides other automated processes including: SLL log generation; feedback generation; and student performance statistics (the latter could be reserved solely for access by teachers). The system's other internal process include for example the identification of users.

4.3 INTERACTION SYSTEM

The interaction system provides both the students and the teachers with synchronous and asynchronous communication tools, which enable a range of: student-student, teacher-teacher and student-teacher interactions. The interaction system also provides the tool for record student learning activities.

4.3.1 Messaging Tool

The messaging tool enables the students to engage in a one-to-one based asynchronous communication within the learning environment. Students could send messages to each other by clicking the user names of the recipients or entering their user names in a "Send message" box. A popup box appears when the user receives a new message.

The system lists all the names of users who are online and categorises the users by name and learning styles. This enables the students to easily find other students with the same preferred learning style.

4.3.2 Chat Room Tool

The chat room tool provides a group-based synchronous interaction environment for both students and teachers. The chat room tool in the study was used for brief tutorials and/or question and answer sessions in order to seek or provide clarification and to consolidate the learning during the training room sessions of the study. Students were able to access the chat room from the learning management interface. The chat room sessions arrangements were posted to the students' learning management interfaces. The YueGuang's source code was used to compile the chat room tools of the course sequencing protocol. The YueGuang chat room source code is under General Public License (YueGuang Inc 2005).

4.3.3 Discussion Forum Tool

The discussion forum tool provides an asynchronous interaction environment for both students and teachers. Both the discussion and chat room tools were used for both academic and social discourses. The Discuz! 4.1.0 source code was used to compile the discussion forum tools of the course sequencing protocol.

The Discuz! 4.1.0's source code is under General Public License (Comsenz Inc 2005).

4.3.4 Ask Tutor Tool

The Ask Tutor tool is a one-to–one based student-teacher interaction tool. There is a link on each course page for accessing the Ask Tutor tool. The course page information is sent along with the Ask Tutor messages for teachers' reference. The Ask Tutor tool was designed as a facility via which teachers can provide responses to students' questions on aspects of the course that they are unsure or unclear about. The Ask Tutor system automatically records all answered and unanswered questions. This function helps make the teacher's role of managing students' learning much easier. The MingKe Online Customer Services System source code was used to compile the Ask Tutor tool of the course sequencing protocol. The MingKe's source code is under General Public License (MingKe Inc 2005).

4.3.5 Individualised Feedback

Individualised Feedback is a tool designed to enable teachers to provide individualised feedback to students on their learning activities. Feedback from the teacher is displayed in the students' learning management interface.

4.4 LEARNING ACTIVITIES RECORD TOOL

The Learning Activities Record Tool is designed to collect and collate information on students' learning activities during the course. Cookies are used to generate logs. The logs are categorised as follows:

4.4.1 General Log

The general log records the students' ID, the course login/logout time, the login duration, the login IP address and the login numbers.

4.4.2 Interaction Logs

The Interaction Logs record the students' ID, their private messages numbers, the chat room login times and duration, the discussion forum posts and reply numbers, the Ask Tutor message numbers and the Ask Tutor feedback.

4.4.3 Individualisation Logs

The Individualisation Logs record the students' ID, the course start and finish points and the duration of each chapter's study.

CHAPTER 5

RESULTS

In this chapter, the results of the study are presented in six sub-sections:

- Course Sequencing Protocol's Reliability Test Results.
- Survey Questionnaire Results.
- Interview Results.
- Course Sequencing Protocol Log Results.
- Researcher's Observation.
- Students' Exam Results.

5.1 COURSE SEQUENCING PROTOCOL'S RELIABILITY TEST RESULTS

The course sequencing protocol reliability test was carried out using the following series of tests in order to ensure the protocol's technical reliabilities:

- Server stress test and an operating system and web browser test
- Legal self-diagnostic test
- Pilot study
- Learning activities record tools test

5.1.1 Server stress test

The server stress test was carried out using the Web server Stress Tool 6.16 (Paessler Inc 2005). The test involved 150 users simultaneously clicking at a target for a period of ten minutes, at 5 second intervals between clicks. The error rate was 0.03% and the average response time was 67ms.

Figure 5.1 shows a plot of the web server load performance stress test against click time and errors.

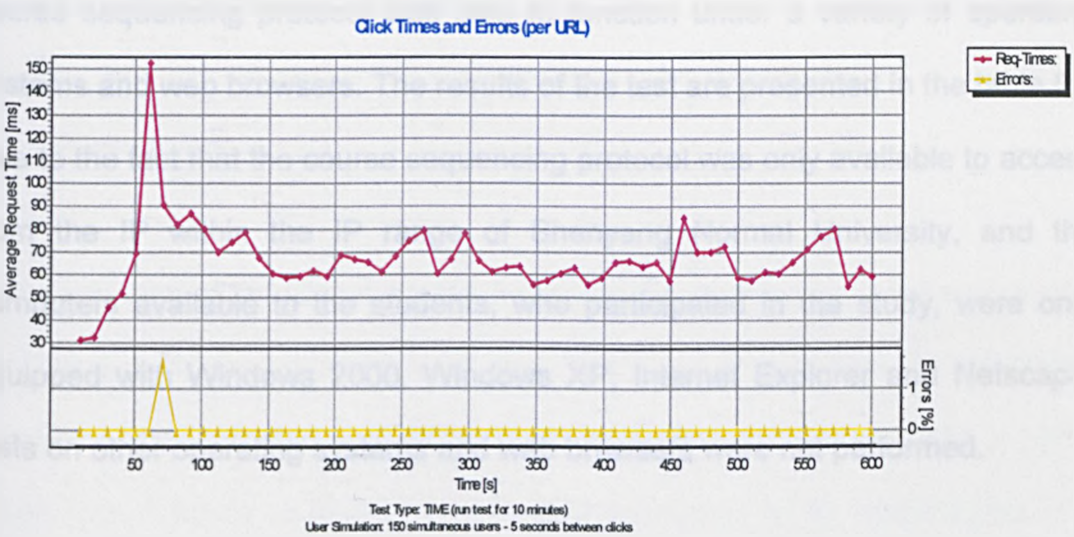


Figure 5.1: Web server Load Performance Stress Test – Click Time and Errors

A ten minute web server work load performance test was conducted. The error rate was 0.03%. A one point five percent (1.5%) error and an average of 150 minutes request time occurred during the 60 second to 75 second time frame of the web server work load performance test. This was because the web server was in a "warming up" mode during this period (see figure 5.1). This is normal for a web server (see Appendix 3 for web server load performance stress test report).

5.1.2 Operating system and web browsers test

The course sequencing protocol was tested under Windows 2000 and Windows XP operating systems using Internet Explorer and Netscape browsers. The operating system and web browser test were carried out to ensure that the course sequencing protocol was able to function under a variety of operating systems and web browsers. The results of the test are presented in the table 5.1. Due to the fact that the course sequencing protocol was only available to access from the IP within the IP range of Shenyang Normal University, and the computers available to the students, who participated in the study, were only equipped with Windows 2000, Windows XP, Internet Explorer and Netscape, tests on other operating systems and web browsers were not performed.

Table 5.1: Operating system and web browser test results

Operating systems and its web browser	Test results
Windows 2000 + Internet Explorer	OK
Windows 2000 + Netscape	OK
Windows XP + Internet Explorer	OK
Windows XP + Netscape	OK

5.1.3 Legal self-diagnostic test

A legal self diagnostic test was required to comply with the Chinese government's initiative to prevent the uploading of illegal content to the web. This test was carried out in accordance with the protocol. The protocol is detailed in the guide for preventing illegal web content produced by the Ministry of Information Industry of the People's Republic of China (2005). Results from the test showed that there was no illegal content found within and/or uploaded to the course sequencing protocol.

5.1.4 Pilot study

The evaluation of the pilot study for the course sequencing protocol was carried out using a survey questionnaire and follow up face-to-face or telephone interviews. One hundred and twelve (112) students were sampled with a 100% return rate. A follow up group interview was conducted for 51 respondents who entered a 'Fair' or 'Poor' response for any of the questions. Table 5.2a summarises the student responses to the evaluation questionnaire in the pilot study.

Table 5.2a: Summary of the Student Responses to the Evaluation Questionnaire for the Course Sequencing Protocol pilot study

Questions	Very Good	Good	Fair	Poor
	Number of respondents (N)			
The speed of website's connection	67	35	10	0
Quality of the website's navigation system	19	64	27	2
Quality of the display of the text learning objects	8	75	20	9
Quality of the display of the flash learning objects	18	56	18	20
Quality of the display of the graphic learning objects	34	72	5	1
The usability of the messaging system	76	23	13	0
The usability of the chat room	99	6	7	0
The usability of the discussion forum	47	54	11	0
The usability of the Ask tutor	45	40	20	7
The usability of the learning management interface	71	17	16	8
The overall design of the course sequencing protocol	22	61	11	18
Did you encounter bad links when using the website	Yes	No		
		112		

Did you experience any difficulty when using the course sequencing protocol	Yes	No		
		112		
How would you describe your ability to use the course sequencing protocol	41	71	0	0

Total number of respondents = 112

Table 5.2b summarises the key issues raised by the follow up interviews of the pilot study and their solution.

Table 5.2b: *Pilot study questionnaire results and follow up interview results*

Questions	Number of the students who rated the question as "Poor" or "Fair"	Summary of key issues highlighted at the follow up interview	Solutions
The speed of website's connection	10	The follow up interviews showed that the students had no connection speed problem. The students who rated "fair" or "bad" thought the loading process of the flash learning objects was due to the connection speed. In fact, the loading process of the flash learning objects was a technical requirement.	No action was taken.
Quality of the	29	Navigation button was difficult to identify;	Navigation button was highlighted.

website's navigation system		Navigation system was unfamiliar; Navigation system was too complicated.	Further training on how to use the navigation system was given to students who reported they were not familiar with the navigation system.
Quality of the display of the text based learning objects	29	Fourteen (14) students reported the font was too small; Nine (9) students reported the font was too big; Six (6) students reported they didn't like the font.	Further training on how to change the font size on Internet Explorer was given to students who reported that the font was big or small. The font used by the course sequencing protocol is "宋体" for Chinese characters and "Arial" for English characters. "宋体" and "Arial" are used by the majority of websites on the Internet, so the font for the course sequencing protocol was not changed.
Quality of the display of the flash learning objects	38	Twenty-eight (28) students reported they could not see flash;	The study found there were 31 computers in the training rooms that didn't have flash player. All computers used in the pilot study were checked to

		Ten (10) students reported they had to wait for flash to be loaded.	see if the requested software had been installed. It is a technical requirement that the flash learning objects have to be loaded before playing.
Quality of the display of the graphic learning objects	6	The reported drawbacks were concerned with the content of the testing graphics. Technically, the graphics could be displayed without problems.	No action was taken.
The usability of the messaging system	13	Thirteen (13) students reported that they were not familiar with the messaging system.	Further training on how to use the messaging system was given to students who reported they were not familiar with the messaging system.
The usability of the chat room	7	Seven (7) students reported that they were not familiar with the "Reply" function in the chat room.	Further training on how to use the "Reply" function in the chat room was given to students who reported they were not familiar with the "Reply" function.
The usability of the discussion forum	11	Eleven (11) students reported they were not familiar with the discussion forum.	Further training on how to use the discussion forum was given to the students who reported

			they were not familiar with the discussion forum.
The usability of the Ask tutor	27	Twenty-four (24) students reported that they had to wait for the tutor while using the "Ask Tutor" function; Three (3) students reported that they were not familiar with the "Ask Tutor" function.	In the pilot study, one tutor was available to reply to the "Ask Tutor" questions. The pilot study on this function lasted 30 minutes. The tutor could not reply to a large amount of questions in a very short time. This is a resource rather than a technical issue. The "Ask Tutor" function did not have any technical problems. Further training on how to use the "Ask Tutor" function was given to students who reported they were not familiar with the "Ask Tutor" function.
The usability of the learning management interface	24	Sixteen (16) students reported that they were not satisfied with the layout of the learning management interface; Six (6) students reported that the learning	Since the majority of students were satisfied with the layout of the learning management interface, the layout of the learning management interface was not changed.

		management interface was complicated.	Further training on how to use the learning management interface was given to the students who reported that they were not familiar with the learning management interface.
The overall design of the course sequencing protocol	29	Most students' reported that they were concerned about the poor visual design of the website.	The visual design was enhanced.

5.1.5 Learning activities record tools test

The results showed the system had a 99.7% efficacy in recording the student's actions.

The learning activities record tools test handed out 112 report notes to the students and 112 report notes were collected back. In comparison to the actions recorded on the student report notes, 99.7% of students' actions were recorded on the system. There was a 0.3% error rate in the test. The error rate is small and well within acceptable limits. It may be suggested that the error rate was due either to mistakes by the students or to network errors or a combination of both factors. A 99.7% match rate suggests that the learning activities record tools had no technical problems.

5.2 EVALUATION QUESTIONNAIRE RESULTS

On finishing the training room sessions, the three groups of students were invited to complete the questionnaires. The questionnaire was set out in four parts in order to find out the students' opinions on:

- The basic course properties
- The interaction system
- The individualisation system

- The overall opinions for the course

The results from the evaluation questionnaire are summarised below.

5.2.1 The basic course properties

The study indented to find out, the students' learning styles (Figure 5.2), the prior knowledge assumed (Figure 5.3), whether the course objectives were clearly explained (Figure 5.4), whether the course content was clear and understandable (Figure 5.5), whether the course appeared to have been carefully planned (Figure 5.6) and whether the difficulty level of the course was appropriate (Figure 5.7).

5.2.1.1 Question 1 "Learning styles"

Figure 5.2 shows the students' preferred learning styles: 43% were Convergers; 20% were Accommodators; 28% were Assimilators and 9% were Divergers.

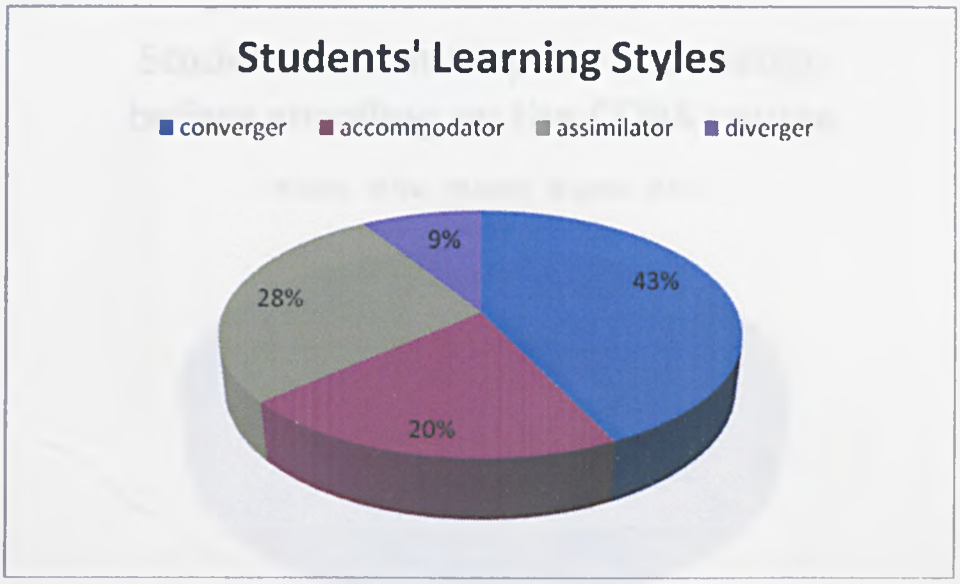


Figure 5.2: Students' learning styles

5.2.1.2 Question 2 "Prior knowledge assumed" results

Figure 5.3 shows the students' assumed prior knowledge of the CCNA course content before enrolling on the course. Fourteen percent (14%) of the students had very little knowledge of the content of the CCNA course; 30% had some knowledge; 55% reported having a good knowledge and 1% had no prior knowledge of the CCNA course content. No student reported having full knowledge of the CCNA course content.

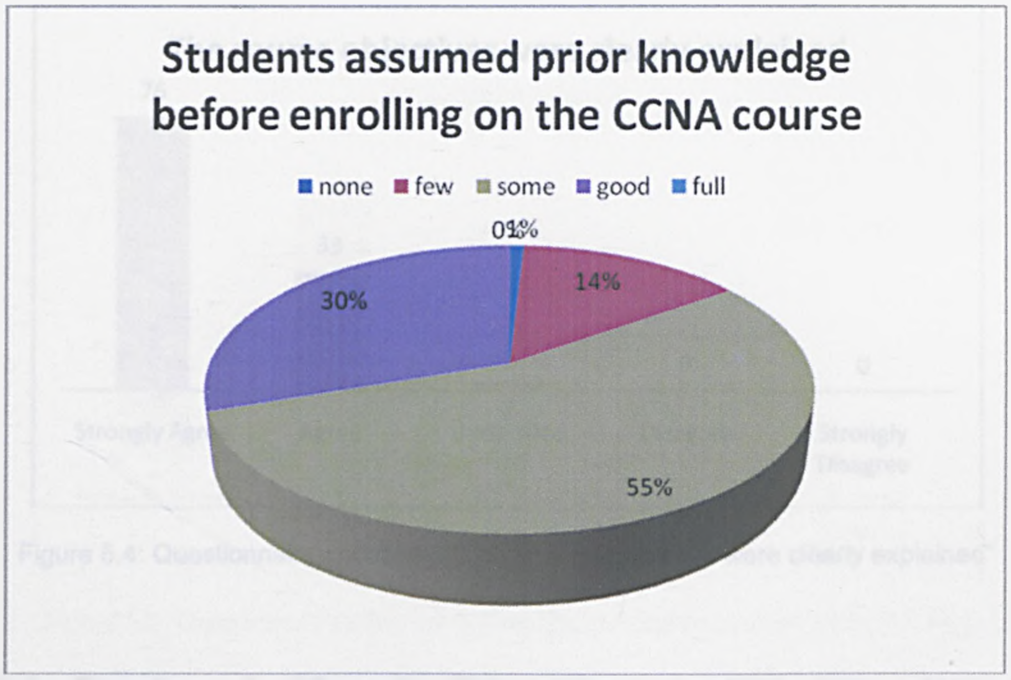


Figure 5.3: Students assumed prior knowledge before enrolling on the CCNA course

5.2.1.3 Question 3 "The course objectives were clearly explained"

Seventy six (76) of the 112 students strongly agreed that the course objectives were clearly explained; 33 agreed and 3 were undecided (see figure 5.4).

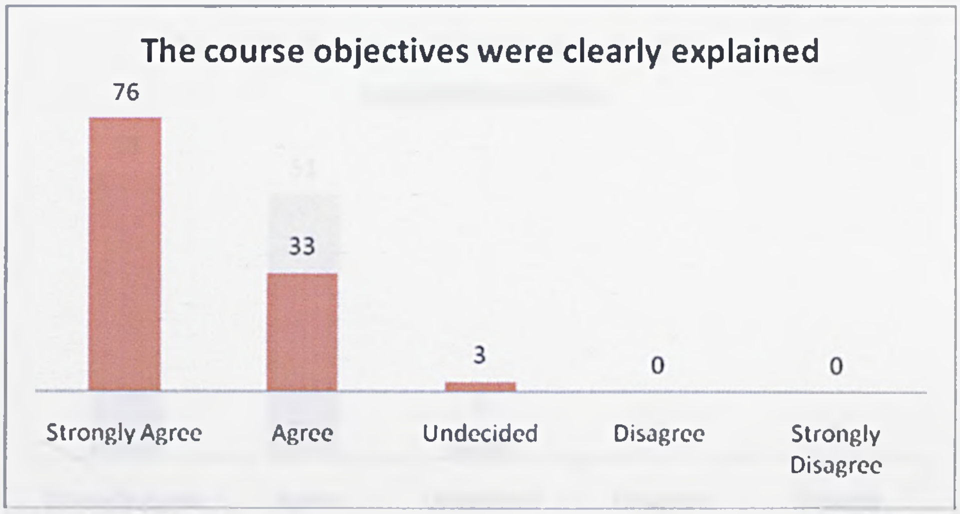


Figure 5.4: Questionnaire question 3 "The course objectives were clearly explained"

5.2.1.4 Question 4 "Overall, the course content was clear and understandable"

Fifty five (55) of the 112 students strongly agreed that the course content was clear and understandable; 51 agreed and 6 were undecided (see Figure 5.5).

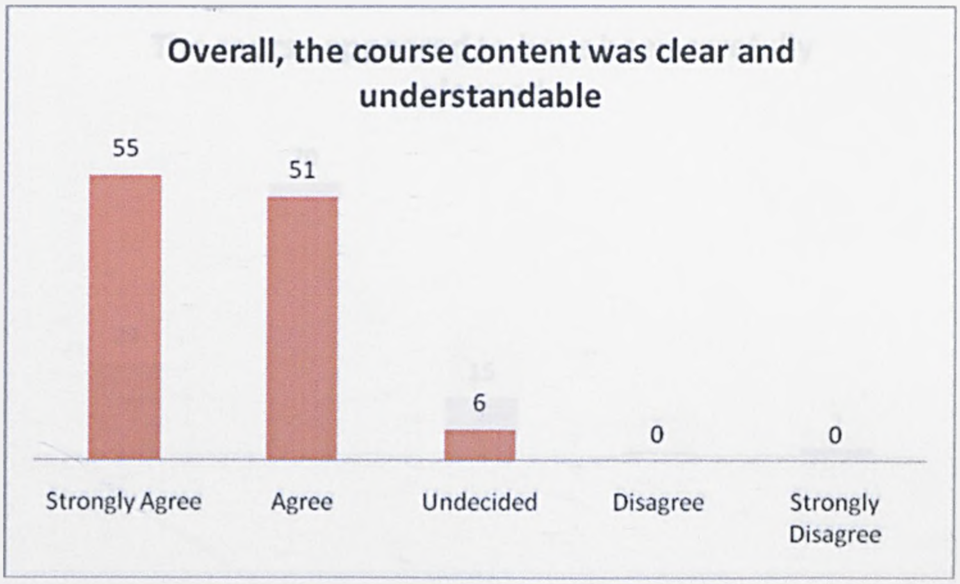


Figure 5.5: Questionnaire question 4 "Overall, the course content was clear and understandable"

5.2.1.5 Question 5 "The course appeared to have been carefully planned"

In terms of course planning, twenty four (24) of the 112 students strongly agreed that the course was well planned; 70 agreed and 15 were undecided (see Figure 5.6).

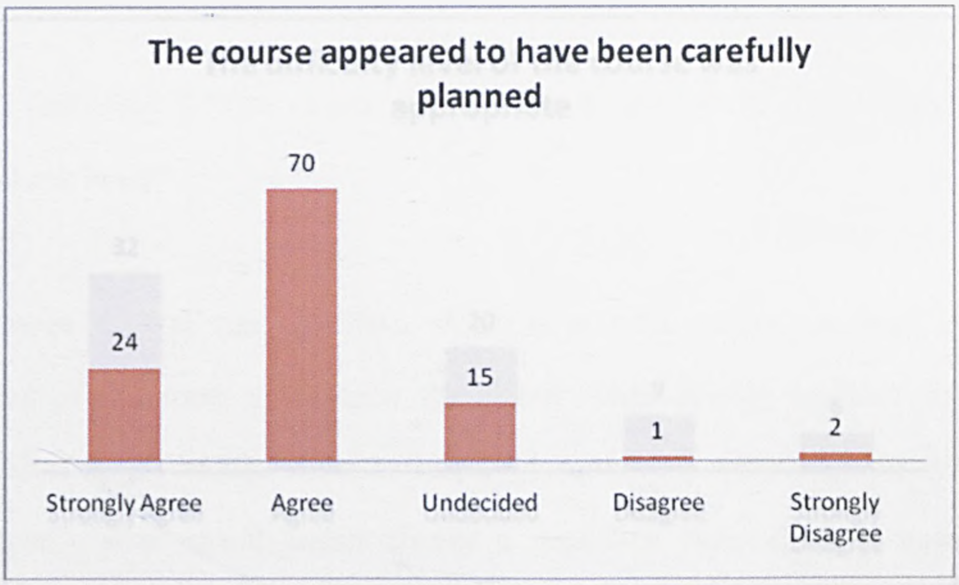


Figure 5.6: Questionnaire Question 5 "The course appeared to have been carefully planned"

5.2.1.6 Question 6 "The difficulty level of the course was appropriate"

Figure 5.7 shows the students' response to the level of difficulty of the course. Thirty two (32) of the 112 students strongly agreed that the level of difficulty was appropriate; 45 agreed; 20 were undecided; 9 disagreed and 6 strongly disagreed.

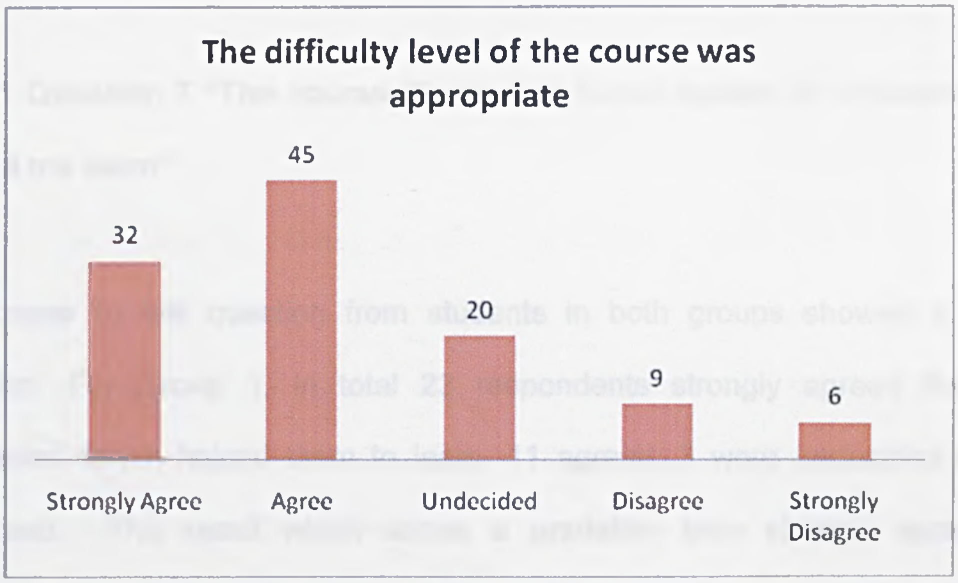


Figure 5.7: Questionnaire Question 6 “The difficulty level of the course was appropriate”

5.2.2 The interaction system

The study indented to find out the students’ opinions on the interaction system: The discussion system (Figure 5.8); the Ask Tutor function (Figure 5.9), the chat room function (Figure 5.10) and the messaging tools function (Figure 5.11).

Only the results for Groups 1 and 2 are presented in the results of Question 7 to 10 (Figure 5.7 to 5.11). No results are presented for Group 3 as the interaction tools were not available to this group during the time when Chapters 6 to 10 were covered.

5.2.2.1 Question 7 "The course discussion forum system in chapters 6-10 helped me learn"

Responses to this question from students in both groups showed a slight variation. For Group 1, in total 23 respondents strongly agreed that the discussion forum helped them to learn, 11 agreed, 3 were undecided and 1 disagreed. This result which shows a gradation from strongly agreed to disagree differed slightly from that of Group 2 in which 14 respondents strongly agreed, 20 agreed and 3 were undecided (see Figure 5.8).

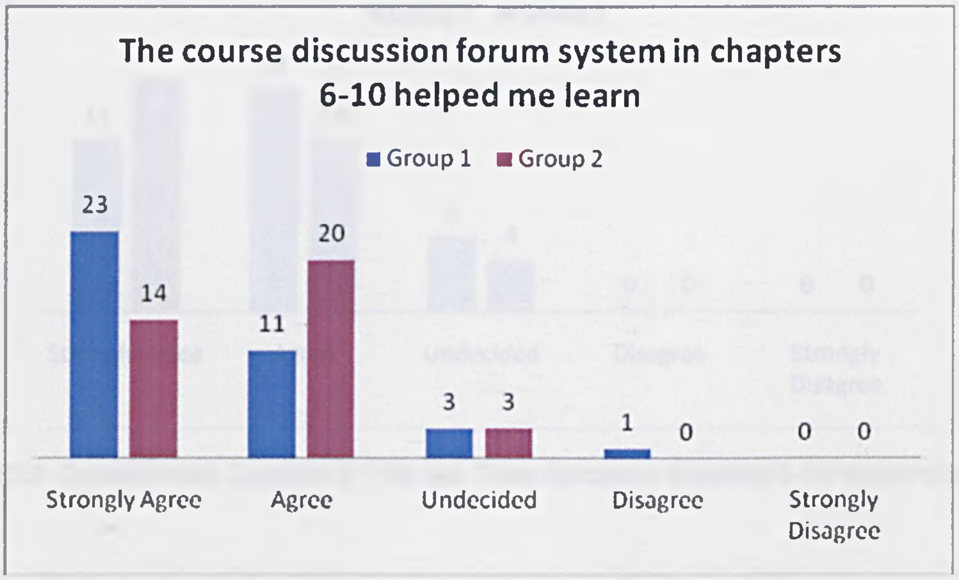


Figure 5.8: Questionnaire Question 7 "The course discussion forum system in chapters 6-10 helped me learn"

5.2.2.2 Question 8 "The Ask Tutor function in chapters 6-10 helped me learn"

Figure 5.9 shows the results for the Ask Tutor function. For Group 1, in total 14 respondents strongly agreed that the Ask Tutor function helped them to learn, 13 agreed and 6 were undecided. Again, the results differed slightly from that of Group 2 in which 19 respondents strongly agreed, 14 agreed and 4 were undecided.

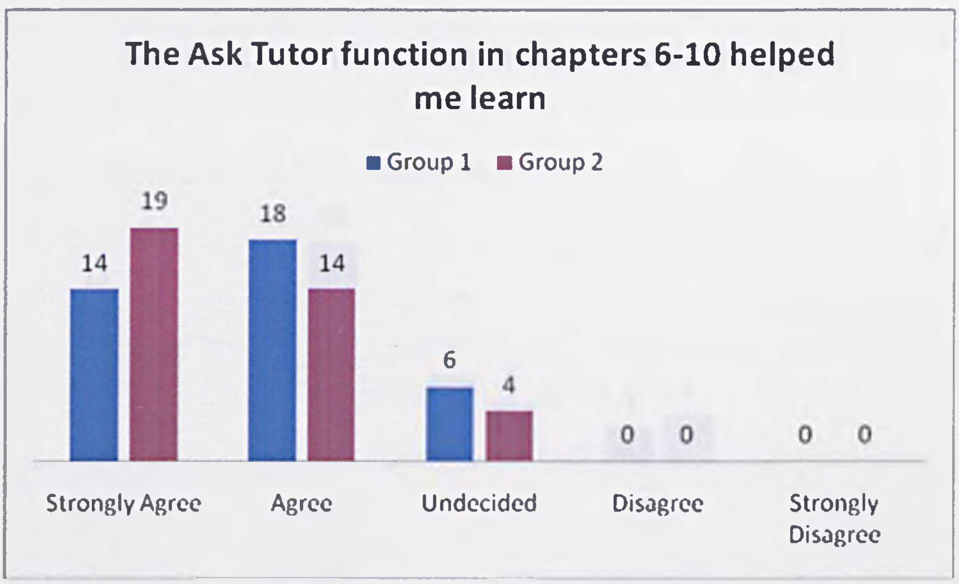


Figure 5.9: Questionnaire Question 8 "The Ask Tutor function in chapters 6-10 helped me learn"

5.2.2.3 Question 9 "The chat room function in chapters 6-10 helped me learn"

The results shown in Figure 5.10 suggest that the chat room function helped the students to learn. For Group 1, in total 13 respondents strongly agreed that chat forum was helpful, 15 agreed, 3 were undecided and 3 disagreed. A similar pattern was observed for Group 2 where 10 respondents strongly agreed, 18 agreed, 7 were undecided and 4 disagreed.

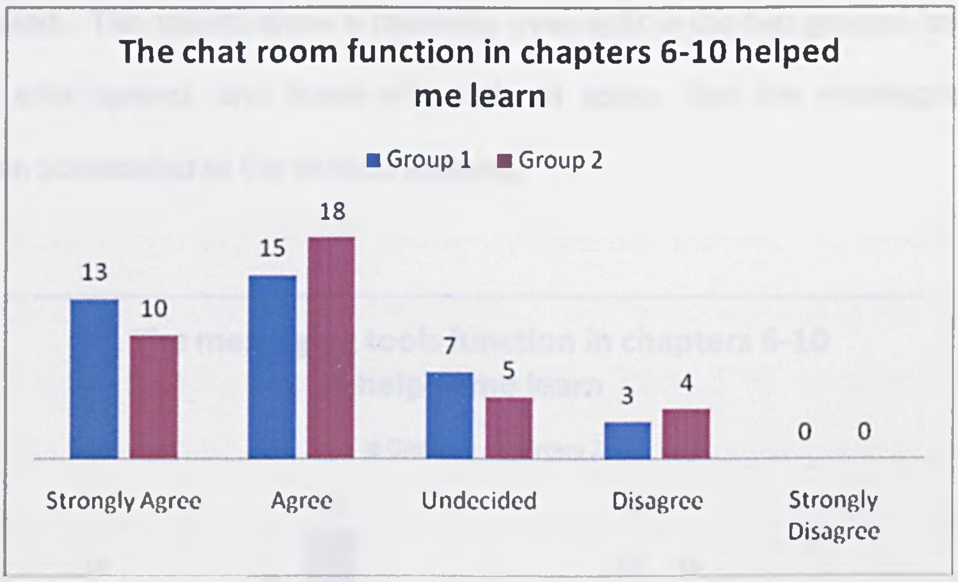


Figure 5.10: Questionnaire Question 9 "The chat room function in chapters 6-10 helped me learn"

5.2.2.4 Question 10 "The Messaging Tool function in chapters 6-10 helped me learn"

The results shown in Figure 5.11 suggest that the messaging function did not significantly contribute to the students' learning. For Group 1, in total 10 students strongly agreed that the tool helped their learning, 9 agreed, 3 were undecided, 10 disagreed and 6 strongly disagreed. A similar pattern was observed for Group 2 where 3 students strongly agreed that the messaging tool helped their learning, 14 agreed, 2 were undecided, 10 disagreed and 8 strongly disagreed. The results show a relatively even split in the two groups, between those who agreed, and those who did not agree, that the messaging tool function contributed to the student learning.

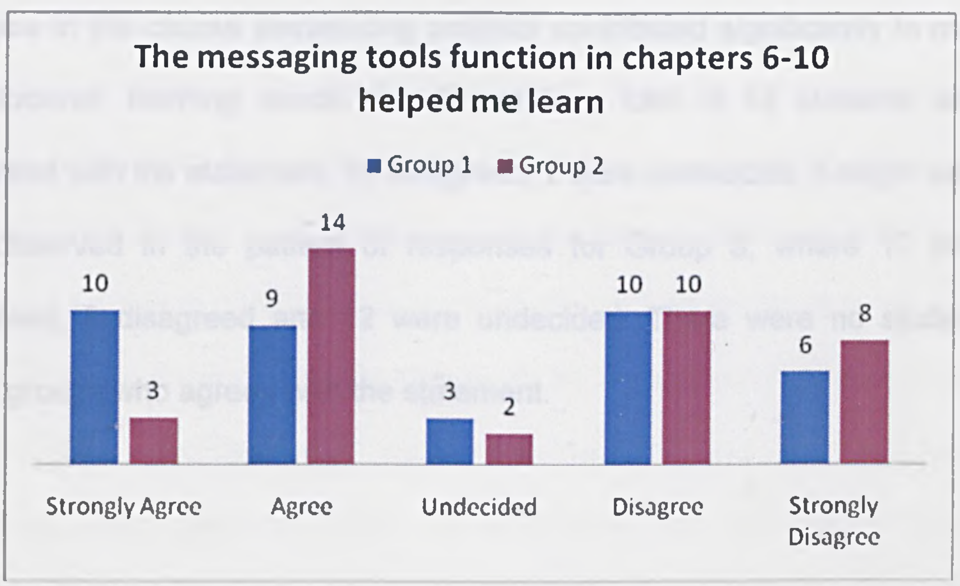


Figure 5.11: Questionnaire Question 10 "The Messaging Tools function in chapters 6-10 helped me learn"

5.2.3 The individualisation system

The study indented to find out the students' opinions on the individualisation system: The learning management interface (Figure 5.12) and the course content (Figure 5.13). Group 1's results were not presented in Figure 5.12 as learning management interface were not switched off for Group 1 during the whole course sessions.

5.2.3.1 Question 11 "Lack of a learning management interface in chapter 6-10 suitable to my learning needs"

The results shown in Figure 5.12 demonstrate that the learning management interface in the course sequencing protocol contributed significantly in meeting the students' learning needs. For Group 2, a total of 12 students strongly disagreed with the statement, 18 disagreed, 7 were undecided. A slight variation was observed in the pattern of responses for Group 3, where 17 strongly disagreed, 8 disagreed and 12 were undecided. There were no students in either groups who agreed with the statement.

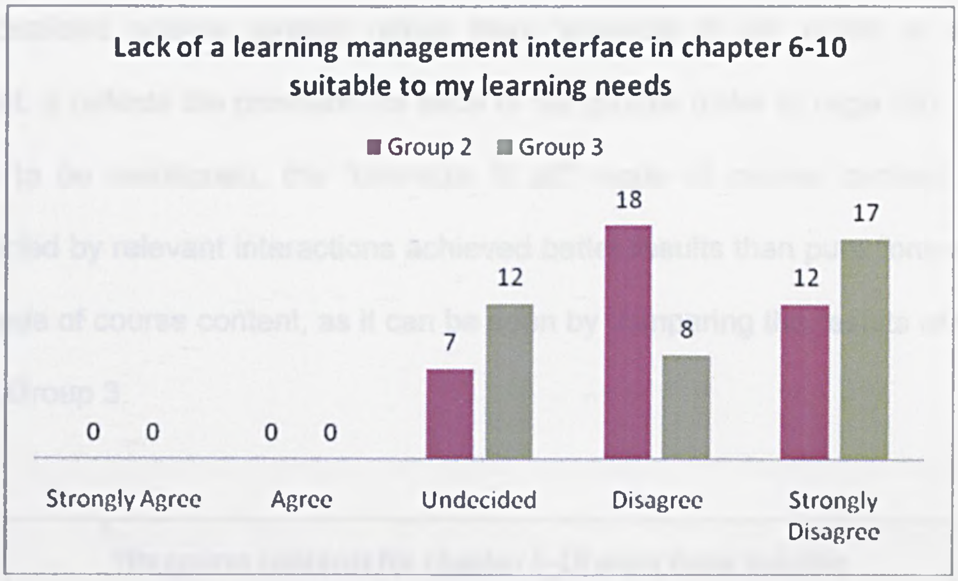


Figure 5.12: Questionnaire question 11 "Lack of a learning management interface in chapter 6-10 suitable to my learning needs"

5.2.3.2 Question 12 "The course contents for Chapters 6-10 were more suitable to my learning needs"

Figure 5.13 provides the results of the students' opinions on whether the course contents of chapters 6-10 were more suitable than the remainder of the course chapters. For Group 1, 10 students strongly agreed with the statement, 17 agreed and 10 were undecided. In contrast, Group 3 students were not satisfied with the course contents for Chapters 6-10; 24 of them strongly disagreed with the statement, 4 disagreed, 7 were undecided and only 2 agreed with the statement. Responses from Group 2 students were between those of Groups 1 and 3, where 15 strongly disagreed with the statement, 3 disagreed, 10 were undecided and 9 agreed. The results suggest that the students preferred individualised course content rather than "one-size fit all" mode of course content. It reflects the provision for each of the groups (refer to page 96). It also worth to be mentioned, the "one-size fit all" mode of course content which supported by relevant interactions achieved better results than pure "one-size fit all" mode of course content, as it can be seen by comparing the results of Group 2 and Group 3.

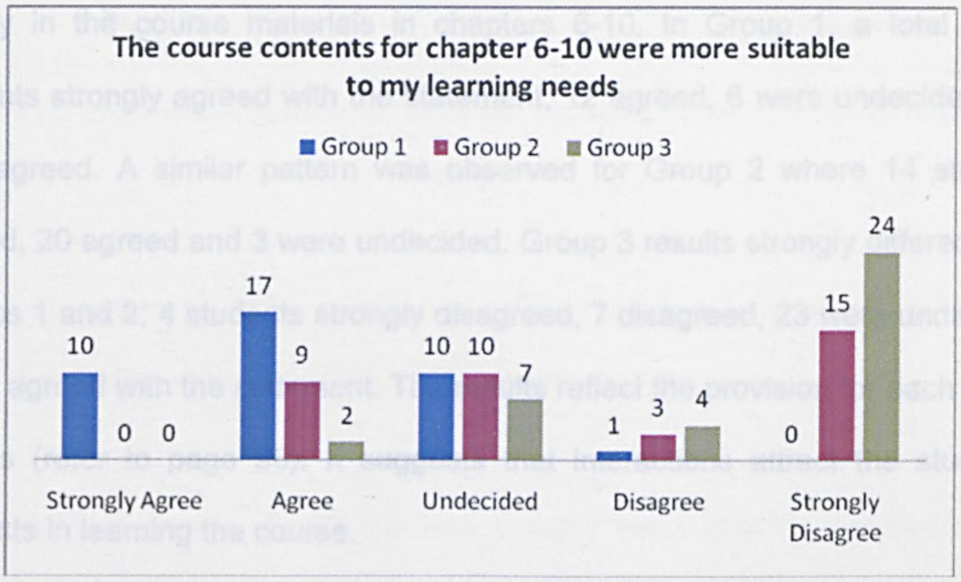


Figure 5.13: Questionnaire question 12 "The course contents for chapters 6-10 were more suitable to my learning needs"

5.2.4 The overall opinions for the course

The study indented to find out the students' overall opinions for the course by examining the following: Whether there was interesting variety in the course

(Figure 5.14); the amount of effort required (Figure 5.15) and the overall satisfaction (Figure 5.16).

5.2.4.1 Question 13 "There was interesting variety in the course materials in chapters 6-10"

Figure 5.14 illustrates the students' opinions on whether there was interesting variety in the course materials in chapters 6-10. In Group 1, a total of 19 students strongly agreed with the statement, 12 agreed, 6 were undecided and 1 disagreed. A similar pattern was observed for Group 2 where 14 strongly agreed, 20 agreed and 3 were undecided. Group 3 results strongly differed from Groups 1 and 2; 4 students strongly disagreed, 7 disagreed, 23 were undecided and 3 agreed with the statement. The results reflect the provision for each of the groups (refer to page 96). It suggests that interactions attract the students' interests in learning the course.

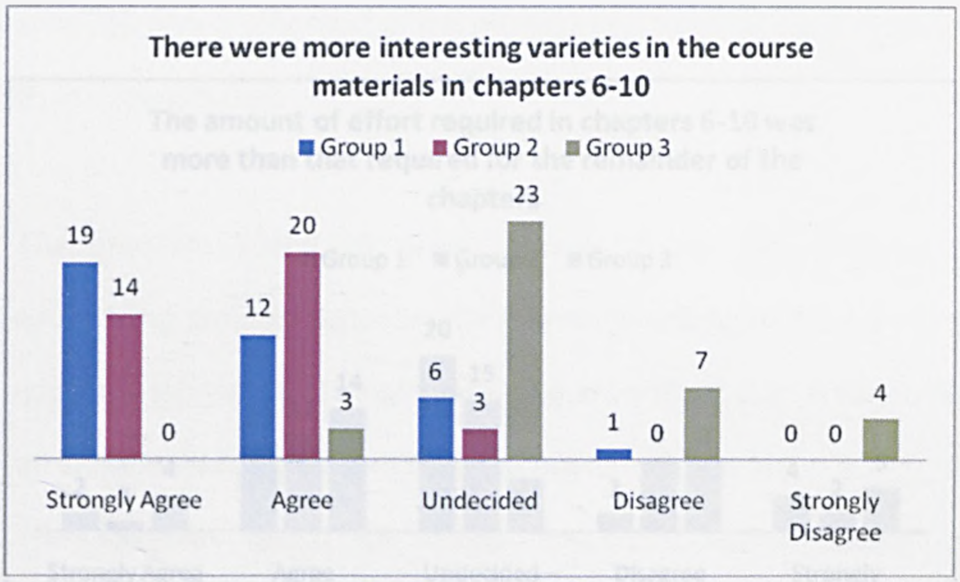


Figure 5.14: Questionnaire question 13 "There was interesting variety in the course materials in chapters 6-10"

5.2.4.2 Question 14 "The amount of effort required in chapters 6-10 was more than that required for the remainder of the chapters"

Figure 5.15 illustrates that there was a fairly even split for or against the statement, the amount of effort required in chapters 6-10 was more than required for the remainder of the chapters. Responses from Group 1 showed that 2 students strongly agreed with the statement, 10 agreed, 20 were undecided, 2 disagreed and 4 strongly disagreed. A similar pattern was observed for that of Group 2 students - 1 strongly agreed the statement, 11 agreed, 15 were undecided, 8 disagreed and 2 strongly disagreed. Again, Group 3 had a similar pattern - 4 strongly agreed the statement, 14 agreed, 6 were undecided, 8 disagreed and 5 strongly disagreed.

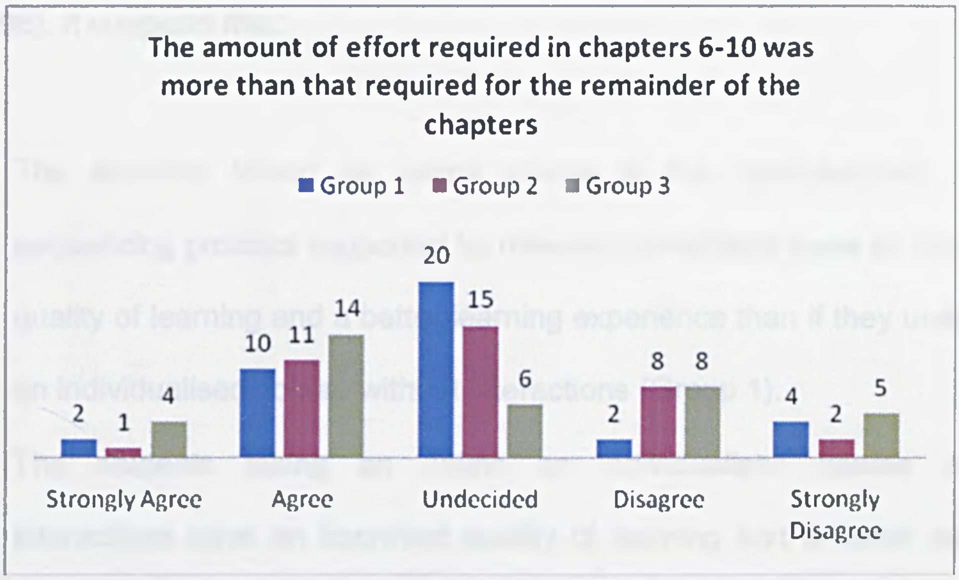


Figure 5.15: Questionnaire question 14 "The amount of effort required in chapters 6-10 was more than that required for the remainder of the chapters"

5.2.4.3 Question 15 "Overall, the level of satisfaction for chapters 6-10 was better than that for chapters 1-5"

Figure 5.16 shows the students' opinions about their level of satisfaction of chapters 6-10 compared with those of chapters 1-5. For Group 1, a total of 16 students strongly agreed, 19 agreed and 3 were undecided. By contrast, the students in Group 3 were more satisfied with Chapters 1-5 than with 6-10; this was reflected in the number of responses: 20 students strongly disagreed with the statement, 10 disagreed, 5 were undecided and 2 agreed. Group 2 opinions stayed between those of Groups 1 and 3 – showing 8 strongly disagreed with the statement, 9 disagreed, 11 were undecided, 8 agreed and 1 strongly agreed.

The results are also a reflection of the provision for each of the groups (refer to page 96). It suggests that:

- The students taking an online course in the individualised course sequencing protocol supported by relevant interactions have an improved quality of learning and a better learning experience than if they undertake an individualised course without interactions (Group 1).
- The students taking an online an individualised course without interactions have an improved quality of learning and a better learning experience than if they undertake "one-size fit all" mode of course sequencing protocol without interactions (Group 3).
- The individualised course without interactions contributes to the students' learning experiences slightly more than "one-size fit all" mode of course sequencing protocol without interactions (Group 2).

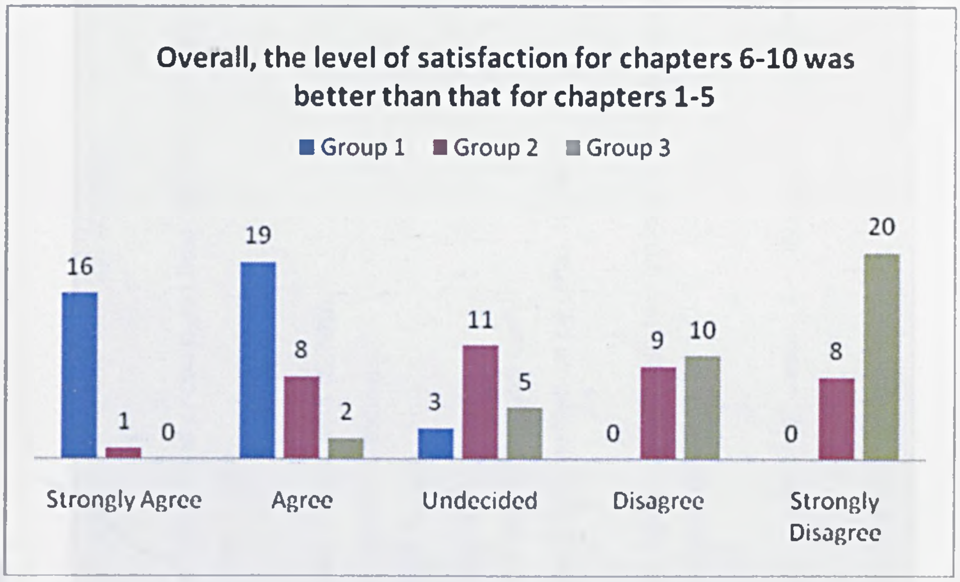


Figure 5.16: Questionnaire question 15 "Overall, the level of satisfaction for chapters 6-10 was better than that for chapters 1-5"

5.3 INTERVIEW RESULTS

Semi-structured interviews were carried out with all (121) students who participated in the course. These interviews were face-to-face and were held within three days of the students completing the CCNA exam. The average interview time was 27 minutes per student. The results of the interviews are presented in Table 5.3. The interviews were intended to gather feedback from the students of their experience of:

- The interaction system
- The individualisation system
- The overall satisfaction for the course

Table 5.3: Interview Results

	Interview Questions	Results
The interaction system (Question 1 to 4)	**Question 1** Comments on the discussion forum system of the course sequencing protocol	All (121) students used the discussion forum system during the course and after the course. The students reported that the discussion forum system helped and encouraged them to learn the CCNA course. The reasons given by the students are summarised below: • The forum acted as a source of motivation and encouragement to learn. • Other students' threads about the CCNA course were informative. • The students learned new knowledge in the CCNA course. • The students refreshed the old knowledge in the CCNA course. • The students solved some questions that they did not understand earlier. • The students felt confident and proud when threads commented on by other students. Thirty two (32) students suggested the discussion forum system should use two structures, both the tree structure and parallel structure. The reasons was summarised below: • The tree structure of the discussion forum system is useful for interactions between students/instructors. • The parallel structure of the discussion forum system can highlight the topic.

	Question 2 Comments on the ask tutor function of the course sequencing protocol	Again, all (112) the students used the ask tutor function during the course and after the course. Ninety nine (99) students reported the ask tutor function helped them to learn the content of the CCNA course. The reason is summarised below: • The instructor gave synchronous feedback to their questions. Seventy four (64) students were not satisfied with the delay reply from the teachers. They had to post their questions to the discussion forum or wait for the replies.

	Question 3 Comments on the chat room function of the course sequencing protocol	All (112) students used the chat room function during the course and after the course. Ninety one (91) students reported the chat room function helped them to learn the CCNA course. The reason is summarised below: • The students got synchronous replies to their posts and contributions during the tutorial sessions. • They benefited from the discussions between teachers and other students. Seventy nine (79) students were not satisfied with the chat room function. The reasons given are summarised below: • The chat room's discussion topics between the students were not related to the CCNA course. • The chat room was empty. Forty five (45) students suggested the instructor should host the chat sessions and moderate the discussion topic.

	Question 4 Comments on the messaging tools function of the course sequencing protocol	All students used the messaging tools function during the course and after the course. Sixty seven (67) students reported the messaging tools function helped them to learn the contents of the CCNA course. The reason given for are summarised below: • The facility enabled the students to identify who was online and then sent them private messages to discuss aspects of their studies. • The students got faster replies from the messaging facility than the web based email programmes they use out of the course system. Forty one (41) students were not satisfied with the messaging tools. The reason is summarised below: • The students were disturbed by the incoming message during their study. Eighty three (83) students suggested remove the popup window of the incoming message alert.

The individualisation system (Question 5 and 6)	**Question 5** Comments on the course contents	All (112) students used the course contents during the course and after the course. Of these, 92 students reported that the course contents were better than the CCNA training book (Xu 2002) provided by Shenyang Normal University. Other reasons given by the students are summarised below: • The course contents were appropriate for their and met their learning needs. • The course contents matched their learning styles. The students found they were happy to learn the CCNA course. • The course contents were useful in helping them prepare for the exam. Seventeen (17) students reported that the course contents and assigned tasks were too difficult for them. Thirty five (35) students reported the course contents and assigned tasks were too much for them to cope with.

	Question 6 Comments on the learning management interface	All (121) students used the course learning management interface during the course and after the course. The students reported that the course learning management interface helped them to learn the contents of the CCNA course. The reason given are summarised below: • The course learning management interface provided dynamic and up-to-date instructions and feedback to support their study. • The Learning management system provided an easy tool with which they could manage the pace of their learning. • It was easy for them to navigate the course sequencing protocol from the learning management system.
The overall satisfaction for the course (Question 7)	**Question 7** Comments on the overall design of the course sequencing protocol	All (121) students used the course sequencing protocol during the course and after the course. The students reported the course sequencing protocol helped them to learn the contents of the CCNA course. The reason given are summarised below: • The course sequencing protocol offered a student friendly learning environment. • The students were motivated and encouraged to study the CCNA course. • The course sequencing protocol enhanced their learning experience compared with the experience of the basic model of e-learning courses offered by their university. Seventy three (73) students suggested that the art design of the course website be updated.

5.4 COURSE SEQUENCING PROTOCOL LOG RESULTS DURING THE TRAINING ROOM SESSIONS

The results of course sequencing protocol logs used during the training sessions are presented in this section. The log results were intended to provide the students' activities in:

- The individualised course sequencing protocol
- The interaction system

5.4.1 The individualised course sequencing protocol

The students' activities in the individualised course sequencing protocol during the training room sessions are present in this section, it includes: the number of students who logged in daily to the course sequencing protocol (Figure 5.17); the daily average access time spent by students who logged into the course sequencing protocol (Figure 5.18) and the daily average access time spent by students who logged into the course content (Figure 5.19).

5.4.1.1 Number of students who logged on to the course sequencing protocol during the training room sessions

Figure 5.17 illustrates the number of login for each group of students who logged on to the course sequencing protocol during the training room sessions. Multiple logins to the course sequencing protocol in a single day under one username was counted as one login. The vertical axis' scale represents the number of the students and the horizonal axis' scale represents time in days. All students were requested to attend the course From Day 1 to Day 10 by Shenyang Normal University, the students who failed to present in the course had proper reasons.

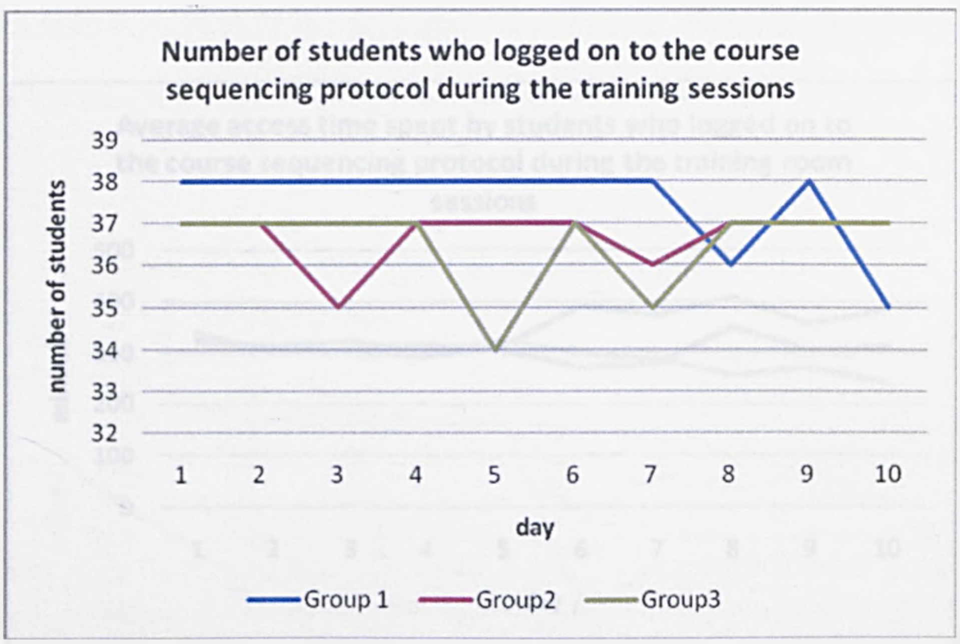


Figure 5.17: Number of students who logged on to the course sequencing protocol during the training sessions

5.4.1.2 Average access time spent by students who logged on to the course sequencing protocol during the training room sessions

Figure 5.18 illustrates that the initial daily average access time spent by students in each group who logged into the course sequencing protocol from days 1 -5, stayed nearly same during the chapters 1-5 learning sessions. However, from Day 6 on, students in Group 1 spent more time using the course sequencing protocol than the students in Group 2 and Group 3. Group 3 students spent the least time of all students that were logged on to the course website during the training room sessions.

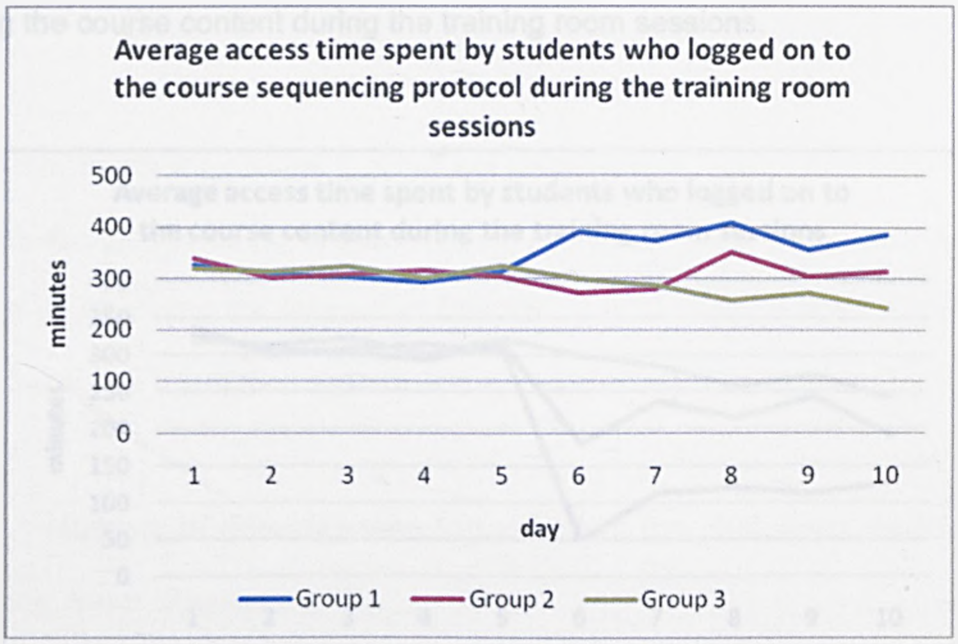


Figure 5.18: Average access time spent by students who logged on to the course sequencing protocol during the training room sessions

5.4.1.3 Average access time spent by students who logged on to the course content during the training room sessions

Figure 5.19 illustrates that the initial daily average of access time spent by each group of students who logged into the course content from days 1 -5, stayed almost the same during the chapters 1-5 learning sessions. However, from Day 6, students in Group 3 spent more time accessing the course content than group's 1 and 2 students. Group 2 students spent the least time (about less than 35% of the time spent by Group 3 students) accessing and using the course content during the training room sessions.

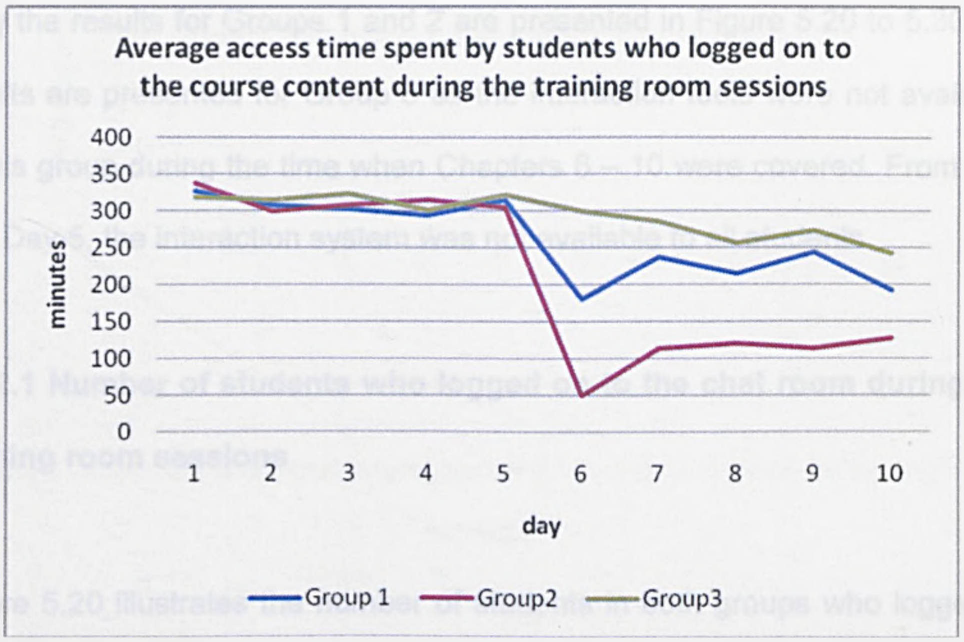


Figure 5.19: Average access time spent by students who logged on to the course content during the training room sessions

5.4.2 The interaction system

The students' activities in the interaction system during the training room sessions are present in this section, it includes their activities in: The chat room (Figure 5.20, Figure 5.21 and Figure 5.22); the discussion forum (Figure 5.23, Figure 5.24, Figure 5.25 and Figure 5.26); the Ask Tutor function Figure 5.27 and Figure 5.28) and the messaging tools (Figure 5.29 and Figure 5.30).

Only the results for Groups 1 and 2 are presented in Figure 5.20 to 5.30. No results are presented for Group 3 as the interaction tools were not available to this group during the time when Chapters 6 – 10 were covered. From Day 1 to Day 5, the interaction system was not available to all students.

5.4.2.1 Number of students who logged on to the chat room during the training room sessions

Figure 5.20 illustrates the number of students in both groups who logged in daily to the chat room during the training room sessions. The pattern matched those of the number of students in each group who logged in daily to the course sequencing protocol from Day 6 (Figure 5.17), and it indicates that all students in both groups used chat room at least once per day.

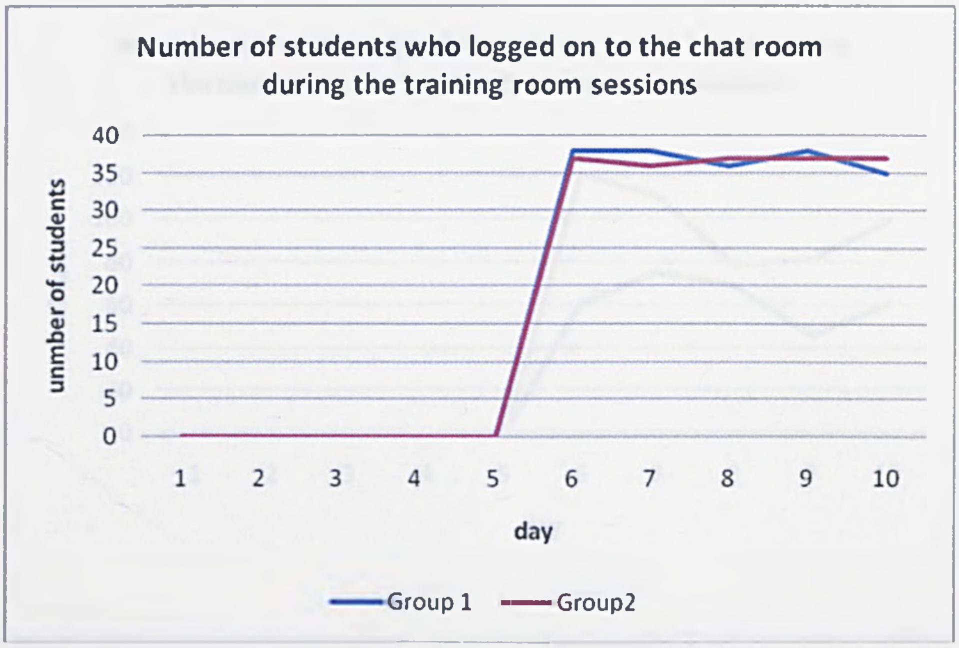


Figure 5.20: Number of students who logged on to the chat room during the training room sessions

5.4.2.2 Average access time spent by students who logged on to the chat room during the training room sessions

Figure 5.21 illustrates the average access time spent by students in the chat room during training room sessions. Group 2 students spent about 25% more time in the chat room than group 1 students.

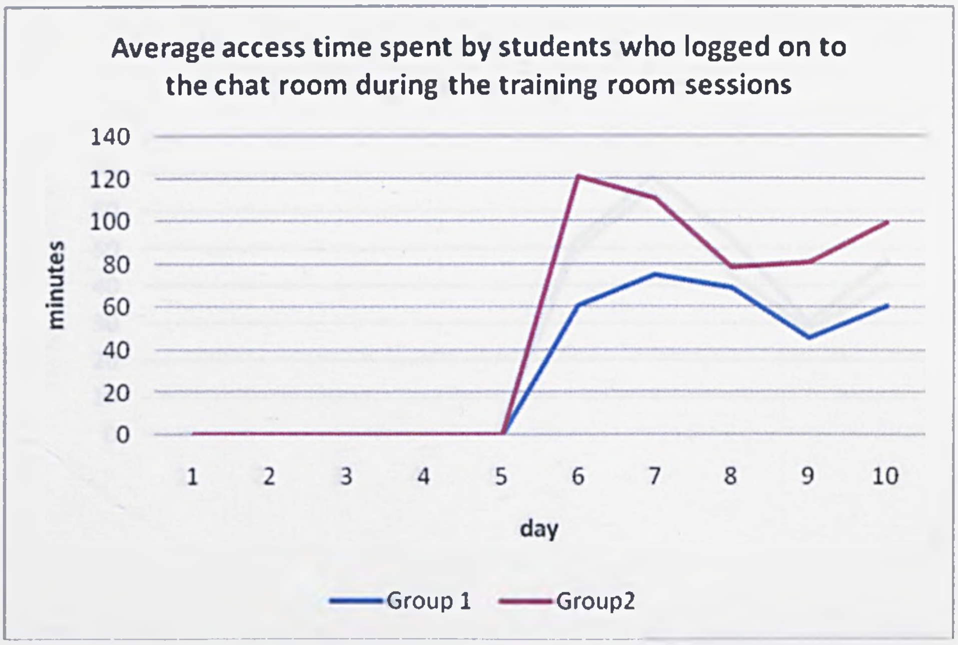


Figure 5.21: Average access time spent by students who logged on to the chat room during the training room sessions

5.4.2.3 Duration of time spent on the pre-arranged chat room sessions during the training room sessions

Figure 5.22 suggests that the duration of time spent daily, by both groups, on the pre-arranged chat room sessions during the training room sessions, were almost the same.

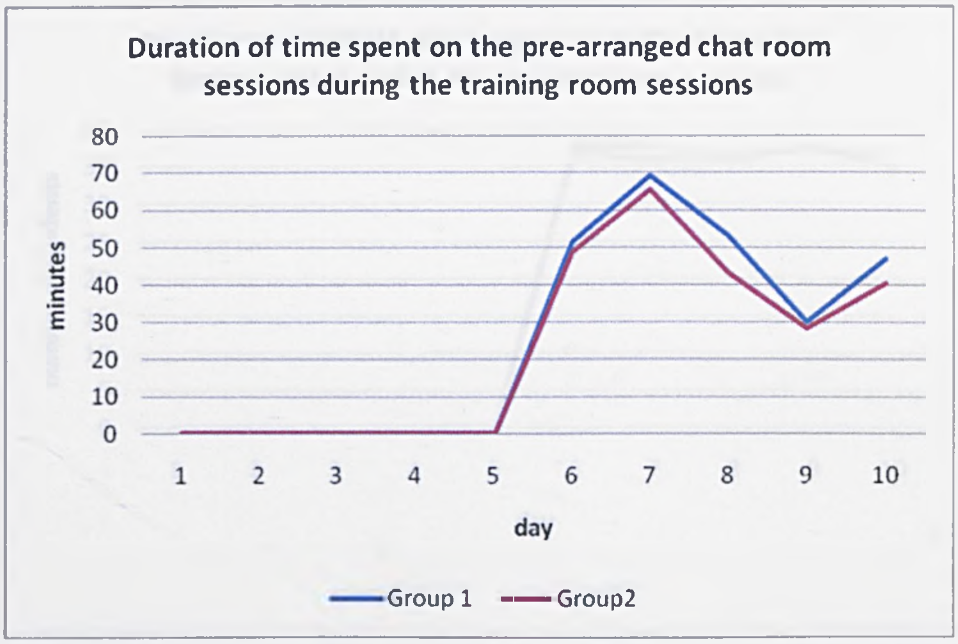


Figure 5.22: Duration of time spent on the pre-arranged chat room sessions during the training room sessions

5.4.2.4 Number of students who logged on to the discussion forum system during the training room sessions

Figure 5.23 illustrates the number of students in both groups who logged in daily to the discussion forum system during the training room sessions. The pattern matched those of the number of students in each group who logged in daily to the course sequencing protocol from Day 6 (Figure 5.17). It indicates that all students in both groups used the discussion forum at least once per day.

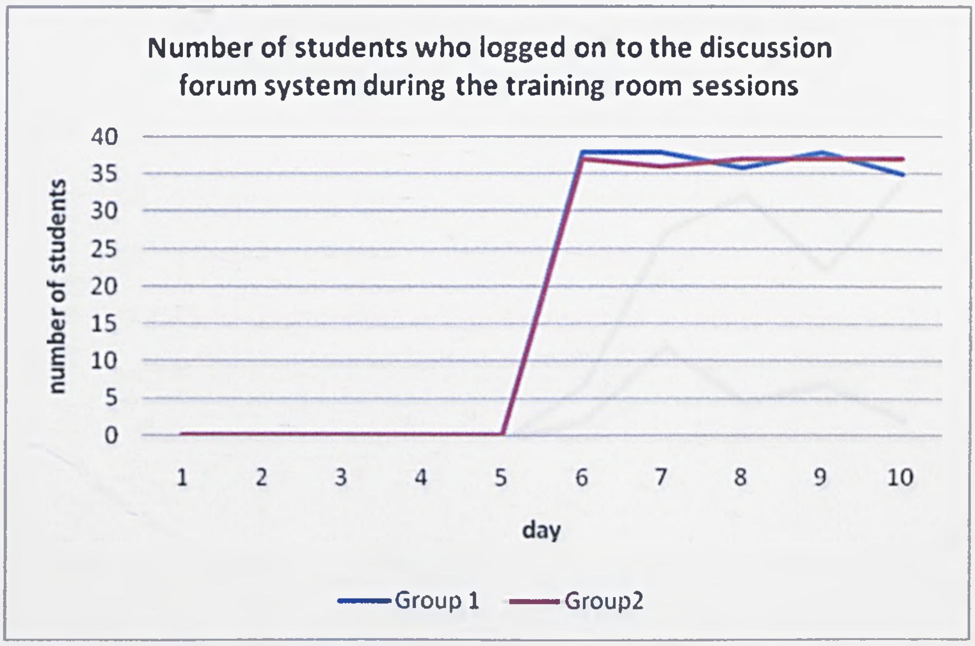


Figure 5.23: Number of students who logged on to the discussion forum system during the training room sessions

5.4.2.5 Number of new discussion forum threads during the training room sessions

Figure 5.24 shows the number of new discussion forum threads generated each day by students in both groups. Whilst Group 2 students spent on average a longer time using the chat room (Figure 5.21), it is interesting to note that Group 1 students produced more new forum threads than Group 2 students.

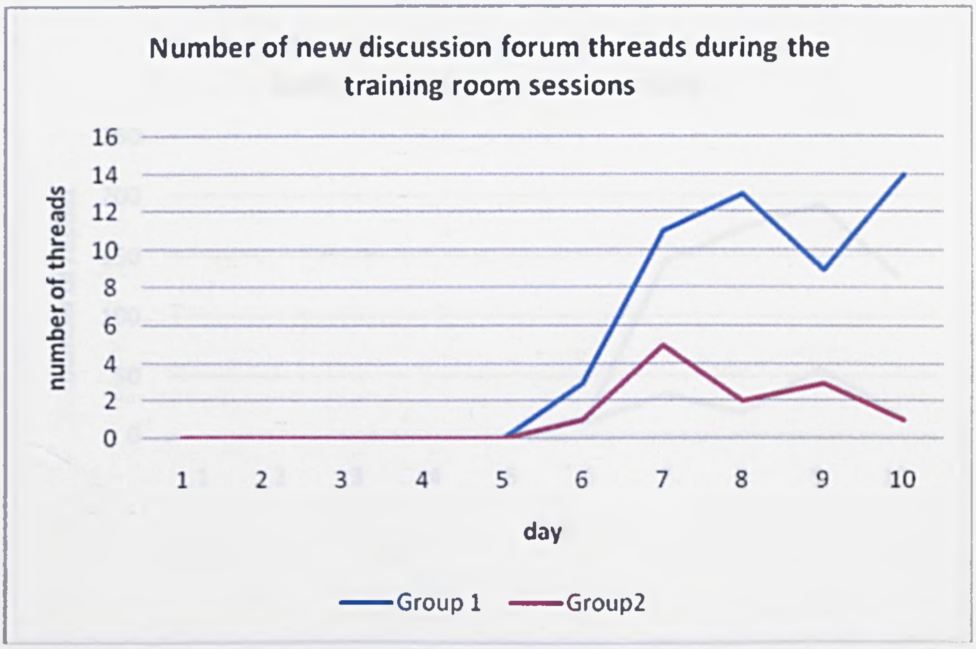


Figure 5.24: Number of new discussion forum threads during the training room sessions

5.4.2.6 Number of replies to the discussion forum threads during the training room sessions

Figure 5.25 shows the number of new replies to the discussion forum threads during the training sessions. Again, as in Figure 5.24, Group 1 students produced more replies to the forum threads than Group 2 students.

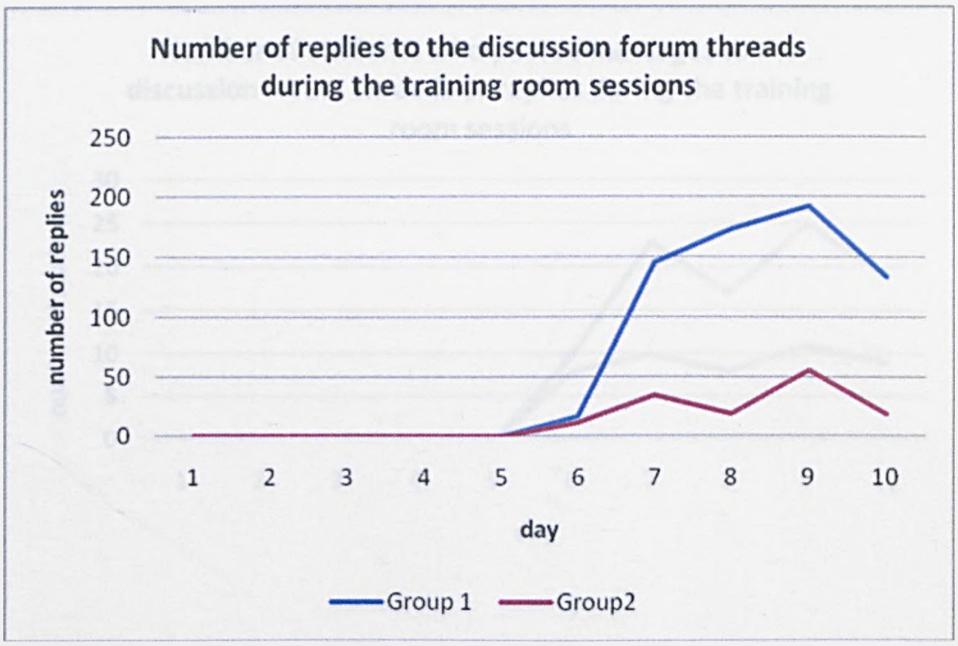


Figure 5.25: Number of replies to the discussion forum threads during the training room sessions

5.4.2.7 Number of students who posted messages to the discussion forum threads or replies during the training room sessions

Figure 5.26 suggests that the number of students who posted messages including replies to the discussion forum threads was about 100% higher in Group. This results seem to replicate the trend seen in Figures 5.24 and 5.25.

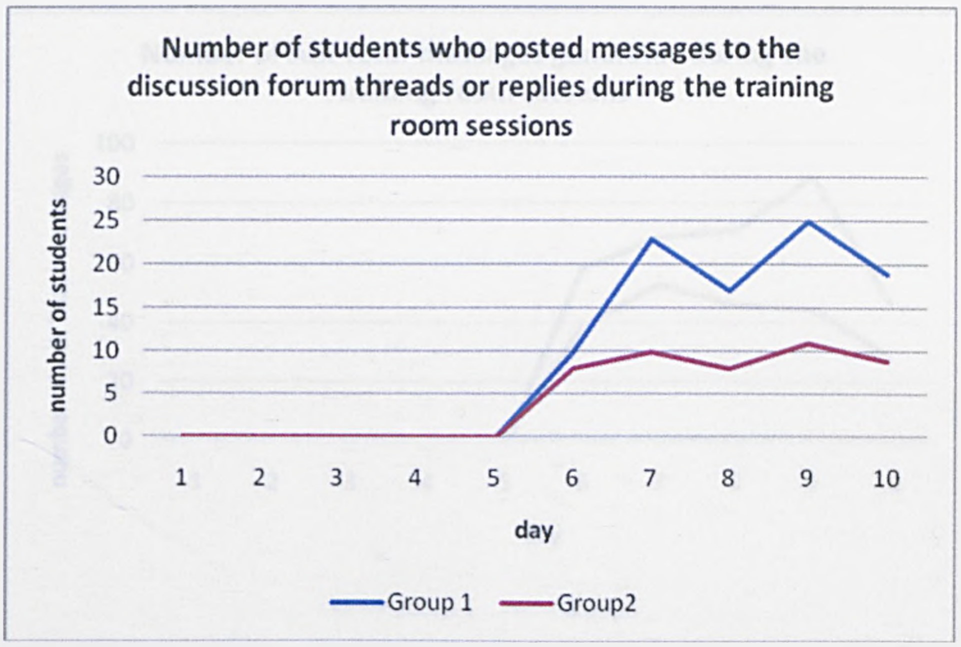


Figure 5.26: Number of students who posted messages to the discussion forum threads or replies during the training room sessions

5.4.2.8 Number of Ask Tutor messages generated during the training room sessions

Again, the results shown in Figure 5.27 suggest that Group 1 students produced more Ask Tutor messages than Group 2 students.

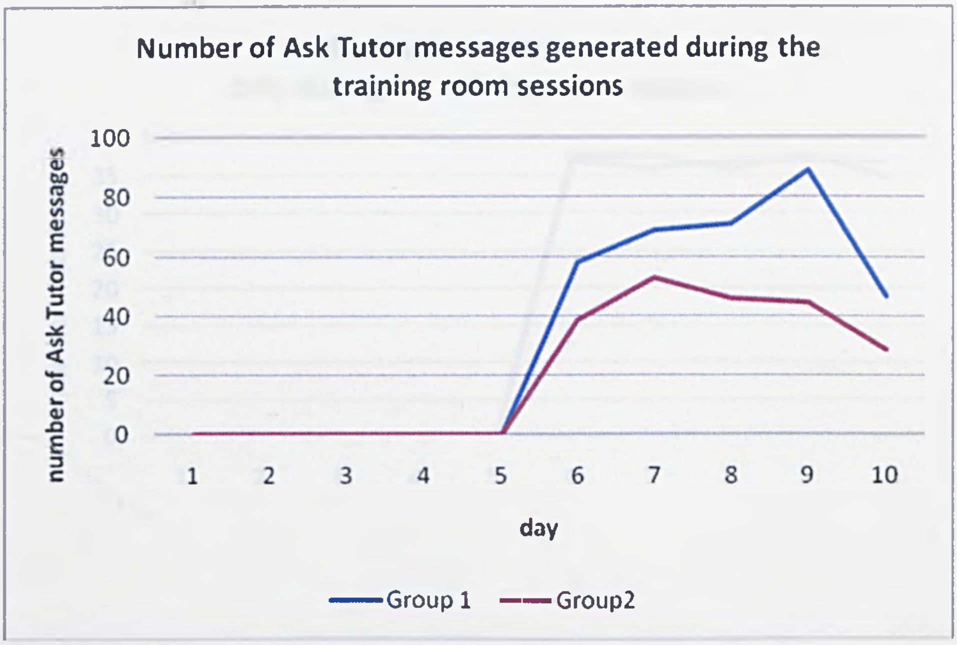


Figure 5.27: Number of Ask Tutor messages generated during the training room sessions

5.4.2.9 Number of students who used the Ask Tutor function during the training room sessions

Figure 5.28 gives the number of students in each group who used the Ask Tutor function daily during the training room sessions. The pattern matches those of the number of students in each group who logged into the course sequencing protocol on a daily basis from Day 6 onwards (Figure 5.17). It demonstrates that all students, in both groups, used the Ask Tutor function at least once a day.

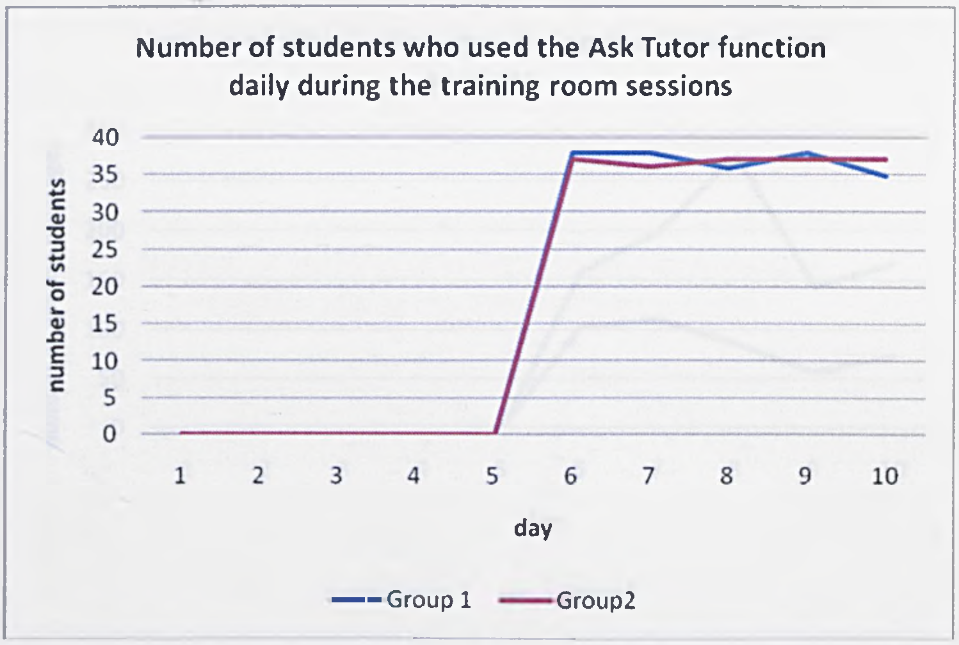


Figure 5.28: Number of students who used the Ask Tutor function daily during the training room sessions

5.4.2.10 Number of private messages during the training room sessions

Figure 5.29 shows that the number of private messages generated on a daily basis by both group of students. Group 1 students produced more private messages than Group 2 students.

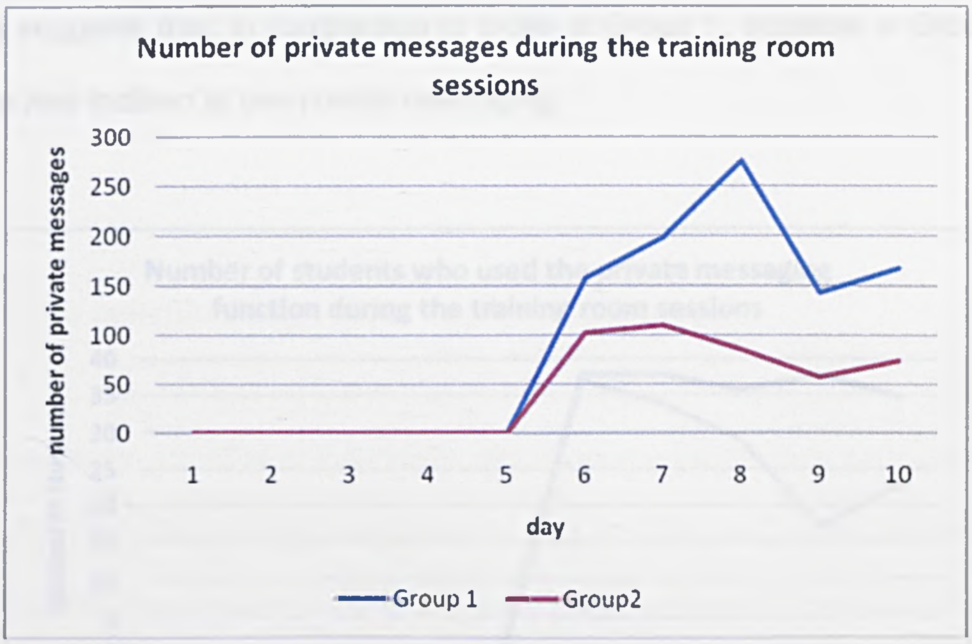


Figure 5.29: Number of private messages during the training room sessions

5.4.2.11 Number of students who used the private messaging function during the training room sessions

Figure 5.30 illustrates the number of students in each group who used the private messaging function during the training room sessions. The pattern of use for Group 1 matched the number of students who logged in daily to the course sequencing protocol from Day 6 onwards (see Figure 5.17), indicating that students in Group 1 used private messaging at least once per day. The pattern for Group 2 differed to the number of 2 students who logged in daily to the course sequencing protocol from Day 6 onwards (see Figure 5.17).

This suggests that, in comparison to those in Group 1, students in Group 2 were less inclined to use private messaging.

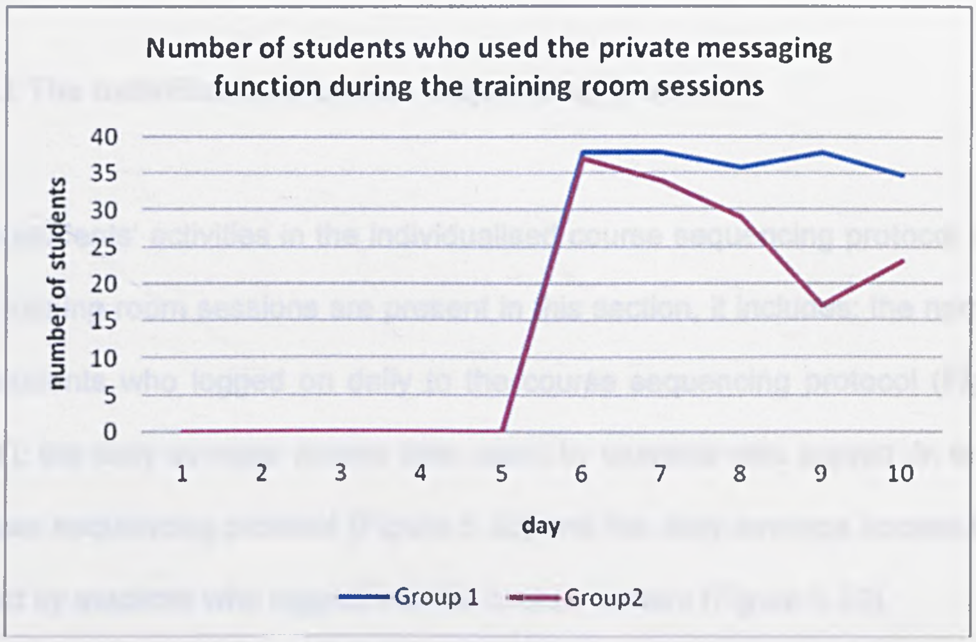


Figure 5.30: Number of students who used the private messaging function during the training room sessions

5.5 COURSE SEQUENCING PROTOCOL LOG RESULTS AFTER THE TRAINING ROOM SESSIONS

This section presents results of the usage of the course sequencing protocol log results after the training room sessions. The log results were intended to provide the students' activities in:

- The individualised course sequencing protocol (Figure 5.31 to 5.33)
- The interaction system (Figure 5.34 to 5.43)

5.5.1 The individualised course sequencing protocol

The students' activities in the individualised course sequencing protocol after the training room sessions are present in this section, it includes: the number of students who logged on daily to the course sequencing protocol (Figure 5.31); the daily average access time spent by students who logged on to the course sequencing protocol (Figure 5.32) and the daily average access time spent by students who logged into the course content (Figure 5.33).

5.5.1.1 Number of students who logged on to the course sequencing protocol after the training room sessions

Figure 5.31 illustrates that the number of students who logged on to use the course sequencing protocol after the training room sessions varied on a daily basis. The number of logins were far less during the weekends. The number of logins to the course sequencing protocol declined sharply during the weekends. However, there was an increase in the number of students using the protocol in the period preceding the exam, despite the weekend (from Day 24).

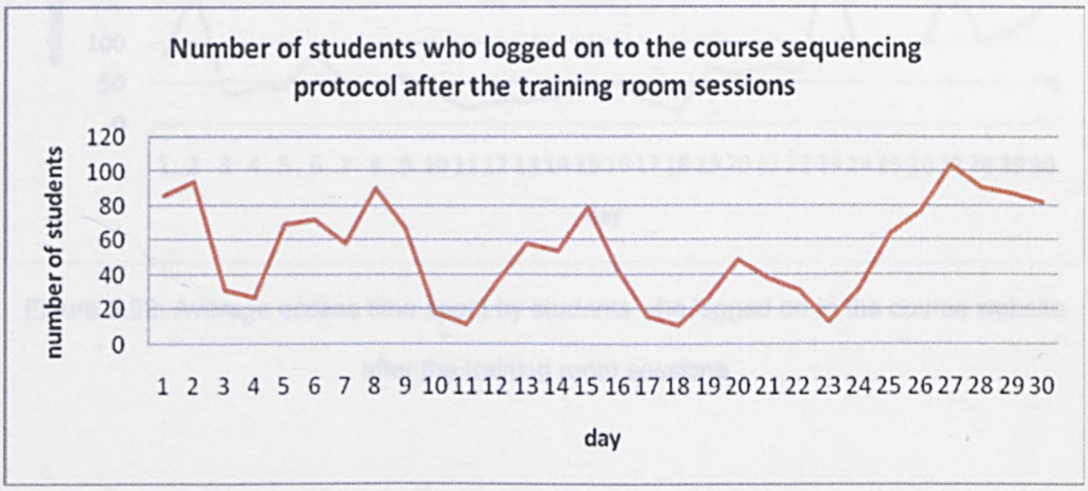


Figure 5.31: Number of students who logged on to the course sequencing protocol after the training room sessions

5.5.1.2 Average access time spent by students who logged on to the course sequencing protocol after the training room sessions

The results show a descending pattern for the average access time spent by students who logged on daily to the course sequencing protocol after the training room sessions. However, the pattern seemed to reverse before the exam.

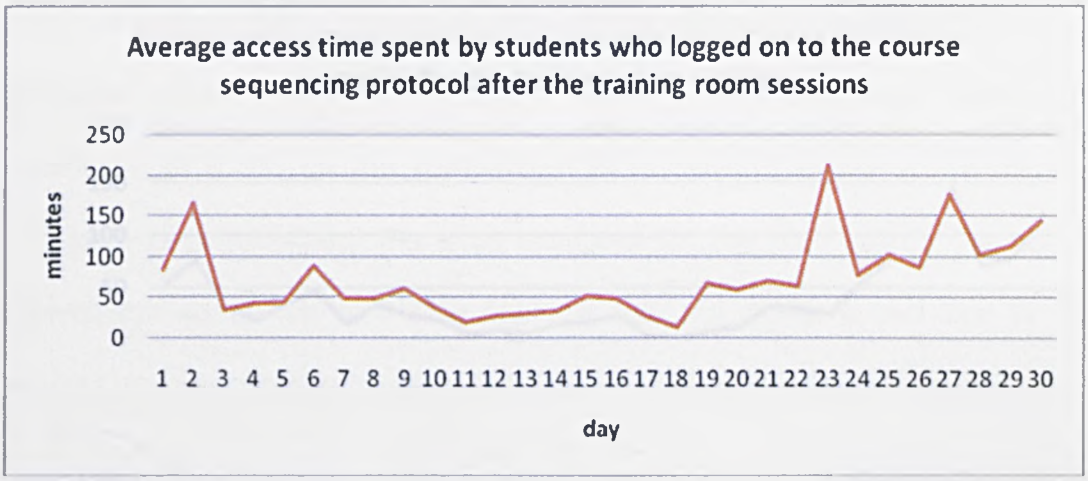


Figure 5.32: Average access time spent by students who logged on to the course website after the training room sessions

5.5.1.3 Average access time spent by students who logged into the course content after the training room sessions

A "U" shape pattern is shown in Figure 5.33 indicating that students spent more time engaging with the course content online at the beginning of the self learning sessions than in the immediate period before the exam.

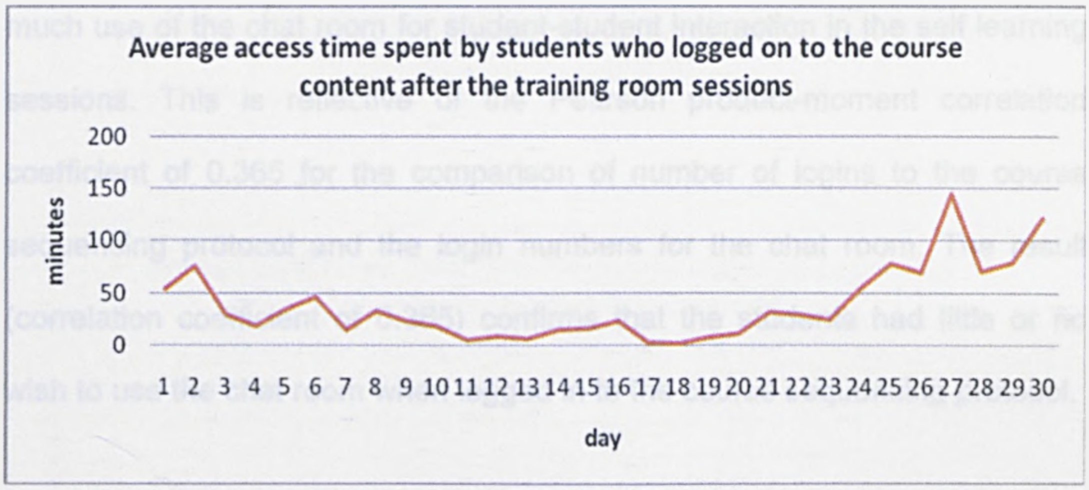


Figure 5.33: Average access time spent by students who logged into the course content after the training room sessions

5.5.2 The interaction system

The students' activities in the interaction system after the training room sessions are present in this section, it includes their activities in: The chat room (Figure 5.34 and Figure 5.35); the discussion forum (Figure 5.36, Figure 5.37, Figure 5.38 and Figure 5.39); the Ask Tutor function Figure 5.40 and Figure 5.41) and the messaging tools (Figure 5.42 and Figure 5.43).

5.5.2.1 Number of students who logged on to the chat room after the training room sessions

A "L" shape pattern is shown in Figure 5.34 for the use of the chat room after the training room sessions. This indicates that the students did not make much use of the chat room for student-student interaction in the self learning sessions. This is reflective of the Pearson product-moment correlation coefficient of 0.365 for the comparison of number of logins to the course sequencing protocol and the login numbers for the chat room. The result (correlation coefficient of 0.365) confirms that the students had little or no wish to use the chat room when logged in to the course sequencing protocol.

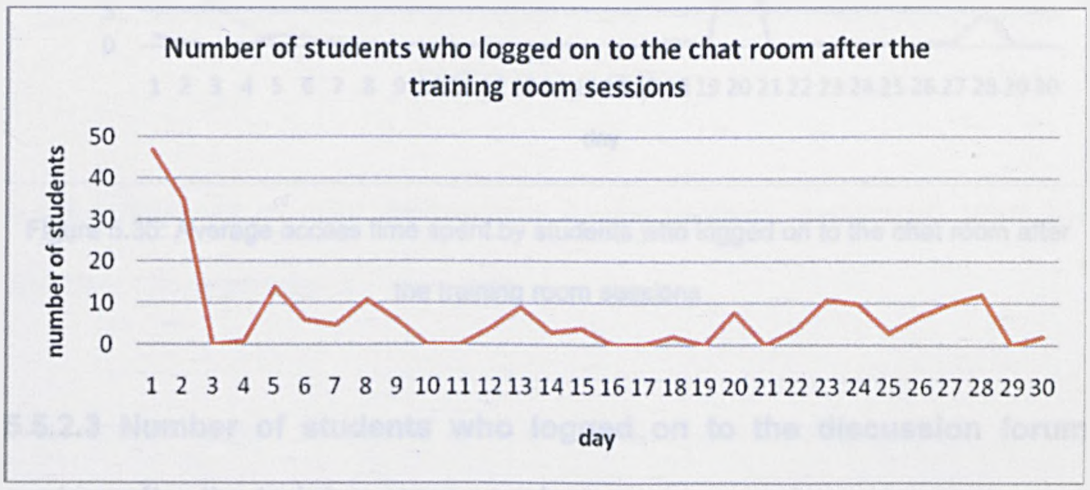


Figure 5.34: Number of students who logged on to the chat room after the training room sessions

5.5.2.2 Average access time spent by students who logged on to the chat room after the training room sessions

The results shown in Figure 5.35 suggest a very low daily average access time spent by students who logged on to the chat room after the training room sessions. This also confirms that students tended not to use the chat room for student-student interactions. The peak which appears at Day 20 lasted about 25 minutes.

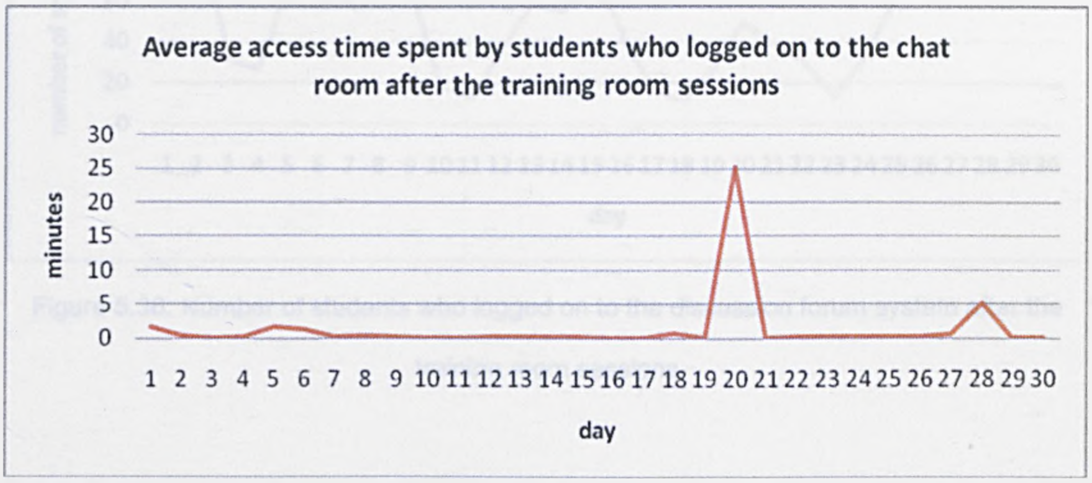


Figure 5.35: Average access time spent by students who logged on to the chat room after the training room sessions

5.5.2.3 Number of students who logged on to the discussion forum system after the training room sessions

Figure 5.36 illustrates the number of students who logged on daily to the discussion forum system after the training room sessions. A Pearson product-moment correlation coefficient of 0.975 suggests a very strong association between the number of logins to the course sequencing protocol and the number of logins to discussion forum.

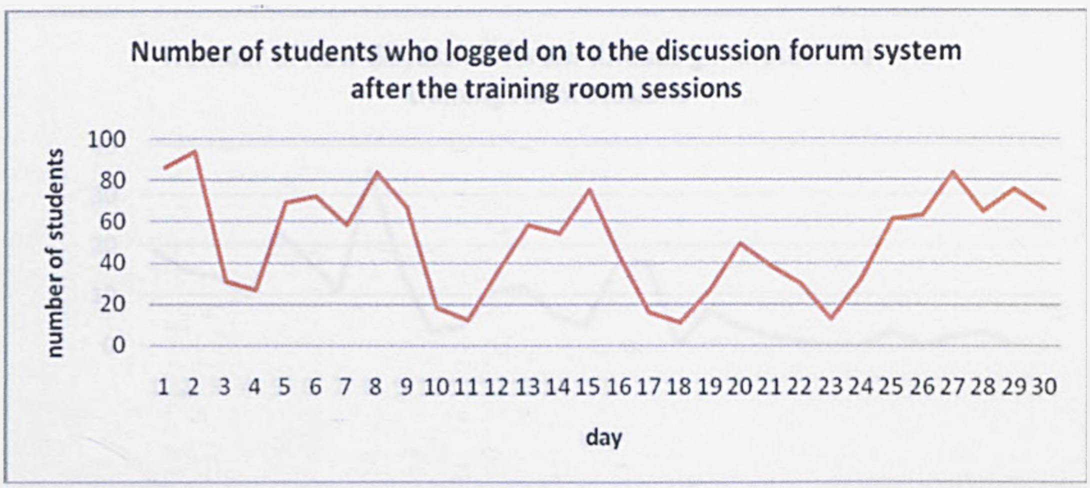


Figure 5.36: Number of students who logged on to the discussion forum system after the training room sessions

5.5.2.4 Number of new discussion forum threads generated after the training room sessions

The results shown in Figure 5.37 illustrate a descending pattern for the number of new discussion threads posted to the forum after the training sessions. The results indicate that the more discussion threads were posted at the beginning of the self learning sessions and the numbers declined over the entire period of the self learning process.

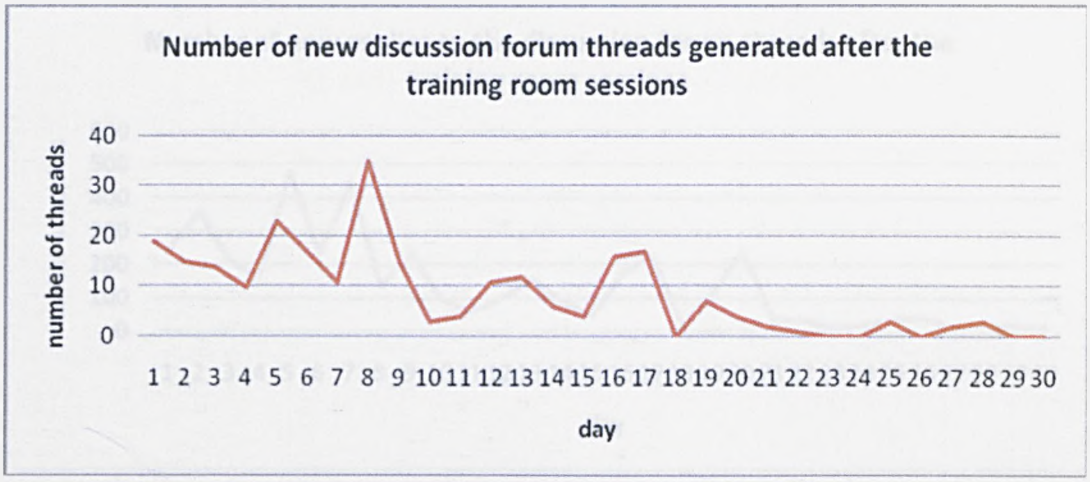


Figure 5.37: Number of new discussion forum threads generated after the training room sessions

5.5.2.5 Number of new replies to the discussion forum threads after the training room sessions

Again, a similar trend of result in Figures 5.37 is observed for the number of replies to discussion forum (see Figure 5.38). More replies were posted to the forum at the beginning of the self learning sessions and the number of replies subsequently declined over the course of the self learning process.

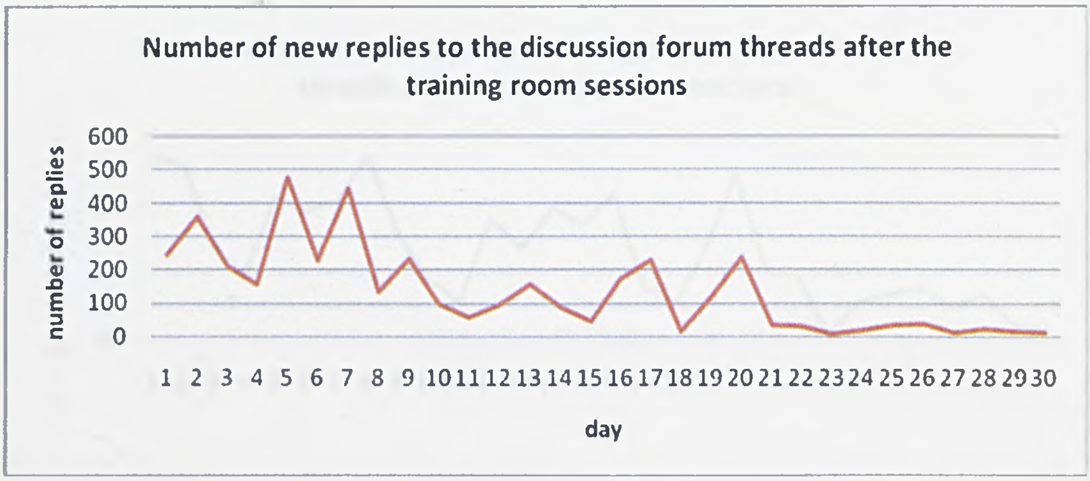


Figure 5.38: Number of new replies to the discussion forum threads after the training room sessions

5.5.2.6 Number of students who posted messages to the discussion forum after the training room sessions

This results in Figure 5.39 illustrate a pattern of decline in the number of students who posted messages daily to the discussion forum after the training sessions. The results indicate that the students initiated more discussion forum interactions at the beginning of the self learning sessions and that the interactions via discussion forum declined over the course of the self learning process.

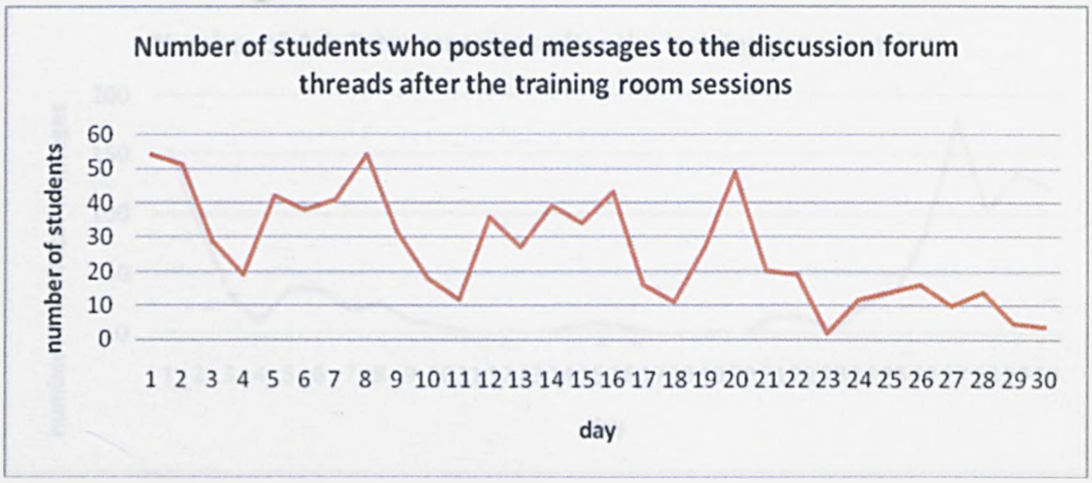


Figure 5.39: Number of students who posted messages to the discussion forum after the training room sessions

5.5.2.7 Number of Ask Tutor messages after the training room sessions

Figure 5.40 shows a "U" shape pattern of interactions. The number of Ask Tutor messages were more during days 1-3 and between days 25-28. This result indicates that the students had more student-teacher interaction activities at the beginning of the self learning sessions and before the exam.

Figure 5.40: Number of Ask Tutor messages after the training room sessions

5.5.2.8 Number of students who used the Ask Tutor function after the training room sessions

Again, the results shown in Figure 5.41 is a "U" shape pattern simialr to that in Figure 5.40. More students used this function early on at the start of the course and before the exam than during the intervening period between days 4-24. The result confirms that the students had more student-teacher interactions activities at the beginning of the self learning sessions and also before the exam.

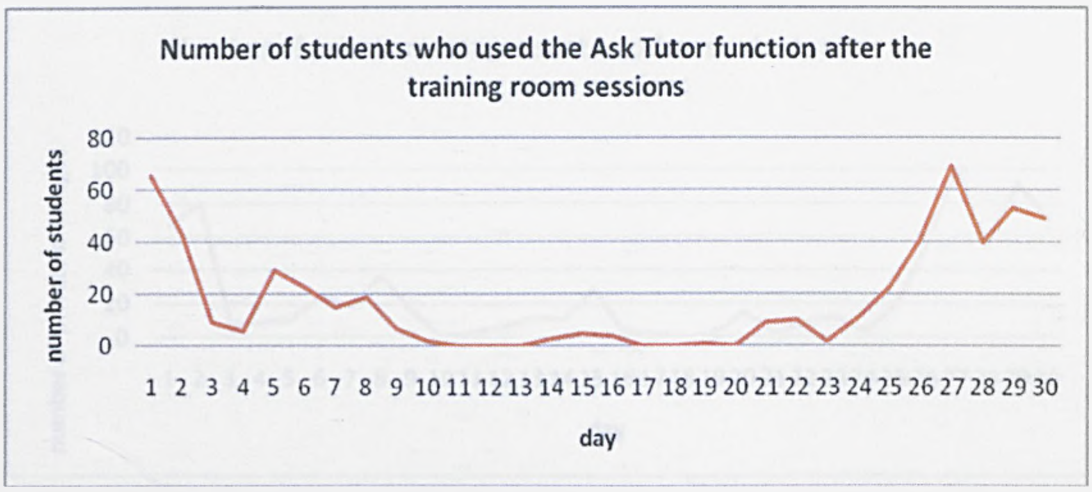


Figure 5.41: Number of students who used the Ask Tutor function after the training room sessions

5.5.2.9 Number of private messages sent to other students after the training room sessions

The result shown in Figure 5.42 suggests that the students had more student-student interactions via private messaging at the beginning of the self learning sessions and also before the exam. During the intervening period between days 4-24 the number of messages were very low.

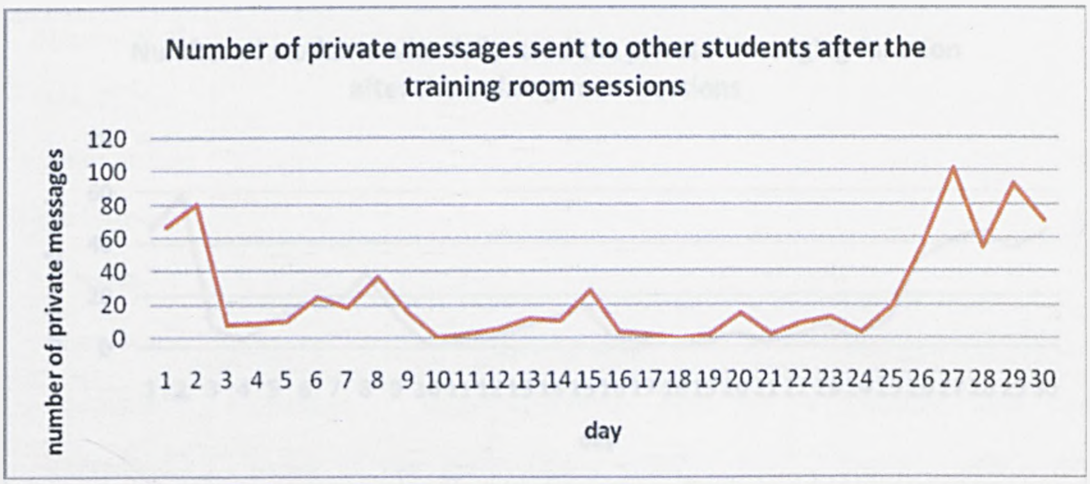


Figure 5.42: Number of private messages sent to other students after the training room sessions

5.5.2.10 Number of students who used the private messaging function after the training room sessions

The result shown in Figure 5.43 is similar in the pattern to that in Figure 5.42. The result indicates that more students used the private messaging function for student-student interactions at the beginning of the self learning sessions (days 1-3) and before the exam (days 25-30) than between days 4-24.

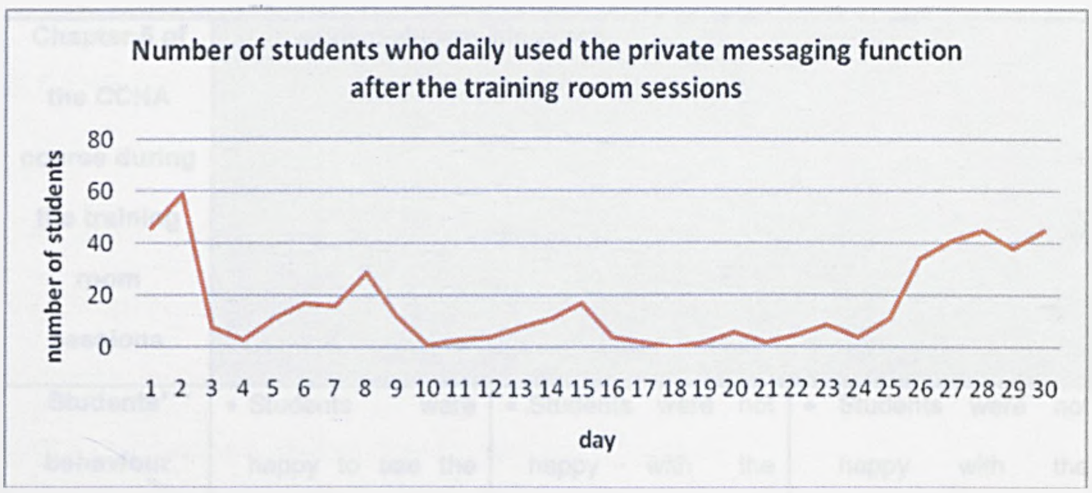


Figure 5.43: Number of students who used the private messaging function after the training room sessions

5.6 RESEARCHER OBSERVATION DURING THE TRAINING ROOM SESSIONS

Table 5.4 below summarises the researcher's observation of the students' behaviour during the training room sessions of the CCNA course.

Table 5.4: The results of research observation done during the training room sessions

	Group 1	Group 2	Group 3
Students' behaviour when they studied Chapter 1-	• Students were happy to participate in the research. • Most students were able to concentrate on the study of the CCNA course. • Students were able to use the CCNA course learning system. • Some students sought offline student-teacher interaction and offline		

Chapter 5 of the CCNA course during the training room sessions	student-student interaction.		
Students' behaviour when they studied Chapter 6-Chapter 10 of the CCNA course during the training room sessions	• Students were happy to use the online interaction system. • Offline student-teacher interactions and student-student interactions were gradually replaced by online interaction. • Most students were able to concentrate on the study of the CCNA course.	• Students were not happy with the sudden change of the course content. • Offline student-teacher interactions and student-student interactions were gradually replaced by online interaction. • Online and offline discussions, which were not related to the CCNA course, were increasing. • Some students did not concentrate on the CCNA course content.	• Students were not happy with the sudden change of course content styles. • Most students sought offline student-teacher interaction and offline student-student interactions. • Offline discussions, which were not related to the CCNA course, were increasing. • Some students did not concentrate on the CCNA course content.

5.7 THE STUDENTS' EXAM RESULTS

The exam results showed that at the first attempt the students achieved a 97.3% pass rate and this increased to 100% at the second attempt. The increase in pass rate may be attributed in part to the quality of interactions and individualised course content and tutor support.

CHAPTER 6

DISCUSSION

In this chapter, the interpretation of the key findings and the discussion on how this study relates to previous works are presented. The original contribution to the knowledge and the limitations of the study are also discussed.

6.1 INTERPRETATION OF THE KEY FINDINGS

There are seventeen key findings which will be discussed and analysed separately under the sub-headings 6.1.1 to 6.1.17.

6.1.1 Reliability of the Course sequencing protocol and course content's validity

This study carried out five tests to ascertain and ensure the reliability of the course sequencing protocol. These tests were based on guidelines to test a web server reviewed in the literature review section of this thesis (refer to page 71). The results of the web server stress test (Figure 5.1) demonstrated the effective performance of the web server and course sequencing protocol as technically reliable. The results of the operating system and web browser test (Table 5.1) confirmed that the course sequencing protocol could be displayed effectively in both Windows 2000 and Windows XP operating systems using Internet Explorer or Netscape. Being able to display in both the Windows operating systems and the Internet Explorer or Netscape browsers ensures easy access to all students participating in the study, as the students use either of the operating systems or browsers. The results of the legal self-diagnostic session (section 5.1.3) showed that the contents of the course sequencing protocol conformed to the Chinese government's legal requirements on information for public consumption, and were suitable for delivery to the students. The students were trained on how to use the course sequencing protocol before the CCNA course started. Post training, a pilot study was carried out using a survey questionnaire and followed by a face-to-face or telephone interviews (refer to page 91) to evaluate the usability of the prototype course sequencing protocol. Results from the pilot study (Table 5.2a) identified some technical problems with the course sequencing protocol. All the problems were solved. (Table 5.2b) In this study, the learning activities record tools were very important for gathering data on the students' learning behaviour. The test results for the learning activities record tools (section 5.1.5) demonstrated the effectiveness and robustness of the learning activities record tools. These results strongly support the technical reliability of the course sequencing protocol.

The course content used in this study was mainly adapted from the official CCNA training book, published by Shenyang Normal University (Xu, 1998). The accuracy of the new course content, in terms of knowledge, was checked by the researcher developer and by Dr. Zhitao Xu, the original content author. The methodology used to develop the course content also ensured the appropriateness of chunking information into relevant learning objects, as well as ensuring validity of the knowledge to be covered during the course.

Figures 5.4, 5.5 and 5.6 demonstrate that the course objectives were clearly explained, the course content was clear and understandable and the course content was appropriately thought through and sequenced respectively. Based on these results, this research study concludes that the course content as presented to the students via the course sequencing system meets the scope, level and standards of the traditional CCNA course.

6.1.2 Student feedback and behaviour in an individualised learning environment without interaction tools

During the training room sessions, Group 3 students were provided with an online individualised learning course while studying chapters 1-5, but the individualised system was switched off for chapters 6-10. Instead, the students were presented the contents of the “one-size-fits-all” style of online course. By comparing the feedback and the learning behaviours of the Group 3 students during chapters 1-5 and in chapters 6-10, the study confirmed the findings that the students’ learning experience within an individualised online learning was better than the conventional “one-size-fits-all” online course (Figure 5.12).

In terms of managing students’ learning, the individualised course content is more suited to the student’s learning needs and learning style (Figure 5.13). The study also revealed that the “one-size-fits-all” mode course content lacked the interest required to attract and maintain student attention (Figure 5.14, Figure 5.18 and Table 5.4).

It was observed that delivering an individualised online course online slightly increased the students’ workload compared to amount of effort for a “one-size-fits-all” format. However, the amount of additional work and effort involved was still acceptable to the students (Figure 5.15).

Overall, the study confirmed that the students liked the individualised course more than the “one-size-fits-all” course (Figure 5.16). The findings of this study match those of previous research discussed in the literature review (refer to page 44).

6.1.3 Student feedback and behaviour in a "one-size-fits-all" online course with interaction tools

During the training room sessions for chapters 6-10, Group 3 students were provided with content in a traditional "one-size-fits-all" format with no access to the interaction tools. Group 2 students, for chapters 6-10, they were given access to the interaction tools, and their course content was in "one-size-fits-all" format. Students' feedback and the analysis of records of the students' learning behaviour showed that the interaction tools helped the students to learn.

Findings showed that the students' level of interest in the course was improved (Figure 5.14) and results also confirmed the effectiveness of the interaction system in the "one-size fit all" mode of online course (Figure 5.16).

When we examine the interaction tools in the interaction system, the results confirm the effectiveness of the discussion forum (Figures 5.8 and 5.23), the Ask Tutor tools (Figures 5.9 and 5.28) and the chat room (Figures 5.10 and 5.20), in helping the students to learn. It was surprising to find, as demonstrated in Figures 5.11 and 5.30, that the messaging function did not significantly contribute to the student's learning. Careful consideration should be given when using the chat room tool in an online learning course. Whilst the results confirmed that the chat room tool helped students to learn, a tracking of the students' chat sessions revealed high numbers of discussions, which were not course related (Table 5.4). This leads the researcher to conclude that a host person should be assigned to moderate chat room discussions to ensure that they are for course specific purposes.

It may be concluded that the interaction learning tools used in this study, except for the messaging tool, helped the students to learn in a 'one-size-fits-all' online learning environment and that the chat room tools must be hosted when being used. The results of this study match the conclusions from previous work discussed in the literature review (refer to page 61).

6.1.4 Comparison of the Individualised learning environment with and without interaction tools

For this experiment, Group 1 students were provided with the content of chapters 1-5 in an environment with individualised learning features but no access to the interaction tools. However, for chapters 6-10, they were provided with content in an environment with both the individualised learning features and the interaction tools. Comparing results from both learning environments, it was observed that the environment with both the learning features and interaction tools was better in enhancing the students' experience than that environment with only the individualised learning features (Figures 5.13 and 5.14).

The incorporation of interaction tools into the course sequencing protocol contributed by increasing the students' interest to engage in learning, as well as enhancing the students' learning process (Figures 5.13 and 5.14).

Figures 5.8, 5.9 and 5.10 demonstrate that the discussion forum, the Ask Tutor tool and the chat room and the individualisation provided within the course sequencing protocol helped the students to learn. These tools contributed significantly to students' learning as the students used these functionalities very frequently during the learning process (Figures 5.20, 5.23 and 5.28). As with the findings in section 6.1.3, the messaging tool did not sigificantly contribute to the students' learning (Figure 5.11).

Overall, the results revealed that the students were more satisfied using the course sequencing protocol with both individualised features and interaction tools than with a protocol system with individualised learning features only. Also, the results demonstrated that in an individualised online course, interaction tools are effective for supporting the sequencing operations, the presentation of information and enhanced the quality of tuition (Figure 5.16).

6.1.5 Comparison of the "One-size-fits-all" format learning environment with interaction tools and the individualised learning environment with the interaction tools

In section 6.1.3, the conclusion reached was that the interactive features helped the students to learn. In this experiment, the effectiveness of the interaction tools are measured by comparing the learning activities logs of Group 1 students during the training room session, with those of Group 2 students. Group 1 students were provided content of chapters 6-10 within a learning environment that had both the individualised learning features and interaction tools, whilst Group 2 students were provided same content within a "one-size-fits-all" learning environment with interaction tools only. The findings from this study confirmed that student interaction activities were enhanced in the learning environment with both the individualised course sequencing protocol and the interaction tools. It was noted that students were more engaged in learning when they were provided with the interactions and individualised functionalities.

Interaction tools contributed to the students' learning regardless of the learning environment (Figures 5.8, 5.9 and 5.10). However, the results showed that the students who used the individualised course sequencing protocol with interaction tools, had an increased interest in learning during the course (Figure 5.18), and were more involved in interaction activities (Figures 5.24, 5.25, 5.26, 5.27 and 5.29) compared with those who studied in a "one-size-fits-all" course sequencing protocol with only the interaction tools.

It should be mentioned that Group 1 students were less active than Group 2 students in the chat room activities (Figure 5.21). Since the chat room was designed to give brief tutorials and/or respond to question and answer sessions (refer to page 118), the study compared the ratio between the duration of the pre-arranged chat room sessions and the total duration of the chat room sessions (see Figures 5.21 and 5.22 respectively). The ratio for Group 1 was "1:1.24" and that for Group 2 was "1:2.16". The researcher observed an increase in Group 2's online discussions, which were not related to the CCNA course. Hence, the study confirmed that the Group 1's chat room sessions were more effective and more related to learning activities than those of Group 2.

Overall, the results demonstrated that students were more satisfied with a learning environment with the individualised course sequencing protocol and the interaction tools than with the "one-size-fits-all" learning environment with the interaction tools only (Figure 5.16).

6.1.6 Comparison of the Individualised course sequencing protocol without interaction tools and the "one-size-fits-all" learning environment with interaction tools

In this experiment, Group 2 students were provided with the content of chapters 1-5 within a learning environment with individualised learning features. The contents for chapters 6-10 were provided in a learning environment with only the interaction tools, but using the "one-size-fits-all" mode.

By comparing the students' feedback from these two learning sessions, the findings confirmed that, in terms of enhancing the students' learning needs and learning experiences, the individualised course sequencing protocol without the interaction tools was more effective than the "one-size-fits-all" course sequencing protocol with the interaction tools. This result suggests that presenting content to suit an individual's learning styles increases his/her interest, motivation and engagement.

The learning needs of the students, in terms of managing their learning process, were not fulfilled in the "one-size-fits-all" course sequencing protocol with the interaction tools (Figure 5.12). The students were not satisfied with this mode ("one-size-fits-all") of delivery. This finding was confirmed by the researcher's observations (Figure 5.13 and Table 5.6).

However, Figure 5.14 demonstrates that the students' interests in learning could be enhanced by adding interaction tools into the "one-size-fits-all" course sequencing protocol.

Overall, the results revealed that the students had a greater tendency to use the learning environment with the individualised course sequencing protocol rather than the "one-size-fits-all" learning environment with only the interaction tools (Figure 5.16).

6.1.7 Student-instruction interaction

The student-instruction interaction refers to the interaction between students and pedagogical design. In the previous sections of the Discussion chapter, the study argues in favour of the effectiveness of the individualised course sequencing protocol with the interaction tools, as the findings suggest that the students were very satisfied with it. All the students who participated in the course said that the course sequencing protocol helped them to learn and they reported that the course sequencing protocol provided them with a good learning experience, compared with the other e-learning courses offered by their university (Table 5.3).

This study argues that the reasons behind the students' positive feedback are as follows:

- The course sequencing design was effective in meeting individual's learning needs and styles, as the design was well informed by pedagogical, course design and interaction theories.
- The design of the course sequencing protocol and the course content was also informed by students' learning styles.
- Easy to access and effective interaction features were designed into the learning environment to support the diverse range of activities during the learning process.

In short, the above analysis is mainly concerned with the design. On the other hand and from a logical perspective, it is impossible to build something properly without a good design plan and process.

In general, the students interacted with a pedagogical method throughout the learning process. Hence, this study argues that the student-instruction interaction was the most important interaction of all, as it guided the:

- individualisation process,
- interaction design and
- implementation of the design of the learning environment.

This conclusion is in accord with and supports the validity of Hirumi's Level 3 interaction theory (Hirumi 2006).

6.1.8 Student self-interaction

The discussions in section 6.1.6 showed that, in terms of the students' learning needs and learning experiences, the individualised course sequencing protocol without interaction tools was more effective than the "one-size-fits-all" course sequencing protocol with only the interaction tools. Hence, this study demonstrates that the implementation of the student self-interaction in course design should have priority over other types of interactions, except the student-instruction interaction.

Hirumi (2006) defines student self-interaction as consisting "of the cognitive operations that constitute learning and the meta-cognitive processes that help individuals monitor and regulate learning". With regard to the properties of the individualised learning (refer to section 2.2), the individualisation process in this study was classified as student self-interaction. Hence, the nature of the individualised learning is identified as a type of mental interaction, which occurs within the students' mind.

6.1.9 Student-content interaction

The student-content interaction refers to the interaction between students and the course content. In this study, students spent 70.5% of their time interacting with the course content (Figures 5.32 and 5.33). Eighty two percent (82%) of the students gave positive feedback on the course contents used in this study (Table 5.3).

In view of feedback from the students, the researcher is inclined to argue that the student-content interaction was the primary source through which the students gained knowledge of the CCNA course.

6.1.10 Student-student interaction

Student-student interaction refers to interaction between students in a one to one or one to group basis. In this study, the chat room, the messaging system and the discussion forum were the three main tools designed for the student-student interaction. The following subsections examine their usage.

6.1.10.1 Chat room in the student-student interaction

There was evidence of a 0.365 correlation between the login numbers for the course sequencing protocol and those for the chat room (Figure 5.34). This indicated that the students who accessed the course sequencing protocol did not intend to access the chat room. In addition, Figure 5.35 recorded an average login duration time of 1.3 minutes per student per day was spent in the chat room after the training room session. This further confirms that the students tended not to use the chat room for student-student interaction. Evidence from students' feedback suggest that the chat room sessions amongst students were not effective in helping them to learn (Table 5.3).

Based on the above results, this study confirms that the non-hosted chat room sessions amongst students was not an effective student-student interaction in terms of enhancing the students' learning experience.

6.1.10.2 Messaging system in the student-student interaction

In sections 6.1.3 and 6.1.4, this study found that the messaging system had no real effect in helping the students to learn. The following section intends to analyse the reasons why the messaging system had no real effect in helping the students to learn.

In total, 59.8% of students reported that the messaging system helped them to learn because they could find out who was online and send private messages in order to discuss their studies. In addition, the students got faster replies than with the web based email programmes they used outside the course system (Table 5.3). However, 36.6% of students reported that incoming messages from other students disturbed their studies (Table 5.3) and 74.1% of the students suggested that the incoming message alert should be removed (Table 5.3).

Based on the above results, this study argues that, although the students tended to seek the synchronous or semi-synchronous student-student interactions, they did not like being disturbed during their studies. If the incoming message alert was removed, the messaging system would become an asynchronous student-student interaction tool. Therefore, it can be concluded that the problem with the messaging system is a paradox.

6.1.10.3 Discussion forum in the student-student interaction

The interview results shown in Table 5.3 indicate that all (100%) of the students thought that the discussion forum helped them to learn. The results showed that the students were very active in the discussion forum (Figures 5.37, 5.38 and 5.39). A 0.975 correlation coefficient (Figure 5.36) between the number of students who used the discussion forum daily and those students, who used the course sequencing protocol daily clearly, demonstrates that the students had a very strong intention to use the discussion forum when they logged into the course sequencing protocol. These results make it quite clear that the discussion forum was the main student-student interaction tool used in within the learning environment.

6.1.11 Student-teacher interaction

Student-teacher interaction occurs between students and teachers. In this study, the chat room, the Ask Tutor function and the discussion forums were designed for the student-teacher interaction.

6.1.11.1 Usage of the chat room in student-teacher interaction

In total, 81.3% of the students interviewed reported that the chat room function helped them to learn the CCNA course. The reasons for this were that they got synchronous replies in the tutorial session and that they also benefited from the discussions between teachers and other students (Table 5.3). It could also be said that chat room discussions and synchronous feedback from the teachers benefited the students.

6.1.11.2 Usage of Ask Tutor tools in the student-teacher interaction

Again, the students reported that the synchronous or semi-synchronous feedback from the tutor via the Ask Tutor function helped to learn. Sixty six percent (66.1%) of the students reported delayed replies from the teachers and when they did not get timely replies from the teachers, the students posted their questions to the discussion forum or waited for the replies (Table 5.3). No students reported they were de-motivated.

Findings from this study leads one to conclude that the students tended to seek synchronous or semi-synchronous student-teacher interaction to enable them to clarify issues or to confirm view points with their teachers. When this opportunity was not available, the students resorted to asynchronous student-teacher interaction.

6.1.11.3 Usage of the discussion forum in the student-teacher interaction

In the discussion forum, the main role of the teacher is to act as a moderator and to regulate the topics discussed within the forum. The teachers also enhanced the student-student interaction by posting threads and replies to the discussions. In addition, the teachers selected some of the students' works which they posted to the forum as a trigger to stimulate the students' thinking and promote further discussion. Results shown in Table 5.3 indicate that the students' learning experiences were enhanced by the student-teacher interaction in the discussion forum.

6.1.12 Teacher-teacher interaction

The teacher-teacher interaction refers to the interactions amongst teachers. Due to the sampling size of this study, four teachers were involved in the study. (refer to page 94) The Ask Tutor tool, the teacher management system and a private calendar system of the discussion forum were employed as tools for teacher-teacher interaction.

In this study, the main role of the teacher was that of providing support to the students by giving tutorials, responding to question and answer sessions and providing the students with individualised feedback. To perform the above roles effectively, the teacher-teacher interaction was crucial, because any forms of co-operative work and scheduling required teacher-teacher interaction.

The results from this study found that teachers tended not to use the online teacher-teacher interaction tool during the training room session. This was because they were all physically based in the same room. However, the online teacher-teacher interaction activities increased after the training room session because the teachers were no longer in the same location.

6.1.13 Teacher-content interaction

Similar to the student-content interaction, this refers to the interaction between teachers and the course content. Anderson and Garrison (2003) define teacher-content interaction as the process of creating learning objects and developing the course content. In this study, the process of creating course content and learning objects was classified as student-instruction interaction because they constituted the process of developing pedagogy. In addition, the process by which the teachers created the course content during the course teaching period is also referred to as teacher-content interaction. Examples of these interactions include: The teachers posting selected the students' finished assignments to the discussion forum for other students to consult with (refer to Table 3.1b). The selected work was available to other students as exemplars and in turn it became one of the learning objects. This process was widely used in the study and got excellent results because it encouraged students to learn and to support each other (Table 5.3).

6.1.14 Content-content interaction

Content-content interaction refers to the interaction between features and the modules of the course sequencing protocol.

It is apparent that various modules in the course sequencing protocol needed to interact with each other to serve both the individualisation and interaction processes (refer to Figure 4.1). Where no information is passed through the course sequencing protocol, the individualised course sequencing protocol would then become a static "one-size-fits-all" html page.

6.1.15 Student/teacher-environment interaction

This study treats student/teacher-environment interaction as a support type interaction, which enables the students/teachers to participate in the learning/teaching process. For example, technical support from computer engineers is considered a student/teacher-environment interaction.

6.1.16 Students' participation rate and interaction activities at the weekends and prior to the examinations

A 100% student participation rates was observed during the training room sessions and after the training room sessions (refer to Figures 5.17 and 5.31 and Table 5.3). Attendance during the training room sessions was obligatory, (as requested by the Shenyang Normal University) but attendance after the training room sessions was voluntary. The attendance after the training room sessions demonstrated that the course sequencing protocol offered the students an enjoyable learning experience (Figure 5.31). Compared to the other online learning courses reviewed in the Introduction chapter, the participation rate on this course was much higher than the university run CCNA courses and there were no drop-outs from the course.

It should also be mentioned that the course participation rates after the training room sessions was weekend and exam sensitive.

The login numbers for the course sequencing protocol declined sharply at weekends (Figure 5.31). The results also showed that before an exam, the login numbers for the course sequencing protocol and the course content increased (Figures 5.31 and 5.33) demonstrating that the students looked for more student-content interaction before an exam. In addition, the study found that the interaction activities in the discussion forum decreased (Figures 5.37, 5.38 and 5.39). However, the login numbers for the discussion forum showed an ascending pattern (Figure 5.36) indicating that the students came to the discussion forum to "read" rather than "talk". Reading previous posts is considered to be student-content interaction. This finding further confirmed that students tend to seek student-content interaction before an exam. It may be argued that previous post served as revision materials for the students.

Semi-synchronous student-student interaction and semi-synchronous student-teacher interaction showed an ascending pattern before an exam (Figures 5.42 and 5.40). This suggests that the students benefited from semi-synchronous interaction amongst students and teachers and, compared with the synchronous (Figure 5.34) and asynchronous interactions (Figures 5.37, 5.38 and 5.39), semi-synchronous interactions were shown to be more effective.

These results demonstrated that the effectiveness of the range of interactions in an online learning course varied in different learning sessions, although all the interactions enhanced the student learning experience and the quality of the learning. The study shows that the differences between each learning session should be taken into consideration before designing an online learning course.

6.1.17 Students' exam results

There was no formal course evaluation proforma from Shenyang Normal University available to me. Also, the exam results from previous students on the CCNA courses are not disclosed to the public. For this study, part of the feedback on students' previous course experience and information on the previous students' exam results came from having personal communication with Dr. Zhitao XU, the course organiser of the CCNA course at the university. Results from this study showed that 97.5% of the students passed the formal CCNA exam in their first attempt and 100% of students passed the exam in their second attempt (section 5.7). This is in comparison with the previous students' exam results of an average first-attempt pass rate of 90% (Xu, Z., personal communication, 28 September 2004). The difference in the first-attempt pass rates may be due in part to the individualisation of the learning environment and the range of interactions which contributed in enhancing the quality of learning and the students' experience.

6.2 RESEARCH QUESTION

In response to the research question, it can be argued that students taking an online course in which the content/material is individualised, based on learning style, pace of learning, prior knowledge structure and supported with relevant interactions and learning objects technology, provided an improved quality of learning and a better learning experience than if they undertake as:

- a normal 'one-size-fits-all text/graphic based format' online course (refer to section 6.1.2 to 6.1.4)
- an online course with only individualised features (refer to section 6.1.4)
- an online course with only interaction features (refer to section 6.1.5).

6.3 SYNERGIES IN THE INDIVIDUALISED COURSE SEQUENCING PROTOCOL WITH INTERACTION TOOLS

Two types of synergies have been identified in this study. In section 6.1.5, it is noted that the students' interaction activities were improved in the learning environment with individualised learning features and interaction features, in comparison with the "one-size-fits-all" learning environment with interaction tools only. The findings established that the synergy was created by adding individualised learning and interactive learning to the learning environment.

In sections 6.1.10.3 and 6.1.11.3, the research showed that the discussion forum helped students to learn. Students reported that they benefited from other students' threads and replies in terms of gaining new knowledge and consolidating previous knowledge (Table 5.3). Also, the students' finished assignments selected by the teachers and posted to the discussion forum for other students as examples of good work contributed in supporting the students' learning (refer to Table 3.1b). Students with different learning styles had different tasks assigned to them (refer to Table 3.1b). However, all students used one discussion forum. Findings from this study verify that a synergy existed between students with different learning styles which interact within one learning environment. The results match previous studies undertaken in an offline teaching environment (Halstead and Martin 2002;

Kayes 2001) and demonstrate that students with different learning styles interact more effectively in terms of knowledge sharing. These findings provide responses to the Research Aim 1 (refer to page 10).

6.4 THE NATURE OF INTERACTIVE LEARNING AND INDIVIDUALISED LEARNING

In response to Research Aim 2 (refer to page 10), individualised learning has been identified as a process of student-self interaction (section 6.1.8). This will enable the study to develop a model, which takes into account both interactive and individualised learning (see Figure 6.1).

6.5 INTERACTIONS MODEL

Based on the discussions in section 6.1, this study developed a new interaction model by modifying Hirumi's (2006) Interaction Model and Anderson's (2004) Interaction Model shown in Figure 6.1.

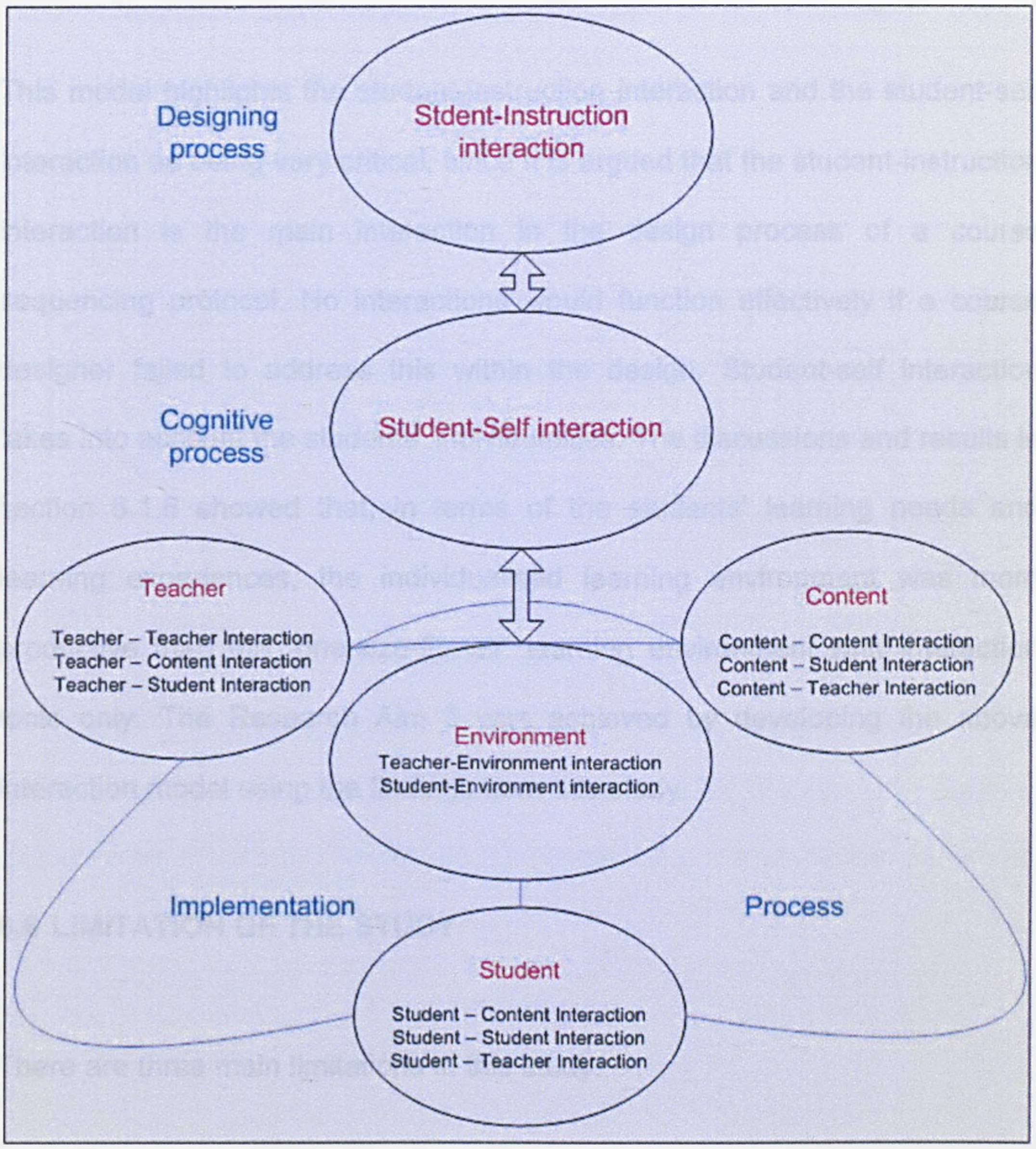


Figure 6.1: Interaction Model, modified from Hirumi's (2006) Interaction Model and Anderson's (2004) Interaction Model

This interaction model covers the design, the cognitive process and the implementation processes of an online course. It also covers all types of interaction that have been identified by this study (Figure 6.1).

This model highlights the student-instruction interaction and the student-self interaction as being very critical, since it is argued that the student-instruction interaction is the main interaction in the design process of a course sequencing protocol. No interactions would function effectively if a course designer failed to address this within the design. Student-self interaction takes into account the students' individualities. The discussions and results in section 6.1.6 showed that, in terms of the students' learning needs and learning experiences, the individualised learning environment was more productive than the "one-size-fits-all" learning environment with interaction tools only. The Research Aim 3 was achieved by developing the above interaction model using the findings from this study.

6.6 LIMITATION OF THE STUDY

There are three main limitations in this study:

- The CCNA course is a core and exam based subject for Computing students at the Shenyang Normal University. Most online courses are not exam based. Therefore, a direct comparison of the findings from this study with other online courses will not be possible.

- With the CCNA being a core course at the Shenyang Normal University, it is a requirement for the students to attend training room sessions. Failure to attend and participate in the training room sessions would result in the student being awarded a fail grade.
- The third issue is cultural. In the Chinese educational context, strict compliance with rules and regulations is a norm. This cultural norm it is my belief may influence (rightly or wrongly) the student's volition and ability to self-manage the pace of their learning during the training room sessions.

Put together, these factors may have some effect on the students' behaviour to learning and consequently on associated data for behaviour to learning gathered for this study. Therefore, inferences from the study are made with caution.

CHAPTER 7

CONCLUSION

7.1 FOCUS OF THE STUDY

It has been widely reported that students' learning experience in online learning courses needs to be improved. This is true for both developing and developed countries. So what should be done to address the problem?

This research study has investigated the individualisation of, and interactions in, online learning courses. It demonstrates that students will get an enhanced quality of learning in an online individualised learning environment which is supported with relevant interactions.

7.2 SUMMARY OF THE OUTCOME OF THE LITERATURE REVIEW

First of all, there is a need to identify the existing problems in the online learning field and to relate to previous studies, which addressed student learning. The literature review provides evidence that:

Individualised courses are better than the traditional "one-size-fits-all" mode of online courses in terms of learning needs, learning quality and learning experiences (Conlan, Wade, Bruen and Gargan 2002; Shute and Towle 2003);

Interactions in online learning courses enhance both the quality of learning and the students' learning experience (Thorpe 2008; Zhang, Luo, Jiang, Liu and Zhang 2004).

However, there is little evidence to indicate that previous studies have tried to combine individualisation and interaction into one online learning platform.

Learning object theories, technology-enhanced learning management system theories and online course design theories were reviewed to provide this study with guidelines for designing the course sequencing protocol and sequencing the course content.

7.3 ENHANCING INTERACTIONS AND INDIVIDUALISED LEARNING IN ONLINE LEARNING ENVIRONMENTS

The study demonstrates that students taking an online course in which the contents/materials are individualised based on learning style, pace of learning and prior knowledge structure, and supported with relevant interactions and learning objects technology, have an improved quality of learning and learning experience. This is in comparison to those studying on the traditional 'one-size-fits-all text/graphic based format' online course or the online course with only individualised features or interaction tools.

This finding demonstrates the success of combining individualised learning and interaction tools into one online learning platform. It provides a new direction in which to improve the student learning experience of online learning courses.

7.4 SYNERGIES IN AN ONLINE LEARNING COURSE

Is there evidence to suggest that studying an individualised online learning course with interaction tools provides an enhanced learning experience? The study addressed this question by recognising the two synergies, which exist in such an online course:

- The synergy which is created by combining individualised learning and interactive learning. The combination of individualised learning and interactive learning has enhanced quality of learning and learning experience. (i.e. Students interact more effectively in the individualised course sequencing protocol with interaction tools than in any other platforms.)

- The interactions between students with different learning styles helps students learn. The effect can be increased by performing particular teacher-content interactions during the course.

7.5 THE NATURE OF INDIVIDUALISATION AND INTERACTION IN ONLINE LEARNING COURSE

What is the difference between individualisation and interaction in online learning courses? The findings of the study show that individualisation is another type of interaction, which occurs in the mind of the student. This type of interaction is named as student-self interaction. The recognition of individualisation as student-self interaction provides the connection between individualisation and interaction. Therefore, the study could merge them into one applicable model.

Each interaction has its own functionalities in helping students to have a better learning experience than would have been the case with limited or no interactions. The quality of the students' learning experience can be improved by linking the identified interactions in a systematic manner (i.e. enabling association and inter connection of various interactions)

7.6 INTERACTION MODEL

How is an effective online learning platform built? Drawing on the findings from research studies, an interaction model was developed by modifying Hirumi's (2006) Interaction Model and Anderson's (2004) Interaction Model in order to guide the design and implementation of the online interaction. (refer to section 6.5) In this model, interactions are classified into the three main processes:

- **Design Process**. This includes student-instruction interaction. It refers to the interaction, which occurs between students and pedagogical design. The Constructivist student-centred learning theory is reflected in the design process and guides the course design tasks in an online learning platform.
- **Cognitive Process**. This includes student-self interaction. It refers to the cognitive operations that constitute learning which includes how particular learners perceive, interact with, and respond to the learning environment. This process occurs within students' minds. The students' individualities are considered in the cognitive process, which helps online course facilitators to recognise and understand these individualities.

- **Implementation Process**. This includes the student-student interaction, the student-content interaction, the student-teacher interaction, the teacher-teacher interaction, the content-content interaction and the student/teacher-environment interaction. Those interactions, which occur during the teaching process of an online course, are covered in the implementation process, which provides a systematic view on how the above interactions link with each other.

This new interaction model covers all identified interaction types in the literature and the findings of this study support the validity of the model.

7.7 ORIGINAL CONTRIBUTION TO KNOWLEDGE

The original contribution to knowledge is discussed in the Introduction chapter of this thesis (refer to page 11). This contribution will make a significant impact on knowledge in the field of online learning.

A course sequencing protocol was developed which simulates various learning environments enabling content to be adapted to meet learners' needs based on their preferred learning styles.

There is little evidence in previous studies to link individualised learning and interactive learning in an online learning platform. The results of this study show that combining individualisation and interactions has a positive impact on the quality of learning and enhances the learning experience.

It was found that synergies develop as a result of interactions between students with different learning styles. This demonstrates that students with different learning styles interact more effectively in terms of knowledge sharing than is the case in a traditional 'one size fits all' online learning environment.

There is limited evidence to suggest that previous studies have developed an interaction model to guide the design and implementation of online interactions. The model proposed in this study highlighted three processes which underscore interactive learning: Design Process, the Cognitive Process and the Implementation Process.

7.8 FUTURE RESEARCH

Findings from this study suggest the following directions for future research:

- The development of a robust, fit for the purpose, online learning environment with appropriate social-constructivist tools that can provide effective individualisation based on learning styles.
- The development of an automatic or semi-automatic course content generator to convert the one-size fit all mode of course content into individualised course content.
- Conduct further research in different cultural contexts to make the results of this study more generalisable.
- Conduct further research using a non-exam based course to find out the students' behaviours when using the individualised course sequencing protocol with interaction tools.
- Conduct further research to find out whether students in different occupations prefer particular type of learning styles.

7.9 RECOMMENDATION

Whilst recognising the cultural and pedagogical limitations of the study (Refer to Section 6.6), there are some emerging pedagogical principles from this study which are transferable to any online learning contexts. These are:

- Individualised learning and interactive learning should be used together to enhance both the quality of learning and the students' experience online.
- Pedagogical principles for students with different learning styles listed in Tables 3.1a and 3.1b should be adopted for individualising courses.
- The interaction model (refer to Figure 6.1.) should be used to inform and underscore the design of online learning courses.
- Online learning courses should be designed in the socio-constructivist approach to effectively promote collaboration between students with different learning styles.
- Learning styles influence how students learn. Good use can be made of learning style inventories and the information gained from the test should be used to guide and support students in their learning.

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APPENDIX 1 PILOT STUDY QUESTIONNAIRE

(Note: This questionnaire is an English translation of the Chinese version. The questionnaire was delivered online through the course sequencing protocol and not in the offline Microsoft Word format as shown below.)

Evaluation of Web based Individualized Learning Environment

Notes:

Please complete the questionnaire by placing a tick (√) in the appropriate box of your choice. Also, please provide appropriate commentary in the boxes provided.

Please rate the items listed below

No.		Very good	Good	Fair	Poor
1	The speed of website's connection				
2	Quality of the website's navigation system				
	Please comment as appropriate :				
3a	Quality of the display of the text learning objects				

	Please comment as appropriate :				
3b	Quality of the display of the flash learning objects				
	Please comment as appropriate :				
3c	Quality of the display of the graphic learning objects				
	Please comment as appropriate :				
4	The usability of the messaging system				
	Please comment as appropriate :				
5	The usability of the chat room				
	Please comment as appropriate :				
6	The usability of the discussion forum				
	Please comment as appropriate :				
7	The usability of the Ask tutor				

	Please comment as appropriate :				
8	The usability of the learning management interface				
	Please comment as appropriate :				
9	The overall design of the course sequencing protocol				
	Please comment as appropriate :				
		Yes	**No**		
10	Did you encounter bad links when using the website?				
11	Did you experience any difficulty when using the course sequencing protocol?				
12	Did you have any difficulty when using the website?				
	If yes, please give details:				

		Very Good	Good	Fair	Poor
13	How would you describe your ability to use the course sequencing protocol?				
	Contact Details:				
	i) Name: ii) Department: iii) Email address:				

APPENDIX 2 CCNA COURSE EVALUATION QUESTIONNAIRE

(Note: This questionnaire is an English translation of the Chinese version. The questionnaire was online via the course sequencing protocol and not in the offline Microsoft Word format as shown below.)

CCNA course evaluation questionnaire

Dear CCNA students,

We would like to express our congratulations to you for successfully completing the CCNA course.

We would like to find out about your experiences at CCNA, which will help us to improve and develop our services to all students in the future. The following questionnaire seeks to explore your experience about the CCNA course designing, organisation and management of the teaching and learning support provided by the CCNA course group.

Your responses will be anonymous and the information will be used only in statistical form.

Good luck in the official exam.

Best wishes!

CCNA course group

Notes:

Please complete the questionnaire by filling in the spaces provided as appropriate or by placing a tick (√) beside the appropriate box of your choice.

1.	Your course number	A	B	C	D

2.	Prior knowledge assumed	**None**	**Few**	**Normal**	**Many**	**All**

Based on your experience **OVERALL**, please indicate to what extent you agree with the following statements:

		Strongly Agree	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**
3.	The course objectives were clearly explained.					
4.	Overall, the course content was clear and understandable.					
5.	The course appeared to have been carefully planned.					

6.	The difficulty level of the course was appropriate.					

COMPARED to the learning experience of chapters 1-5, please indicate to what extent you agree with the following statements based on your learning experience of chapters 6-10.

		Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	N/A
7.	The course discussion forum system in chapters 6-10 helped me learn.						
8.	The Ask Tutor function in chapters 6-10 helped me learn.						
9.	The chat room function in chapters 6-10 helped me						

	learn.						
10..	The Messaging Tool function in chapters 6-10 helped me learn.						
11.	Lack of a learning management interface in chapter 6-10 suitable to my learning needs.						
12.	The course contents for Chapters 6-10 were more suitable to my learning needs.						
13.	There was interesting variety in the course						

	materials in chapters 6-10.						
14	The amount of effort required in chapters 6-10 was more than that required for the remainder of the chapters.						
15	Overall, the level of satisfaction for chapters 6-10 was better than that for chapters 1-5.						

Your comment

Online learning students may encounter specific challenges when undertaking their course of study. Please tell us about your experiences, both good and bad, so that we can make improvements for future students.

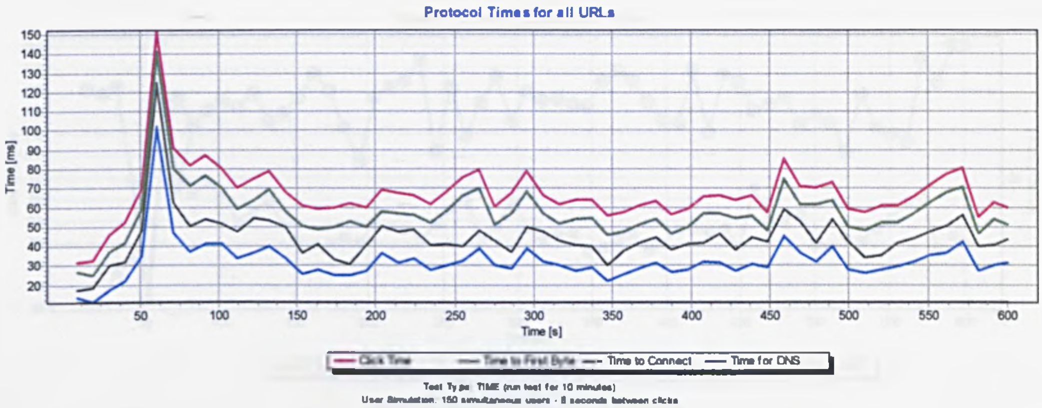
APPENDIX 3 WEB SERVER LOAD PERFORMANCE STRESS TEST REPORT

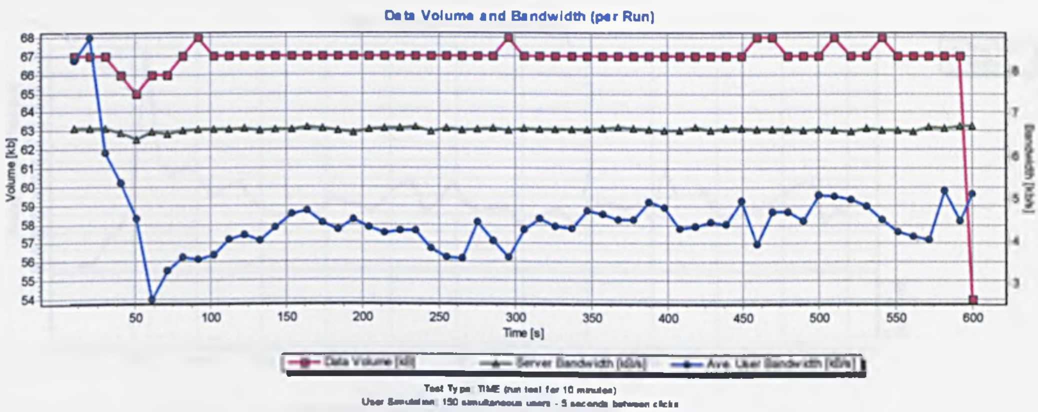
Test Report

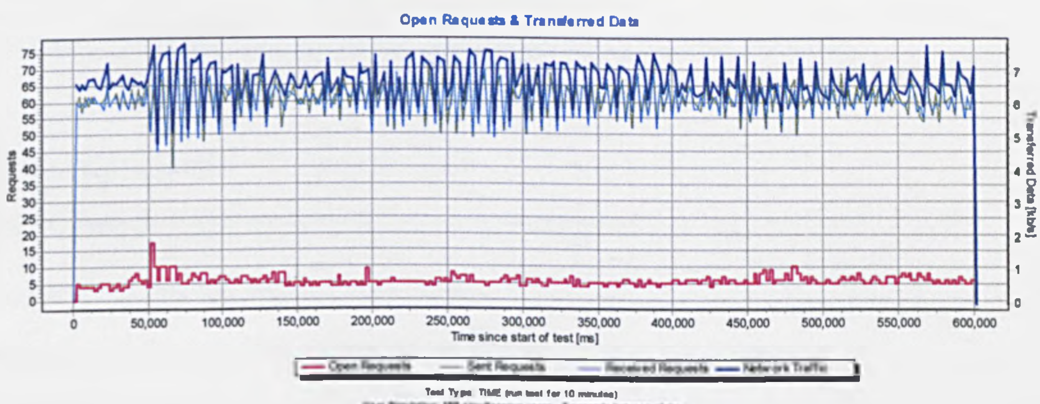
Web server Load Performance Stress Test

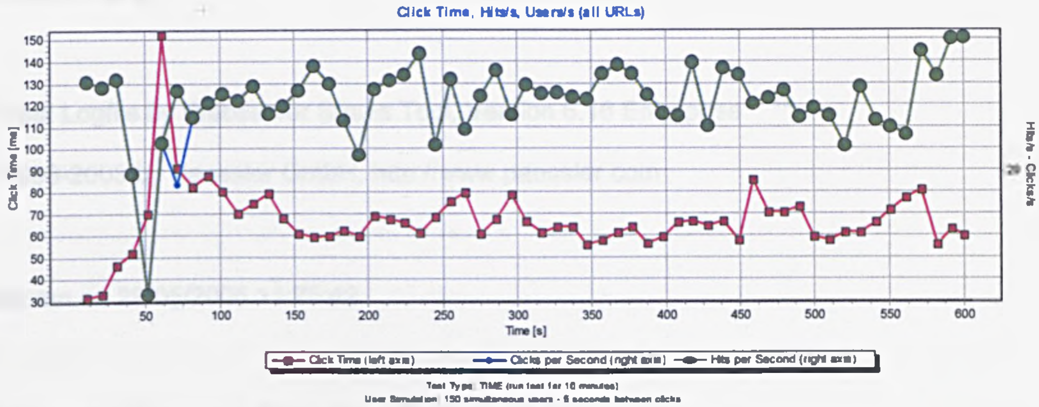
Test Type: TIME (run test for 10 minutes)

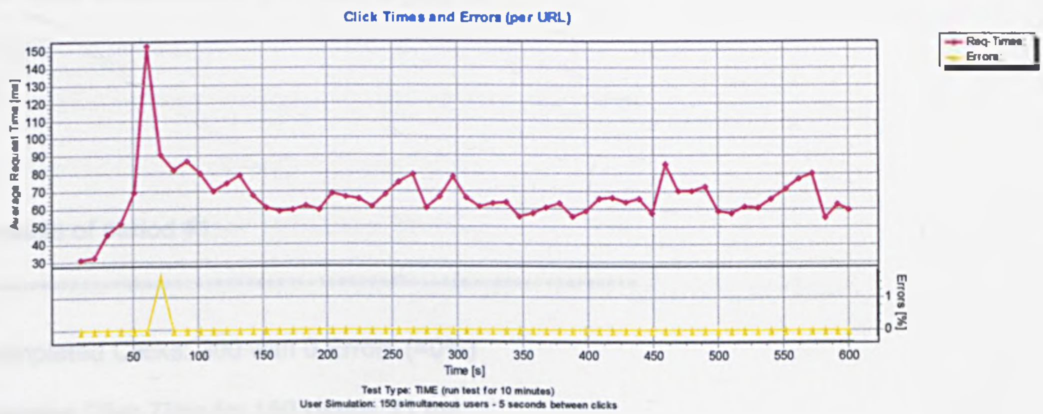
User Simulation: 150 simultaneous users - 5 seconds between clicks


Protocol Times for all URLs
Time [ms]
Time [s]
Click Time
Time to First Byte
Time to Connect
Time for DNS
Test Type: TIME (run test for 10 minutes)
User Simulation: 150 simultaneous users - 5 seconds between clicks


Data Volume and Bandwidth (per Run)
Volume [kb]
Bandwidth [kb/s]
Time [s]
Data Volume [kB]
Server Bandwidth [kB/s]
Ave. User Bandwidth [kB/s]
Test Type: TIME (run test for 10 minutes)
User Simulation: 150 simultaneous users - 5 seconds between clicks


Open Requests & Transferred Data
Requests
Transferred Data [kb/s]
Time since start of test [ms]
Open Requests
Sent Requests
Received Requests
Network Traffic
Test Type: TIME (run test for 10 minutes)


Click Time, Hits/s, Users/s (all URLs)
Click Time [ms]
Hits/s - Clicks/s
Time [s]
Click Time (left axis)
Clicks per Second (right axis)
Hits per Second (right axis)
Test Type: TIME (run test for 10 minutes)
User Simulation: 150 simultaneous users - 5 seconds between clicks


Click Times and Errors (per URL)
Average Request Time [ms]
Errors [%]
Time [s]
Req-Times
Errors
Test Type: TIME (run test for 10 minutes)
User Simulation: 150 simultaneous users - 5 seconds between clicks

Summary Log

** Test Logfile by Webserver Stress Tool, Version 6.16 Enterprise **

Test run on 29/05/2005 11:25:42

** Project and Scenario Comments, Operator **

Results of period #1:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 31 ms

Successful clicks per Second: 29.478 (equals 106122.301 Clicks per Hour)

Results of period #2:

****

Completed Clicks: 297 with 0 Errors (=0%)

Average Click Time for 150 Users: 33 ms

Successful clicks per Second: 29.445 (equals 106002.814 Clicks per Hour)

Results of period #3:

****

Completed Clicks: 299 with 0 Errors (=0%)

Average Click Time for 150 Users: 46 ms

Successful clicks per Second: 29.49 (equals 106163.174 Clicks per Hour)

Results of period #4:

****

Completed Clicks: 294 with 0 Errors (=0%)

Average Click Time for 150 Users: 52 ms

Successful clicks per Second: 28.994 (equals 104377.54 Clicks per Hour)

Results of period #5:

****

Completed Clicks: 290 with 0 Errors (=0%)

Average Click Time for 150 Users: 70 ms

Successful clicks per Second: 28.371 (equals 102134.252 Clicks per Hour)

Results of period #6:

****

Completed Clicks: 296 with 0 Errors (=0%)

Average Click Time for 150 Users: 152 ms

Successful clicks per Second: 29.157 (equals 104966.673 Clicks per Hour)

Results of period #7:

****

Completed Clicks: 301 with 5 Errors (=1.66%)

Average Click Time for 150 Users: 91 ms

Successful clicks per Second: 28.941 (equals 104185.975 Clicks per Hour)

Results of period #8:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 82 ms

Successful clicks per Second: 29.292 (equals 105451.986 Clicks per Hour)

Results of period #9:

****

Completed Clicks: 301 with 0 Errors (=0%)

Average Click Time for 150 Users: 87 ms

Successful clicks per Second: 29.367 (equals 105721.99 Clicks per Hour)

Results of period #10:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 80 ms

Successful clicks per Second: 29.411 (equals 105878.032 Clicks per Hour)

Results of period #11:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 70 ms

Successful clicks per Second: 29.38 (equals 105769.313 Clicks per Hour)

Results of period #12:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 75 ms

Successful clicks per Second: 29.454 (equals 106035.066 Clicks per Hour)

Results of period #13:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 79 ms

Successful clicks per Second: 29.307 (equals 105505.103 Clicks per Hour)

Results of period #14:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 68 ms

Successful clicks per Second: 29.351 (equals 105662.888 Clicks per Hour)

Results of period #15:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 61 ms

Successful clicks per Second: 29.43 (equals 105947.953 Clicks per Hour)

Results of period #16:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 59 ms

Successful clicks per Second: 29.557 (equals 106404.327 Clicks per Hour)

Results of period #17:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 60 ms

Successful clicks per Second: 29.466 (equals 106077.58 Clicks per Hour)

Results of period #18:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 62 ms

Successful clicks per Second: 29.276 (equals 105392.241 Clicks per Hour)

Results of period #19:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 60 ms

Successful clicks per Second: 29.092 (equals 104729.726 Clicks per Hour)

Results of period #20:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 69 ms

Successful clicks per Second: 29.436 (equals 105970.38 Clicks per Hour)

Results of period #21:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 67 ms

Successful clicks per Second: 29.48 (equals 106128.733 Clicks per Hour)

Results of period #22:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 66 ms

Successful clicks per Second: 29.51 (equals 106235.168 Clicks per Hour)

Results of period #23:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 61 ms

Successful clicks per Second: 29.62 (equals 106633.706 Clicks per Hour)

Results of period #24:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 68 ms

Successful clicks per Second: 29.147 (equals 104928.439 Clicks per Hour)

Results of period #25:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 76 ms

Successful clicks per Second: 29.487 (equals 106151.478 Clicks per Hour)

Results of period #26:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 80 ms

Successful clicks per Second: 29.227 (equals 105215.457 Clicks per Hour)

Results of period #27:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 61 ms

Successful clicks per Second: 29.402 (equals 105848.733 Clicks per Hour)

Results of period #28:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 67 ms

Successful clicks per Second: 29.533 (equals 106317.677 Clicks per Hour)

Results of period #29:

****

Completed Clicks: 301 with 0 Errors (=0%)

Average Click Time for 150 Users: 79 ms

Successful clicks per Second: 29.303 (equals 105491.685 Clicks per Hour)

Results of period #30:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 66 ms

Successful clicks per Second: 29.457 (equals 106046.232 Clicks per Hour)

Results of period #31:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 61 ms

Successful clicks per Second: 29.412 (equals 105883.6 Clicks per Hour)

Results of period #32:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 64 ms

Successful clicks per Second: 29.418 (equals 105905.001 Clicks per Hour)

Results of period #33:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 64 ms

Successful clicks per Second: 29.397 (equals 105828.415 Clicks per Hour)

Results of period #34:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 56 ms

Successful clicks per Second: 29.381 (equals 105770.656 Clicks per Hour)

Results of period #35:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 58 ms

Successful clicks per Second: 29.516 (equals 106258.399 Clicks per Hour)

Results of period #36:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 61 ms

Successful clicks per Second: 29.565 (equals 106432.754 Clicks per Hour)

Results of period #37:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 63 ms

Successful clicks per Second: 29.515 (equals 106253.963 Clicks per Hour)

Results of period #38:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 56 ms

Successful clicks per Second: 29.408 (equals 105868.333 Clicks per Hour)

Results of period #39:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 59 ms

Successful clicks per Second: 29.305 (equals 105499.564 Clicks per Hour)

Results of period #40:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 66 ms

Successful clicks per Second: 29.295 (equals 105462.552 Clicks per Hour)

Results of period #41:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 66 ms

Successful clicks per Second: 29.572 (equals 106459.927 Clicks per Hour)

Results of period #42:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 64 ms

Successful clicks per Second: 29.247 (equals 105290.932 Clicks per Hour)

Results of period #43:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 66 ms

Successful clicks per Second: 29.543 (equals 106355.429 Clicks per Hour)

Results of period #44:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 58 ms

Successful clicks per Second: 29.509 (equals 106233.072 Clicks per Hour)

Results of period #45:

****

Completed Clicks: 301 with 0 Errors (=0%)

Average Click Time for 150 Users: 85 ms

Successful clicks per Second: 29.36 (equals 105697.444 Clicks per Hour)

Results of period #46:

****

Completed Clicks: 301 with 0 Errors (=0%)

Average Click Time for 150 Users: 71 ms

Successful clicks per Second: 29.39 (equals 105804.494 Clicks per Hour)

Results of period #47:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 70 ms

Successful clicks per Second: 29.428 (equals 105941.064 Clicks per Hour)

Results of period #48:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 73 ms

Successful clicks per Second: 29.29 (equals 105442.569 Clicks per Hour)

Results of period #49:

****

Completed Clicks: 297 with 0 Errors (=0%)

Average Click Time for 150 Users: 59 ms

Successful clicks per Second: 29.338 (equals 105618.004 Clicks per Hour)

Results of period #50:

****

Completed Clicks: 301 with 0 Errors (=0%)

Average Click Time for 150 Users: 58 ms

Successful clicks per Second: 29.298 (equals 105472.337 Clicks per Hour)

Results of period #51:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 61 ms

Successful clicks per Second: 29.142 (equals 104909.467 Clicks per Hour)

Results of period #52:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 61 ms

Successful clicks per Second: 29.445 (equals 106002.822 Clicks per Hour)

Results of period #53:

****

Completed Clicks: 301 with 0 Errors (=0%)

Average Click Time for 150 Users: 66 ms

Successful clicks per Second: 29.276 (equals 105392.766 Clicks per Hour)

Results of period #54:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 71 ms

Successful clicks per Second: 29.238 (equals 105257.689 Clicks per Hour)

Results of period #55:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 77 ms

Successful clicks per Second: 29.197 (equals 105110.738 Clicks per Hour)

Results of period #56:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 80 ms

Successful clicks per Second: 29.635 (equals 106684.261 Clicks per Hour)

Results of period #57:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 55 ms

Successful clicks per Second: 29.504 (equals 106213.347 Clicks per Hour)

Results of period #58:

****

Completed Clicks: 300 with 0 Errors (=0%)

Average Click Time for 150 Users: 63 ms

Successful clicks per Second: 29.694 (equals 106897.12 Clicks per Hour)

Results of period #59:

****

Completed Clicks: 240 with 0 Errors (=0%)

Average Click Time for 150 Users: 59 ms

Successful clicks per Second: 29.702 (equals 106926.817 Clicks per Hour)

Results of complete test

****

** Results per URL for complete test **

URL#1 (): Average Click Time 67 ms, 17620 Clicks, 5 Errors

Total Number of Clicks: 17620 (5 Errors)

Average Click Time of all URLs: 67 ms

!! Glossary:

!! Click: A simulated mouse click of a user sending a request (one of the URLs from the URL list) to the server and immediately requesting any necessary redirects, frames and images (if enabled).

!! Request: A HTTP request sent to the server regardless of an answer.

!! Hit: A completed HTTP request (i.e. sent to the server and answered completely). Hits can be the PAGE request of a "click" or its frames, images etc.

!! Time for DNS: Time to resolve a URL's domain name using the client system's current DNS server.

!! Time to connect: Time to set up a connection to the server.

!! Time to first byte (TFB): Time between initiating a request and receiving the first byte of data from the server.

!! Click Time: The time a user had to wait until his "click" was finished (including redirections/frames/images etc.).

!! User Bandwidth: The bandwidth a user was able to achieve.

!! Sent Requests: Number of requests sent to the server during a period.

!! Received Requests: Number of answers received from the server during a period.

URLs to Test

URL#	Name	Click Delay [s]	URL	POST data	Username	Password
1			http://10.0.0.1/index.html			

Results per User

User No.	Clicks	Hits	Errors	Avg. Click Time [ms]	Bytes	kB/s	Cookies
1	119	118	0	70	26668	3.249	
2	119	118	0	67	26668	3.354	
3	119	118	0	68	26668	3.324	
4	119	118	0	70	26668	3.218	
5	119	118	0	72	26668	3.118	
6	119	118	0	73	26668	3.105	
7	119	118	0	72	26668	3.16	
8	119	118	0	63	26668	3.56	
9	119	118	0	65	26668	3.46	
10	119	118	0	69	26668	3.274	
11	119	118	0	71	26668	3.175	
12	119	118	0	63	26668	3.613	
13	119	118	0	71	26668	3.169	

14	119	118	0	66	26668	3.446	
15	119	118	0	65	26668	3.495	
16	119	118	0	69	26668	3.299	
17	119	118	0	70	26668	3.249	
18	119	118	0	69	26668	3.256	
19	119	118	0	66	26668	3.429	
20	119	118	0	68	26668	3.326	
21	119	118	0	68	26668	3.307	
22	119	118	0	66	26668	3.413	
23	119	118	0	70	26668	3.227	
24	119	118	0	67	26668	3.355	
25	119	118	0	69	26668	3.281	
26	119	118	0	65	26668	3.487	
27	119	118	0	66	26668	3.435	
28	119	118	0	68	26668	3.34	
29	119	118	0	65	26668	3.491	
30	119	118	0	68	26668	3.3	
31	119	118	0	65	26668	3.493	
32	119	118	0	69	26668	3.272	
33	119	118	0	67	26668	3.359	
34	119	118	0	69	26668	3.28	
35	119	118	0	62	26668	3.668	
36	119	118	0	71	26668	3.193	
37	119	118	0	67	26668	3.376	

38	119	118	0	68	26668	3.333	
39	119	118	0	67	26668	3.383	
40	119	118	0	65	26668	3.455	
41	119	118	0	66	26668	3.402	
42	119	118	0	62	26668	3.617	
43	119	118	0	67	26668	3.357	
44	119	118	0	67	26668	3.381	
45	118	118	1	69	26442	3.245	
46	119	118	0	64	26668	3.511	
47	119	118	0	62	26668	3.66	
48	119	118	0	66	26668	3.425	
49	119	118	0	65	26668	3.462	
50	119	118	0	72	26668	3.124	
51	119	118	0	61	26668	3.686	
52	119	118	0	66	26668	3.44	
53	119	118	0	66	26668	3.417	
54	119	118	0	65	26668	3.455	
55	119	118	0	63	26668	3.559	
56	119	118	0	66	26668	3.449	
57	119	118	0	65	26668	3.46	
58	119	118	0	71	26668	3.2	
59	119	118	0	65	26668	3.46	
60	119	118	0	64	26668	3.513	
61	119	118	0	65	26668	3.492	

62	119	118	0	68	26668	3.347	
63	119	118	0	71	26668	3.193	
64	118	117	0	67	26442	3.352	
65	119	118	0	67	26668	3.376	
66	119	118	0	65	26668	3.467	
67	118	118	1	70	26442	3.221	
68	118	117	0	68	26442	3.322	
69	119	118	0	64	26668	3.534	
70	118	117	0	70	26442	3.231	
71	119	118	0	62	26668	3.639	
72	118	117	0	69	26442	3.288	
73	118	117	0	69	26442	3.284	
74	118	117	0	73	26442	3.08	
75	118	117	0	70	26442	3.215	
76	119	118	0	68	26668	3.345	
77	118	117	0	72	26442	3.122	
78	118	117	0	64	26442	3.532	
79	118	118	1	65	26442	3.466	
80	119	118	0	62	26668	3.618	
81	118	117	0	68	26442	3.343	
82	118	117	0	73	26442	3.113	
83	118	117	0	64	26442	3.542	
84	118	117	0	65	26442	3.456	
85	118	117	0	69	26442	3.296	

86	119	118	0	63	26668	3.563	
87	118	117	0	66	26442	3.426	
88	118	117	0	65	26442	3.463	
89	118	117	0	69	26442	3.29	
90	118	117	0	63	26442	3.611	
91	119	118	0	64	26668	3.532	
92	118	117	0	68	26442	3.3	
93	118	117	0	66	26442	3.405	
94	118	118	1	64	26442	3.527	
95	118	117	0	71	26442	3.191	
96	118	117	0	72	26442	3.148	
97	118	117	0	67	26442	3.375	
98	118	117	0	67	26442	3.355	
99	118	118	1	59	26442	3.789	
100	118	117	0	70	26442	3.249	
101	118	117	0	66	26442	3.411	
102	118	117	0	66	26442	3.428	
103	118	117	0	65	26442	3.485	
104	118	117	0	67	26442	3.351	
105	118	117	0	62	26442	3.632	
106	118	117	0	66	26442	3.449	
107	118	117	0	68	26442	3.303	
108	118	117	0	65	26442	3.488	
109	118	117	0	70	26442	3.227	

110	118	117	0	70	26442	3.226	
111	118	117	0	69	26442	3.293	
112	118	117	0	72	26442	3.146	
113	118	117	0	62	26442	3.633	
114	118	117	0	72	26442	3.156	
115	118	117	0	67	26442	3.385	
116	118	117	0	65	26442	3.476	
117	118	117	0	66	26442	3.425	
118	118	117	0	69	26442	3.291	
119	118	117	0	60	26442	3.751	
120	118	117	0	60	26442	3.789	
121	118	117	0	67	26442	3.395	
122	118	117	0	65	26442	3.473	
123	118	117	0	67	26442	3.397	
124	118	117	0	66	26216	3.381	
125	118	117	0	61	26442	3.728	
126	118	117	0	64	26442	3.536	
127	118	117	0	62	26442	3.67	
128	118	117	0	61	26216	3.687	
129	118	117	0	67	26442	3.398	
130	118	117	0	68	26442	3.321	
131	118	117	0	69	26216	3.257	
132	118	117	0	66	26442	3.415	
133	118	117	0	72	26442	3.147	

134	118	117	0	65	26442	3.481	
135	118	117	0	59	26442	3.855	
136	118	117	0	71	26442	3.2	
137	118	117	0	72	26442	3.151	
138	118	117	0	72	26442	3.146	
139	118	117	0	71	26442	3.187	
140	118	117	0	66	26442	3.443	
141	118	117	0	67	26216	3.322	
142	118	117	0	62	26216	3.589	
143	118	117	0	70	26442	3.227	
144	118	117	0	72	26442	3.141	
145	118	117	0	67	26442	3.371	
146	118	117	0	63	26442	3.567	
147	118	117	0	69	26442	3.261	
148	118	117	0	69	26442	3.27	
149	118	117	0	70	26442	3.21	
150	118	117	0	68	26442	3.329	

Results per URL

URL No.	Name	Clicks	Errors	Errors [%]	Time Spent [ms]	Avg. Click Time [ms]
1		17620	5	0.03	1178617	67