

E-LEARNING AND LEARNING
STYLES: IMPLEMENTING AND
EVALUATION OF LEARNING
SEQUENCE METHOD

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List of Abbreviations

Abbreviation	Description
IT	Information Technology
CAL	Computer Assisted Learning
CBI	Computer Based Instruction
WBL	Web Based Learning
DL	Distance Learning
WBE	Web Based Education
LS	Learning Styles
HE	Higher Education
HTML	Hyper Text Mark-up Language
AHA	Adaptive Hypermedia Architecture
LSQ	Learning Styles Questionnaire
SPSS	Statistical Package for the Social Sciences
EL	Electronic Learning (eLearning)
OLS	Online Learning System

Abstract

ABSTRACT OF THESIS submitted by Agil Hossin for the Degree of Master of Philosophy and entitled “eLearning and Learning Styles: Implementing and Evaluation of Learning Sequence Method” in the Department of Computing and Informatics (School of Science and Technology) in April 2008.

This research began by accepting that different people learn differently from one another; have different learning styles, strengths and preferences in the ways they take in and process information. The research reported here asks whether, in Higher Education, and using new online technologies, the learning process can be enhanced by matching it to student learning style. To test this hypothesis blocks of eLearning material to support different learning activities was created for, and delivered to, students on the Computer Technology Module of a first year of a degree in Computer Technology. The author employed Honey and Mumford's (1986) classifications, and each student participating in the research was characterised as having one of four learning styles; Activist, Pragmatist, Reflector or Theorist. The material was designed so that the blocks could be delivered in four different sequences, each sequence in which the blocks was presented matched one of the learning styles. All students were tested to establish their learning style so that there was control of whether or not they were allocated to a group where order of delivery matched learning style. At the end of the course a Post-test assessed progress achieved, and student questionnaires evaluated attitudes towards the online course material and other aspects of the course. Three separate experiments were carried out:

The first was to evaluate the methodology and test the practical arrangements. The lessons learned were incorporated into the two subsequent experiments.

The second experiment showed that those students who followed the course material in a sequence that matched their learning styles; (a) were significantly more confident they had understood the course material, (b) expressed significantly more interest in the course material, (c) felt significantly more comfortable with the course material, and (d) performed significantly better in the end of course test, than did those student whose learning style did not match the sequence in which the material was delivered to them.

The third experiment was intended to repeat the second experiment with an even larger number of students. Unfortunately, so many failed to complete the questionnaires that the only conclusions obtained were those that confirmed findings (a), (b) and (c), for the second experiment.

The result of this research which are generally applicable:

Experiment one, confirmed by the two following experiments, showed that it is possible to deliver learning content in different sequences to match different learning styles.

All significant results suggest that where the order in which the material presented matched student learning style, the students were more confident with, expressed greater interest in, and were more comfortable with the course material.

Significantly higher Post-test marks were obtained where learning sequence matched learning style. The findings support the proposition that learning styles, and the order in which learning material is presented, can have significant effect on learning outcomes.

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Chapter One

Background

1.1 Introduction.

New inventions in information technologies (IT) have enabled qualitatively new types of developments in interpersonal communication which have revolutionised both traditional face-to-face, and distance education. Computer mediated learning in all formats, from Computer Assisted Learning (CAL), through Computer Based Instruction (CBI) to the emerging Web Based Learning (WBL), has become common-place in most education institutions (Allen and Seaman, 2006).

The integration of information and telecommunication technologies has supported the development of distance learning by providing access to learning sources for most individuals at any time, in almost any place (Franklin and Peat, 2001). Zapalska and Brozik have recently suggested that by providing the many types of communication facilities necessary to support collaborative activities, WBL is the future of all types of distance learning (Zapalska and Brozik, 2007). As communication technology now plays such an important and increasingly pervasive role in society it is essential that academic researchers extend their investigations into the effectiveness of using web based technologies as instructional tools. The Web provides both the medium and the educational environment; the educators design the learning experience by preparing the educational material, deciding on the pedagogical approach, outlining the learning objectives of the course and how these are fulfilled, and supports the learners; lastly, learners are mainly responsible for planning, carrying out and evaluating their own learning (Hall and Moseley, 2005; Villaverde, et al. 2006).

Personalization in an educational context needs a certain understanding of the learner as well as of the tasks that are important to learning. Thus, the design of the learner model and the instructional model adopted, strongly influence the system's adaptation (Hall

and Moseley, 2005; Villaverde, et al. 2006). The learner model should represent those discriminative characteristics of the learner which can be proven relevant to learning in a particular educational environment, such as prior knowledge of the domain, experience, learning preferences, learning/cognitive style, etc., (Campbell and Oblinger 2007).

Studies in this area have confirmed that not only do education technologies have the potential to enhance student learning, but developments in instruction technology have already required educators to re-evaluate teaching methods, with one of the most important, and on-going, questions being whether the designs of web-based learning environments are taking maximum advantage of the opportunities offered (Allen and Seaman 2006; Krichen, 2007). Exploration of this and similar issues will help educators to make better decisions on how to implement WBL in its most effective form (Villaverde et al. 2006).

Research is recommended into adaptive presentation techniques, where multiple representations of educational material, each following an alternative instructional strategy for the same concepts and each focusing on a different perspective of the concept, are combined in different sequences. In this way, specific instructional strategies can be tailored to different learning styles (Zapalska and Brozik, 2006). This study is aimed to evaluate the effectiveness of this approach. The research asks whether, using new online technologies, learning in HE can be enhanced by matching student learning style with the order in which the component parts of the educational material comprising a first year module is presented to them. The eLearning material which supports the module has been designed for different learning activities structured to match the four learning styles identified by Honey and Mumford (1986).

In the face of the widespread availability of relevant technology, it has been realised that there has been little change in higher education which makes learning really fun, where the student can make errors or fail without the risk of being seen as inefficient or ineffective (Garrison and Anderson, 2003; Roger, 1997) It has also been reported that in order to take advantage of the growth of the Internet more effort needs to be put into recognising further progress in the use of technology to support lifelong education (Garrison and Anderson, 2003; Roger, 1997). Given the significance of training and

education, specialists in the field (Clark, 2001; Miller et al., 2003; Roger, 2002) recommend that research must be conducted to investigate online learning to help it be more effective and boost its quality. The need for such research is demonstrated by the results of a survey conducted by the European Training Village, concerning the teaching of five European languages, which showed that nearly three-fifths (61%) of all respondents rated the current status of eLearning as being of only fair or poor quality (Massy, 2002).

There are, of course many other avenues of research required, and the literature concerning eLearning has illustrated, for example, the need for a knowledge of, or familiarity with, cognitive psychology to establish a theoretical basis for web-based instructional design which eases the gap between how students learn and how instructors teach (Alexander and Boud, 2001; Clark, 2001; Stephenson, 2001). This research project, however, restricts itself to investigating the use of online technology to enhance student learning by matching student learning style to the order in which the appropriately designed elements of a first year module are presented.

1.2 The Aims of the Research.

The author employed learning styles theory to determine whether it is possible to use new online technologies in higher education to improve and enhance student learning, and the research reported here was designed to assess the effectiveness of matching the order of the delivery of material to the user's learning style as defined by Honey and Mumford. In this initial experiment, material was created for one topic, Logic Circuits, in the first year

The researcher created an online experiment in which the same specially designed course material was presented to sequence selected groups of students in a different order. The research question was to find whether any correlation existed between student learning styles and the order in which the component parts of the course material was presented to them.

1.3 The Research Objectives.

The objectives of the research were:

1. To determine whether the same learning material can be structured and delivered in forms matching the different learning styles of the students.
2. To determine whether by changing the sequence of delivery of the elements of the learning material, it can be made to match different learning styles.
3. To determine what advantage(s) are gained from using different learning sequences in the learning process.
4. To investigate whether the Honey and Mumford learning model offers a satisfactory practical model of a real learning environment that enables increased interactivity in the given online course module.

1.4 Hypotheses

Four hypotheses have been formulated to define the research question more precisely and clarify the particular variables to be investigated:

Hypothesis 1: Matching a student's learning style to the sequence in which the course material is delivered will have a significant effect on the student's test score or on their appreciation of the course. Null hypothesis: There will be no significant difference between the mean scores for matched and non-matched students in their level of knowledge either before beginning or after completing the online course, nor in the Pre- and Post-test marks obtained.

Hypothesis 2: Matching a student's learning style to the sequence in which the course material is delivered will have a significant effect on the student's confidence, interest and comfort levels. Null hypothesis: there will be no significant difference in student ranking of preferred learning sequence.

Hypothesis 3: Matching a student's learning style to the sequence in which the course material is delivered will offers an equal balance of learning opportunity to all students no matter what their learning style. Null hypothesis: there will be no significant difference in the performance of students with different learning styles, as measured by their achievement in any of the assessments (student ranking their level of knowledge after completing the online course, and Post-test scores).

Hypothesis 4: It is expected that students with different learning styles will differ in their confidence with the course material, their level of interest in the course, and their comfort level when using different learning sequences. Null hypothesis: there will be no significant difference in student ranking of preferred learning sequence according to learning style.

Chapter Two

Literature Review

2.1 Introduction

This chapter reviews the background and approaches to Distance Learning (DL). The chapter also considers the literature on learning theory to establish a framework for the research.

2.2 Distance Learning.

Distance Learning (DL) has passed through many different forms, including; books, radio and TV broadcasts, both video and audio tapes and satellite conferencing. More recently DL has been seen predominantly as employing computer technology as a tool that can provide additional support to learning processes. The involvement of Computer Technology Aided/Assisted/Supported Learning (CAL) targeted the use of the computer to deliver learning material on, e.g., a floppy disk to be used by the learner on a computer in his/her own time. Today, there has been a shift to what is often called Web-Based Education/Instruction/Teaching/Learning (WBE), which uses the Internet to deliver the learning material in a faster, more flexible and more accessible learning process. WBE is centred on computer and telecommunication technology to distribute the educational material to a broader audience (Serdiukov, 2001). These developments have led many education authorities around the world to investment huge sums of money in adding these new technologies to their schools and colleges as important learning tools.

2.3 Learning Technology.

Learning technology has been developed with the intention of helping people learn, whether in a classroom or at a distance. There are many different forms of learning technology ranging from books, broadcasts, video tapes, to satellite broadcast conferences and, more recently, using computer technology as a tool to provide core support to the learning process. For example, computer technology in education has passed through several development stages variously labelled Computer Aided/Assisted/Support, as in, for example, Computer Aided Learning (CAL) which aimed at using the computer to deliver the learning material via floppy disks or CDs that could be viewed by the learner on a computer in his/her own time. The widespread availability of computer and telecommunication technologies enables the distribution of educational material world-wide, faster than ever before, with much greater flexibility, and with greater accessibility to the learning process, so much so that today there is a shift towards what is called Web-Based Education/Instruction/ Teaching/Learning (WBE) or what is called eLearning which uses Intranets and the Internet to deliver learning material. eLearning has grown on the back of the emergence of the Internet, using its facilities to organise learning activities on a world-wide basis and have tended to refer to the use of web technologies for academic education.

2.4 Computer Aided Learning.

Sidman, and Jones (2007) and have all suggested that the problem which faces the traditional teacher; that his or her class may include individuals with a variety of learning styles, which may require the delivery of different material to the different students, can be resolved by CAL. However this appears a costly option as, at first sight, it involves multiple versions of learning material to cover the same subject matter in different ways. Additionally, the controversy over the application and effectiveness of learning styles to conventional teaching apply equally to CAL.

A suggestion which would reduce the cost and facilitate the introduction of such schemes has been suggested by a number of authors, including Stash and De Bra (2004), Stash et al 2004, and Liegle and Janicki (2006). The proposal is that CAL systems can respond to user learning styles by controlling the order in which the same

material is presented to the student. In particular, Papanikolaou et al (2001) describe how the INSPIRE system can be used to present material to Activists or Reflectors, as defined by Honey and Mumford, in a way that starts at the most appropriate point in their learning cycle. Stash, Cristea and De Bra (2004) propose that their adaptive hypermedia system, AHA!, could also be used to present material to students who are identified as either Reflectors or Activists, according to the Honey and Mumford learning style model (Honey and Mumford 1992), in an order that most appropriately reflected their learning style. However it has not been possible to find reports of experiments which have assessed the effectiveness of this approach.

2.5 eLearning.

eLearning is an educational environment in which learners and educators are able to perform classroom-like tasks: the Web provides the medium and accommodates the educational environment; the educators design the learning experience by preparing the educational material, deciding on the pedagogical approach, outlining the learning objectives of the course and how these are fulfilled, and support the learners; lastly, learners are mainly responsible to plan, carry out and evaluate their own learning.

The so-called eLearning model uses communication technologies and media from previous generations (e.g. audio and video) to take advantage of the capacity for both asynchronous and synchronous human interaction. This generation of learning technology is a flexible learning model and uses interactive multimedia, internet based access to www resources, and CMC (Computer-Mediated Communication) (Garrison and Anderson, 2003).

The use of interactive information and communication technologies is now thoroughly ingrained in higher education, but their role is constantly changing, and deepening. The complexity of the interactions between such technologies, people and higher education needs to be better understood to give course design a more solid foundation. Without exception, effective online learning programs should begin with careful planning and a focused understanding of course requirements and cost implications.

On the other hand, pedagogy greatly affects the activity design; an activity based on information transmission theories of teaching will present didactic content in an organised, building-block fashion, while a truly constructivist activity will consider previous knowledge, experiences, and conceptions of the learners and find ways to help them assimilate and accommodate new concepts. The learning method should aim to build a constructivist learning environment where learners can arrange their knowledge and the instructors will act as facilitator (Sidman, and Jones, 2007). Many educationalists, (for example, Alexander and Boud, 2001; Garrison and Anderson, 2003), stress the urgent need for a theoretical foundation, based in cognitive psychology if technology based instructional design is to benefit to the full from the potential facilities and services that technology offers.

2.6 What is Learning?

Human nature contains implicit motivation to learn how to do things not previously done. This basic attitude enables humanity to learn by practice from the beginning of life, for example, to move things, to sit, to stand, to talk. Accordingly, learning can be defined as implicit activity that human beings undertake to gain progress to be able to do things, to do things better, or to do things in different ways, in order to make a change in the current situation (Kolb, 1984; Knowles, 1990).

There is no agreed standard definition of learning, here are two other author's definitions:

“learning is a change in human disposition or capability, which can be retained and which is not simple ascribable to the process of growth” (Gagne, 1965:5)

“learning is the process by which an activity originates or is changed through reacting to an encountered situation, providing the characteristics of the change in activity can not be explained on the basis of native response tendencies, maturation, or temporary states of the organism” (Hilgard and Bower, 1966:2)

2.7 Learning Styles.

The first problem is how to categorize learning differences because there is no universally agreed meaning of what a learning style is, despite the frequent use of the term 'learning styles' in the literature. For example, Coffield et al (2004) have identified

71 models of learning styles and suggest there is considerable confusion over the reliability and applicability of these models. Other researchers question whether learning styles are fixed for individuals or whether they vary in time and context. Pheiffer et al (2005) have analysed some of the major controversies in this area, have discussed the matching versus mismatching debate and found that some definitions of learning styles theory suggests that learning will be most effective when the teaching matches the student's learning style. This is supported by some empirical evidence (Dunn 1993), but is disputed by others (Coffield et al 2004). They also point out that even if this is true there are the practical problems of preparing appropriate material for a class that may contain students with a variety of styles.

The work by Honey and Mumford is widely recognised and proposes four learning styles, Activist, Pragmatist, Theorist and Reflector. Adaptive hypermedia systems have been used in this research work to allow various types of learning material, related to the different stages of the Kolb learn cycle, to be presented to students with different learning styles in different orders. Such an approach will test the Learning and Skills Research Centre report that no evidence was found by researchers of the pedagogical impact of the Honey and Mumford learning style model (Coffield et al 2004;35)

"The concept of learning styles is rooted in the classification of psychological types" (Villaverde et al. 2006), so students would be expected to differ in their strengths and preferences of how they take in and process information: some prefer to work with "hard facts", while others are more at ease with abstractions. Some students like to learn by experimenting, others by observing what happens, and yet others by a process of analysis. Honey, and many previous workers, have analysed and classified these differences as different styles of the learning process (Honey and Mumford,1992).

There is a growing body of theoretical and empirical research in the UK, the US and Western Europe on learning styles. This began in the early years of the 20th century and is still producing ideas and an ever proliferating number of instruments. Unfortunately, the term 'learning styles' has no single definition and in much of the literature is used loosely and often interchangeably with terms such as 'thinking styles', 'cognitive styles' and 'learning modalities'. Possibly because, as Becta (2005) has pointed out, research in the field of learning styles is conflicting and often methodologically flawed.

Learning style (LS) has been investigated by many authors, here are three definitions:

“A learning style refers to the way in which individuals acquire and use information.” (Karuppan, 2001:140).

“People learn in different ways. These differences depend on many things: who we are, where we are, how we see ourselves, and what people ask us ... We hover near different places on a continuum. And our hovering place is our most comfortable place.” (McCarthy, 1980:3-4).

“The term learning styles is used as a description of the attitudes and behaviors that determine our preferred way of learning” (Honey and Mumford,1992:3).

Assessing students’ learning styles provides an awareness of their particular preferences, which can then be used to design, develop, and deliver educational resources to maximally motivate and stimulate their acquisition of subject matter in an attempt to individualize instruction (Wang. et al, 2006). Understanding individual learning styles can improve the planning, production, and implementing of educational experiences, so that they are more appropriately compatible with students’ desires in order to enhance learning, retention, and retrieval (Krichen, 2007).

2.7.1 Supporting Different Learning Styles.

The ultimate aim of determining the learner’s individual learning style is to facilitate personalisation of the learning content. There has been much research into learning style in the classical (face to face) educational setting, but there has been considerably less research on learning styles in the new educational space of eLearning. Given the importance of training and education, it is strongly recommended by a number of eminent educationalists that more research needs to be undertaken if high quality eLearning environments are to be developed (Krichen, 2007; Kttanurak, 2001). Stash et al (2004) have specifically identified the need, created by the rapid and all-pervasive development of the world-wide web, for more research into the application of eLearning styles' space on the grounds that:

- ❖ Students will learn better when using preferences in which they're successful
- ❖ Students will be better learners when they can expand their preferences

Such research should include means of identification and self identification of learning styles since, argues Honey, "We can also confirm that people are helped to be more effective learners if they are aware of their learning styles" (Honey and Mumford, 1992:6).

2.8 Honey and Mumford Learning Style Model.

Honey and Mumford developed their learning styles system as a variation on the Kolb model, while working on a project for the Chloride Corporation in the 1970's. Honey and Mumford say of their system: "Our description of the stages in the learning cycle originated from the work of David Kolb. Kolb uses different words to describe the stages of the learning cycle and four learning styles" and the "similarities between the Kolb model and Honey and Mumford are greater than the differences" (Honey and Mumford, 1992:4).

Kolb (1984) saw learning as a process that requires different styles of activity at different stages of the process. He proposes a four stage cycle comprising of concrete experience, reflection on the experience, abstract conceptualisation and active experimentation. Effective learning then consists of proceeding round the cycle. Honey and Mumford (1986) developed a learning style questionnaire which identifies an individual's relative strengths in the various stages of the cycle and then labels the learner as an Activist, Reflector, Theorist or Pragmatist, depending on the stage in which he/she is strongest.

However, because these views suggest that learners should complete all four stages of the cycle, the meaning of matching or mismatching the material to the student becomes less clear.

Following Honey and Mumford (1992) the four stages of the Kolb cycle are:

- Having an experience: the two types of experiences one can have are reactive (letting the experience come to you) and proactive (deliberately seeking the experience). Opportunities to learn from experience are greatly increased if the normal things that happen to us are supplemented by extra experiences we create.
- Reviewing the experience: if one is to learn from an experience it is vital to review what has happened.
- Concluding from the experience: this involves scanning the raw material from the review for conclusions, answers or lessons learned.
- Planning the next step: planning involves translating some of the conclusions into a form where they can be put into action.

In the learning cycle according to Honey and Mumford, see Figure 2.1, the learner can start anywhere, not necessarily at Stage 1, because each stage feeds cyclically into the next. For example, an individual could start at Stage 2 by acquiring some information and think about it before reaching some conclusions at Stage 3 and then decide how to apply this knowledge at Stage 4. (Honey and Mumford, 1992:4)

A particular learning style is associated with each of the stages identified in Figure 2.1, as shown in Figure 2.2. The four learning styles identified are Activist, Reflector, Theorist and Pragmatist (Honey and Mumford, 1992:5-6). These learning styles are briefly described below.

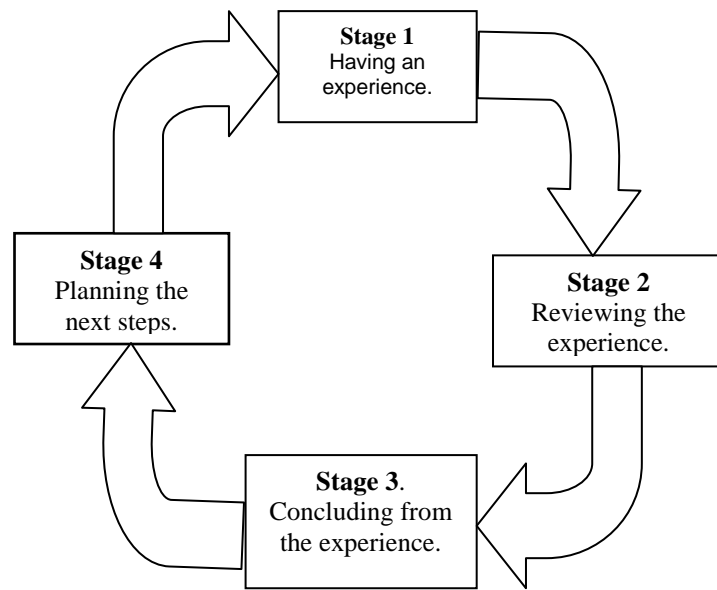


Figure 2.1: The Honey and Mumford learning cycle (Honey and Mumford, 1992)

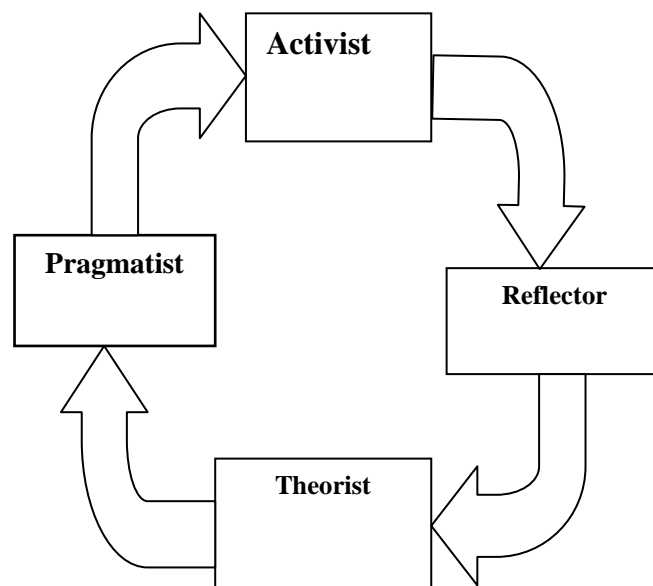


Figure 2.2: The Honey and Mumford learning styles (Honey and Mumford, 1992)

Activists:

Honey and Mumford. (2000:11) describe this group of people as follows: “*Activists involve themselves fully and without bias in new experiences. Their philosophy is I will try anything once. Their days are filled with activity, and they tend to act first, considering the consequences later.*” Activists enjoy being at the centre of attention and seek to focus activities around themselves. “*They get easily bored, and once the excitement of an activity has died down will be busy looking for the next challenge*”. (Honey and Mumford 2000:11).

Reflectors:

Honey and Mumford. (2000) refer to Reflectors as being keen on standing back and deliberating about experiences from many different perspectives. “*They like to have all information available about a problem or subject so they can chew it over and come to a conclusion in their own time. They tend to adopt a low profile, taking a back seat in meetings, preferring to listen carefully to others' points of view before making their own*”. (Honey and Mumford 2000:11)

Theorists:

According to Honey and Mumford. (2000:11), Theorists “[a]dapt their observations and experiences into complex but logically sound theories. They use logical step-by-step processes to solve problem. They tend to be perfectionists who do not rest until things fit into a rational scheme, and reject anything which does not. They will ask questions like: *How does this fit with that? and What are the basic assumptions? They tend to be detached, analytical and objective, and steer away from anything which is subjective or ambiguous.*”

Pragmatists:

Pragmatists are most interested in trying out new ideas, theories and techniques to check whether they work in practice (Honey and Mumford, 2000). They positively seek new ideas and take the first opportunity to experiment with applications; their philosophy is that there is always a better way, and if it works it is good (Honey and Mumford 2000:11).

2.9 Previous Work on Learning Styles .

Wang et al (2006) have suggest that many CAL course have been designed to focus more on delivery rather than content, and this has created a credibility gap between academics who feel they have created excellent courses and the students who feel the courses do not deliver the expected subject matter.

On the other hand, (Wang., et al, 2006) argues that by designing a course in a way that takes into account the learning styles of students, it is possible to generate two benefits: improvement in student response to the material, and simultaneously help students become better learners. Continuing this theme Bajraktarevic et al (2003:10) contend that "the learning outcome can be improved if designer of hypermedia courseware provides a different sequence and presentation of material to accommodate individual learning style difference."

Only a few systems that attempt to adapt to learning styles have been developed, however, and these have been based an different models of learning styles. It is not clear which model will provide the best design of learning material, and even if a specific model is chosen it is still not clear how the material should be constructed to correspond to the model (Paredes and Rodriguez, 2002).

System	Learning styles model
System to teach (GCSE) geography course, (Bajraktarevic et al, 2003).	Felder and Soloman learning styles model.
CS383 system, (Carver et al, 1996).	Felder-Silverman learning styles model.
System to teach HTML, (Nigel et al, 2001).	Field-dependent (FD) and Field-independent (FI) style.
AHA system, (Stash et al, 2004).	Honey and Mumford learning styles model.

Table 2.1 Some of learning styles incorporated into online systems

Case 1: Bajraktarevic et al (2003) created a system that has been used to teach GCSE geography. The learning styles were assessed using the Index of Learning Styles Questionnaire developed by Felder and Soloman (2006). The core of the study was that it sought to explore the relationship between matching and mismatching of learning style preference in hypermedia material. It used so-called "global and sequential learning styles" where individuals with a global learning style are classified as holistic, system thinkers, learning in large leaps, and individuals with a sequential learning style are classified as linear, orderly and learn in small incremental steps. The population consisted of 21 students. Where nine had a sequential and twelve had a global learning style. The approach of the research was to design two different formats for the taught material. For students with a preference for the global learning style, the pages comprised elements such as tables of contents, summary and overview of information. But for students with a preference for the sequential learning style, the pages contained small chunk of information, text-only with 'forward and back' buttons.

Summary of results: The research showed all students achieved significantly higher scores if the sequence of presentation of the material matched the individual learning style.

Case 2: Carver et al (1996) created a Computer System, system (CS383), which was offered to third year undergraduate students. This course was used to teach hardware technologies as well as providing brief introduction to several areas in computer science. It consisted of a range of learning styles tools based on a learning style model developed using the Felder-Silverman model (Felder and Silverman, 1988). The student was given the option of exploring the course material in a manner that either accorded with their learning styles or not. This approach uses different types of media

such as graphs, movies and text. In this work the task was to determine what types of media are most applicable and appropriate to different learning styles. As a result, an adaptive hypermedia interface was developed that tailored the presentation of course material to individual student learning styles.

Case 3: Nigel and Sherry (2001) created a system to teach HTML. The system was designed as two versions of the same learning package; the two versions differed only in the order in which information was presented. The aim of this study was to explore whether the relationship between matching or mismatching of instructional presentation style (breadth-first and depth-first) with students' cognitive style (field-dependence/independence) in a computer-based learning environment, had any effects on learning outcomes. The population of the study comprised postgraduate students from a range of departments at the University of Sheffield. A total of 73 postgraduate students volunteered to participate in the study. Fifteen field-independent and twelve field-dependent students were allocated to the breadth-first version, sixteen field-independent and twelve field-dependent students were allocated to the depth-first version. Eighteen students were classed as intermediate, and were equally allocated to the breadth-first and depth-first versions. This research found there are significant differences in learning achievement, as measured using a multiple choice test, between matched and mismatched students, with those students whose learning style matched the style of presentation scoring significantly higher.

Stash et al (2004:14) claimed “ that there have been very few studies, which have set out specifically to investigate the relationship between learning styles and hypermedia applications”, and so they attempted to create a flexible system (AHA) that allowed them to integrate into it as many variation as they liked, of the learning styles of Kolb, and Honey and Mumford 1986.

Case 4: Stash et al created an adaptive application entitled “Learning Java Programming”, which providing the learners with different presentations of the learning material in different orders. If the learner knows what his/her learning styles is, then he/she can manually state it through the registration form. If the learner specifies his/her learning style then the system will present the material according to that student's learning style. If a student specifies his/her learning style as “Reflector” then it

would be suggested that this student first attempt a ready-made example and then read the explanation. Only afterwards would this learner proceed to attempt to building his/her own applet, similar to the one given in the example. If a student specifies his/her learning style as “Activist” this student would first attempt to create his/her own applet, compile and run it. Then he/she might take a look at a working example and compare it with the applet he/she had created.

This review of adaptive hypermedia systems has shown that different systems have used different learning styles' models and different methods of incorporating learning styles into online learning systems.

This author in seeking to employ pedagogical learning theory to determine how it is possible to improve the use of technology in the eLearning process will focus on the use of learning styles methodology applied to learning online. The work will apply learning styles' theory to an online learning system in order to discover better ways of using technology in eLearning to enhance student learning.

An attempt was made to find the best tools to develop the online environment. The first tool the researcher investigated was AHA Adaptive Hypermedia software from Eindhoven University. After downloading the software and configuring it with a Tomcat web server and Java SDK, the researcher tried to used it re-create some pages but it soon became clear that this tool was still under development, with many bugs in it. It was necessary to use other software, in this case Authorware⁷.

Following the line of argument developed by Stash et al that “ the concept should be presented to the learner from various perspectives depending on his/her preferences and on the progress while working the application ... the main issue is presenting the aspects of a concept in a different order” (Stash et al, 2004:15). This research will create an online experiment in which the same specially designed course material will be presented, in a different order, to each different group of students.

The research question will be: Is there any significant difference in student response to the course depending on whether the learning style of the student (Activist, Reflector, Theorist and Pragmatist) did or did not match order in which the component parts of the course material were presented to them?.

Chapter Three

Selection of the Design of Experiment One

3.1 Introduction

This chapter is concerned with the selection of a research methodology appropriate for the main project in accord with the themes outlined in previous chapters. The chapter begins with a brief discussion of the requirements of a suitable experimental method which will provide an answer to the given research question, see Section 1.2. The chapter describes the research method and its implementation and testing in a pilot study, and ends by discussing the structure of the method in detail and proposing remedies for the problems encountered.

3.2 Selection of Experimental Research Method.

Experimental research (including both true and quasi-experiments) is the methodology most commonly utilised by social studies researchers, followed closely by survey research (Fraenkel and Wallen, 1991). Such a combination provides experimental control and the capacity to generalise the research results (Zmud et al., 1989). However, any methodology offering a problem-solving framework would help to improve efficiency and effectiveness of the research (Jayaratna, 1994).

The outcome of this research project is expected to be the production of clear practical guidance for educators on how to help students learn more effectively when using CAL as a learning medium, and in this way help enable a change in focus in the education field, from preoccupation with theory to more practical issues. The researcher will apply learning style theory to the eLearning environment of a given group of students, to identify constraints on the learning process and determine whether immediate

improvements can be made in the way people learn. This will be achieved by using different learning sequences with different subsets of one student group; enabling the researcher to understand how learners with specific learning styles perform when faced with a course delivered in a number of different learning styles, and find out whether each learning style has a preferred learning activity and/or delivery medium for the learning process.

The research reported here, is designed to assess the effectiveness of matching the order of the delivery of learning material to user learning styles, as defined by Honey and Mumford (1986). As an initial experiment, the course material for the single topic of Logic Circuits, part of the Computer Technology module in the first year undergraduate course in Nottingham Trent University. Three sections were produced in Macromedia Authorware, (Kellogg and Bhatnagar, 2003). A Theory Section, consisting of a simple textual explanation of the components (logic gates) of a logic circuit and how they can be combined to make a circuit. An Example Section, which presents examples of logic circuits and how they operate. A 'Have-a-Go' Section, which consists of an interactive simulation whereby students can combine logic gates and discover, by experimenting, how they operate and interact.

The topic consists of two parts (Introduction to Logic Circuit Design and Advanced Logic Circuit Design), and each was designed to include the three sections (Have-a-Go, Example and Theory), based on the Honey and Mumford categories of learning styles (Activist, Reflector, Theorist and Pragmatist). The orders in which the sections were delivered were based on the idea that a student would want to start with an activity that related most strongly to their learning style and then proceed in the order suggested by the Kolb learning cycle (1984). Thus the order of delivery of the material which 'matched' the learning style of the user was:-

Activist:	Have-a-Go	Example	Theory
Reflector:	Example	Theory	Have-a-Go
Theorist:	Theory	Have-a-Go	Example

No Pragmatists were identified in the sample of students studied, so there was no need to devise an order of delivery for them. However, it was decided that the most appropriate order of delivery for them would have been the same as for the Activists, as this would have been the next stage of the Kolb learning cycle.

3.2.1 The Structure of Research Method.

The three blocks of learning material can be delivered in a maximum of six possible combinations. Thus there were six possible learning paths through the course, and the students were organised so that there was one group of students for each path. Every student is assessed both before commencing (Pre-test, see appendix B), and after finishing all three blocks of learning material (Post-test, see appendix C).

At the same time as the Post-test all students were given an online Honey and Mumford Learning Style Questionnaire (LSQ) (Honey and Mumford, 2000) and a separate questionnaire which assessed their perception of the learning activity. The marks obtained in the tests were correlated with the results of the questionnaire(s) to see if some or any of the learning styles performed better than the others. Also, attitudes to the topic were assessed in terms of whether or not students felt more positively about their learning experience if their learning styles matched the order of delivery of the three sections.

Unfortunately, the attempt to objectively assess what the students had learned was unsuccessful because the Post-test was not sufficiently discriminating, and all the students were all able to answer all questions correctly. However, the results of the questionnaire were analysed in order to see if there were correlations between the order in which the material was presented and the perception of the teaching experience.

The researcher began by designing and constructing an online course consisting of the three sections, see Table 3.1 and Figure 3.1, with six possible learning paths. All 112 students enrolled on Computer Technology were invited to join the experiment, and all agreed. The 112 students were divided by random selection into six groups, two with 18 students and four with 19 students, see Figure 3.1. Each group separately attended the first session of the online course in the computer laboratory. The instructor (the researcher) met each group of students, and presented that group with the course plan.

Group number	Sequence followed			
Group 1	Sequence 1	Theory section	Example section	Have-a-go section
Group 2	Sequence 2	Example section	Theory section	Have-a-go section
Group 3	Sequence 3	Have-a-go section	Example section	Theory section
Group 4	Sequence 4	Theory section	Have-a-go section	Example section
Group 5	Sequence 5	Have-a-go section	Theory section	Example section
Group 6	Sequence 6	Example section	Have-a-go section	Theory section

Table 3.1: Order in which the different sections were taken by each of the six groups of students.

The second step was the Pre-test. This was an initial assessment of how familiar the students were with the subject content, and determined every student's level of knowledge at the start point of learning process (see appendix B).

The third step was the delivery of the online course material, see Table 3.1. The online course was delivered to the student in two weeks, the first week was 'Basic Logic Gates' and second week was 'Advanced Logic Circuit Design'.

3.3 Participation.

As can be seen from Figure 3.1 due to the number of students who dropped out only twenty two actually successfully completed both the Post-test and the LSQ.

3.3.1 Data Collection Timetable and Procedures.

Data collection was planned and implemented as follows:

1. When the students registered on the course module they were asked if they wished to participate in the study and, if so, they would have to complete the Pre-test. On the first day of the course the researcher met each of the six groups separately in the computer laboratory and gave them a full explanation of the experiment and the part of the module covered in this study.
2. The Pre-test was given to the students in hard copy, paper format, on the first day. It contained four questions that covered the online material only (see Appendix B). Students were not informed of the marks obtained, but as some students were unable to answer any questions they knew their scores were 0.

3. The questions used in the Post-test were the same as those used in the Pre-test, and were delivered to, and submitted by the students electronically, as email. This was done in the third week of the programme (see Appendix C).
4. Also during the third week of the programme an online course evaluation questionnaire was sent to, and returned by, the students via email (see Appendix C). This questionnaire, which was sent with the Post-test, was intended to investigate the effectiveness of the course design and the learning materials used. It also attempted to identify the preferred learning sequence for each learning style, and gather student opinion about this experience in general.
5. The LSQ questionnaire used to identify each student's learning style, was delivered and submitted online in the fourth week of the programme.

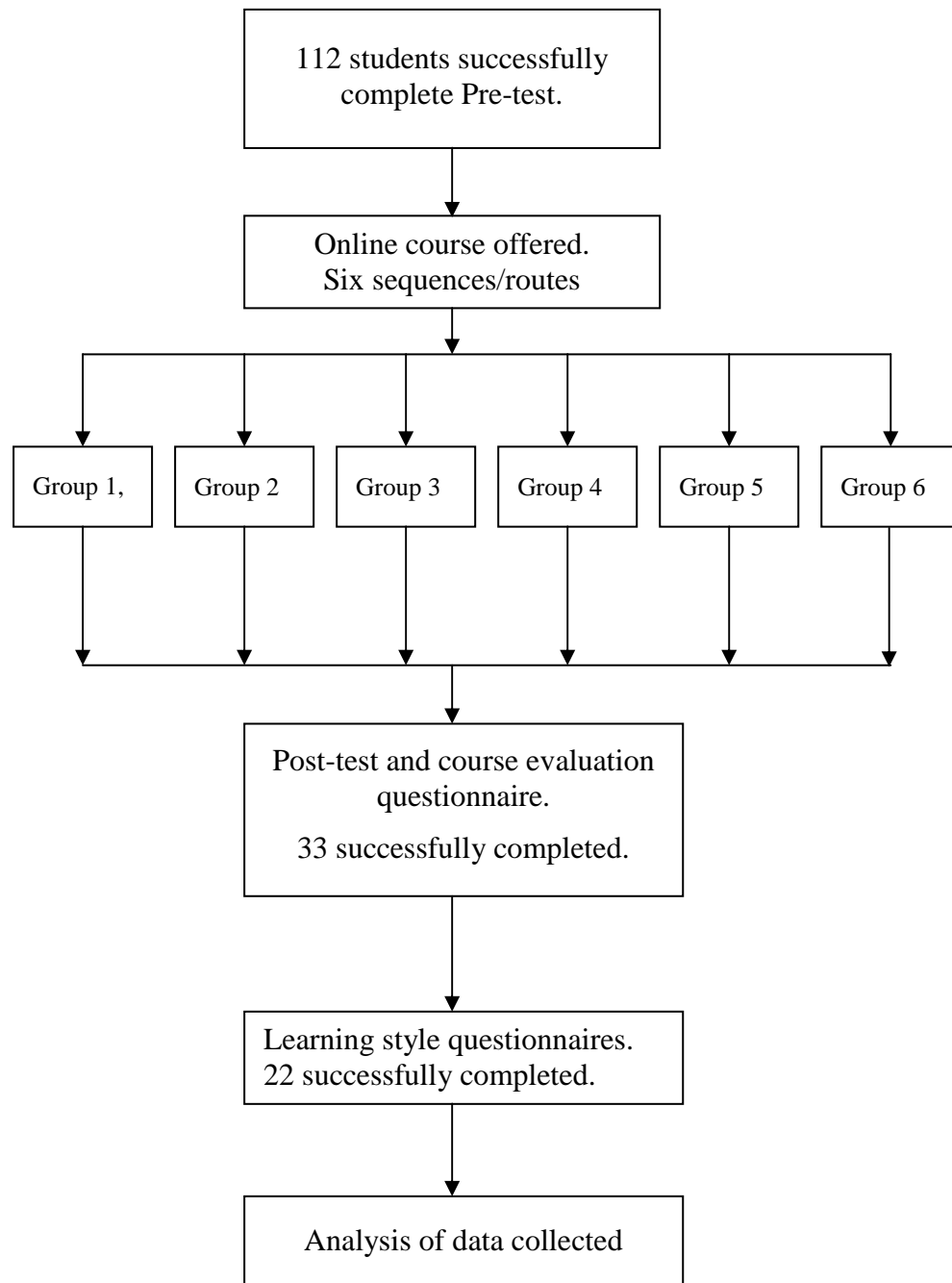


Figure 3.1: General diagram of actual research methodology

The Pre-test, Post-test and course evaluation questionnaires were designed by the researcher. All the data was delivered and collected by the researcher himself, as was the marking of the Pre-test, Post-test and evaluation questionnaires. This was considered legitimate as this initial experiment was also intended to identify problem areas, and the personal participation of the researcher in every phase was desirable. All data had been collected by the end of the fourth week of the experiment. Tables 3.2 and 3.3 clarify the design of the experimental structure.

Group	Group selection	Pre-test	Intervention	Post-test
Group 1	Random	√	X	√
Group 2	Random	√	X	√
Group 3	Random	√	X	√
Group 4	Random	√	X	√
Group 5	Random	√	X	√
Group 6	Random	√	X	√

Table 3.2: Research method - true experiment.

Week 1	The title of the first week was "Introduction to Logic Circuit Design" and consisted of truth tables, Boolean expressions, symbols of logic operators, basic logic gates, proof using truth tables, logic circuits and transmission formulae, equivalent circuits, standard results, De Morgan laws and simplifying circuits.
Week 2	The title of the second week was "Advanced Gates and Logic Design" and consisted of NAND and NOR gates, XOR, the design process, problem definition, truth tables, transmission function, simplification, circuit diagrams and construction.

Table 3.3: Weekly course plan for the research experiment.

For the two weeks during which the online course was delivered, the students were supported by the researcher. For one hour per week, for each group, the researcher was available in the computer laboratory, to discuss with students any difficulties in accessing or using the online course materials.

3.3.2 Questionnaires.

The questionnaire is one of the most widely used data collecting tools in academic research, and particularly in evaluation studies. The questionnaire is a major tool for collecting primary data and often provides the main source of data in a study. It can also be used to provide a wealth of descriptive data pertaining to individuals or groups (Clarke, 1999). The LSQ used in this study was a variation of the LSQ designed by Honey and Mumford. The questionnaire consisted of 80 questions relating to the four different types of learning styles (Activists, Pragmatists, Reflectors and Theorists) as identified by Honey and Mumford (1986), with 20 questions designed to identify each of the four learning styles.

The online student course evaluation questionnaire (Appendix C) was intended to investigate the design and effectiveness of the learning materials used, the preferred learning sequence for each learning style, and collect student opinions about this experience. The questionnaire contained eight questions. The first five questions were survey type questions which ranked opinion on a five point scale. The last three questions were open-ended questions that aimed to evaluate the design of the online course. This questionnaire was completed and returned by 33 students.

3.3.2.1 Pre-Test and Post-Test.

A Pre-test designed specifically for the material of Computer Technology was given to all 112 students. It contained four multiple choice questions about the subject of the course module (see Appendix B). The aims of this test were to determine the students' existing level of knowledge of logic gates. The data from the Pre-test captured an essential baseline of knowledge and skill, against which any improvements, following use of the online material, could be measured.

The Post-test consisted of the same questions as the Pre-test and was intended to assess student achievement after they had used the online material (see Appendix C). Unfortunately, the Post-test was not sufficiently discriminating and all students gained 100% of the marks available. Nevertheless it is considered that the comparison of Pre and Post-tests offers some insight into the minimum improvement in student performance. The Post-test was completed and returned by 33 students. The post-test is expected to help provide the answer to hypothesis three.

3.3.3 Question Coding:

Question 1 asked; **What level of knowledge would you say that you had before using the Logic gates material?**

Coding used for the question 1 is: 1 = **None at all**, 2 = **Very Little**, 3 = **Ok**, 4 = **Good**, and 5 = **Very Good**.

The first question is expected to determine the students' self-assessment of their level of knowledge before accessing the online course in order to compare it with their self assessment of their level after completing the online course. This comparison will help provide the answer to hypotheses one and three, see Section 1.4.

Question 2 asked; **What level of knowledge would you say that you now have on the subject of Logic gates?**

Coding used for the question 2 is: 1 = **None at all**, 2 = **Very Little**, 3 = **Ok**, 4 = **Good** and 5 = **Very Good**.

The second question was expected to determine students' self-assessment of their level of knowledge after completing the course. This question is expected to help provide the answer to hypotheses one and three, to determine the effect of learning sequence on students' self-assessment of their level of knowledge after completing the online course.

Question 3 asked; **What level of confidence do you have, that you understood the course material?**

Coding used for the question 3 is: 1 = **None**, 2 = **Very little**, 3 = **Moderate**, 4 = **Confident** and 5 = **Very Confident**.

The third question is expected to provide the answer to hypotheses two and four, and help determine the effect of learning sequence on the students' level of self-confidence which may have a direct effect on the students' achievement.

Question 4 asked: **How well did the course keep you interested and motivated?**

Coding used for the question 4 is: 1 = **Not at all**, 2 = **Very little**, 3 = **Ok**, 4 = **Good** and 5 = **Very Good**.

The fourth question is expected to help provide the answer to hypotheses two and four, to determine the effect of learning sequence on the students' level of interest which may have a direct effect on the students' achievement.

Question 5 asked: **Did you feel comfortable completing the Logic gates material in the order that it was presented to you?**

Coding used for the question 5 is: 1 = **NO**, 2 = **YES**.

The fifth question is expected to help provide the answer to hypotheses two and four to determine the effect of learning sequence on the how comfortable students felt with the eLearning experience, which may have a direct effect on their achievement.

Each of the six sub-groups contained students with different learning styles, so that in each group there would be both those who found the learning sequence matching their learning style, and those who found a mismatch. The researcher also analysed and compared the data after the sample data was re-divided into only two groups (matched and mismatched learning styles) instead of six, because the number in each sub-group was too small to provide significant information. The approach to be used in any subsequent experiments, will be to divide the cohort of students enrolled on the course into two groups. The first group will be given a learning sequence which matches their learning styles. The second group will be given a learning sequence that does not match their learning styles.

3.4 Data Analysis.

The Statistical Package for the Social Sciences (SPSS) software package version 11.5 was used for all the statistical analyses performed on the data. All statistical tests were carried out at the 0.05 level of significance, unless otherwise stated. The data was analysed in terms of both descriptive statistics and inferential statistics. There was some non-uniformity in the data sets due to missing data because some students did not complete all parts of the questionnaires or Post-test (Kottegoda and Rosso 1997).

The data was analysis in two ways:

The firstly it was analysis to see if there were significant different between the six groups.

Secondly an analysis was done to see if students with different learning styles were affected different by whether the material Matched their learning style or not.

The analysis started with level of knowledge before accessing the online course and after completing the online course to see if there is any significant different between all groups, differences in the level of self-confidence, the level of interest, the level of comfort with the online course.

In each case:

The chi-square test was used to examine the variance between learning types in preferred learning sequence and learning styles in the evaluation of the learning materials. The full results are presented in Appendix D.

The chi-square test is used when you want to see if there is any different between two or more categorical variables(Kottegoda and Rosso 1997).

The independent samples, a non-parametric test was used to check the differences between the learning styles in evaluating the online learning material design and delivery method (Morgan et al., 2001; Tilley, 1996).

3.5 Ethical Considerations

To be ethical, all data gathered was reported in the aggregate form to protect anonymity. Although the six groups used the same learning material, the learning sequence was different for each group. However, this was deemed fair to all groups as the students were supported by the researcher who offered a post-topic tutorial, in the computer laboratory, to all students who felt that had not progressed as well as they should.

3.6 Structure of the online course

Figure 3.2 shows the structure of the online course. After they had logged on and registered, the main page asked students for their group number which then determined the sequence in which the program was presented.

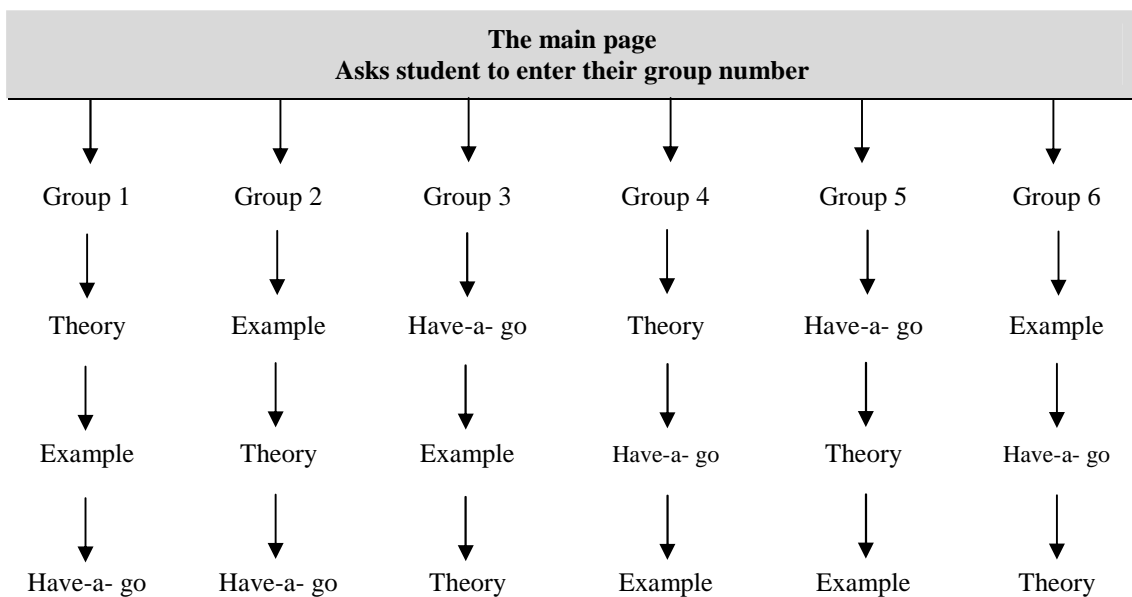


Figure 3.2: High level design architecture for the online course

3.7 Implementing the User Interface Design.

It was important to get the user interface right. The look and "feel" of the screens should be consistent throughout the entire material. If the material looks difficult to use, or dull or boring, a student may have negative feelings towards it immediately, which could have a detrimental effect on his/her learning. "Poor applications destroy the motivation of the user, it is surprisingly easy to destroy some users' confidence in a computer program" (Cox and Walker 1993).

It was decided that to make it clear when the user was in the online course material, each screen would include a top bar which would describe to the user their current position. It was simply the page title of each section. There was also a global bar at the bottom of the screen which contained the navigation buttons, 'Next', 'Previous' and 'Exit'. This bar was available to the user at all times to allow the user to freely move around the section/material. These global buttons on the bottom bar provide visual feedback to the user to indicate that they are live, and can be selected. As the mouse passed over each button, that button turned to green to show that it could be selected and pressed. When the mouse moved away the button returned to its original colour (black). See Figure 3.3.

3.8 Incorporating Learning Styles into the Learning Material.

There have been many studies on the association of learning preference with type of instructional material, and it has been shown that the order in which the same topics are presented can produce very different learning experiences (Wenger, 1987; Honey and Mumford, 1992; McLoughlin, 1999; Papanikolaou et al, 2000; Stash et al, 2004). The approach used in this research is to provide all learners with the same learning material, but the order of the presentation of the three sections making up the learning material is adapted according to different instructional strategies, so that the difference in order gives a different perspective on the concepts being taught (Brown et al, 2005). The order of presentation of the learning material can be matched to the students' learning style, so the order of presentation will differ depending in the learning style of the student.

The content of each of the three sections, Theory, Example and Have-a-Go was determined after reviewing other research into CAL implementations. Each learning style is taken to have its own strengths and preferences, and that means the student learns best when he or she meet those educational activities which are congruent with their strengths. Honey and Mumford (1986) recommended that the teacher try and make the learning activities suit the learning style of the student, as described in “Using your learning styles”, and "How to choose learning activities to suit your learning style". Of course, it is only possible to be sure that the different activities have been appropriately designed when the students have used the material and results have been collected and analysed.

3.9 Design of the Online Course.

This section of the chapter describes the online course that has been developed to help in the evaluation of using learning styles that aimed to improve student learning. This contains the description of the course content and the design of the online course model.

3.9.1 Design of the Theory Section of the Learning Material.

The theory section contained mostly textual information, see Figure 3.3, and some images which showed logic gates (symbolically). It was based on the hard facts of the topic, but also included some transitions on the screen to make it visually more attractive, the screen transitions are visual effects that vary the way objects are displayed and erased on the screen. Use of transitions can add impact and drama to information. See Appendix A, Figures A3.4 and A3.5.

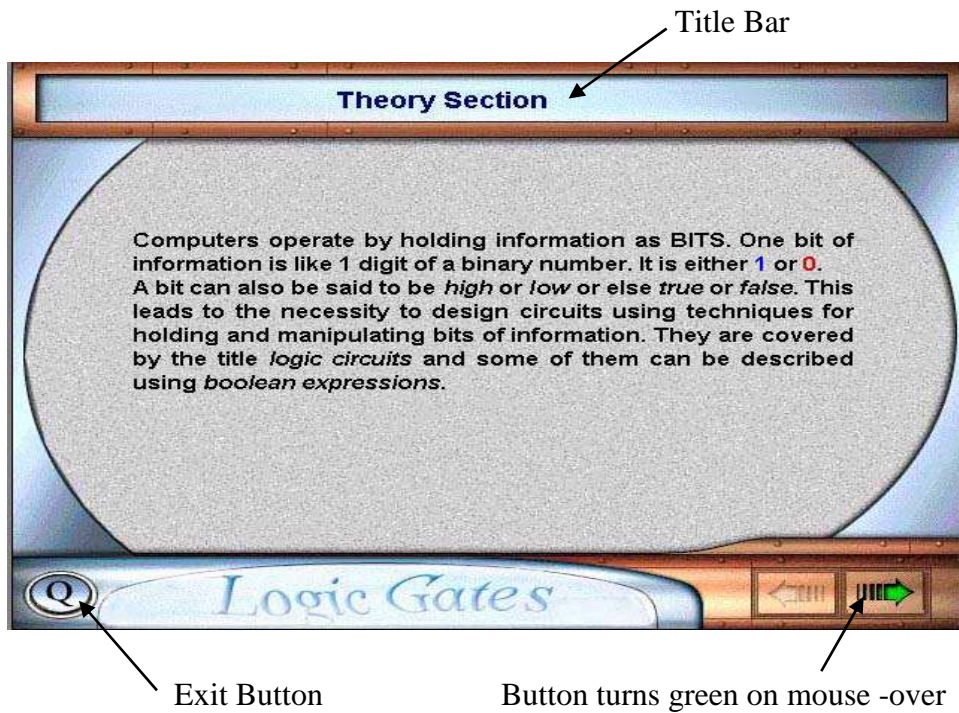


Figure 3.3: Screenshot of online course from the Theory Section

3.9.2 Design of the Example Section of the Learning Material.

This section presented a series of simulations which were examples of how logic gates operate. Information extracted from the examples was used to explain how to draw a circuit diagram for the logic expression $X = (B+C)+DE$. This is an expression that can be translated into gate design using animation, see Figure 3.6.

Each page which included a simulation also had an icon, giving the user the option to re-run the simulation. This ensured that anyone who felt they needed to see the simulation again could do so, as many time as they liked. This was considered essential for Reflectors who, it is believed, prefer to ponder situations for longer than the other learning styles. See Appendix A, Figures A3.7, A3.8 and A3.9.

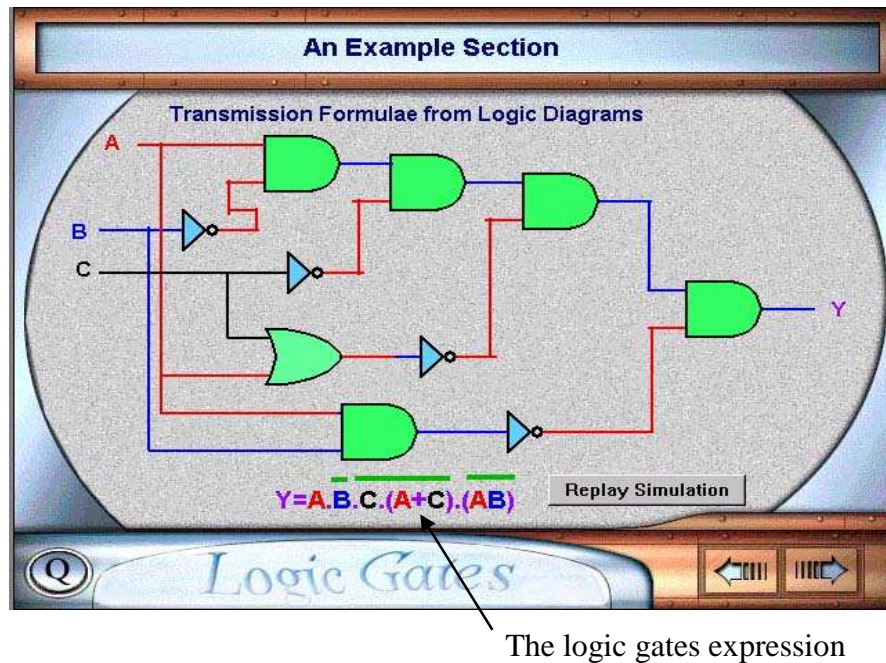
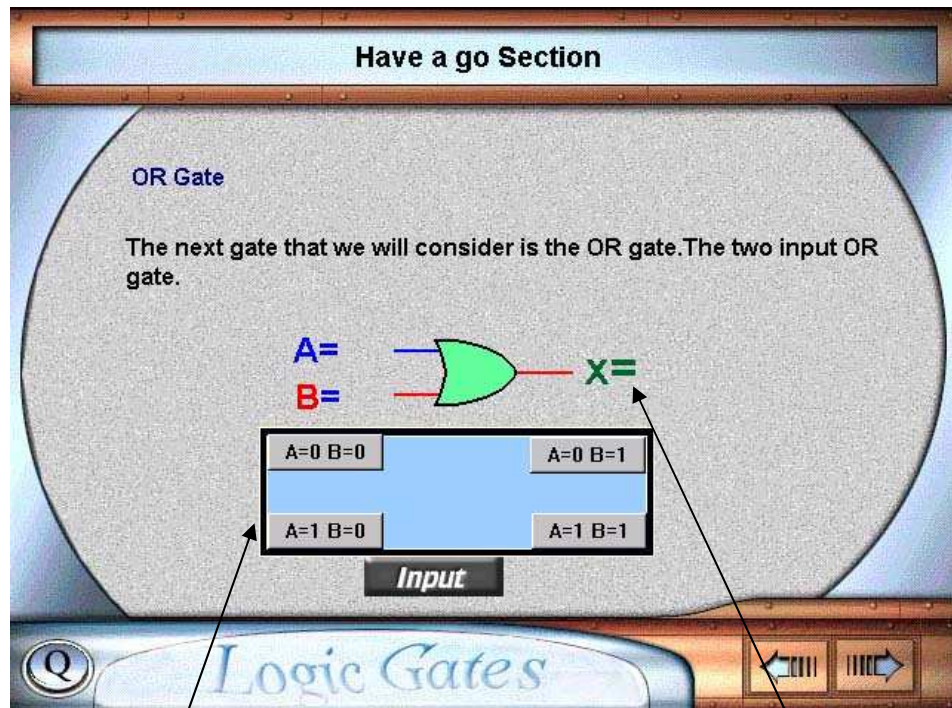


Figure 3.6 : Screenshot of online course from the Example Section.

3.9.3 Design of the Have-a-Go Section of the Learning Material

This section is the practical part of the course, and was designed especially for those student who like to learn by doing; the Activists. The concepts behind this section are that some students approach a problem with the attitude; 'I will try this once and see what happens'. The logic gate is presented to the student with an icon labeled 'Input', and when the student pressed it, small windows appeared containing the input data to that gate. For example "A = 0, B = 0". Also when the student pressed the 'Input' the screen presented him or her, (using animation) the output signal of the gate, see Figure 3.10 and Appendix A, Figures A3.11, and A3.12.



The input data to the gate (A and B)

The output from the gate (X)

Figure 3.10: Screenshot of online course from the Have-a-Go Section.

As an example the input and the output of a gate are presented to the user as a truth table of input and output signals. At the end of this section there were more practical examples/exercises to make sure the student applied the knowledge learned. The student was asked to draw the circuit diagrams for given logic expressions by dragging and dropping the image of the logic gate to the target area.

The online course made little effort to provide useful feedback to the student as to where they may be going wrong if they got the answer incorrect. Answers tended to be a straight correct or incorrect. This part included icons to help the user check their answer to see if it was correct, or if it was necessary to attempt the question again, possibly many times. Those viewing the contents of the 'Have-a-Go' section in advance of having seen any examples or reading any theory, needed extra help to understand the questions and work out the correct answers.

The range of interactions required in response to this section will give student the maximum opportunity to prove their skills knowledge in an interesting way.

Chapter Four

Data Analysis of Experiment One

4.1 Introduction.

This chapter reports the findings of the outcomes of this study and analyses the data from the 33 students who completed the Pre-test, Post-test, and online survey questionnaire, and the 22 students who also completed the learning styles questionnaire (of course the 22 students are a sub-set of the 33 students).

4.2 Evaluation by Groups.

This part of the data analysis focuses on the differences between groups. The data here is for the 33 students who completed the Pre-test, Post-test, and online survey questionnaire.

4.2.1 Difference Between Student Groups in Level of Knowledge Before the Course.

33 students who completed both the Pre-test and Post-test, 60% of the students considered they started the course with very little or no knowledge of logic gates.

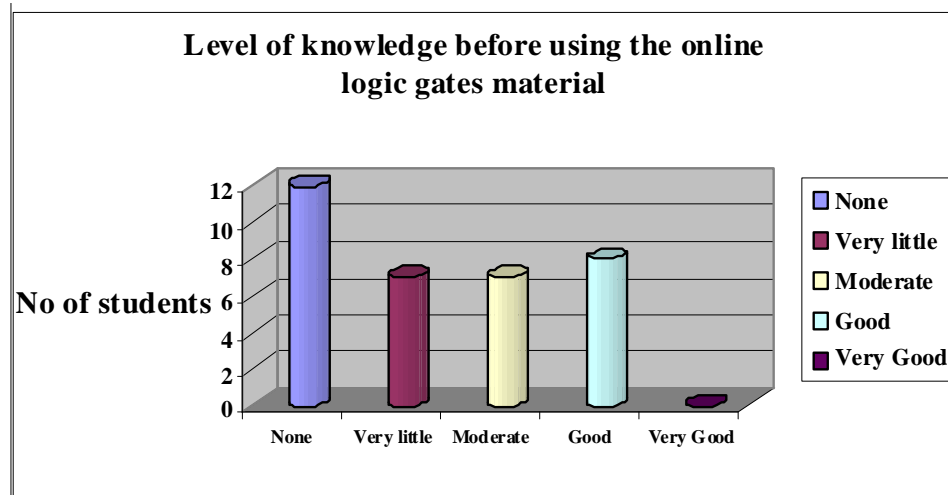


Figure 4.1: How students assessed their own level of knowledge before accessing the online course

The Chi-Square value obtained in the Kruskal-Wallis test showed no significant difference between any of the six groups in how students assessed their own level of knowledge before they started taken the course (Chi-Square = 1.01, $P > 0.05$), see Table 4.1. The full results are presented in Appendix D.

Group	Sample Size, N	Mean Score in level of knowledge before	Standard Deviation, SD	CHI-SQUARE	<i>P</i>
GROUP 1	11	2.45	1.29	1.01	0.96
GROUP 2	7	2.14	1.06		
GROUP 3	5	2.20	1.64		
GROUP 4	2	3.00	1.41		
GROUP 5	3	2.33	0.58		
GROUP 6	5	2.40	1.34		

Table 4.1: How students assessed their own level of knowledge before accessing the online course

4.2.2 Differences between Student Groups in Level of Knowledge after Accessing the Online Course.

After taking the online course the Post-test showed that every one of the 33 students increased their score but, unfortunately, all 33 students obtained 100% of the marks available. Responses to the online survey questionnaire concerning attitudes to the course showed that 28 responders (85%) believed that they now have a good or very good knowledge of logic gates, while 5 responders (15%) were happy that their knowledge of the subject was now very good, see Figure 4.2.

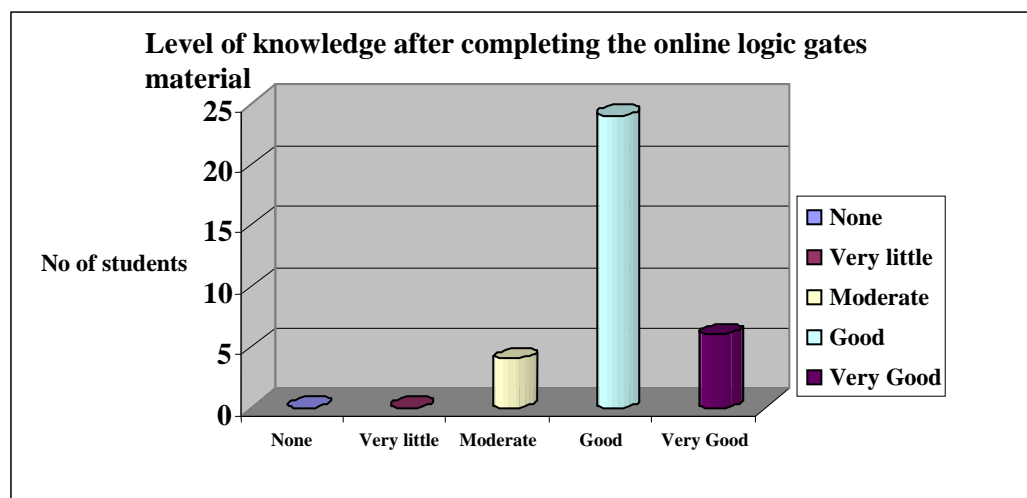


Figure 4.2: How students assessed their own level of knowledge after completing the online course

Again the Chi-Square value for the Kruskal-Wallis test showed no significant difference between any groups in how students assessed their own level of knowledge after completing the online course (Chi-Square = 8.6, $P > 0.05$), see Table 4.2. This result is interpreted as showing that the chances the students had to achieve some improvement in their level of knowledge were not significantly different. The full results are presented in Appendix D.

Group	N	Mean Score in level of knowledge after	SD	CHI-SQUARE	P
GROUP 1	11	4.18	0.6	8.6	0.13
GROUP 2	7	4	0		
GROUP 3	5	4.4	0.55		
GROUP 4	2	3.50	0.71		
GROUP 5	3	4.33	0.58		
GROUP 6	5	3.60	0.55		

Table 4.2: How students assessed their own level of knowledge after completing the online course.

4.2.3 Differences between Student Groups in Level of Confidence of how well they Understood the Course Material.

After completing the Post-test, the students were asked to fill in an evaluation questionnaire and record, on a five point scale, their level of confidence of their understanding of the online course material. The results are shown in Figure 4.3.

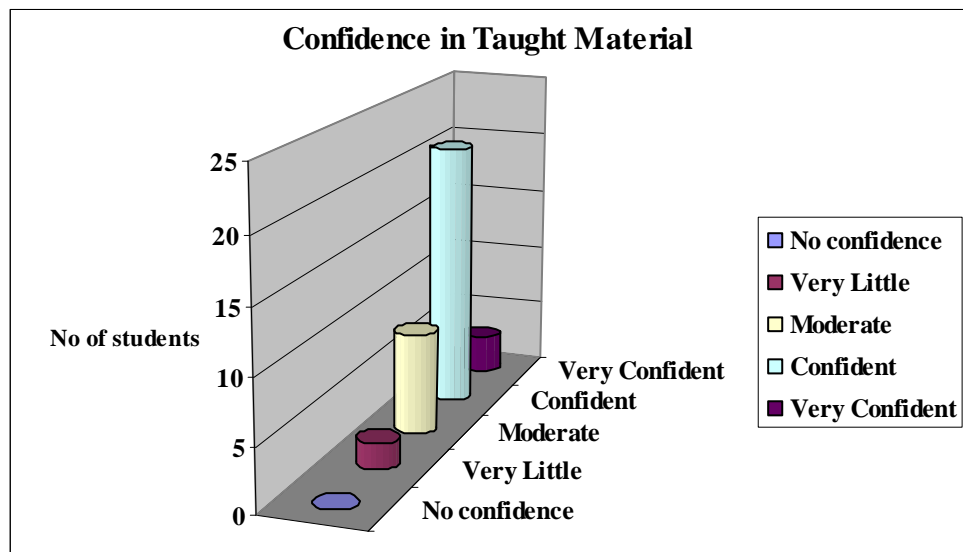


Figure 4.3: Students' level of confidence in their understanding of the online material

As illustrated in Table 4.3 the Chi-Square value showed that there is no significant difference (at the 0.05 level) in the students' level of confidence in the material accessed on the online course between any of the six groups (Chi-Square = 4.55, $P > 0.05$). The full results are presented in Appendix D.

Group	N	Mean Score in Level of confident	SD	CHI-SQUARE	P
GROUP 1	11	3.64	0.81	4.55	0.47
GROUP 2	7	3.71	0.49		
GROUP 3	5	4	0		
GROUP 4	2	3.50	0.71		
GROUP 5	3	4.33	0.58		
GROUP 6	5	3.40	1.14		

Table 4.3: Students' level of confidence in their understanding of the online course

4.2.4 Differences between Student Groups in Level of Interest.

When the students finished the course they were asked to self-assess and record how well the course material kept them interested. The results are shown in Figure 4.4. 25 of the respondents (76%) recorded their interest and motivation throughout the course as good or very good, 2 respondents (6%) recorded their interest and motivation as very good.

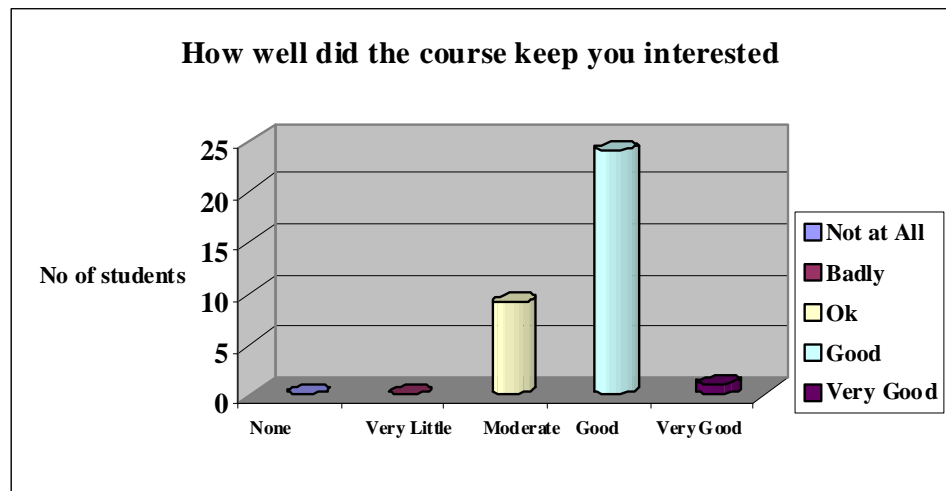


Figure 4.4: Students level of interested in material accessed on the online course.

Table 4.4 shows the mean scores of the six student groups for level of interest in the course. The Chi-Square value showed no significant difference between any of the groups (Chi-Square = 1.08, $P > 0.05$). The full results are presented in Appendix D.

Group	N	Mean Score in Level of interest	SD	CHI-SQUARE	P
GROUP 1	11	3.82	0.6	1.08	0.96
GROUP 2	7	3.71	0.5		
GROUP 3	5	3.8	0.44		
GROUP 4	2	3.50	0.71		
GROUP 5	3	3.7	0.58		
GROUP 6	5	3.6	0.55		

Table 4.4: Students' level of interest material accessed on the online course.

4.3 Evaluation by Learning Styles.

This part of the data analysis focuses on the differences between learning styles. The data here is for the 22 students who completed the Pre-test, Post-test, online survey questionnaire and completed the learning styles questionnaire (11 Activists, 4 Reflectors, 7 Theorists).

4.3.1 Differences between Learning Styles and Self-assessment before Accessing the Online Course.

The difference in student rankings of their levels of knowledge before beginning the online course were compared for the Activist, Reflector and Theorist, see Figure 4.5. Obviously, most students with Activist and Reflector learning styles felt they had little or no knowledge of the subject of Logic Gates, but most students with Theorist had some Knowledge about logic gates.

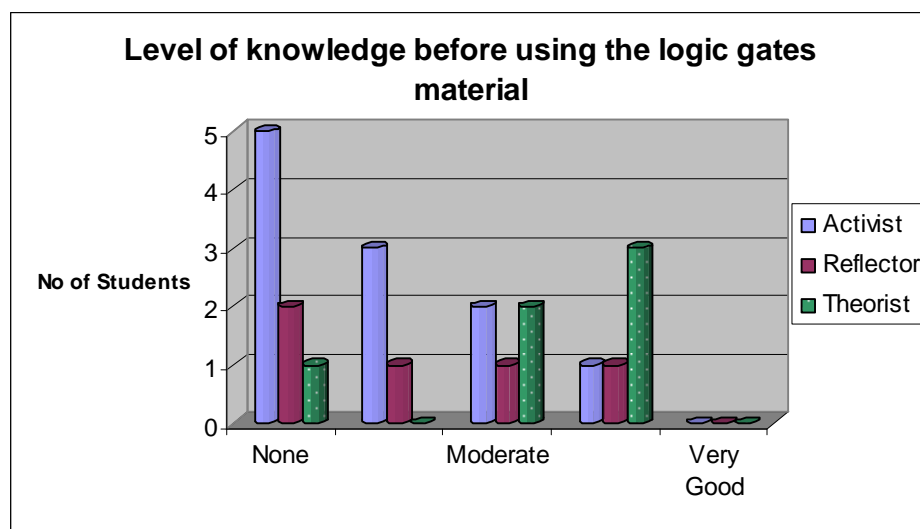


Figure 4.5: How students assessed their own level of knowledge before accessing the online course, according to learning style

There was significant difference between the three learning styles in the level of how knowledgeable the students considered themselves before they started the course (Chi-Square = 6.27, $P < 0.05$) as shown in Table 4.5. Those students classified as Theorists considered themselves significantly more knowledgeable about logic gates than did either of the other two learning styles. The full results are presented in Appendix D.

Group	N	Mean Score in level of knowledge before	SD	CHI-SQUARE	<i>P</i>
Activist	11	1.91	1.04	6.27	0.04
Reflector	4	1.75	0.96		
Theorist	7	3.29	1.11		

Table 4.5: Differences in student self-assessment of their own level of knowledge before accessing the course, according to learning style

4.3.2 Differences between Learning Styles in Self-assessment after Completing the Online Course.

The difference in student rankings of their levels of knowledge after completing the online course were compared Activist, Reflector and Theorist students, see Figure 4.6. There is a clear tendency for the Reflector and Theorist students to rate their increase in knowledge as greater than Activist, students After completing the course the Reflector and Theorist students rated their level of knowledge as good to very good, while for the Activist students it was moderate to Good.

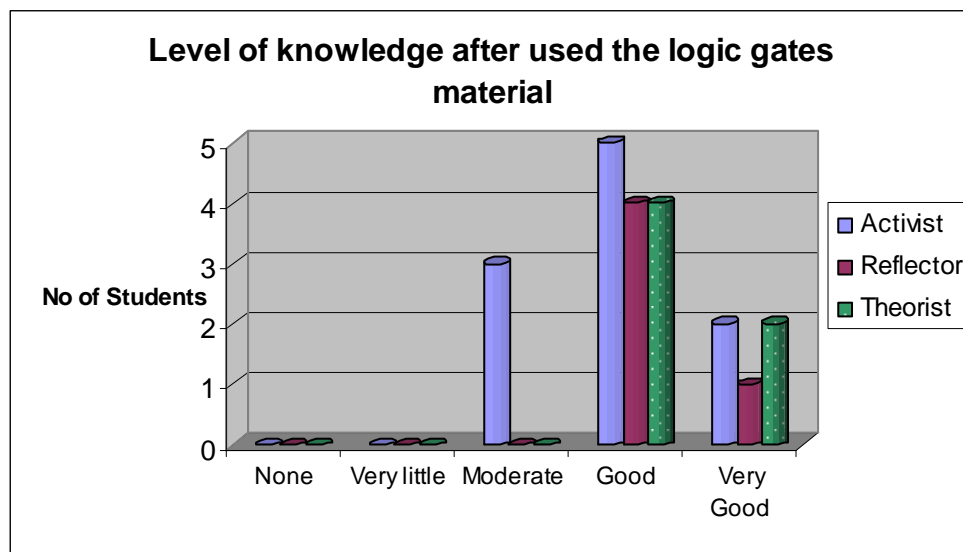


Figure 4.6: How students assessed their own level of knowledge after completing the online course, according to learning style

Table 4.6 shows no significant difference between the three learning styles (Chi-Square = 1.82, $P > 0.05$) in student self-assessment of their own level of knowledge after completing the course. This result can be interpreted as meaning that the course offered the opportunity for all students with different learning styles, and different levels of self assessed knowledge, to rise to a 'good' or a 'very good' level, see Figures 4.5 and 4.6, irrespective of learning style. The full results are presented in Appendix D.

Group	N	Mean Score in level of knowledge after	SD	CHI-SQUARE	P
Activist	11	3.91	0.70	1.82	0.40
Reflector	4	4.25	0.50		
Theorist	7	4.29	0.49		

Table 4.6: Differences in student self-assessment of their own level of knowledge after completing the course, according to learning style

4.3.3 Differences between Learning Styles and Student Self-assessment of how Confident they were in the Material Accessed on the Online Course.

After completing the Post-test, the students were asked to fill in an evaluation questionnaire and record, on a five point scale, their level of confidence of their understanding of the online course material. The results are shown in Figure 4.7.

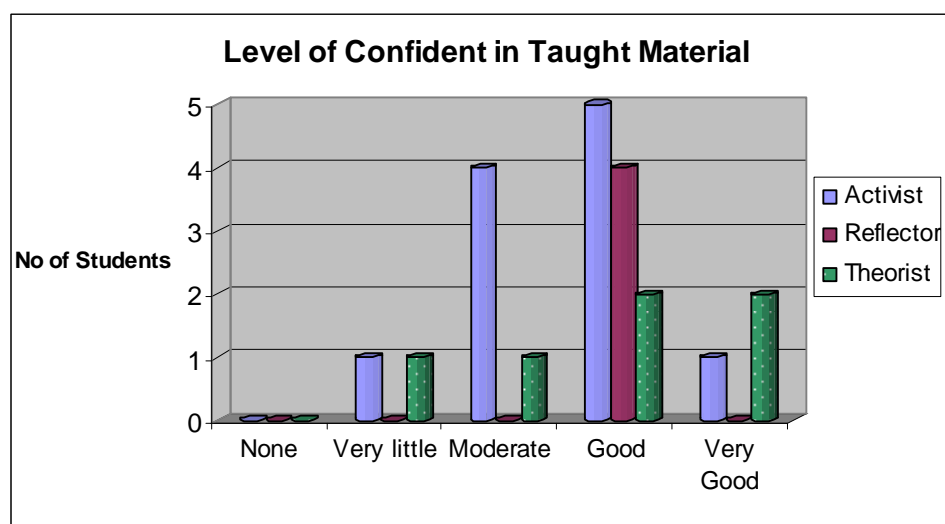


Figure 4.7: Students' level of confidence in their understanding of the online material, according to learning style

Table 4.7 shows that there was no significant difference between the learning styles in the level of student confidence in the material of the online course after completing it, (Chi-Square = 1.46, $P > 0.05$). The full results are presented in Appendix D.

Group	N	Mean Score in Level of confident	SD	CHI-SQUARE	P
Activist	11	3.55	0.820	1.46	0.48
Reflector	4	2.6	0		
Theorist	7	3.9	1.06		

Table 4.7: Differences between learning styles and student self-assessment of confidence in material accessed on the online course .

4.3.4 Differences between Learning Styles and Student Level of Interest.

When the students finished the course they were asked to self-assess and record how well the course material kept them interested. The results are shown in Figure 4.8. All the (4 Reflector and 7 Theorist) respondents that their interest and throughout the course as good or very good, while the 11 Activist respondents their interest and as Moderate or good.

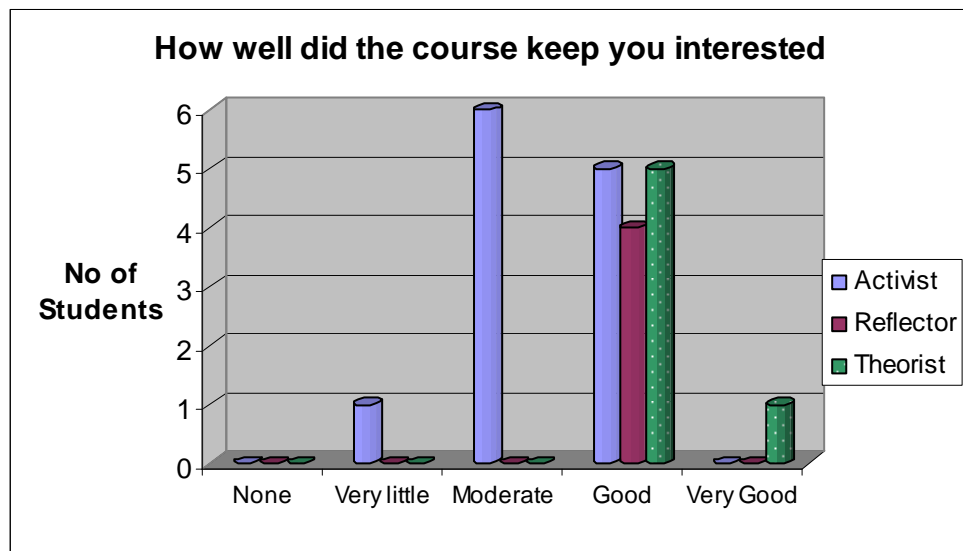


Figure 4.8: Students level of interested in material accessed on the online course .

The results, see Table 4.8, showed there was a significant difference among the learning styles in level of interest in the online course. Reflector type learners (N=4, M= 4.00, SD = 0) and Theorist type learners (N=7, M=4.14, SD = 0.03) found the online course significantly more interesting than Activist type learners (N=11, M= 3.45, SD = 5.22),

at a significance level of $P = 0.02$. This could be interpreted as meaning that students with an Activist learning style require relatively more activities in a course to engage their interest and make them want, for example, to access and use an online course. The full results are presented in Appendix D.

Group	N	Mean Score in Level of interest	SD	CHI-SQUARE	P
Activist	11	3.45	5.22	8.30	0.02
Reflector	4	4.00	0		
Theorist	7	4.14	0.03		

Table 4.8: Differences between Learning Styles and Student Level of Interest, according to learning style

4.3.5 How Well Students Whose Learning Style Was Considered to Match the Online Course, Rated Their Knowledge Before and After Accessing the Course.

Of the 22 students who completed the learning styles questionnaire at the end of the experiment, the researcher deemed that five accessed the material in an order that matched their learning styles. These five made a self-assessment of their knowledge of the subject of logic gates, both before and after taking the course. The results showed that 3 (60%) started the course with no knowledge, and 2 (40%) with very little knowledge of logic gates, see Figure 4.9. When the students rated themselves after taking the online course all the students recorded an increase in their knowledge. 3 (60%) believed that they had a good knowledge of logic gates and 2 (40%) were happy that their knowledge of the subject was very good, see Figure 4.9.

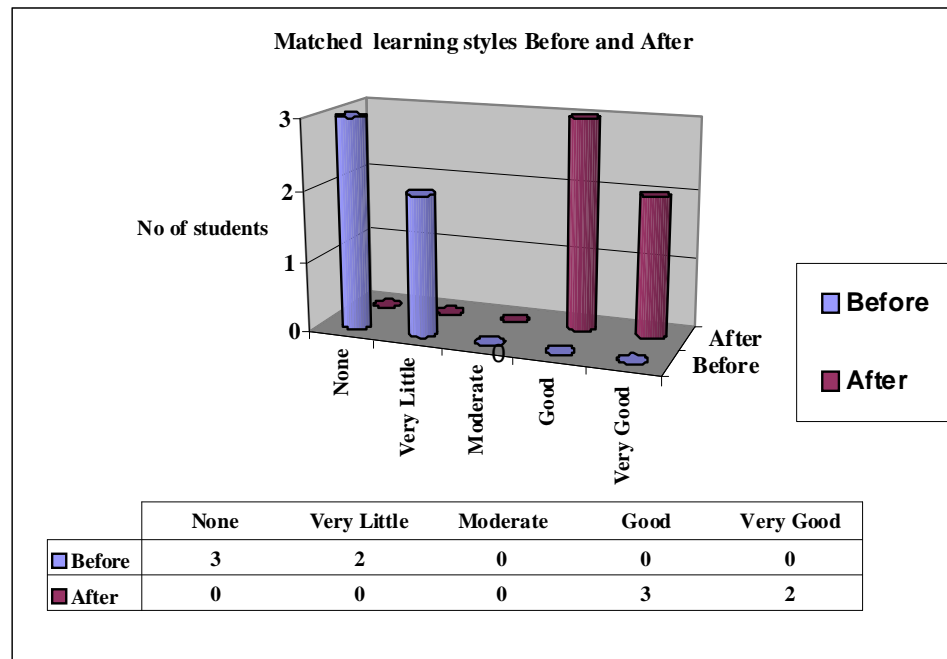


Figure 4.9: How students whose learning style was considered to match the online course rated their knowledge before and after completing the course, according to learning style

4.3.6 How Well Students Whose Learning Style Was Considered Not to Match the Online Course, Rated Their Knowledge Before and After Accessing the Course.

Of the 17 unmatched students, 5 (29%) of the students started the course believing they had no knowledge, 3 (18%) believed they had very little knowledge, 5 (29%) believed they had moderate knowledge, and 4 (24%) believed their knowledge of the subject was good, see Figure 4.10.

After the students completed the experiment their responses showed, see Figure 4.10, that 3 (18%) believed they had moderate knowledge of logic gates, 10 (59%) believed their knowledge was good, and 4 (23%) believed their knowledge was very good.

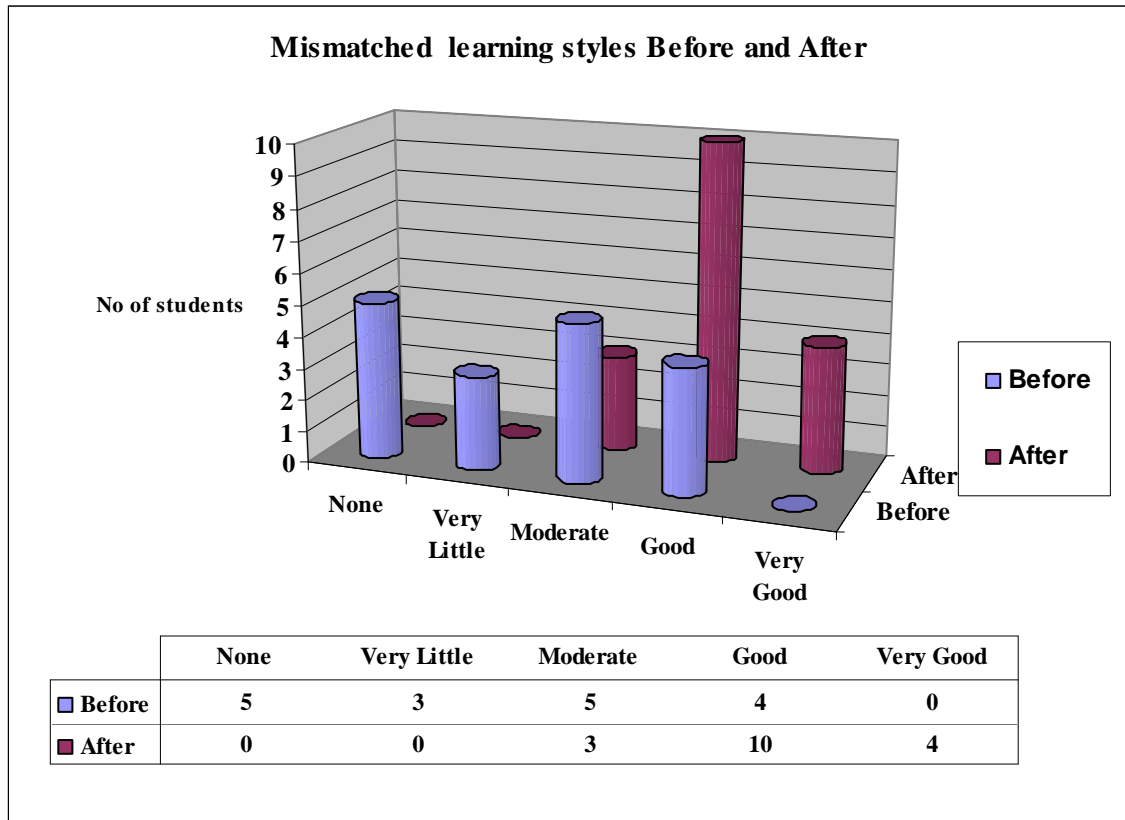


Figure 4.10: How students whose learning style was considered to not match the online course rated their knowledge before and after completing the course.

Comparing Figures 4.9 and 4.10 it can be seen that, overall, the matched students reported a greater positive shift in their knowledge of the subject after completing the online material than was reported by the unmatched students.

4.4 Conclusions, Discussion and Possible Further Work.

This was a pilot study to evaluate the practicability and worthiness of a larger research project; to evaluate the likely impact on learning outcomes, of designing online courses to be delivered in a manner that matches the students' learning styles.

4.4.1 Conclusions.

The main points that can be concluded from this pilot study as following :

- Students whose learning style matched the order/sequence in which the learning material was presented to them, recorded higher level improved in their knowledge after accessing the online course than did students whose learning styles did not match the order/sequence in which the learning material was presented to them.

- Reflector and Theorist learning styles found the online material presented significantly more interesting than did Activists.
- No student with a Pragmatist learning style was in this student group.

4.4.2 Discussion.

The experiment one was done as pilot study which can help the researcher to improve his plan for next experiment. These experiment was targeted only 22 students who completed the experiment only 5 followed a learning experience that matched their learning style. Although there was no significant result from this experiment but it raised important points which should taken into account in the next experiment.

The difficulties in conducting the experiment arose partly from the constraints imposed by the environment. The number of students in the experiment was to some extent outside the control of the researcher, although ways of maximising this by understanding how to manage the experiment in the context of variable student attendance are clearer with the benefit of experience. The effect of the low number of participants was exacerbated by the experimental design which, by using random allocation, placed students in activity orders (e.g. group 5 - Have-a-Go, Theory, Example) which were outside the hypothesis being tested. Whilst the first problem is easily rectifiable, it is harder to assign activity orders systematically according to preferred learning style, because of the need to test students first. This has associated logistical and timing problems in the context of a large first year undergraduate cohort, when the material being tested addresses early learning outcomes.

4.5 Limitations of the study

This study covers one part of one subject module on the first year of an undergraduate degree programme.

1. This study was limited to self-selecting students who registered to take this course.
2. All the participants have much the same educational level.
3. Gender, age, ethnicity or social background of participants will not be considered as part of this study.

4.6 The Plan for Further Work.

Further work is planned for a new research experiment which should obtain more, and better, results. The new experiment will eliminate, or at least significantly reduce the two key problems that the researcher faced in the first experiment.

4.6.1 Increased Sample Size:-

- 1 In the proposed experiment, the researcher will encourage more students to participate through to the end, and so obtain a much larger sample.
- 2 The researcher is planning a better presentation to the students in order to make clear the importance of the research experiment for them and future students.
- 3 The researcher is arranging the experiment so there will be a minimum clash with the participating students' other subject/module tests/assessments, etc.
- 4 The researcher is planning to perform the experiment in only two lecture laboratories rather than three and so reduce the problem of participation by allowing the continued involvement of more students.
- 5 Rather than delivering the four sections of online material in all possible orders (24), there will be only four routes through the sections. These will match the Kolb learning cycle and this should result in a higher proportion of the students having material that matches their styles.

4.6.2 Provision of Matching Sections for all Four Learning Styles

- 1 The design of the new online course will be based on four self-contained sections, rather than three. A new section, titled "Explanation" will be added, this will allow the sections to be combined in four different ways that will constitute four different and alternative instructional strategies that will allow Pragmatists to follow a separate route best suited to their learning style.
- 2 Students with a pragmatists learning style want to know the reason why they are to learn material before they take any action, so pragmatist learners will follow the route: Explanation section, Have-a-Go section, Example section and Theory section.

4.6.3 Other Important Changes

There will be three further important changes:

- 1 The student's learning style will be assessed at the beginning of the experiment rather than at the end. The new experiment procedure will automatically determine each student's route when they first log in, and allocate it to them. In this way half the students will be matched, and half the students mismatched, to their learning styles.
- 2 A more discriminatory Post-test will be used to allow a more objective measure of what the students have learned (see Appendix E).

Chapter Five

Design of Experiment Two

5.1 Introduction.

This chapter is concerned with a second experiment that was intended to remedy the problems encountered in the first, and will describe the changes made in both the research techniques and the online course design. Results are presented and discussed, as are conclusions drawn from the research.

5.2 Revised Structure of Research Method.

The learning material was restructured to be delivered in four blocks, in four combinations with each sequence matching one of the four learning styles described by Honey and Mumford (1986): Activist, Reflector, Pragmatist and Theorist. This approach had the benefit of more fully matching the Kolb learning cycle (Kolb, 1984) than did the first experiment which catered for only three learning styles.

The experiment began by the instructor (the researcher) attending the first session of the Computer Technology module, meeting all 64 students enrolled on it, and inviting them to join the experiment. All agreed. The students were then presented with the course plan, and a revised and shortened version of Honey's Learning Styles Questionnaire (LSQ) which containing forty questions. (Honey, 2006) (the one used in the first experiment contained eighty questions, Honey and Mumford 1986). This was done so students could complete the Learning Styles Questionnaire online, during the first session of the module. (this takes about 10 minutes to complete LSQ. After completing the LSQ in the first session of the first week students were informed of their learning styles, also online. The results were input to the research program which allocated the students their study sequence, before they accessed the

online course. Next the students were asked to complete the Pre-test (see Appendix B).

The researcher had designed and constructed an online course consisting of four sections, see Table 5.1, giving a sequence that would match each of the four learning styles. The students were divided into four sub-groups, one sub-group for each sequence, see Figure 5.1. Each of the 64 participating students was automatically allocated a route through the course material that either matched their particular learning style or a route which did not. Group one contained thirty students where the routes matched the student's learning style and Group two contained thirty-four students where the route did not match the student's learning style. Group one contained 10 Activists, 5 Reflectors, 6 Pragmatists, and 9 Theorists. Group two contained 12 Activists, 4 Reflectors, 9 Pragmatists, and 9 Theorists. A t-test showed that the distribution of the students in the two groups was not significantly different at the 5% level. Each group attended a two-hour session in the computer laboratory, each week, for two weeks. The two groups attended separately.

Activist/Sequence 1	Reflector/Sequence 2	Theorist /Sequence 3	Pragmatist/Sequence 4
Have-a-Go section	Example section	Theory section	Explanation section
Example section	Theory section	Explanation section	Have-a-Go section
Theory section	Explanation section	Have-a-Go section	Example section
Explanation section	Have-a-Go section	Example section	Theory section

Table 5.1 : Orders in which the sections of the online course were sequenced to match learning styles.

In the second week, each group of students was, separately, given a short introductory explanation of how the computer system would deliver the online course. They started by logging-in to the system. On entering their name, their learning style automatically determined each student's route, matched or mismatched. After the students had completed the online course they completed the new version of the Post-test and the evaluation form in hard copy, paper format (see Appendix E).

Also in the second week of the programme, during the laboratory session (to obtain a good number of responses) the students were asked to complete an online evaluation course questionnaire in hard copy, (see Appendix E). This questionnaire, which was submitted with the Post-test, was intended to investigate the design and effectiveness of the online learning materials used, the preferred learning sequence for each learning style, and students' opinion about this experience in general.

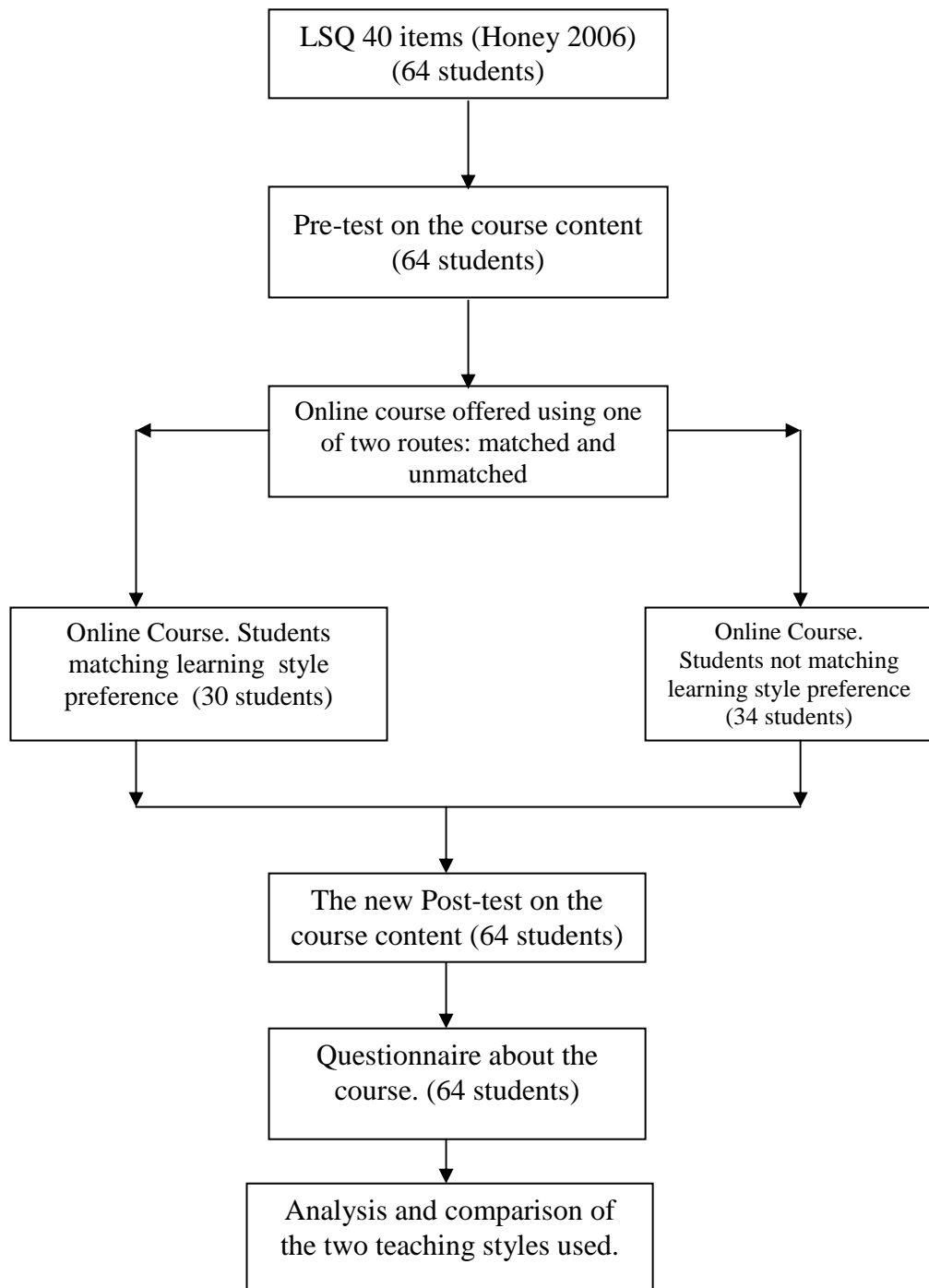


Figure 5.1: General diagram of the new experimental structure.

5.3 Data Collection Timetable and Procedures.

Data collection was planned and implemented as follows:

1. The students registered on the course module on the first day of the course. At the first session the students gathered in the computer laboratory and were given a full explanation about the experiment as a whole and also the part of the module played in this study. They were asked if they wished to participate in this study and if so, to complete the 40 item LSQ questionnaire.
2. The LSQ 40 a new version of Honey's questionnaire (2006), was used to identify each student's learning style. It was delivered and submitted online in the first session of the programme.
3. The Pre-test was a questionnaire submitted to the students in hard copy, paper format, in the first session. It contained four questions that covered the online material only (see Appendix B). Students were not informed of the marks obtained, but as most of students were unable to answer any questions they knew their scores were 0.
4. The two groups of students attended the weekly two hour laboratory sessions separately. Each student logged into the online course simply by entering their name.
5. The Post-test was also submitted to students in hard copy, paper format (see Appendix E). This was done in the laboratory session in the second week of the programme.
6. Also during the second laboratory session the students were asked to complete an online evaluation course questionnaire (hard copy), see Appendix E. This questionnaire, which was submitted with the Post-test, aimed to investigate the design and effectiveness of the learning materials used, the preferred learning sequence for each learning style and student opinion about this experience in general.

The Pre-test, Post-test and course evaluation questionnaires were designed by the researcher and verified by Course Leader and research supervisor. All material was delivered and data collected (including the marking of the Pre-test, Post-test and individual assignment) by the researcher himself. All data was submitted by the end

of the second week of the experiment. Table 4.2 clarifies the design of the experimental structure.

Group	Group selection	Pre-test	Intervention	Post-test
Group One (Matched)	Random	√	X	√
Group Two (Mismatched)	Random	√	X	√

Table 5.2: Research method - true experiment.

During the laboratory when the online course was delivered the students were supported by the researcher. The researcher was available for each group in the computer laboratory, on campus, to discuss with students any difficulties in accessing or using the online course materials. Table 5.3 illustrated the two week project programme.

Week1, Groups one and two meet separately	<i>Introduction to module. Explanation of experiment and research programme. All students invited to participate, all agree. Students given course plan, Pre-test (hard copy, completed and handed in) and LSQ (delivered and completed online). . Explanation of how the computer system will deliver online course. Between the first and second laboratory sessions, Pre-test marked. LSQ assessed and student learning styles determined and entered into the online course program. Students log in to online course. Students allocated to Group one (matched) or Group two (mismatched). Each student randomly allocated, which meant 30 matched students and 34 mismatched students.</i>
Week2 Groups one and two meet separately	<i>Students complete "Introduction to Logic Circuit Design" and consisted of truth tables, Boolean expressions, symbols of logic operators, basic logic gates, proof using truth tables, logic circuits and transmission formulae, equivalent circuits, standard results, De Morgan laws and simplifying circuits. At second session, before the session ends students complete and submit: Post-test (hard copy) and online course questionnaire completed in (hard copy).</i>

Table 5.3 Two week programme of the research project

5.4 Questionnaires.

The LSQ used in this study was a variation of the LSQ 40, a new version designed by Honey (2006). The questionnaire consisted of 40 questions relating to the four different types of learning styles (Activists, Pragmatists, Reflectors and Theorists).

5.4.1 Pre-Test and Post-Test.

A Pre-test was given to all 64 students to find out their start position. The test was designed specifically for the material of Computer Technology 1, and contained four multiple choice questions about the subject of the course module (See Appendix B).

The researcher also designed a new Post-test on the basis of the pilot experiment. This consisted of four multiple questions intended to assess student achievement after they had used the online material.(See Appendix E).

5.5 Data Analysis.

The data was analysis in two ways:

Firstly it was analysis to see if there were significant different between the two groups (Matched and Mismatched).

Secondly an analysis was done to see if students with different learning styles were affected differently by whether the material Matched their learning style or not.

The analysis started with Activist learning style. It begins with the comparison marks obtained in pre- and post-tests, significant different in level of knowledge before accessing the online course and after completing the online course, differences in the level of self-confidence, the level of interest, the level of comfort with the online course.

In each case:

The independent samples t test compares the mean scores of the two groups.

T test used to comparison of the marks obtained in the Pre-test, Post-, for the two groups. This was to compare the scores of each participant and his/her learning style.

The Wilcoxon Signed Ranks Test is non-parametric. It is often used to test the difference between scores of data collected before and after.

This was used determine whether students made significant progress, as measured by the level of knowledge before and their stated after completing the online course. (as measured by the ranking given by the students themselves). The full results are presented in Appendix F.

The Mann-Whitney U-test (Lee and Wang, 2003) the most widely used significance test for comparing two independent samples. The Mann-Whitney U-test used to analyse the ordinal data obtained. Was used to compare the difference between the two groups in (Level of knowledge before, after, Level of Confident, Level of Interest and Level of Comfort) and the four learning styles. The full results are presented in Appendix F.

5.6 The Development of the New Online Learning Course.

This section describes the online course that has been developed to help in the evaluation of the use of Learning Styles to improve student learning. It contains the description of the course content and the design of the online course model.

Evaluation of the pilot experiment led to the conclusions that the two sections relating to Reflectors and Theorists should remain unchanged, that the Activists required some additional practical material in “their” section (Have-A-Go), and that an entirely new section (Explanation) should be added to accommodate those students with a Pragmatist learning style.

Since two of the sections remained unchanged it is obvious that, as in the pilot study, the new online course made little effort to provide useful feedback to the student as to where they went wrong if they got the answer incorrect. Again, response to student answers tended to be a straight: correct or incorrect. However, the Have-a-Go section now included icons to help the user check their answer to see if it was correct, or if it was necessary to attempt the question again, possibly many times. See Figure 5.3.

5.6.1 Adding a New Section to the Learning Material.

According to Honey and Mumford (1992) learners who have a pragmatic learning style need sufficient explanation to be able to establish a good link between their background knowledge and the new learning material in order to answer the question why he/she need to learn the new material. To include a sequence of sections in the online course to match this learning style required the design of a new section, the "Explanation" section, which presents the main reasons why students need to learn the new material, see Figure 5.2.

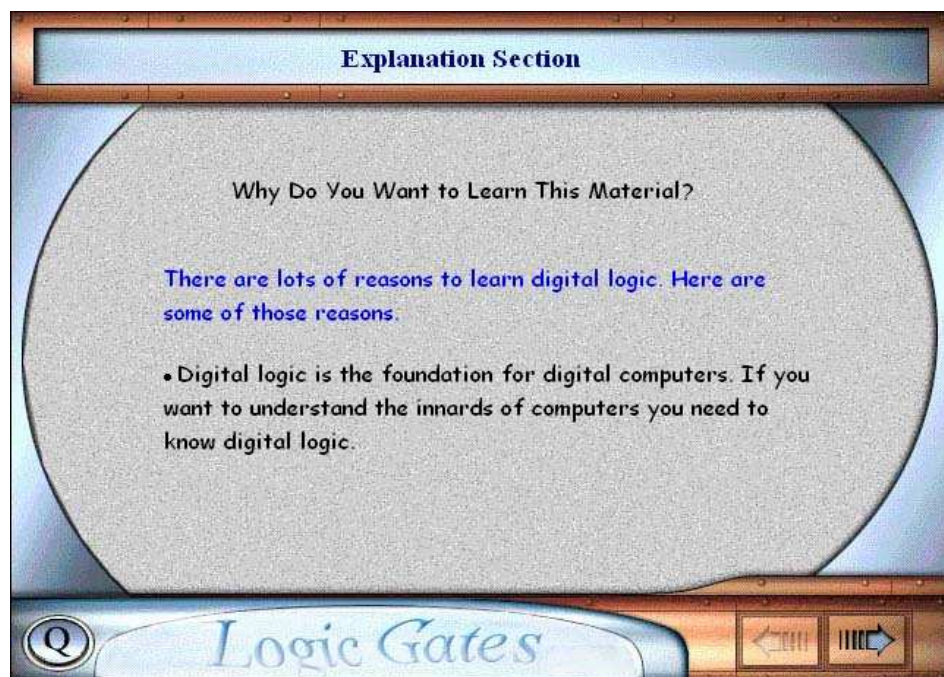


Figure 5.2: Screenshot of Explanation section of the online course

5.6.2 Adding More Practice to the Have-a-Go Section

The feedback that was collected from students in the pilot experiment suggested there was a need for more opportunities to practice in the Have-a-Go section. The student was asked to draw the circuit diagrams for given logic expressions by dragging and dropping the image of the logic gate to the target area.

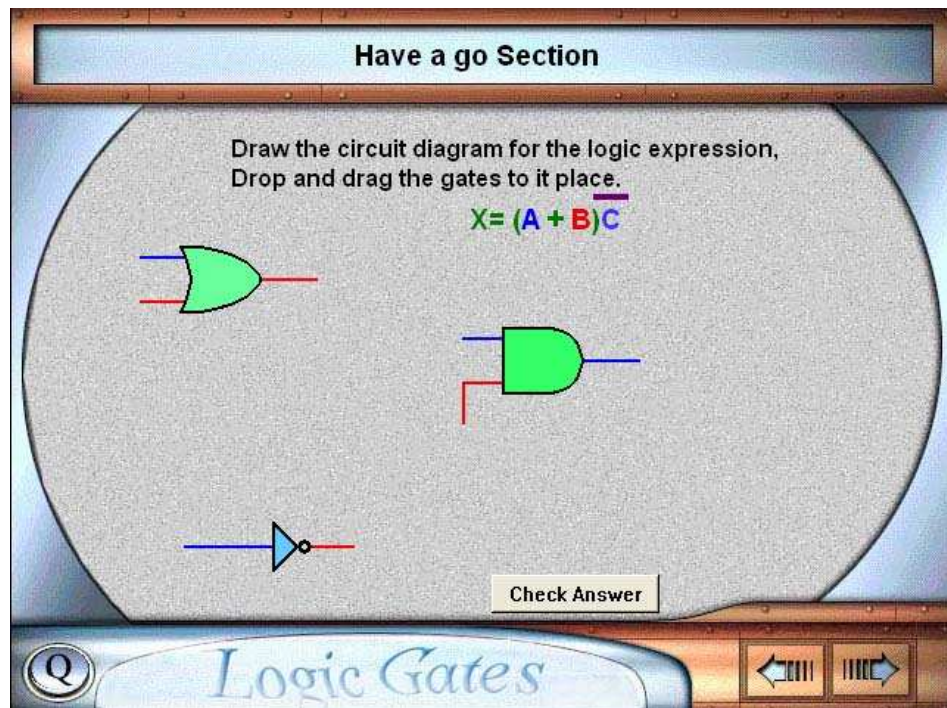


Figure 5.3 Screenshot of Have-a-Go section of online course

Chapter Six

Data Analysis for Second Experiment.

6.1 Introduction.

This chapter reports the findings of the outcomes of this, the second, experiment and analyses the data from the 64 students who completed the Pre-test, Post-test, and online survey questionnaire. There are two type of data in analyses, the first part of the data analysis focuses on differences between groups (matching and non-matching). The second part of the data analysis focuses on differences between student Learning styles in the two groups (Activist, Pragmatist, Reflector and Theorist). The results will be discussed in the Analysis Section (see also Appendix F).

6.2 Evaluation by Groups:

This section will discuss comparisons between the two groups, starting with the a comparison marks obtained in the Pre-test and Post-test ,a comparison of the difference in the level of knowledge before accessing the online course and the level of knowledge after completing the online course. The results will include differences in the level of self-confidence, the level of interest, the level of comfort with the online course. In addition, the analysis will present the results of correlation tests between learning sequence and student responses.

6.2.1 Differences between Marks Awarded to the Matched and Non-Matched Student Groups in Pre-Test and Post-Test

Here the t-test (equal variances not assumed) was used to investigate whether there was a significant difference in marks awarded in the Pre- and Post-tests to the two student groups. The results showed no significant difference between the two groups

in marks awarded in the Pre-test ($t=1.58$, $P > 0.05$), see Table 6.1. However, the t-test showed a significant difference between the two groups ($t=8.44$, $P < 0.001$) in the Post-test marks. In the Post-test the matched students scored, on average, significantly higher ($N=30$, $M=2.70$, $SD=0.47$) than the non-matched students ($N=34$, $M=1.09$, $SD=0.99$). The full results are presented in Appendix F.

Test type	Group	Sample Size, N	Mean Score	Standard Deviation, SD	T-Test: Equal Variances Not Assumed		
					Mean Difference	T	Asymp. Sig. (2-tailed)
Marks in Pre-Test	Group one (Matched)	30	2.07	1.64	0.58	1.58	0.15
	Group two (Mismatched)	34	1.44	1.50			
Marks in Post-Test	Group one (Matched)	30	2.70	0.47	1.61	8.44	0.000
	Group two (Mismatched)	34	1.09	0.99			

Table 6.1: t-test for significance of differences between mean marks awarded to matched and non-matched students in the Pre-and Post-tests.

The same result was confirmed by using ANOVA statistical test as shown in Table 6.2.

Test type	Group	Sample Size, N	Mean Score	Standard Deviation, SD	ANONA Test		
					Mean Square	F	Asymp. Sig. (2-tailed)
Marks in Pre-Test	Group one (Matched)	30	2.07	1.64	6.24	2.54	0.12
	Group two (Mismatched)	34	1.44	1.50			
Marks in Post-Test	Group one (Matched)	30	2.70	0.47	41.40	65.76	0.000
	Group two (Mismatched)	34	1.09	0.99			

Table 6.2 :ANOVA test for significance of differences between mean marks awarded to matched and non-matched students in the Pre-and Post-tests.

6.2.2 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Group One (Learning Style Matching Learning Sequence) .

To determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.1 shows for the 30 matched students in Group one, 29 students believed they had increase their knowledge level, one considered s/he knew as much after completing the online course as at the start, but no-one felt they knew less. The improvement is significant at a level of confidence of 99.9%.

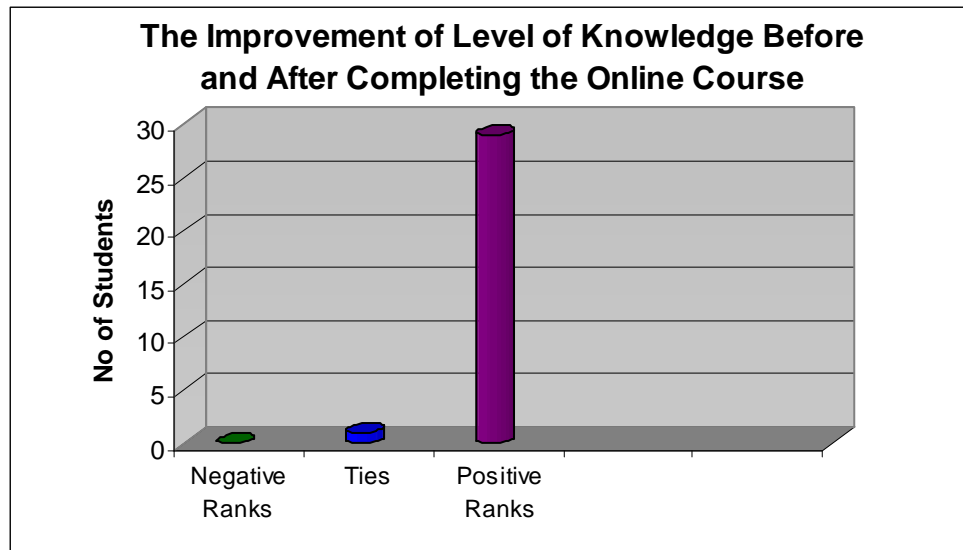


Figure 6.1: Group one, Improvement of Level of Knowledge Before and After Completing the Online course.

a Wilcoxon Signed Ranks Test was carried out. This showed that the increase in (number of student) - which here represents for the number of students who expected to make progress - for the 30 matched students in Group one was significant at a level of confidence of 99.9%, see Table 6.3. Given that the students had two weeks of tuition in the subject matter, with no prior tuition on the course in this subject, any other result would have been most surprising. Twenty nine of the thirty students evaluated themselves as having made progress in the subject. The full results are presented in Appendix F.

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0 ^a	0.000
	Positive Ranks	29 ^b	
	Ties	1 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.3: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Group one (learning style matches learning sequence)

6.2.3 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Group Two (Learning Style Not Matching Learning Sequence)

Again, to determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.2 shows for the 34 mis-matched students in Group two, 19 students believed they had increase their knowledge level, fifteen considered they knew as much after completing the online course as at the start, but no-one felt they knew less. The improvement was not significant at a level of confidence of 95%, but was significant at a level of confidence of 85% .

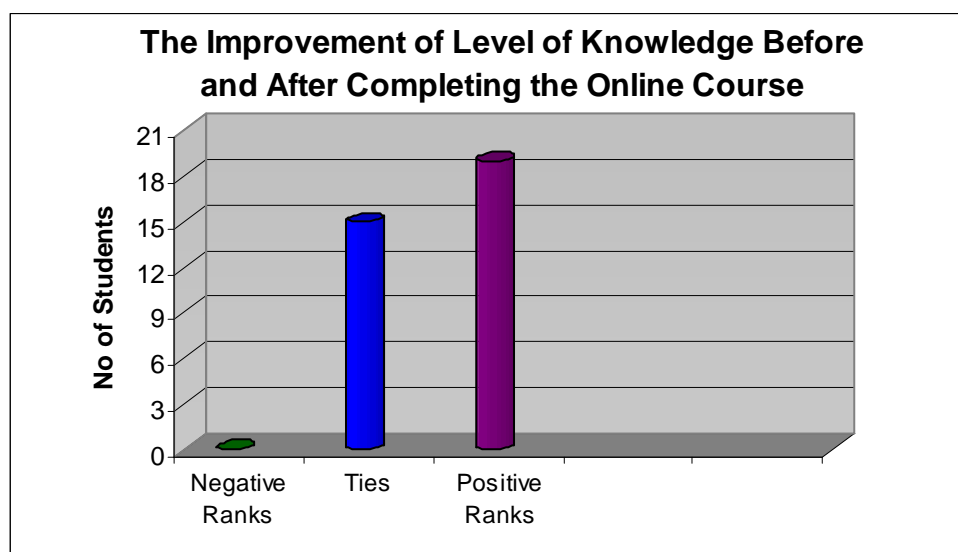


Figure 6.2: Group two - Improvement of Level of Knowledge Before and After Completing the Online course.

The Wilcoxon Signed Ranks Test showed that the increase in mean students' level of knowledge after completing the online course, for the 34 students in Group two who completed the questionnaire was significant at a level of confidence of 85%, see Table 6.4. The full results are presented in Appendix F

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0 ^a	0.000
	Positive Ranks	19 ^b	
	Ties	15 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.4: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Group two (learning style not matching learning sequence)

6.2.4 Differences Between Matched and Non-Matched Student Groups in Self-Assessment of Level of Knowledge Before Accessing the Online Course

The difference in student rankings of their levels of knowledge before beginning the online course were compared for the matched and non-matched students, see Figure 6.3. Obviously, most students in both groups felt they had little or no knowledge of the subject of Logic Gates, and there was no significant difference in the responses of the two groups.

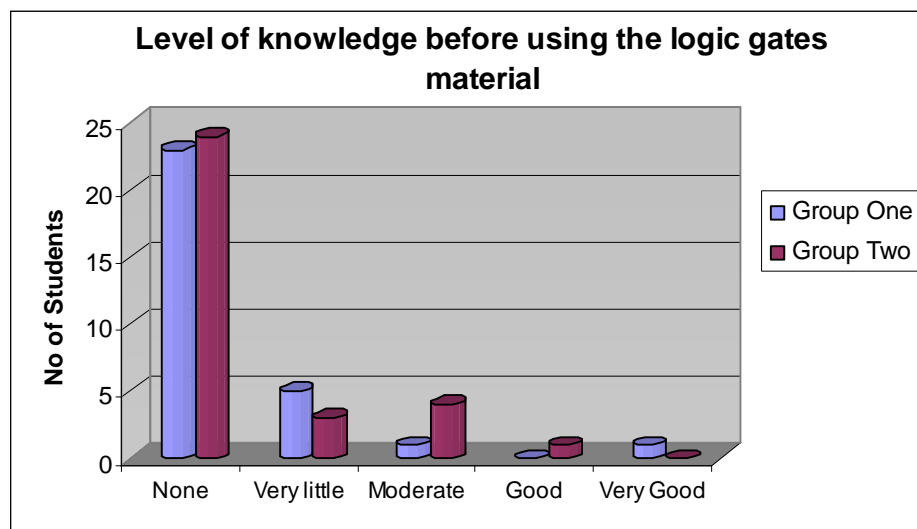


Figure 6.3: How students assessed their own level of relevant knowledge before accessing the online course

The non-parametric test (Mann-Whitney U) was used because the scores given by the students were ordinal data. The result of the test showed that there was no significant difference between the two groups in their self-assessed level of relevant knowledge before accessing the online course ($P>0.05$). This means that both groups of students started the course with no significant difference in perceived background knowledge of the course content, see Table 6.5. The full results are presented in Appendix F.

Group	Sample Size, N	Mean Score in level of knowledge before	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
GROUP one (Matched)	30	1.37	0.85	466.00	0.445
GROUP two (Mismatched)	34	1.62	1.10		

Table 6.5: Mann-Whitney U test for difference in level self-assessment of relevant knowledge before accessing the online course, matched and non-matched student.

6.2.5 Differences Between Matched and Non-Matched Student Groups in Self-Assessment of Level of Knowledge After Completing the Online Course

The difference in student rankings of their levels of knowledge after completing the online course were compared for the matched and non-matched students, see Figure 6.4. There is a clear tendency for the matched students to rate their increase in knowledge as greater than non-matched students. After completing the course the matched students rated their level of knowledge as good to very good, while for the non-matched students it was only moderate.

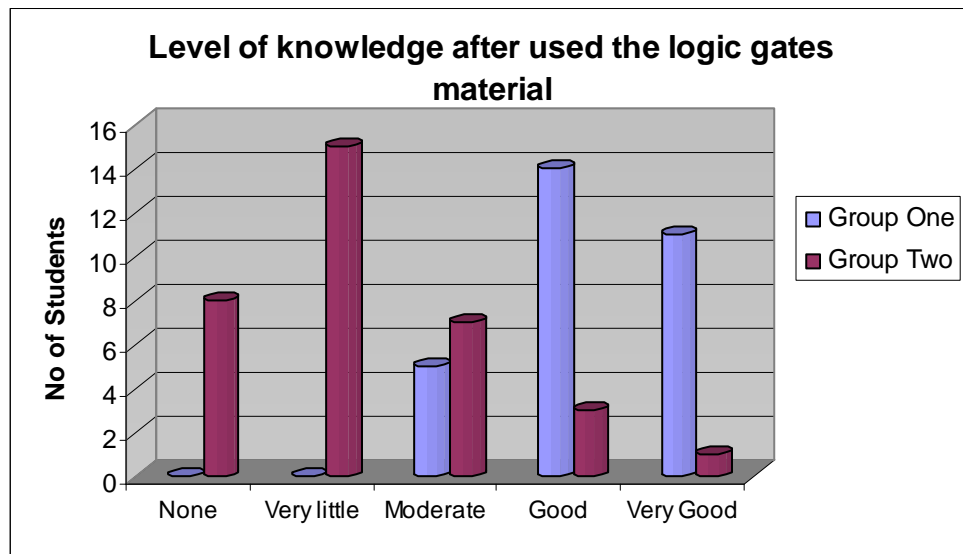


Figure 6.4: How students assessed their own level of knowledge after completing the online course

The Mann-Whitney U test was again used to analyse the ordinal data obtained. A significant difference was found in the level of knowledge between the two groups after completing the online course ($P < 0.001$). The difference showed that the matched students (Group one) considered that their average final level of knowledge was between Good and Very Good ($N=30$, $M=4.20$, $SD=0.71$), which was significantly higher than the non-matched students (Group two), who considered that their average final level of knowledge was between Very little and OK ($N=34$, $M=2.24$, $SD=1.01$), see Table 6.6. The full results are presented in Appendix F

Group	Sample Size, N	Mean Score in level of knowledge after	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	30	4.20	0.71	78.00	0.000
Group two (Mismatched)	34	2.24	1.01		

Table 6.6: Mann-Whitney U test for difference in level self-assessment of relevant knowledge after completing the online course, matched and non-matched student.

6.2.6 Differences between Matched and Non-Matched Student Groups in Level of Confidence that they Understood the Course Material

After completing the Post-test, the students were asked to fill in an evaluation questionnaire and record, on a five point scale, their level of confidence in their understanding of the online course material. The results showed that the matched students (Group one) considered that their average of level of confidence was between Moderate and Very Confident. The non-matched students (Group two) considered that their average level of confidence was between Very little and Confident. The results are shown in Figure 6.5.

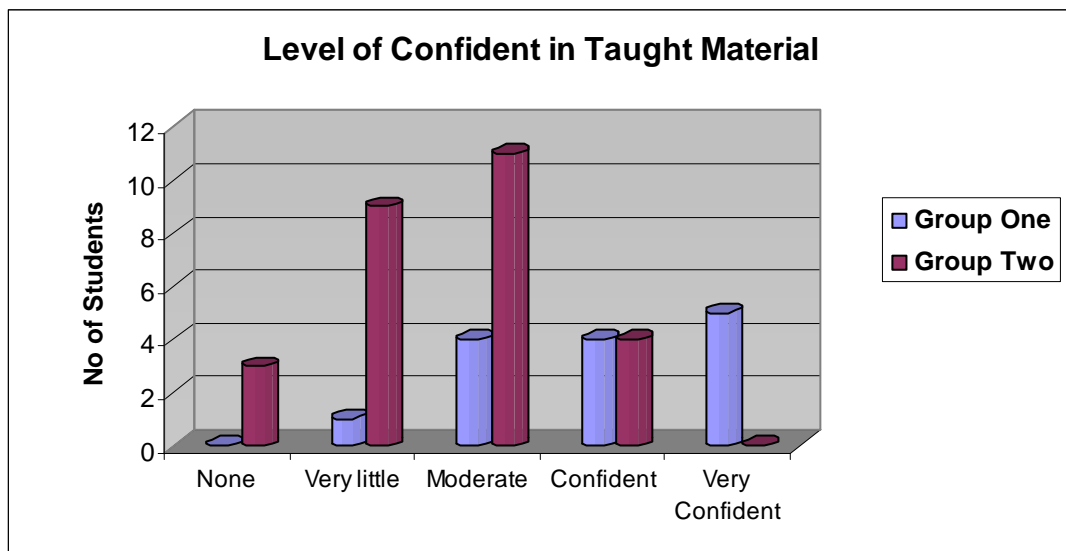


Figure 6.5: Students' level of confidence in their understanding of the online material

The result showed that there is significant difference ($P < 0.001$) between the two groups in their levels of confidence. The matched students (Group one) were, on average, Moderately Confident to Confident ($N=14$, $M=3.93$, $SD=0.99$) while the non-matched students (Group two) scored, on average, between Very Little Confidence and Moderately Confident ($N=27$, $M=2.59$, $SD=0.88$), see Table 6.7. Here the sample size in group one was only fourteen students because not all students answer this part of questionnaire. The full results are presented in Appendix F.

Group	Sample Size, N	Mean Score in Level of confident	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	14	3.93	0.99	65.50	0.000
Group two (Not-Matched)	27	2.59	0.88		

Table 6.7 Mann-Whitney U test for difference in students' level of confidence in material accessed on the online course, matched and non-matched students

6.2.7 Differences between Matched and Non-Matched Student Groups in Level of Interest

When the students finished the course they were asked to assess how well the course material kept them interested. The results are shown in Figure 6.6. The responses of the matched students (Group one) showed they were more interested in the online course, 97% were between Moderate and Good, 1 and one respondent (3%) recorded his interest as very good. For the non-matched (Group two), their average response was between Moderate and Good.

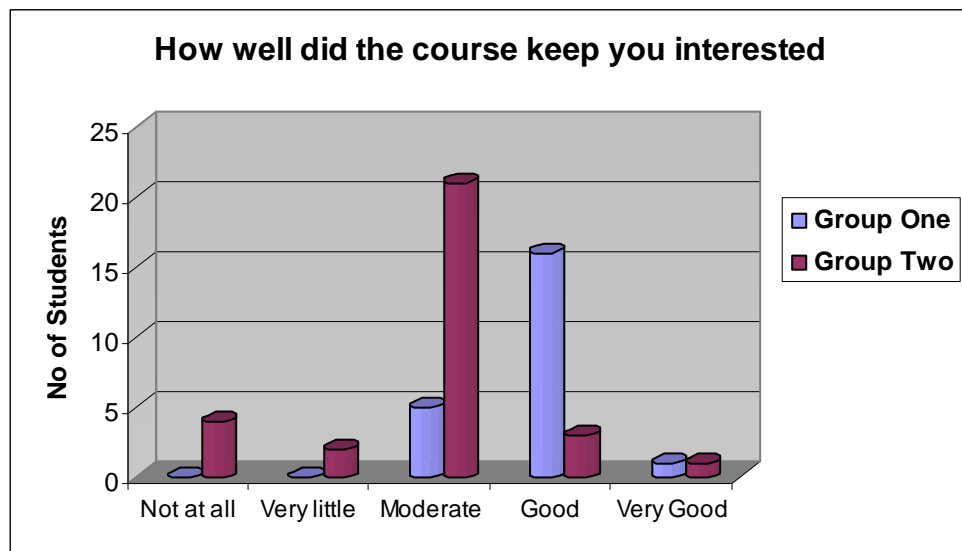


Figure 6.6: Students' level of interested in material accessed on the online course

Students were asked to rank their level of interest in the online course as presented to them. Table 6.8 the shows that there is significant difference between the two groups in their level of interest ($P < 0.001$). The average response of the matched students showed they were more interested in the online course, between Moderate and Good

($N=25$, $M=3.72$, $SD=0.54$) while the mean score for the non-matched group was between Very Little and Moderate ($N=31$, $M=2.84$, $SD=0.89$). Here the sample size in Groups one and two was twenty five and thirty respectively because not all students answer this part of questionnaire. The full results are presented in Appendix F.

Group	Sample Size, N	Mean Score in Level of interest	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	25	3.72	0.54	156.50	0.000
Group two (Mismatched)	31	2.84	0.89		

Table 6.8: Mann-Whitney U test for difference in students' level of interest in material accessed on the online course, matched and non-matched students

6.2.8 Differences between Matched and Non-Matched Student Groups in how Comfortable they felt with the Online Course

In this test the comparison was of how comfortable the students were with the way of online course was presented to them, because for each student learning style the material was presented differently. The average response of the matched students showed that 29 (97%) answered yes, while for the non-matched students only 14 (41%) said they were comfortable with the course. The results are shown in Figure 6.7.

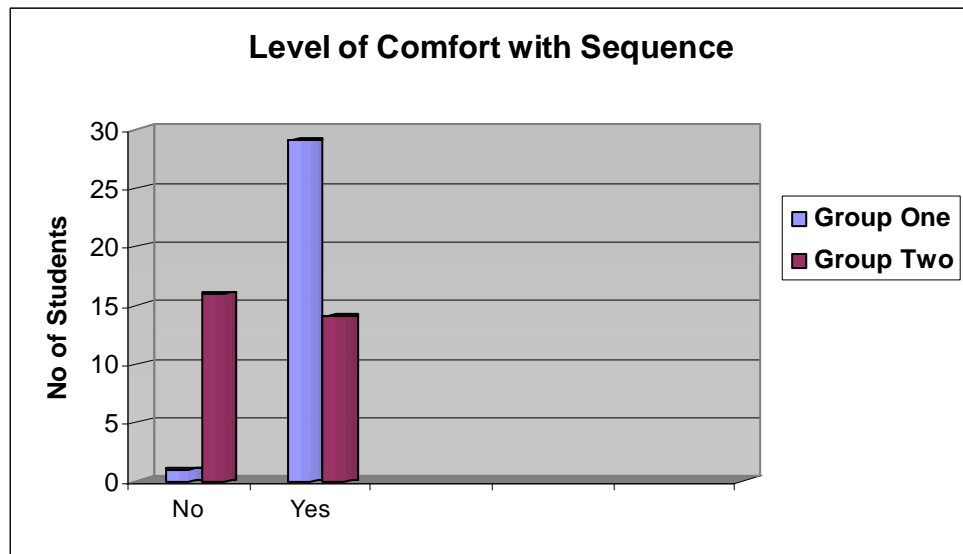


Figure 6.7 Level of Comfort with sequence that was presented to them.

In this test the comparison focused on how comfortable the students were with the way of online course was presented to them. There was significant difference between the two groups ($P < 0.001$) in how comfortable they felt with the online course. Table 6.9 shows that 29 of the 30 students whose learning style matched the course material were comfortable with the course ($N=30$, $M=1.96$, $SD=0.18$), while for the non-matched students only 14 said they were comfortable with the course ($N=30$, $M=1.46$, $SD=0.50$). The full results are presented in Appendix F.

Group	Sample Size, N	Mean Score in Level of comfortable	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	30	1.96	0.18	225.0	0.000
Group two (Mismatched)	30	1.46	0.50		

Table 6.9: Mann-Whitney U test for difference in students' level of comfort in Using the online learning course, matched and non-matched students

6.3 Evaluation by Learning Styles:

This part of the data analysis focuses on the differences matching and non-matching had on students with a given learning style (Activist, Pragmatist, Reflector and Theorist). It begins with the comparison marks obtained in the Pre- and Post-tests , a comparison of the difference in the level of knowledge before accessing the online course and the level of knowledge after completing the online course. The results also include differences in the level of self-confidence, the level of interest, the level of comfort with the online course. In addition, the analysis will present the results of correlation tests between learning sequence and student responses.

6.3.1 Activist Learning Style

It was found that 22 of the 64 students in the sample were Activists, and of these 10 were in Group one (Matched) and 12 were in Group two (Non-matched).

6.3.1.1 Differences in Pre- and Post-Test Marks between Matched and Non-Matched Students

Table 6.10 shows there was no significant difference in mean marks awarded the matched and non-matched groups in the Pre-test ($t=1.58$, $P > 0.05$). However, the t-test did show there was significant difference between mean marks for Activist learners in the two groups in the Post-test ($t=8.12$, $P < 0.001$). In the Post-test Activist learners in Group one scored significantly higher ($N=10$, $M=3.00$, $SD=0.00$) than Activist learners in Group two ($N=12$, $M=1.00$, $SD=0.85$), see Table 6.10. The full results are presented in Appendix F

Test type	Group	Sample size, N	Mean score	Standard deviation, SD	t-test (Equal Variances Not Assumed)		
					Mean Difference	t	Asymp. Sig. (2-tailed)
Pre-test	Group one (Matched)	10	2.20	1.81	1.11	1.55	0.13
	Group two (Mismatched)	12	1.08	1.51			
Post-test	Group one (Matched)	10	3.00	0.00	2.00	8.12	0.00
	Group two (Mismatched)	12	1.00	0.85			

Table 6.10: Activist learning style - difference between mean marks for Pre- and Post-tests

6.3.1.2 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Activist (Learning Style Matching Learning Sequence) .

To determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.8 shows for the 10 matched students in Group one, all students believed they had increase their knowledge level, The improvement is significant at a level of confidence of 100%.

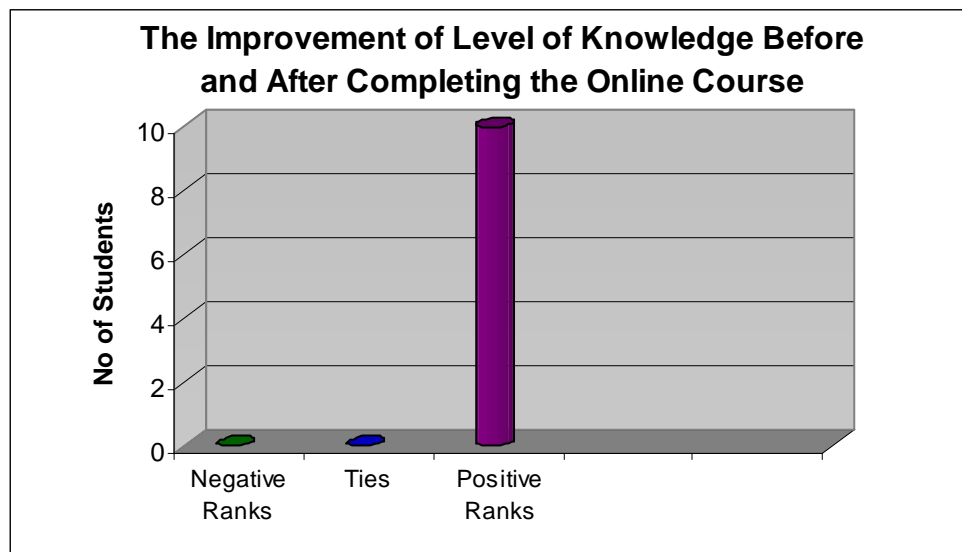


Figure 6.8: Group one, Improvement of Level of Knowledge Before and After Completing the Online course, according to Activist learning style

a Wilcoxon Signed Ranks Test was carried out. This showed that the increase in (number of student) - which here represents for the number of students who expected to make progress - for the 10 Activist students with Matched was significant at a level of confidence of 100%, see Table 6.11. Given that the students had two weeks of tuition in the subject matter, with no prior tuition on the course in this subject, any other result would have been most surprising. All students evaluated themselves as having made progress in the subject. The full results are presented in Appendix F.

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0 ^a	0.004
	Positive Ranks	10 ^b	
	Ties	0 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.11: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Group one (learning style matches learning sequence)

6.3.1.3 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Activist (Learning Style Not Matching Learning Sequence).

Again, to determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.9 shows for the 12 Mis-matched students, 6 students believed they had increase their knowledge level, 6 considered they knew as much after completing the online course as at the start, but no-one felt they knew less.

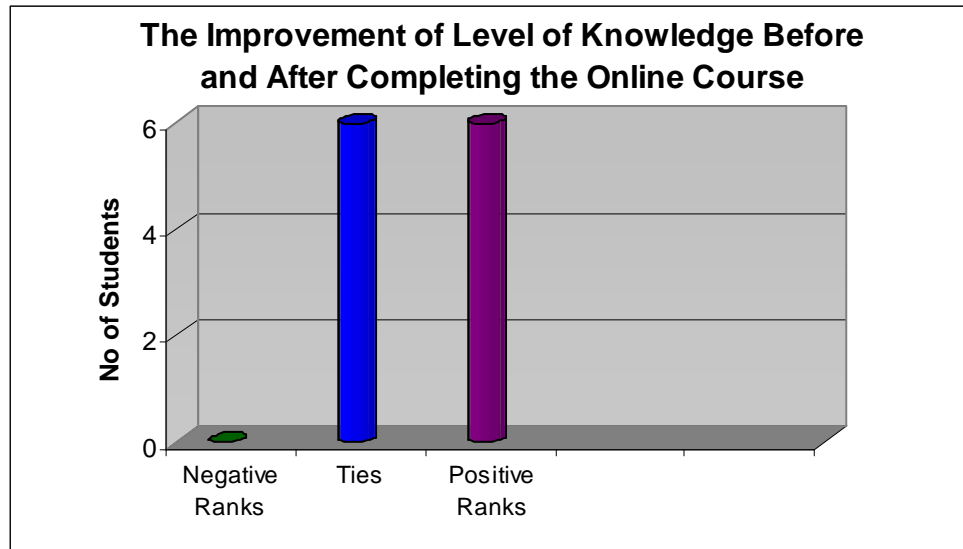


Figure 6.9: Group two - Improvement of Level of Knowledge Before and After Completing the Online course, according to Activist learning style

The Wilcoxon Signed Ranks Test showed that the increase in mean students' level of knowledge after completing the online course, for the 12 students who completed the questionnaire was significant at a level of confidence of 50%, see Table 6.12. The full results are presented in Appendix F

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0 ^a	0.02
	Positive Ranks	6 ^b	
	Ties	6 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.12: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Group two (learning style not matching learning sequence)

6.3.1.4 Differences in Self-Assessment between Matched and Non-matched Students before Accessing the Online Course

Generally, Activist students in the two groups started the course with None or Very little knowledge of logic gates, see figure 6.10.

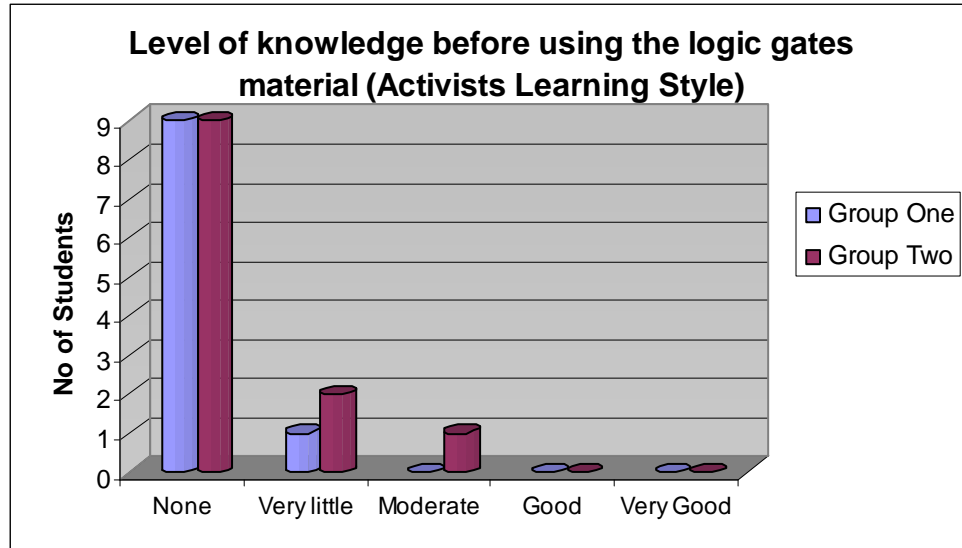


Figure 6.10: How students assessed their own level of relevant knowledge before accessing the online course

The result of the Mann-Whitney U test showed that there was no significant difference between Activist learners in the two groups in their self-assessed level of knowledge before accessing the online course ($P > 0.05$) see Table 6.13. The full results are presented in Appendix F.

Group	Sample Size, N	Mean score in level of knowledge before course (self-assessment)	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group One (Matched)	10	1.10	0.32	50.50	0.35
Group Two (Mismatched)	12	1.33	0.65		

Table 6.13: Activist learning style - differences in self-assessment before accessing the online course

6.3.1.5 Differences in Self-Assessment of Level of Knowledge between Matched and Non-Matched Students After Completing the Online Course.

There is a clear tendency for the matched Activist students to rate their increase in knowledge as greater than non-matched students, see Figure 6.11. The results showed that after completing the online course Activist learners in group one (matched) assessed their level of knowledge as, on average, between Good and Very Good, while Activist learners in Group two (non-matched), assessed their level of knowledge as between None and Very Little.

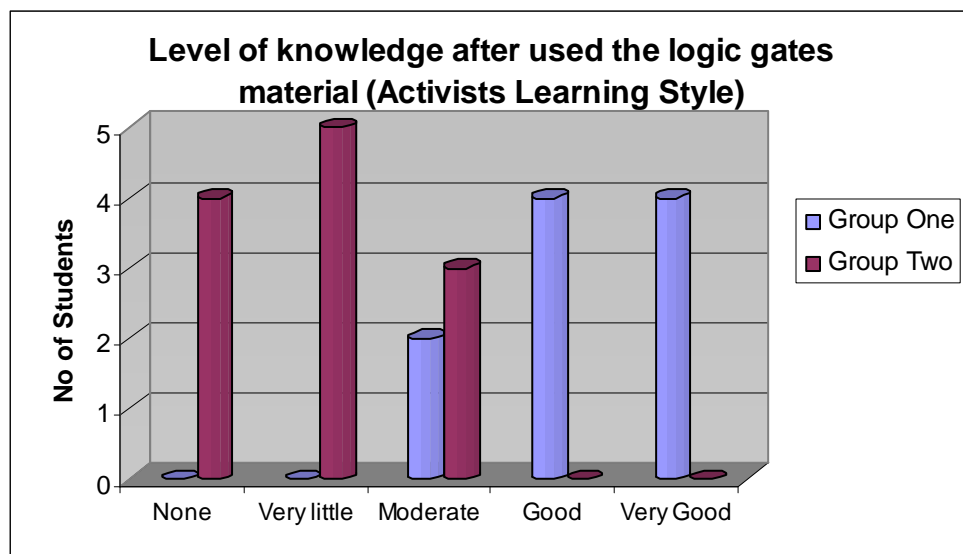


Figure 6.11: How students assessed their own level of knowledge after completing the online course

The Mann-Whitney U test shows a significant difference between Activist learners in the two groups in their level of knowledge after completing the online course ($P < 0.001$). The difference showed that Activist learners where the sequence of delivery in the online course matched their learning style assessed their level of knowledge significantly higher, on average, between Good and Very Good ($N=10$, $M=4.20$, $SD=0.79$), than did the Activist learners in Group two, who assessed their level of knowledge as between None and Very Little ($N=12$, $M=1.92$, $SD=0.79$), see Table 6.14. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of knowledge after (self-assessment)	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	10	4.20	0.79	3.00	0.000
Group two (Mismatched)	12	1.92	0.79		

Table 6.14: Activist learning style - differences in student self-assessment of level of knowledge after completing the course.

6.3.1.6 Differences in Level of Confidence between Matched and Non-Matched Students

The results showed that Activist learners in Group one (matched) were more confident, scoring on average between Confident and Very Confident, than the Activist learners in Group two (non-matched), who scored between Very Little and Moderate. The results are shown in Figure 6.12.

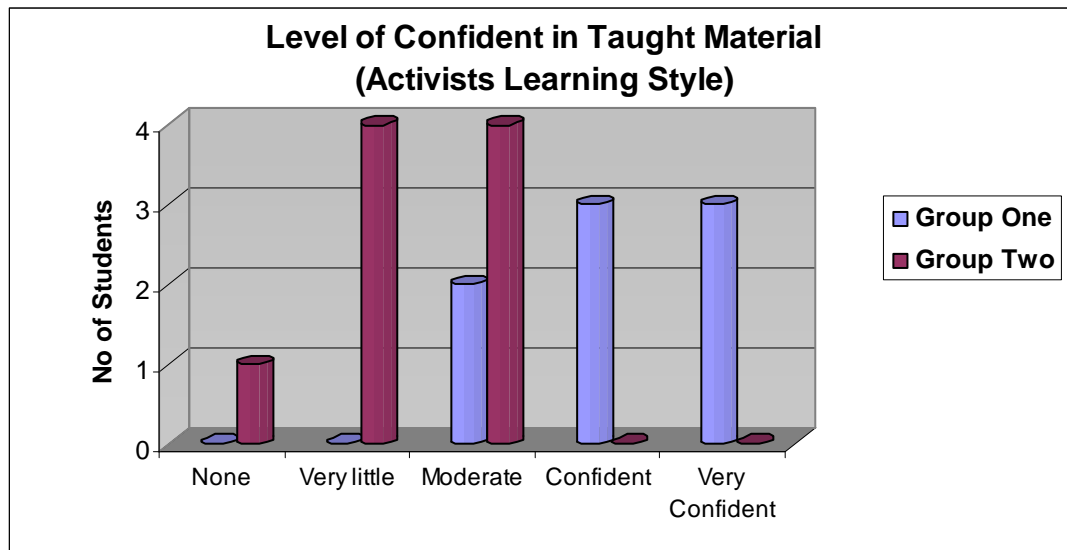


Figure 6.12: Students' level of confidence in their understanding of the online material

The results show there is significant difference in the mean levels of confidence between the Activist learners in the two groups ($P < 0.01$). Activist learners in Group one were significantly more confident, between Confident and Very Confident ($N=8$, $M=4.13$, $SD=0.83$) while the Activist learners in Group two scored between Very little and Moderate ($N=9$, $M=2.33$, $SD=0.71$), see Table 6.15. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of confidence	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	8	4.13	0.83	4.00	0.001
Group two (Mismatched)	9	2.33	0.71		

Table 6.15: Activist learning style - differences between students' level of confidence that they have understood the course material.

6.3.1.7 Differences in Level of Interest Between Matched and Non-Matched Students.

The results show that there is a difference between the levels of interest of the Activist learners in the two groups. The Activist learners in Group one (matched) were, on average, more interested in the learning sequence used, between Moderate and Good, than the Activist learners in Group two who scored between Very little and Moderate, see Figure 6.13.

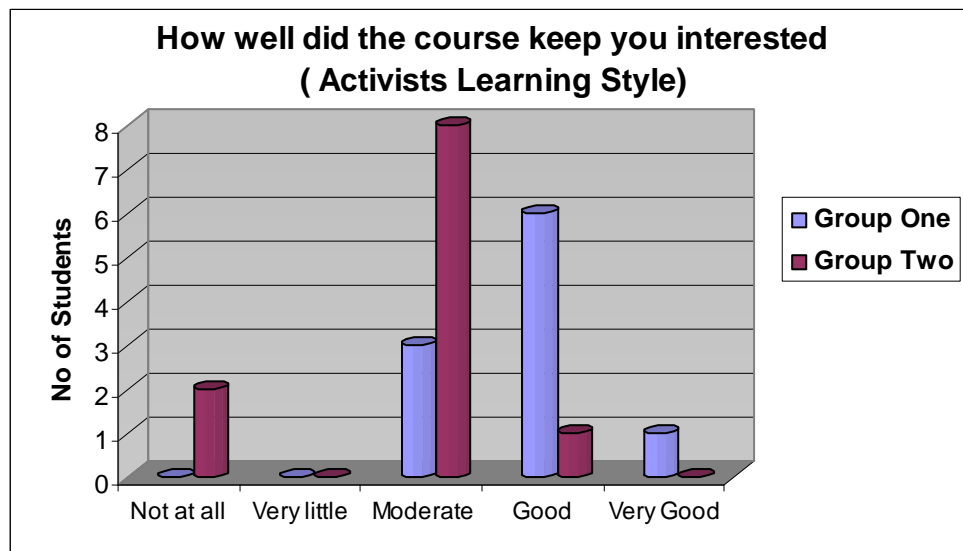


Figure 6.13: Students' level of interested in material accessed on the online course

Table 6.16 shows that there is significant difference between the levels of interest of the Activist learners in the two groups ($P < 0.01$). The Activist learners in Group one were, on average, more interested in the learning sequence used, between Moderate and Good ($N=10$, $M=3.80$, $SD=0.63$), while the Activist learners in Group two scored between Very little and Moderate ($N=11$, $M=2.73$, $SD=0.91$). The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of interest	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	10	3.80	0.63	18.00	0.004
Group two (Mismatched)	11	2.73	0.91		

Table 6.16: Activist learning style - differences between students' level of interest in the course material

6.3.1.8 Difference in Level of Comfort with Course Material between Matched and Non-Matched Students

100% of the matched Activists answered, yes, they were comfortable with the course, while for the non-matched students only six said they were comfortable with the course. The results are shown in Figure 6.14.

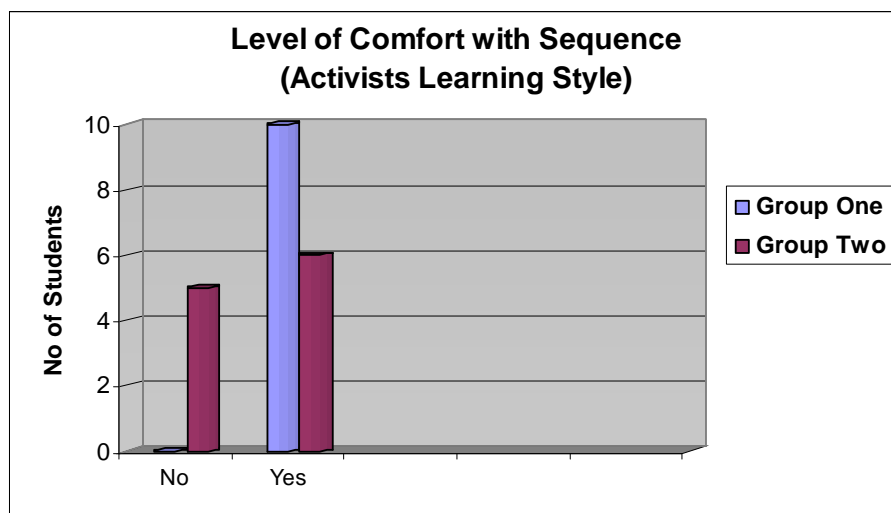


Figure 6.14: Students' level of comfort with sequence that was presented to them

There was significant difference in how comfortable the Activist learners in the two groups felt while they used the online course ($P < 0.05$). As shown in Table 6.17 the Activist learners in Group one were more comfortable with the course, all of them answered: Yes, (N=10, M=2.00, SD= Zero), but of the eleven Activist learners in Group two who responded, five answered No (N=11, M=1.15, SD=0.52). The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of comfort	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	10	2.00	0	30.00	0.02
Group two (Mismatched)	11	1.15	0.52		

Table 6.17: Activist learning style - differences between students' level of comfort with the course material

6.3.2 Pragmatist Learning Style

It was found that 15 of the 64 students in the sample were Pragmatists, and of these 6 were in Group one (Matched) and 9 were in Group two (Non-matched).

6.3.2.1 Differences in Pre- and Post-Test Marks between Matched and Non-Matched Students

Table 6.18 shows no significant difference in mean marks awarded in the Pre-test ($t=0.73$, $P > 0.01$). However, the t-test did show there was significant difference between mean marks for Pragmatist learners in the two groups in the Post-test ($t=3.45$, $P < 0.05$). In the Post-test, Pragmatist learners in Group one scored significantly higher (N=6, M=2.50, SD=0.54) than Activist learners in Group two (N=9, M=1.00, SD=1.12), see Table 6.19. The full results are presented in Appendix F.

Test type	Group	Sample size, N	Mean score	Standard deviation, SD	t-test (Equal Variances Not Assumed)		
					Mean Difference	t	Asymp. Sig. (2-tailed)
Pre-test	Group one (Matched)	6	2.16	1.47	0.61	0.73	0.47
	Group two (Mismatched)	9	1.55	1.74			
Post-test	Group one (Matched)	6	2.50	0.54	1.50	3.45	0.005
	Group two (Mismatched)	9	1.00	1.12			

Table 6.18: Pragmatist learning style - difference between mean marks for Pre- and Post-tests

6.3.2.2 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Pragmatist (Learning Style Matching Learning Sequence) .

To determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.15 shows for the 6 matched students, all students believed they had increase their knowledge level, The improvement is significant at a level of confidence of 100%.

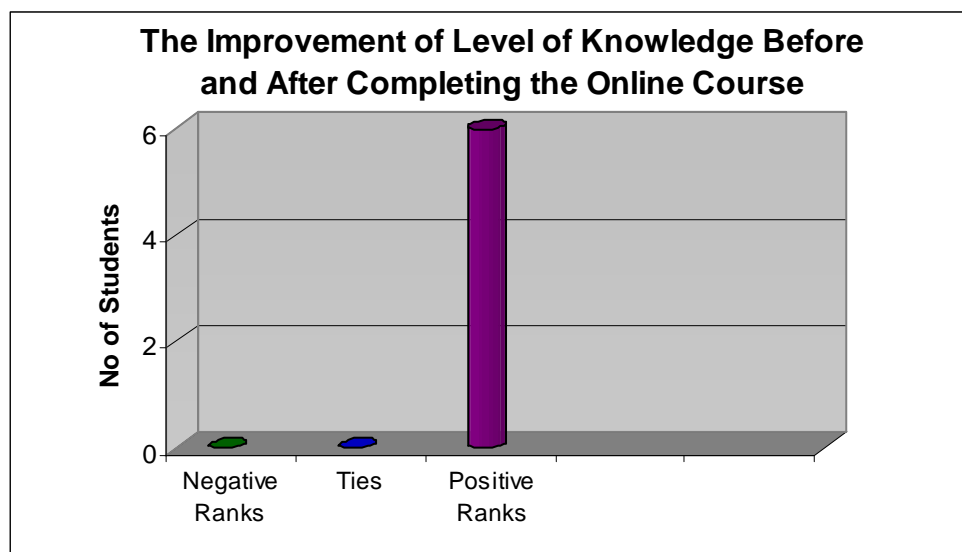


Figure 6.15: Group one, Improvement of Level of Knowledge Before and After Completing the Online course.

a Wilcoxon Signed Ranks Test was carried out. This showed that the increase in (number of student) - which here represents for the number of students who expected to make progress - for the 6 matched students were significant at a level of confidence of 100%, see Table 6.19. Given that the students had two weeks of tuition in the subject matter, with no prior tuition on the course in this subject, any other result would have been most surprising. all students evaluated themselves as having made progress in the subject. The full results are presented in Appendix F.

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0 ^a	0.02
	Positive Ranks	6 ^b	
	Ties	0 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.19: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Pragmatist learning style (learning style matches learning sequence)

6.3.2.3 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Pragmatist (Learning Style Not Matching Learning Sequence)

Again, to determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.16 shows for the 9 Mis-matched students in Group two, 5 students believed they had increase their knowledge level, 4 considered they knew as much after completing the online course as at the start, but no-one felt they knew less.

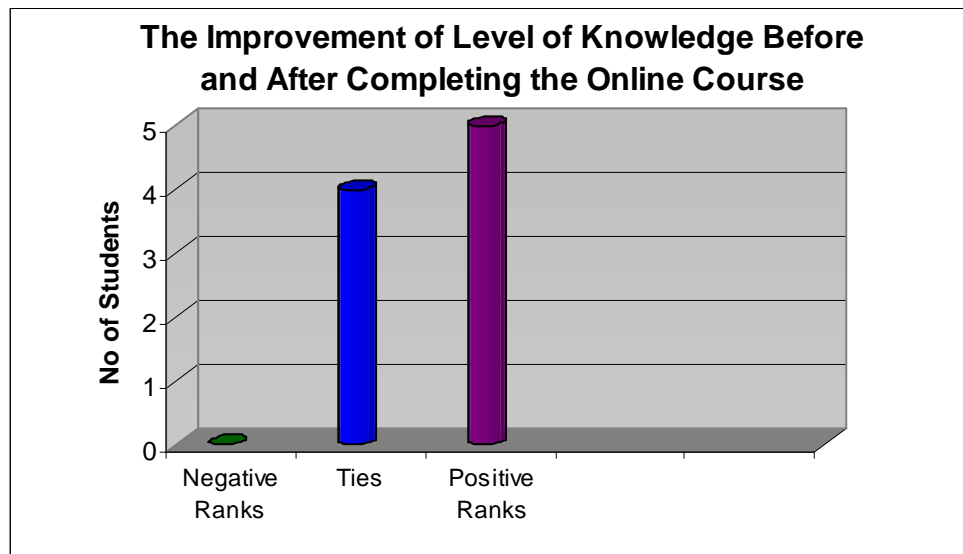


Figure 6.16: Group two - Improvement of Level of Knowledge Before and After Completing the Online course.

The Wilcoxon Signed Ranks Test showed that the increase in mean students' level of knowledge after completing the online course, for the 9 students who completed the questionnaire was significant at a level of confidence of 96%, see Table 6.20. The full results are presented in Appendix F

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0 ^a	0.03
	Positive Ranks	5 ^b	
	Ties	4 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.20: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Pragmatist learning style (learning style not matching learning sequence)

6.3.2.4 Differences in Self-Assessment between Matched and Non-matched Students Before Accessing the Online Course

Pragmatist students in the two groups started the course with no significant difference in their levels of background knowledge about the course content, see Figure 6.17.

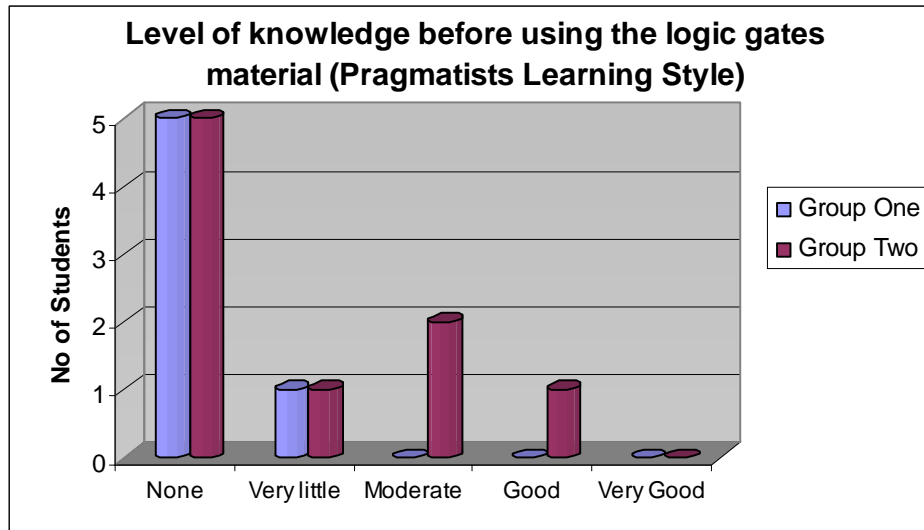


Figure 6.17: How students assessed their own level of relevant knowledge before accessing the online course

The result of the Mann-Whitney U test showed that there was no significant difference between Pragmatist learners in the two groups in their self-assessed level of knowledge before accessing the online course ($P > 0.05$), see Table 6.21. The full results are presented in Appendix F.

Group	Sample Size, N	Mean score in level of knowledge before course (self-assessment)	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	6	1.17	0.41	18.00	0.20
Group two (Mismatched)	9	1.89	1.16		

Table 6.21: Pragmatist learning style - differences between self-assessment before accessing the online course

6.3.2.5 Differences in Self-Assessment of Level of Knowledge between Matched and Non-Matched Students after Completing the Online Course

The Pragmatist learners in group one (matched) assessed their level of knowledge after completing the online course, on average, as between Good and Very Good, while group two (non-matched) assessed their mean level as between Very little and Moderate, see Figure 6.18.

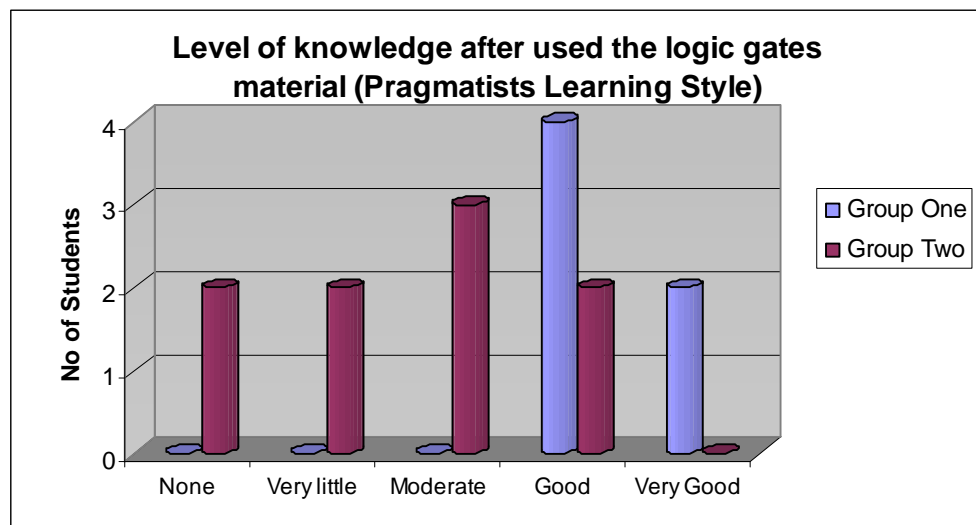


Figure 6.18: How students assessed their own level of knowledge after completing the online course

The Mann-Whitney U test shows a significant difference between Pragmatist learners in the two groups in their level of knowledge after completing the online course ($P < 0.001$). Group one assessed their mean level of knowledge significantly higher, ($N=6$, $M=4.33$, $SD=0.52$), than Group two ($N=9$, $M=2.56$, $SD=1.13$), see Table 6.22 The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of knowledge after (self-assessment)	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	6	4.33	0.52	4.00	0.005
Group two (Mismatched)	9	2.56	1.13		

Table 6.22: Pragmatist learning style - differences in student self-assessment of level of knowledge after completing course

6.3.2.6 Differences in Level of Confidence between Matched and Non-Matched Students

No Pragmatist in Group one answered this question. The results are shown in Figure 6.19.

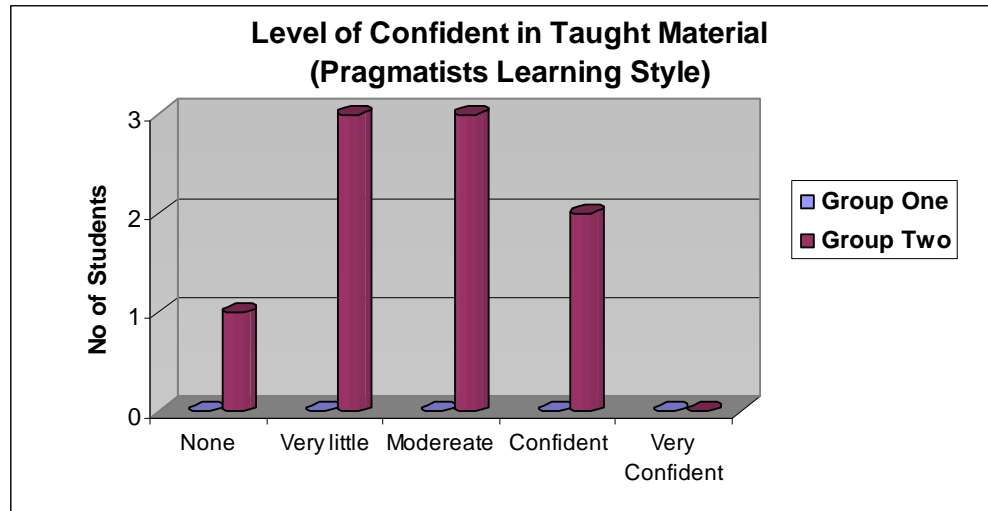


Figure 6.19: Students' level of confidence in their understanding of the online material

As no student in Group one responded no comparison tests could be carried out, see Table 6.23. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of confidence	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	0	-	-	-	-
Group two (Mismatched)	9	2.67	1.00		

Table 6.23: Pragmatist learning style - differences between students' level of confidence that they have understood the course material

6.3.2.7 Differences in Level of Interest between Matched and Non-Matched Students

All The Pragmatist learners in Group one answered Good, while the Pragmatist learners in Group two scored, on average, between Very Little and Good, see Figure 6.20.

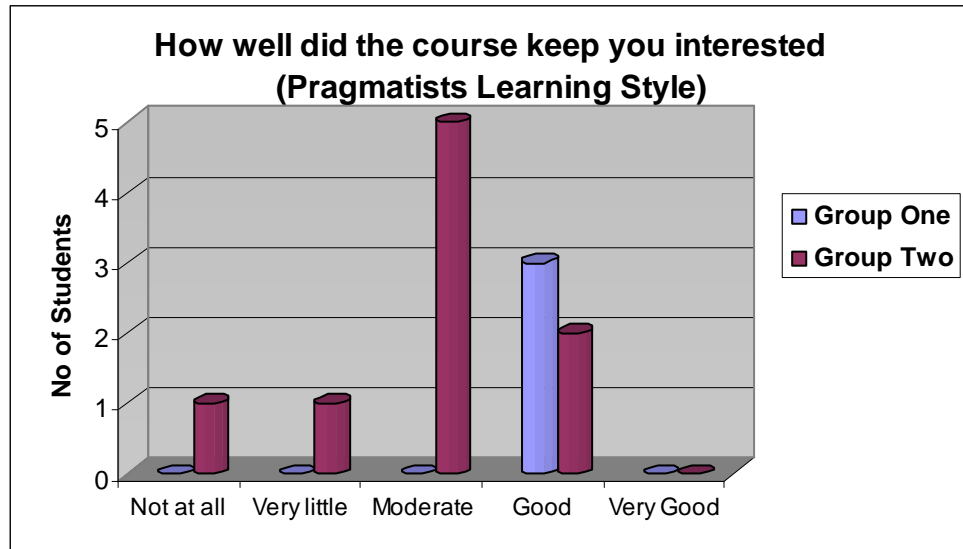


Figure 6.20: Students' level of interested in material accessed on the online course

Table 6.24 shows that there is significant difference between the levels of interest of the Pragmatist learners in the two groups ($P < 0.05$). The Pragmatist learners in Group one were, on average, more interested in the learning sequence used, all answered Good (N=3, M=4, SD=0), while the mean score for Pragmatist learners in Group two was between Very Little and Moderate (N=9, M=2.88, SD=0.99). The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of interest	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	3	4	0	3.00	0.04
Group two (Mismatched)	9	2.88	0.99		

Table 6.24: Pragmatist learning style - differences between students' level of interest in the course material

6.3.2.8 Difference in Level of Comfort with Course Material between Matched and Non-Matched Students

The students self assessment whether or not they felt comfortable with the material of the online course. The Pragmatist learners in Group one were, on average, more comfortable with the sequence that was presented to them, all of them answered Yes, but of the eight Pragmatist learners in Group two who responded, six said No as shown in Figure 6.21.

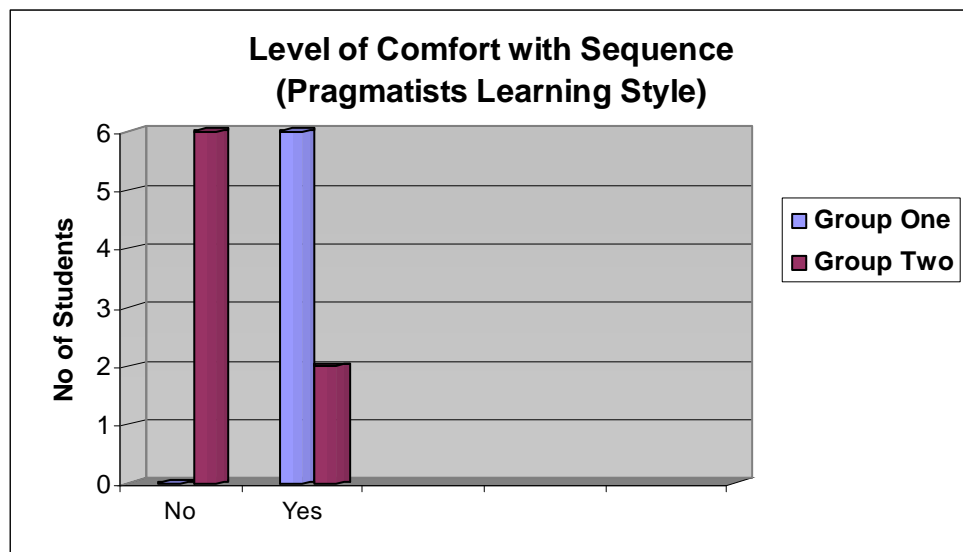


Figure 6.21: Students' level of comfort with sequence that was presented to them

There was significant difference in how comfortable the Pragmatist learners in the two groups felt while they used the online course ($P < 0.01$). As shown in Table 6.25 the Pragmatist learners in Group one were, on average, more comfortable with the course, all of them answered Yes, ($N=6$, $M=2.00$, $SD=0$), but for the eight Pragmatist learners in Group two only two were comfortable with the course ($N=8$, $M=1.25$, $SD=0.46$). The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of comfort	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	6	2.00	0	6.00	0.007
Group two (Mismatched)	8	1.25	0.46		

Table 6.25: Pragmatist learning style - differences between students' level of comfort with the course material.

6.3.3 Reflector Learning Style

It was found that only 9 of the 64 students in the sample were Reflectors, and of these 5 were in Group one (Matched) and 4 were in Group two (Non-matched).

6.3.3.1 Differences in Pre- and Post-Test Marks between Matched and Non-Matched Students

The t-test (equal variances not assumed) found no significant differences between the matched and non-matched groups, see Table 6.26. The full results are presented in Appendix F.

Test type	Group	Sample size, N	Mean score	Standard deviation, SD	t-test (Equal Variances Not Assumed)		
					Mean Difference	t	Asymp. Sig. (2-tailed)
Pre-test	Group one (Matched)	5	1.00	1.41	0.50	0.44	0.68
	Group two (Mismatched)	4	1.50	1.91			
Post-test	Group one (Matched)	5	2.40	0.54	0.15	0.43	0.68
	Group two (Mismatched)	4	2.25	0.50			

Table 6.26: Reflector learning style - difference between mean marks for Pre- and Post-tests

6.3.3.2 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Reflector (Learning Style Matching Learning Sequence) .

To determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.22 shows for the 5 matched students, all students believed they had increase their knowledge level, but no-one felt they knew less.

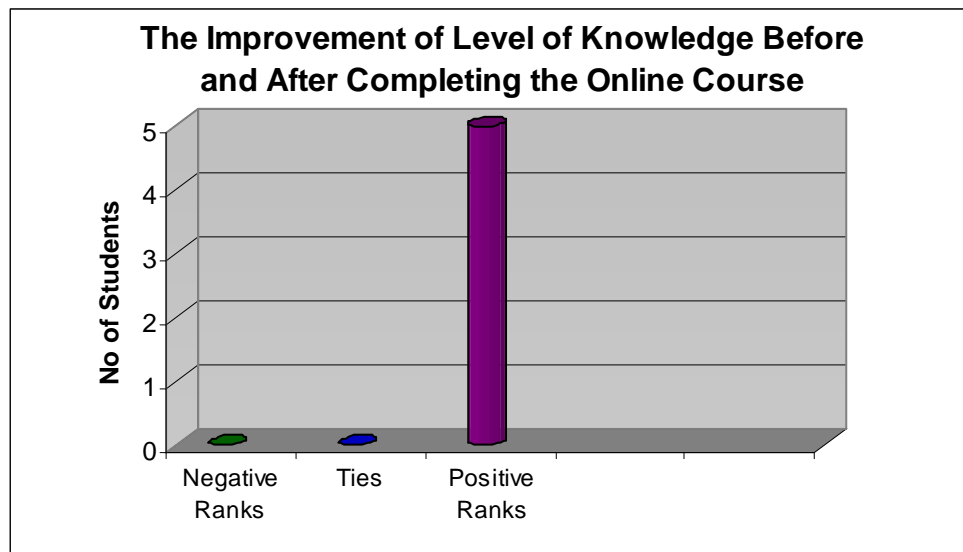


Figure 6.22: Group one, Improvement of Level of Knowledge Before and After Completing the Online course.

a Wilcoxon Signed Ranks Test was carried out. This showed that the increase in (number of student) - which here represents for the number of students who expected to make progress - for the 5 matched students were significant at a level of confidence of 100%, see Table 6.27. Given that the students had two weeks of tuition in the subject matter, with no prior tuition on the course in this subject, any other result would have been most surprising. all themselves as having made progress in the subject. The full results are presented in Appendix F.

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0 ^a	0.04
	Positive Ranks	5 ^b	
	Ties	0 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.27: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Reflector learning style (learning style matches learning sequence)

6.3.3.3 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Reflector (Learning Style Not Matching Learning Sequence)

Again, to determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.23 shows for the 4 Mis-matched students, 2 students believed they had increase their knowledge level, 2 considered they knew as much after completing the online course as at the start, but no-one felt they knew less.

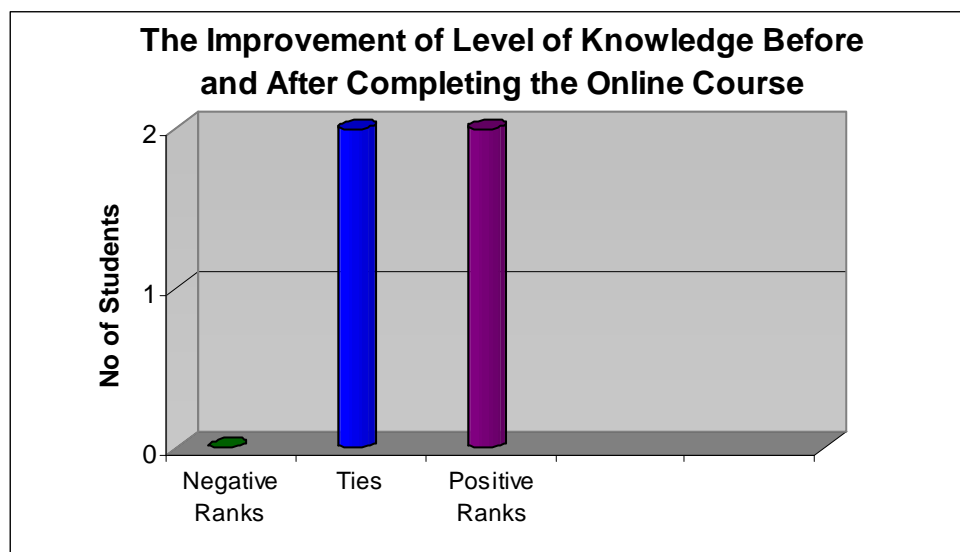


Figure 6.23: Reflector - Improvement of Level of Knowledge Before and After Completing the Online course.

The Wilcoxon Signed Ranks Test showed that the increase in mean students' level of knowledge after completing the online course, for the 4 students who completed the questionnaire was no significant different, see Table 6.28. The full results are presented in Appendix F

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0 ^a	0.15
	Positive Ranks	2 ^b	
	Ties	2 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.28: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Reflector learning style (learning style not matching learning sequence)

6.3.3.4 Differences in Self-Assessment between Matched and Non-matched Students before Accessing the Online Course

With such a small number of Reflector students, significant comparisons would not be expected, and this is what we find. Three of Group one students considered they started the course with no knowledge of logic gates and two with very little, see Figure 6.24. In Group two, two students began with no knowledge, and one each with moderate or a good knowledge of the subject matter.

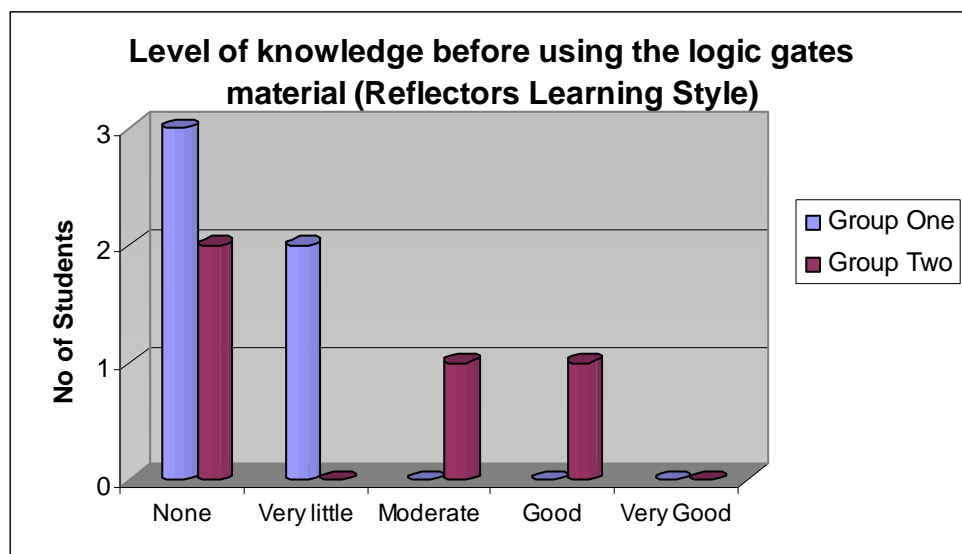


Figure 6.24: How students assessed their own level of relevant knowledge before accessing the online course

The result of the Mann-Whitney U test showed that there was no significant difference between Reflector learners in the two groups in their self-assessed level of knowledge before accessing the online course ($P > 0.05$), see Table 6.29. The full results are presented in Appendix F.

Group	Sample Size, N	Mean score in level of knowledge before course (self-assessment)	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	5	1.40	0.55	7.00	0.42
Group two (Mismatched)	4	2.25	1.50		

Table 6.29: Reflector learning style - differences between self-assessment before accessing the online course

6.3.3.5 Differences in Self-Assessment of Level of Knowledge between Matched and Non-Matched Students after Accessing the Online Course

This test evaluated the difference between the Reflector learners in the two groups in their self-assessment of their level of knowledge after completing the online course. In Group one (matched) their level of knowledge was, on average, between Moderate and Good, while in Group two (non-matched) 50% they tended to assess their level of knowledge after the course as Very little, see Figure 6.25.

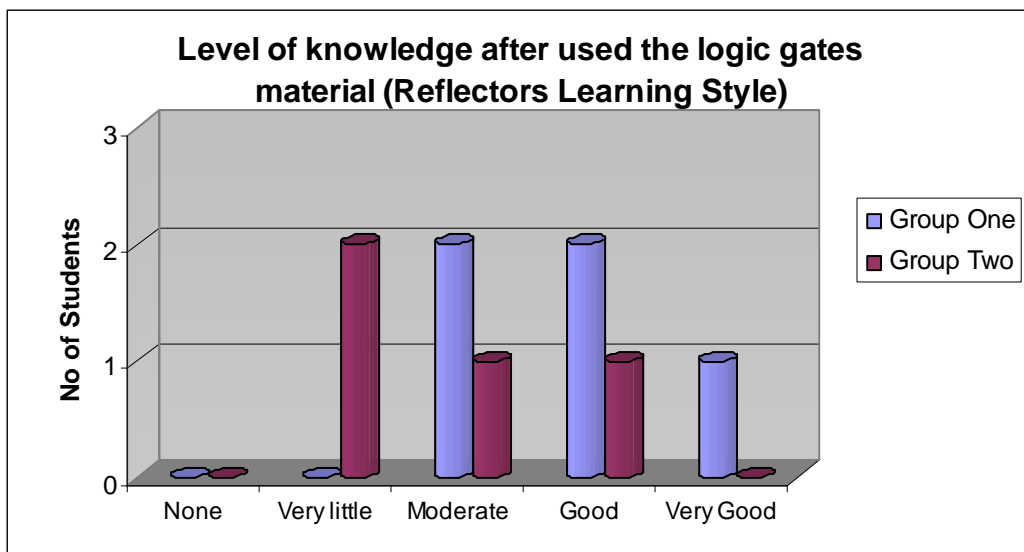


Figure 6.25: How students assessed their own level of knowledge after completing the online course

The Mann-Whitney U test showed no significant difference between Reflector learners in the two groups in their level of knowledge after completing online course ($P > 0.05$). Whether this was due to the small sample size or whether Reflector learners are more adaptable than other learning types needs further investigation, see Table 6.30. Full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of knowledge after (self-assessment)	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	5	3.80	0.84	4.00	0.13
Group two (Mismatched)	4	2.75	0.92		

Table 6.30: Reflector learning style - differences in student self-assessment of level of knowledge after completing the course

6.3.3.6 Differences in Level of Confidence between Matched and Non-Matched Students

The responses from groups of Reflector students showed exactly the same distribution, see Figure 6.26.

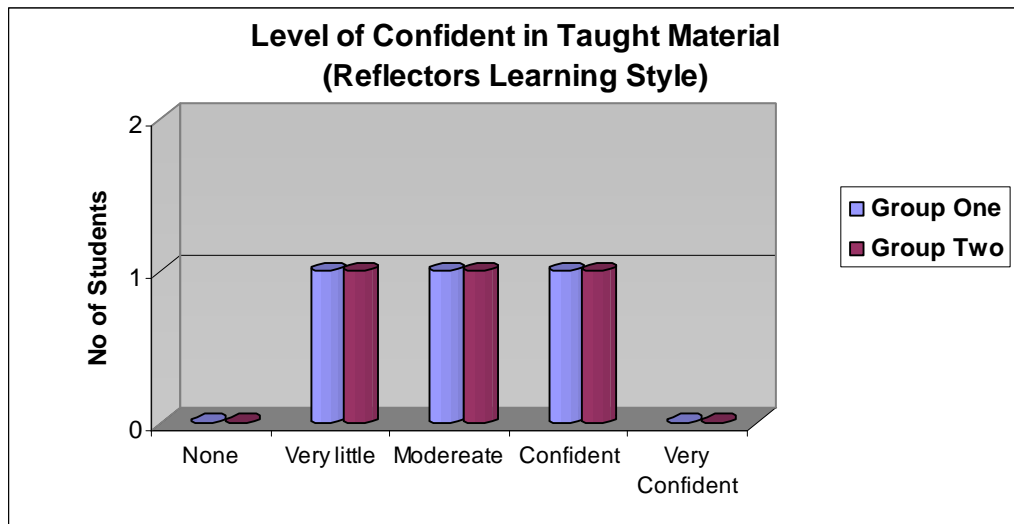


Figure 6.26: Students' level of confidence in their understanding of the online material

No significant difference was found between Reflector type learners in the two student groups in their level of confidence in the course material ($P > 0.05$). Most likely this was due to the small sample size, but both matched and unmatched students obtaining the same mean scores could be taken to suggest that this learning style is more flexible, see Table 6.31. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of confidence	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	3	3.00	1.00	4.50	1.00
Group two (Mismatched)	3	3.00	1.00		

Table 6.31: Reflector learning style - differences between students' level of confidence

6.3.3.7 Differences in Level of Interest between Matched and Non-Matched Students

Both groups self-assessed their mean level of interested as about Moderate, see Figure 6.27. It is clear that if both groups expressed the same level of interest it would support the argument that Reflectors are flexible learners.

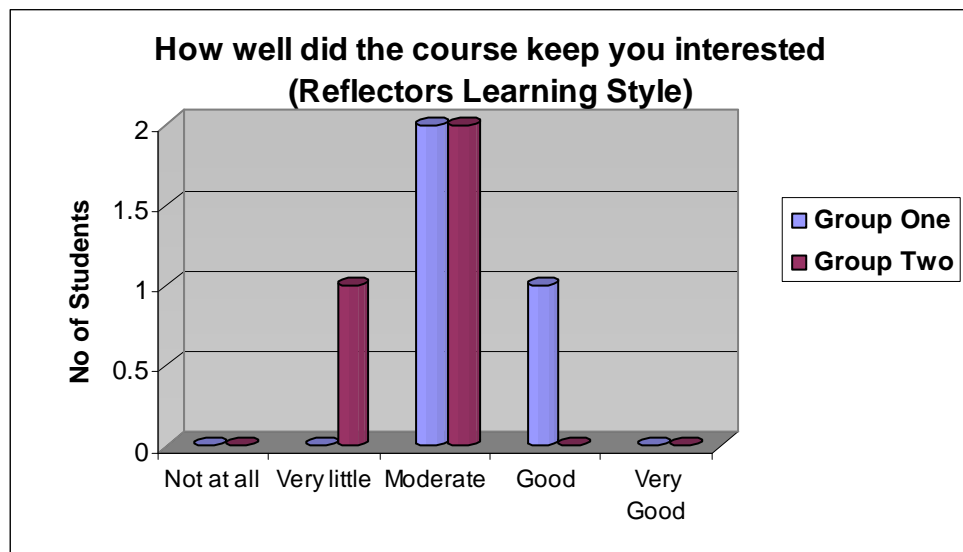


Figure 6.27: Students' level of interested in material accessed on the online course

Table 6.32 shows that there was no significant difference between the levels of interest of the Reflector learners in the two groups ($P > 0.05$), almost certainly due to the small sample size. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of interest	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	3	3.33	0.58	2.00	0.197
Group two (Mismatched)	3	2.70	0.58		

Table 6.32: Reflector learning style - differences between students' level of interest in the course material

6.3.3.8 Difference in Level of Comfort with Course Material between Matched and Non-Matched Students

For both Groups all responses were yes, they did feel comfortable with the course material, see Figure 6.28.

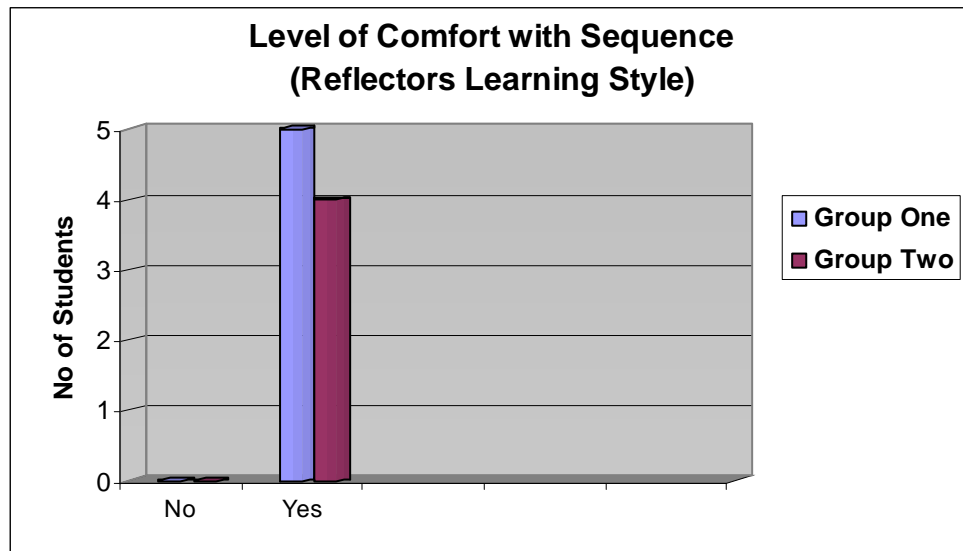


Figure 6.28: Students' level of comfort with sequence that was presented to them

There was no significant difference in how comfortable Reflector learners in the two groups felt while they used the online course, see Table 6.33. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of comfort	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	5	2.00	0	7.50	1.00
Group two (Mismatched)	3	2.00	0		

Table 6.33: Reflector learning style - differences between students' level of comfort with the course material

6.3.4 Theorist Learning Style

It was found that 18 of the 64 students in the sample were Theorist, and of these 9 were in Group one (Matched) and 9 were in Group two (Non-matched).

6.3.4.1 Differences in Pre- and Post-Test Marks between Matched and Non-matched Students

The t-test did show there was a significant difference between mean marks for Theorist learners in the two groups in the Post-test ($t=5.18$, $P < 0.001$), Group one scored significantly higher ($N=9$, $M=2.66$, $SD=0.50$) than Group two ($N=9$, $M=0.77$, $SD=0.97$), see Table 6.34. The full results are presented in Appendix F.

Test type	Group	Sample size, N	Mean score	Standard deviation, SD	t-test (Equal Variances Not Assumed)		
					Mean Difference	t	Asymp. Sig. (2-tailed)
Pre-test	Group one (Matched)	9	2.44	1.66	0.66	0.97	0.35
	Group two (Mismatched)	9	1.77	1.20			
Post-test	Group one (Matched)	9	2.66	0.50	1.88	5.18	0.000
	Group two (Mismatched)	9	0.77	0.97			

Table 6.34: Theorist learning style - difference between mean marks for Pre- and Post-tests

6.3.4.2 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Theorist (Learning Style Matching Learning Sequence) .

To determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.29 shows for the 9 matched students in Group one, 8 students believed they had increase their knowledge level, one considered s/he knew as much after completing the online course as at the start, but no-one felt they knew less. The improvement is significant at a level of confidence of 99.9%.

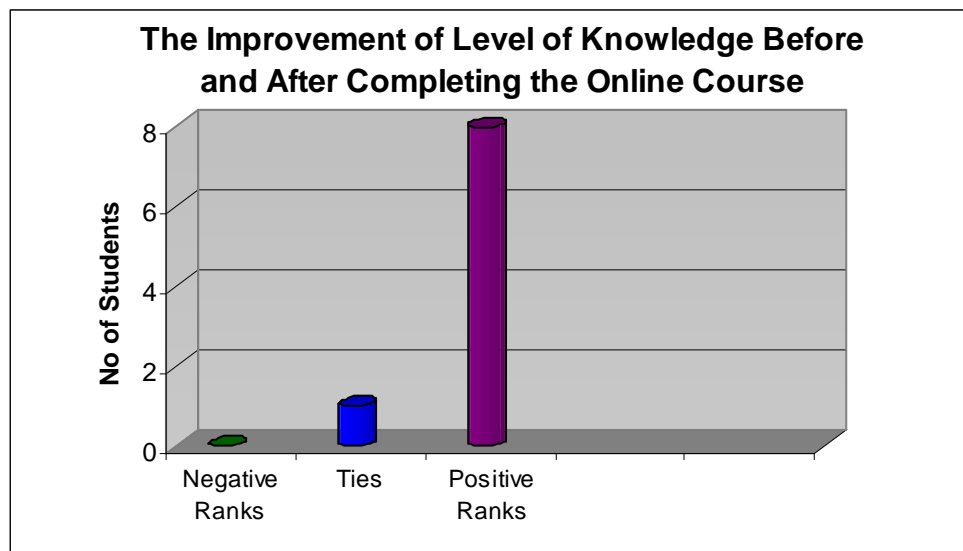


Figure 6.29: Group one, Improvement of Level of Knowledge Before and After Completing the Online course.

a Wilcoxon Signed Ranks Test was carried out. This showed that the increase in (number of student) - which here represents for the number of students who expected to make progress - for the 9 matched students were was significant at a level of confidence of 99.9%, see Table 6.35. Given that the students had two weeks of tuition in the subject matter, with no prior tuition on the course in this subject, any other result would have been most surprising. 8 students evaluated themselves as having made progress in the subject. The full results are presented in Appendix F.

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0 ^a	0.01
	Positive Ranks	8 ^b	
	Ties	1 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.35: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Theorist learning style (learning style matches learning sequence)

6.3.4.3 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Theorist (Learning Style Not Matching Learning Sequence)

Again, to determine whether students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 6.30 shows for the 9 Mis-matched students, 6 students believed they had increase their knowledge level, 3 considered they knew as much after completing the online course as at the start, but no-one felt they knew less. .

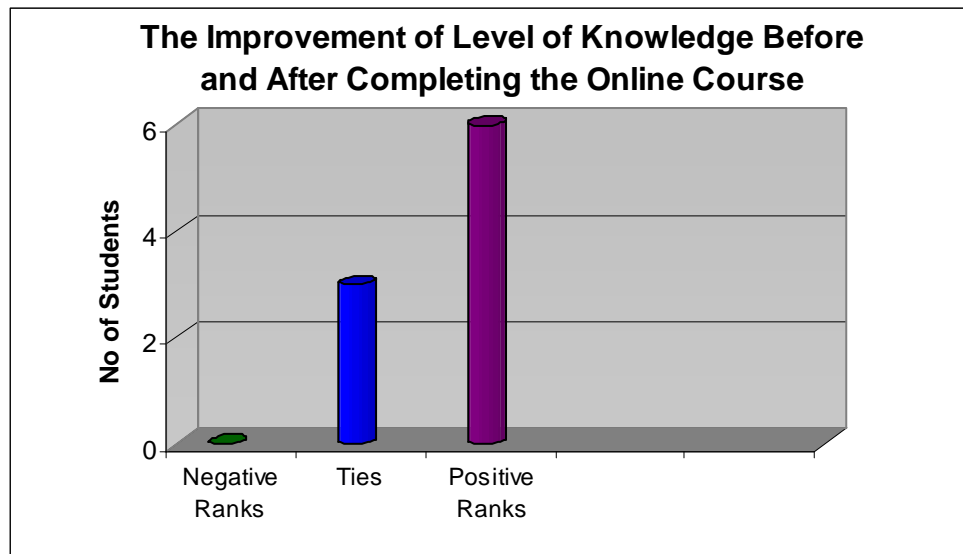


Figure 6.30: Group two - Improvement of Level of Knowledge Before and After Completing the Online course.

The Wilcoxon Signed Ranks Test showed that the increase in mean students' level of knowledge after completing the online course, for the 9 students who completed the questionnaire was significant at a level of confidence of 97%, see Table 6.36. The full results are presented in Appendix F

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0 ^a	0.01
	Positive Ranks	6 ^b	
	Ties	3 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 6.36: Wilcoxon signed ranks test. Student self-assessment of improvement of level of knowledge before and after completing the online course: Theorist learning style (learning style not matching learning sequence)

6.3.4.4 Differences in Self-Assessment between Matched and Non-matched Students before Accessing the Online Course.

In Group one 67% of the students started the course with no knowledge of logic gates, while in Group two 89% of the students considered they started the course with no level of knowledge of logic gates, see Figure 6.31.

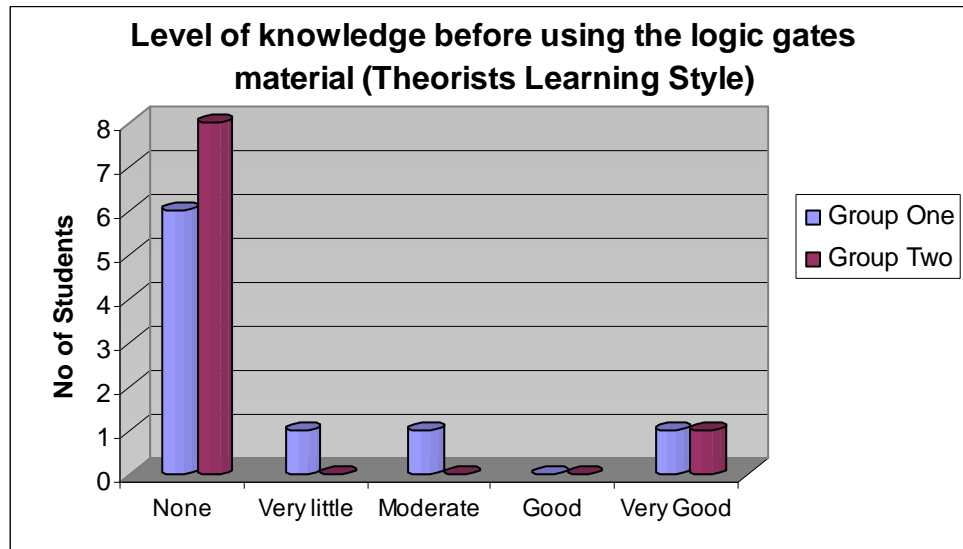


Figure 6.31: How students assessed their own level of relevant knowledge before accessing the online course

The result of the Mann-Whitney U test showed that there was no significant difference between Theorist learners in the two groups in their self-assessed level of knowledge before accessing the online course ($P > 0.05$), see Table 6.37. The full results are presented in Appendix F.

Group	Sample Size, N	Mean score in level of knowledge before course (self-assessment)	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	9	1.78	1.39	32.50	0.33
Group two (Mismatched)	9	1.44	1.33		

Table 6.37: Theorist learning style - differences between self-assessment before accessing the online course

6.3.4.5 Differences in Self-Assessment of Level of Knowledge between Matched and Non-Matched Students after Completing the Online Course

Group one had a mean level of knowledge after completing the online course of between Good and Very Good, while in Group two the level was between None and Very little, see Figure 6.32.

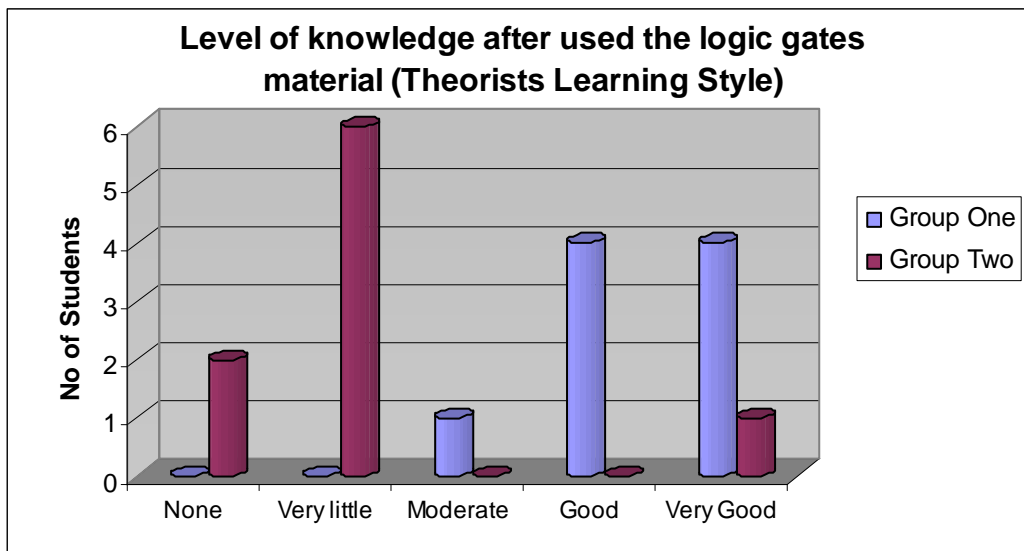


Figure 6.32: How students assessed their own level of knowledge after completing the online course

The Mann-Whitney U test showed a significant difference between Theorist learners in the two groups in their level of knowledge after completing the online course ($P < 0.05$). The difference showed that Theorist learners, where the sequence of delivery in the online course matched their learning style, assessed their mean level of

knowledge significantly higher, (N=9, M=4.33, SD=0.71), than did the Activist learners in Group two, who assessed their level of knowledge as between Very Little and OK (N=9, M=2.11, SD=1.16), see Table 6.38. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of knowledge after (self-assessment)	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	9	4.33	0.71	7.00	0.02
Group two (Mismatched)	9	2.11	1.2		

Table 6.38: Theorist learning style - differences in student self-assessment of level of knowledge after completing the course

6.3.4.6 Differences in Level of Confidence between Matched and Non-Matched Students

Group one, on average, scored between Moderate and Confident, while in Group two the mean score was between Moderate and Confident, see Figure 6.33.

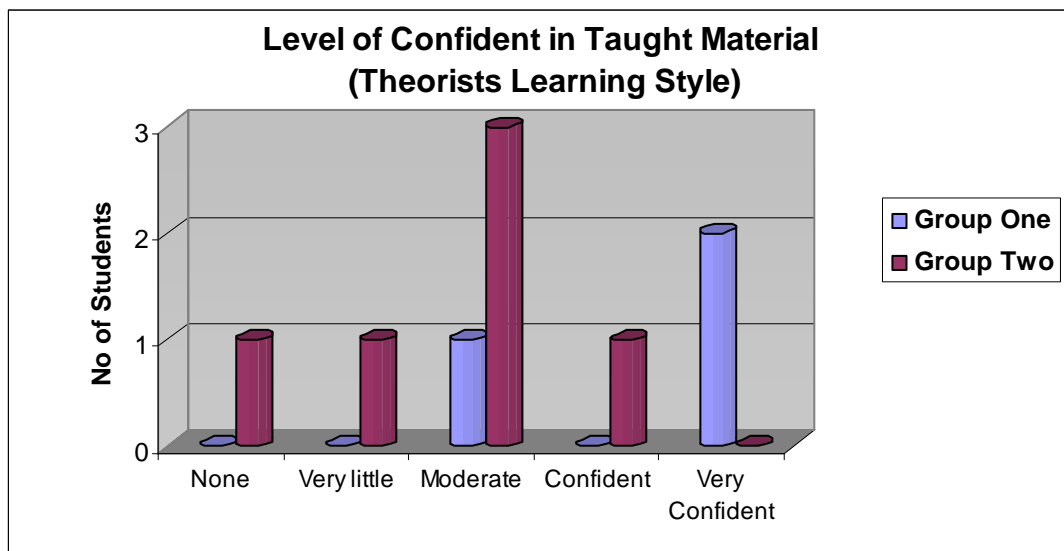


Figure 6.33: Students' level of confidence in their understanding of the online material

There was no significant difference in how confident the two groups of Theorist learners were that they had understood the course material ($P > 0.05$), see Table 6.39. This is likely to be due to the small sample size. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of confidence	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	3	4.33	1.15	2.50	0.08
Group two (Mismatched)	6	2.67	1.03		

Table 6.39: Theorist learning style - differences between students' level of confidence that they have understood the course material

6.3.4.7 Differences in Level of Interest Between Matched and Non-Matched Students

The results from self assessment showed the difference between the levels of interest of the Theorist learners in the two groups on average both groups around Moderate and Good. See Figure 6.34.

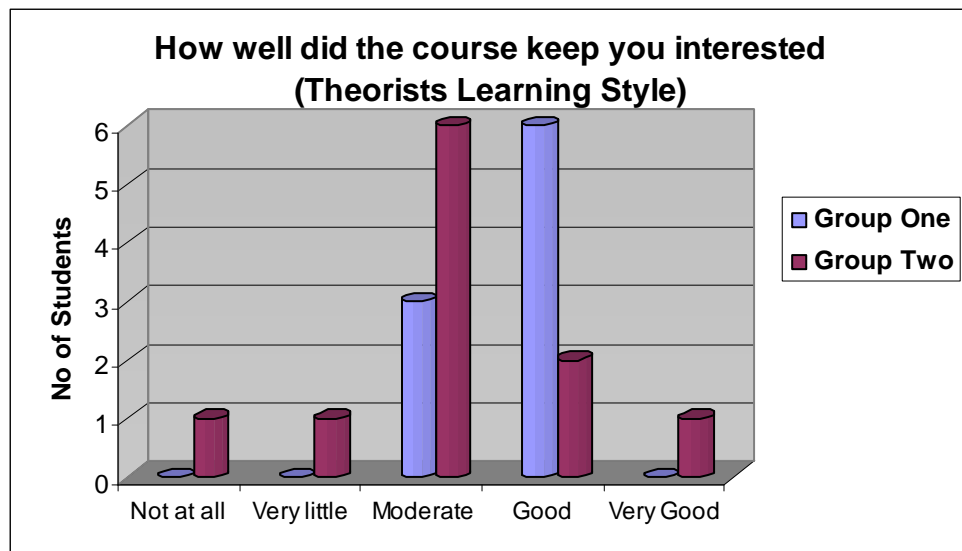


Figure 6.34: Students' level of interested in material accessed on the online course

Table 6.40 shows that there was no significant difference between the levels of interest of the Theorist learners in the two groups ($P > 0.05$), probably because only nine replies were received. The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of interest	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	9	3.67	0.58	18.00	0.05
Group two (Mismatched)	8	3.00	1.06		

Table 6.40: Theorist learning style - differences between students' level of interest in the course material

6.3.4.8 Difference in Level of Comfort with Course Material between Matched and Non-matched Students

Theorist learners in Group one were more comfortable with the course, 89% answered Yes, while in Group two five said No, see Figure 6.35.

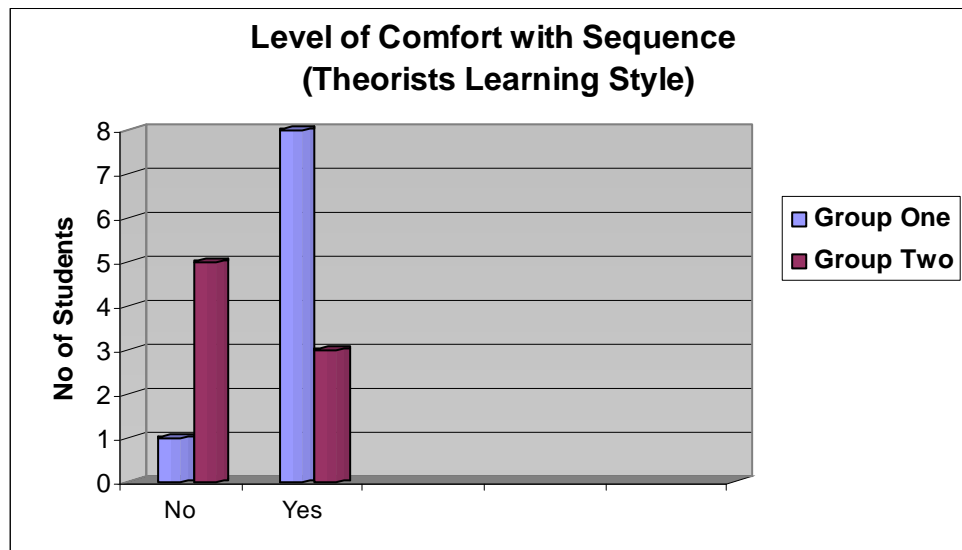


Figure 6.35: Students' level of comfort with sequence that was presented to them

There was significant difference in how comfortable the Theorist learners in two groups felt while they used the online course ($P < 0.05$), see Table 6.41. For Group one ($N=9$, $M=1.88$, $SD=0.58$), but for Group two, ($N=8$, $M=1.37$, $SD=0.52$). The full results are presented in Appendix F.

Group	Sample size, N	Mean score in level of comfort	Standard deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (Matched)	9	1.88	0.33	17.50	0.032
Group two (Mismatched)	8	1.37	0.52		

Table 6.41: Theorist learning style - differences between students' level of comfort with the course material

6.4 Conclusions, Discussion and Suggestions for Further Work

This part discusses and evaluates the learning outcomes achieved.

6.4.1 Conclusions

- There was significant difference between the Groups one and two in their self-assessed level of knowledge after completing the online course ($P < 0.001$). The difference showed that the Group one believed that had learned more than did Group two. Twenty nine of thirty student in Group one (learning styles matched delivery sequence), but only nineteen of thirty four students in Group two (learning styles mismatched delivered sequence) evaluated themselves as having made significant progress in the learning subject of the logic gates after completing the online course. The same test was repeated by using ANOVA test and the same result was found which means that the students who followed the course materiel in sequence that match their learning styles can make better progress than who did not.
- The results showed that there is significant difference between Groups one and two in how confident they were that they had understood the course material ($P < 0.001$). The results showed that the Group one was significantly more confident than Group two.
- The results obtain show that there is significant difference between the two groups in how well the course maintained their interest ($P < 0.001$). Group one was more engaged with the course than Group two.
- There was significant difference between the two groups in how comfortable they felt using the online course material ($P < 0.001$). Group one felt significantly more comfortable than Group two.

- The results showed that there was no significant difference between the two groups in the scores obtained in the Pre-test. However, the t-test (equal variance not assumed) showed there was a significant difference between the two groups in the Post-test, with Group one scoring significantly more than Group two.
- The self-assessed level of knowledge after completing the online course was positively and strongly affected with whether the sequence of material matched the student learning style. Student self assessed level of knowledge is likely to be greater if the learning sequence is delivered in a way that that matches his/her learning style.
- The Post-test marks were strongly correlated with the learning sequence: a student is likely to score better marks if the sequence of the material delivered in the online course matches his/her learning style.
- Activists in Group one rated higher in Post-test, Level of knowledge after, Level of interested and Level of confident scores than Activists in Group two.
- Pragmatists in group one rated higher in comfortable level and Post-test than pragmatists in group two.
- Theorists learners in Group one scored significantly higher in Post-test than students in Group two. (Where there was no difference this was most likely due to small sample size or, as in one case, no students in Group one replying to the question.)
- Reflectors showed no significant difference between the two groups in any test, most likely due to the small sample size..

6.4.2 Discussion.

The results show there was no significant difference between the students in Groups one and two in their self-assessed level of knowledge before they accessed the online course. This was confirmed when no significant differences were found between the mean marks for the two groups in the Pre-test.

The students in both groups, and all learning styles made significant progress in their self-assessed level of learning after using the online course. However, those students for whom the course delivery matched their learning styles considered they had made more progress than those for whom the course delivery did not match their learning styles. This was confirmed when Group one scored significantly more than Group

two in the Post-test. This results can interpreted that students can learn better, and consider they are learning more, if the online course is designed so that the learning sequence matched students' learning styles.

Generally, students who used the learning sequence that matched their learning styles found the online course more interesting and were more comfortable and more confident with the taught material, than students where the learning sequence did not match their learning styles. This was confirmed for the different learning styles separately where the sample size was large enough to get statistically significant results.

This second experiment was a great improvement on the first. The measures taken to reduce student drop-out largely worked, though in a couple of cases - for reasons unknown - some student did not reply to all the questions on the questionnaires. Given that there were four learning styles, each of which had to be divided into matched and unmatched, the average size of each sub-group being tested was eight. This is still too small to give reliable results.

6.4.3 The plan for further work.

The work reported above shown that the matching of course delivery to learning style could be an extremely important development of CAL. However the small size of the samples used meant that little information was obtained on comparisons within learning styles, for example, the number of Reflectors was so small (nine in total) that no significant difference between matched and unmatched students was found in any test.

The decision was therefore to proceed to a third experiment in an attempt to resolve this problem. given the relative success of this second experiment, the researcher considers it could be repeated with a third group of students. This would have the great advantage that the experiment duration, course design, content and presentation of the online material, the questionnaires, LSQ and Pre and Post-test would all be identical with those given to the second group of students.

The third experiment will be with new group of students who, just as the first and second would have received no instruction on logic gates. The researcher arrange that experiment would take place in the Computing and Informatics Department.

Chapter Seven

Design and Results of the Third Experiment

7.1 Introduction.

This chapter is concerned with reporting the results of a third experiment that was also aimed to correct the problems faced in the first, and complement and add to the results of the second experiment. The design and the research method were the same as for the second experiment see previous chapter. The reason behind repeating this experiment is to get sample bigger than the sample of previous one in order to confirm the result of experiment two. Unfortunately the sample for this experiment was only nineteen students (eleven students as the matched group one and eight students as the mismatched group two). These were first year students from the department of Computing and Informatics, and the course was the undergraduate degree in Computing in Mar, 2006.

Before commencing the third experiment, the plan was that the sample would contain be at least 20 to 25 students in each group. The procedure followed was exactly the same as for experiment two, meeting the students as a cohort, describing the experiment and its purpose, and asking if they agree to participate. However, most of the students did not attend the first laboratory session with the researcher and so did not complete either a LSQ or a Pre-test, nor did they login to the online course. As the course leader explained, said there was no mechanism to make these students attend the laboratory session if they did not want to. In this way the sample size for the third experiment was reduced substantially. After discussion with my research

supervisor it was agreed to proceed with and report the third experiment separately, even though the total number in the sample was nineteen.

In group one there were 11 students (7 Activists, 1 Reflector, 2 Theorists and one Pragmatist), and in Group two there were eight students (7 Activists and 1 Theorist). There are two parts to the data in analysis: the first part focuses on differences between the matched and non-matched groups, the second part focuses on differences between students with the Activist Learning style as there were so few students with other learning styles. The results will be discussed in the Analysis Section (see also Appendix G).

7.2 Evaluation by Groups

This section will discuss comparisons between the two groups. Starting with a comparison of the difference between Marks Awarded in Pre-Test and Post-Test. The difference in the level of knowledge before accessing the online course and the level of knowledge after completing the online course. The results will include differences in the level of self-confidence, the level of interest, the level of comfort with the online course.

7.2.1 Differences between Marks Awarded to the Matched and Non-Matched Student Groups in Pre-Test and Post-Test

This is no significant different between pre and post-test in both groups $P > 0.05$, see Table 7.1. All students in group one answered pre and post test correctly.

Test type	Group	Sample Size, N	Mean Score	Standard Deviation, SD	T-Test: Equal Variances Not Assumed	
					T	Asymp. Sig. (2-tailed)
Marks in Pre-Test	Group one (Matched)	11	4.00	0.00	2.39	0.04
	Group two (Mismatched)	8	3.25	0.88		
Marks in Post-Test	Group one (Matched)	11	4.00	0.00	1.53	0.17
	Group two (Mismatched)	8	3.75	0.46		

Table 7.1: t-test for significance of differences between mean marks awarded to matched and non-matched students in the Pre-and Post-tests.

7.2.2 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Group One (Learning Style Matching Learning Sequence)

The difference in the ranking the students gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 7.1 shows for the 11 matched students in Group one, 4 students believed they had increase their knowledge level, but 7 considered they knew as much after completing the online course as at the start (because they felt they had a good knowledge about logic gates before started the course), but no-one felt they knew less.

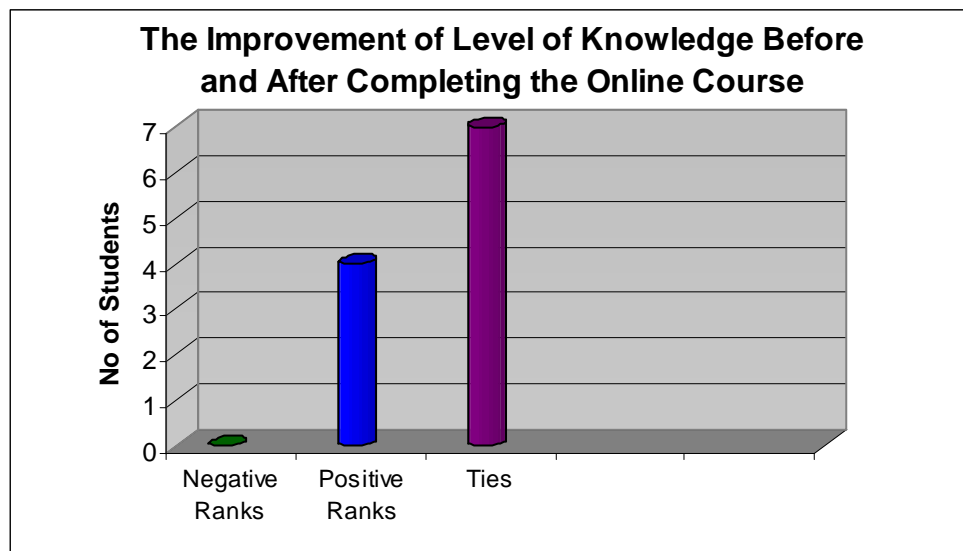


Figure 7.1 Group one, Improvement of Level of Knowledge Before and After Completing the Online course

A Wilcoxon Signed Ranks Test showed that the increase in mean ranking for the 11 matched students in Group one was not significant at a level of confidence of 95.0%, see Table 7.2. The full results are presented in Appendix G.

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0 ^a	0.06
	Positive Ranks	4 ^b	
	Ties	7 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 7.2 Wilcoxon signed ranks test. Improvement in student self-assessment of level of knowledge before and after completing the online course: Group two (learning style matching learning sequence)

7.2.3 Improvement in Student Self-Assessed Level of Knowledge Before and After Completing the Online Course: Group Two (Learning Style Not Matching Learning Sequence)

Again, to determine whether these 8 students considered they, themselves, had made significant progress, after completing the online course, the ranking they gave themselves for their level of relevant knowledge before entering and after completing the online course were compared. Figure 7.2 shows for the 8 non-matched students in Group two, 4 students believed they had increase their knowledge level, 3 considered they knew as much after completing the online course as at the start, and one felt s/he had regressed. The improvement in mean ranking was not significant.

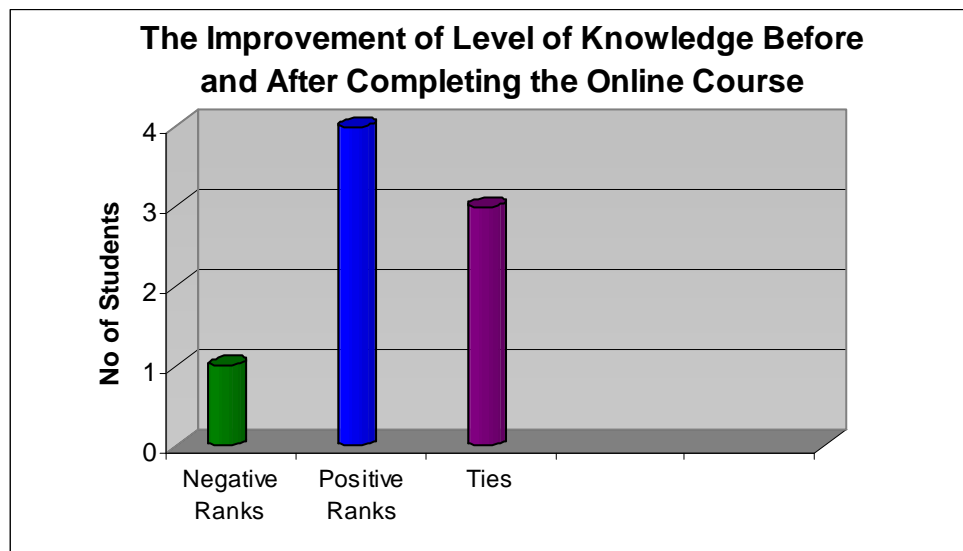


Figure 7.2 Group two - Improvement of Level of Knowledge Before and After Completing the Online course

The Wilcoxon Signed Ranks Test showed that the increase in the mean of the students' self-assessed level of knowledge after completing the online course, for the 8 students in Group two was not significant, see Table 7.3. The full results are presented in Appendix G.

Items of Test	Ranks Types	N	Asymp. Sig. (2-tailed)
Level of knowledge before course - Level of knowledge after course	Negative Ranks	1 ^a	0.16
	Positive Ranks	4 ^b	
	Ties	3 ^c	

a- Level of knowledge after course < Level of knowledge before course

b- Level of knowledge after course > Level of knowledge before course

c- Level of knowledge before course = Level of knowledge after course

Table 7.3 Wilcoxon signed ranks test. Improvement in student self-assessment of level of knowledge before and after completing the online course: Group two (learning style not matching learning sequence)

7.2.4 Differences Between Matched and Non-Matched Student Groups in Self-Assessment of Level of Knowledge Before Accessing the Online Course

The difference in student rankings of their levels of knowledge before beginning the online course were compared for the matched and non-matched students, see Figure 7.3. Obviously, there was a spread of results for each group and so there was no significant difference in the mean responses.

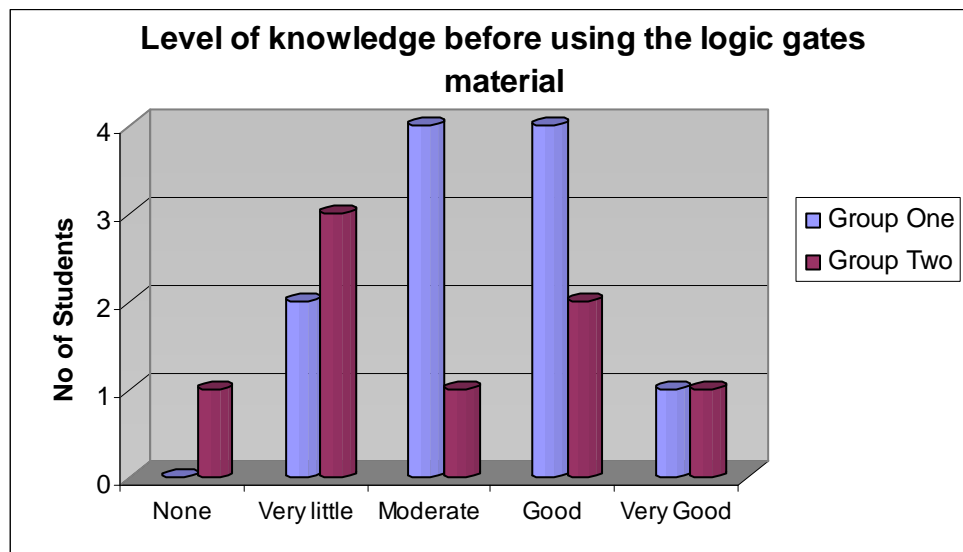


Figure 7.3: How students assessed their own level of knowledge before accessing the online course

The non-parametric test (Mann-Whitney U) used showed that there was no significant difference between the two groups in their mean self-assessed level of relevant knowledge before accessing the online course ($P > 0.05$). This shows that both groups of students started the course with no significant difference in average perceived background knowledge of the course content, see Table 7.4. The full results are presented in Appendix G

Group	Sample Size, N	Mean score in level of knowledge before accessing online course	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (matched)	11	3.36	0.92	33.50	0.37
Group two (non-matched)	8	2.88	1.36		

Table 7.4: Mann-Whitney U test for difference in levels of self-assessment of knowledge before accessing the online course, matched and non-matched student

7.2.5 Differences Between Matched and Non-Matched Student Groups in Self-Assessment of Level of Knowledge After Completing the Online Course

The difference in student rankings of their levels of knowledge after completing the online course were compared for the matched and non-matched students, see Figure 7.4. There appears to be a tendency for the matched students to rate their increase in knowledge as greater than non-matched students. After completing the course the matched students rated their level of knowledge as Good to Very Good, while for the non-matched students it was between Moderate and Good.

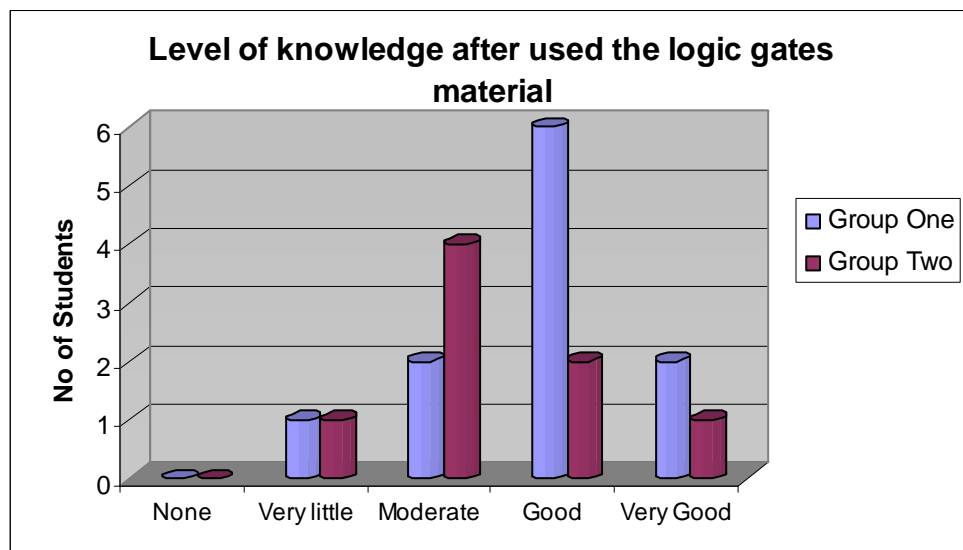


Figure 7.4: How students assessed their own level of knowledge after completing the online course

The Mann-Whitney U test was again used to analyse the ordinal data obtained. No significant difference between the two groups was found in the mean levels of knowledge after completing the online course ($P > 0.05$), see Table 7.5. The full results are presented in Appendix G.

Group	Sample Size, N	Mean score in level of knowledge after completing online course	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one	11	3.82	0.87	30.50	0.24
Group two	8	3.38	0.92		

Table 7.5: Mann-Whitney U test for difference in level self-assessment of knowledge after completing the online course, matched and non-matched students

7.2.6 Differences Between Matched and Non-Matched Student Groups in Level of Confidence That They Have Understood the Course Material

The mean level of self assessed confidence with which the students felt they had understood the online course was, for the matched students, between Moderate and Confident, and for the non-matched students between Very Little and Moderate, see Figure 7.5.

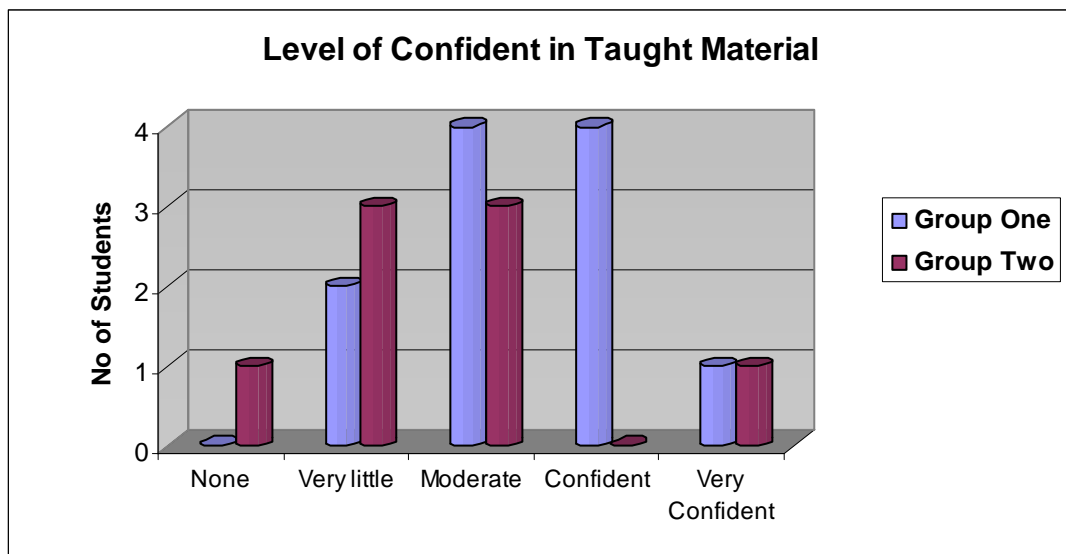


Figure 7.5: Students' level of confidence in their understanding of the online material

The result show that there was no significant difference ($P > 0.05$) between the two groups in their levels of self-confidence, see Table 7.6. The full results are presented in Appendix G.

Group	Sample Size, N	Mean Score in level of confidence	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one	11	3.36	0.92	25.50	0.11
Group two	8	2.63	1.18		

Table:7.6: Mann-Whitney U test for difference in students' level of confidence in material accessed on the online course, matched and non-matched students

7.2.7 Differences Between Matched and Non-Matched Student Groups in How Well the Online Course Maintained Student Interest.

The responses of the matched students showed they tended to be more interested in the online course than the non-matched students. For Group one the responses were either Moderate or Good while, for the non-matched students, the responses were between Not at all and Moderate, see Figure 7.6.

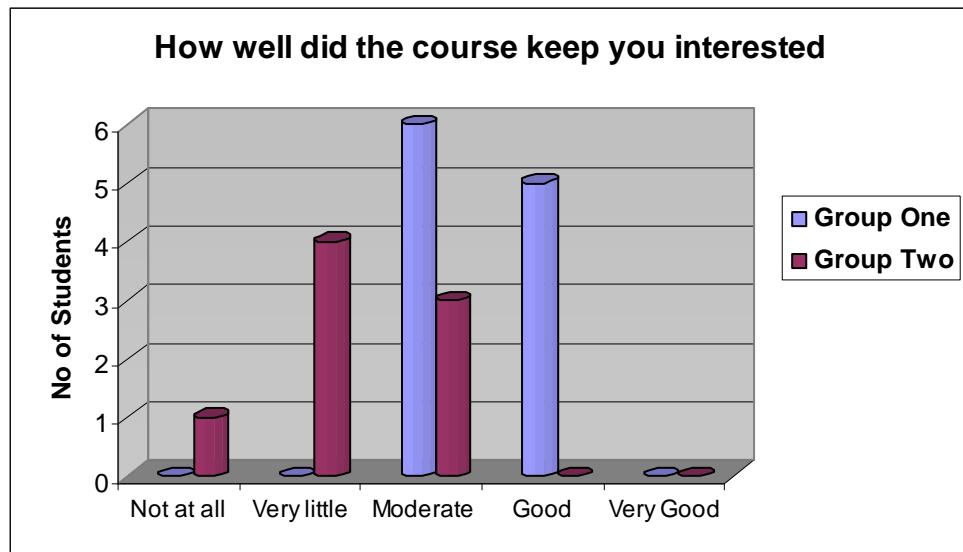


Figure 7.6: Students level of interested in material accessed on the online course.

Table 7.7 the shows that there was significant difference between the two groups in their level of interest ($P < 0.01$). Students in Group were one more interested ($N=11$, $M=3.45$, $SD=0.52$) than Group two ($N=8$, $M=2.25$, $SD=0.71$). The full results are presented in Appendix G.

Group	Sample Size, N	Mean Score in level of interested	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one	11	3.45	0.52	9.00	0.002
Group two	8	2.25	0.71		

Table 7.7: Mann-Whitney U test for difference in students' level of interest in material accessed on the online course, matched and non-matched students

7.2.8 Differences between Matched and Non-Matched Student Groups in Whether They Felt Comfortable With the Online Course

As shown in Figure 7.7 there was significant difference between the two groups in their levels of comfort with the sequence that the online course was presented to them. Group one was the more comfortable, with all students in this Group answering yes.

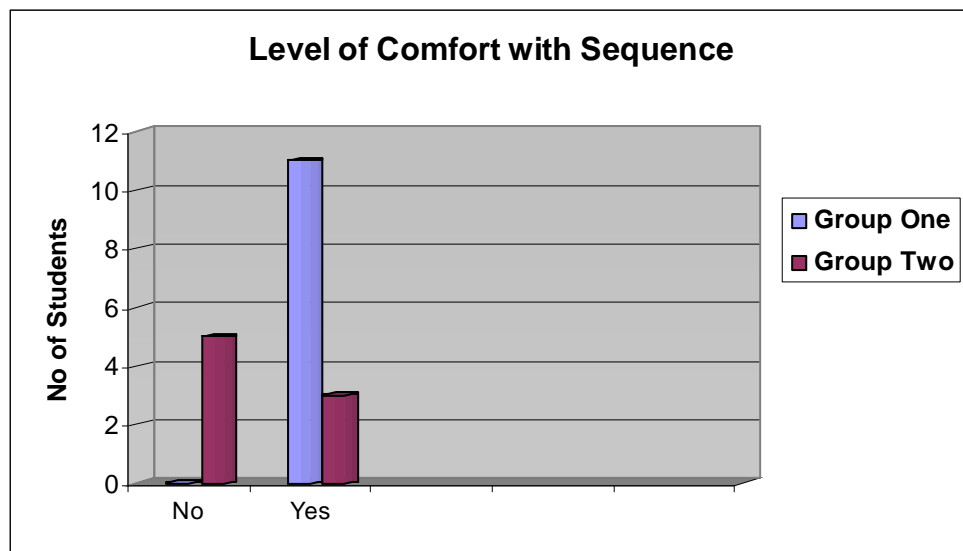


Figure 7.7: Students' level of comfort with sequence that was presented to them

There was significant difference ($P < 0.01$) between the two groups in the level of comfort whilst accessing the online course. Group one was more comfortable ($N=11$, $M=2$, $SD=$ all answered YES) than Group two ($N=8$, $M=1.38$, $SD=0.52$), as shown in Table 7.8. The full results are presented in Appendix G.

Group	Sample Size, N	Mean Score in level of comfortable	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
GROUP 1	11	2.00*	-	16.5	0.003
GROUP 2	8	1.38	0.52		

*all student in group one where answered YES on the question.

Table 7.8: Mann-Whitney U test for difference in whether or not students felt comfortable using the online learning course, matched and non-matched students

7.3 Evaluation by Learning Styles

In this experiment (experiment three) the analysis will be concerned with only Activist learners. Here the sample size is fourteen students, seven in each group. The sample size for the other learning styles was too small to give useful results.

7.3.1 Differences in Self-Assessment between Matched and Non-matched Students before Accessing the Online Course

Both groups started the course with some knowledge in average between Very little and Moderate , see Figure 7.8.

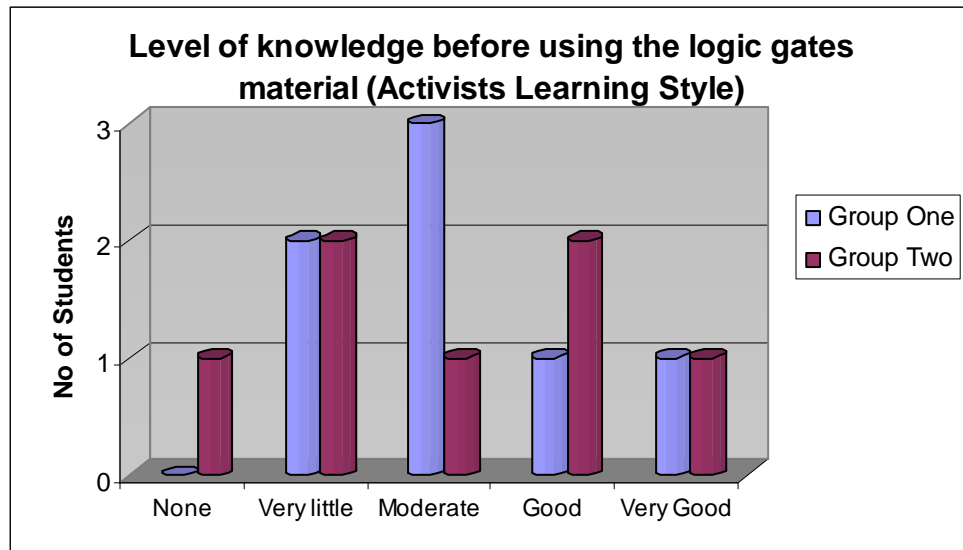


Figure 7.8: How students assessed their own level of knowledge before accessing the online course

There was no significant difference between the Activist learners in the two groups ($P > 0.05$), see Table 7.9. The full results are presented in Appendix G.

Group	Sample Size, N	Mean Score in Pre-test	Standard Deviation, SD	Mann-Whitney U	Asymp . Sig. (2-tailed)
Group one (matched)	7	3.14	1.07	23.00	0.84
Group two (non-matched)	7	3.00	1.41		

Table 7. 9: Activist learning style - differences between self-assessment of relevant knowledge before accessing the online course.

7.3.2 Differences in Self-Assessment of Level of Knowledge between Matched and Non-matched Students After Completing the Online Course

The mean level of knowledge of both groups after completing the online course groups was between Moderate and Good, see Figure 7.9

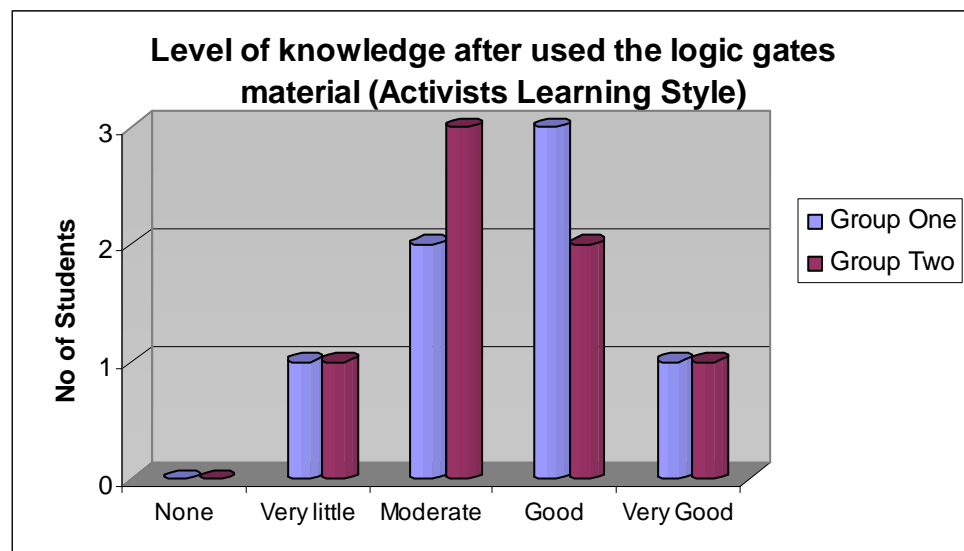


Figure 7.9: How students assessed their own level of knowledge after completing the online course

There was no significant difference between the activist learners in the groups ($P > 0.05$), see Table 7.10. The full results are presented in Appendix G.

Group	Sample Size, N	Mean score in level of knowledge after completing online course	Standard Deviation, SD	Mann-Whitney U	Asymp . Sig. (2-tailed)
Group one (matched)	7	3.57	0.98	22.00	0.74
Group two (non-matched)	7	3.43	0.98		

Table 7.10: Activist learning style - differences in student self-assessment of level of knowledge after completing the course

7.3.3 Differences in Level of Confidence between Matched and Non-Matched Activist Students

Student levels of confidence in the online material showed considerable overlap between Activist learners in the two groups, see Figure 7.10.

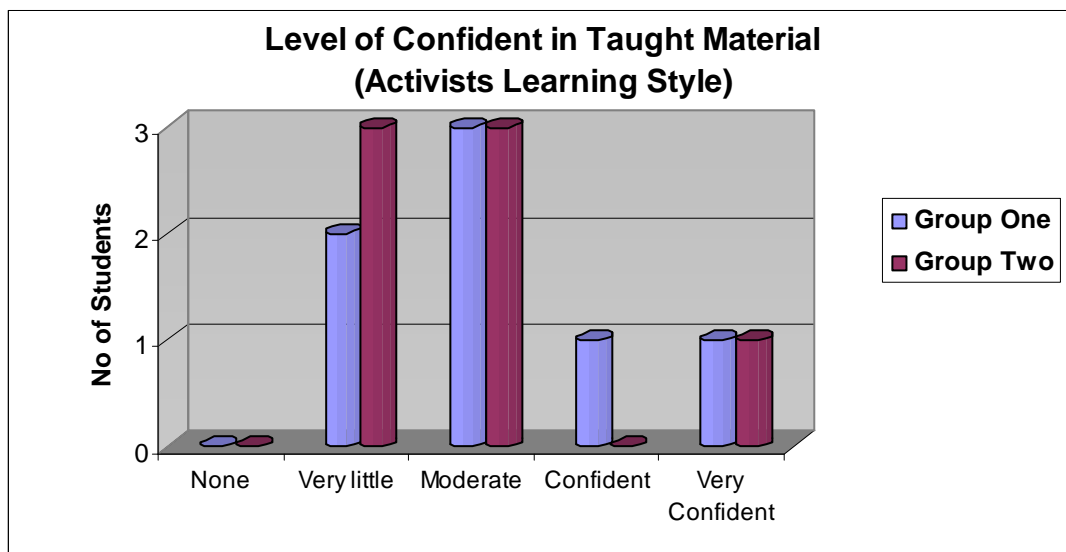


Figure 7.10: Students' level of confidence in their understanding of the online material

There was no significant difference in the mean levels of confidence between the two groups of Activist learners ($P > 0.05$), see Table 7.11. The full results are presented in Appendix G.

Group	Sample Size, N	Mean Score in level of confidence	Standard Deviation, SD	Mann-Whitney U	Asymp . Sig. (2-tailed)
Group one (matched)	7	3.14	1.07	16.50	0.28
Group two (non-matched)	7	2.57	1.27		

Table 7.11: Activist learning style - differences between students' level of confidence that they have understood the course material

7.3.4 Differences in Level of Interest between Matched and Non-Matched Activist Students

The Activist learners in Group one tended to find the online learning more interesting, on average they rated their level of interest between Moderate and Good. The Activist learners in Group had a mean level of interest between Very little and Moderate, see Figure 7.11.

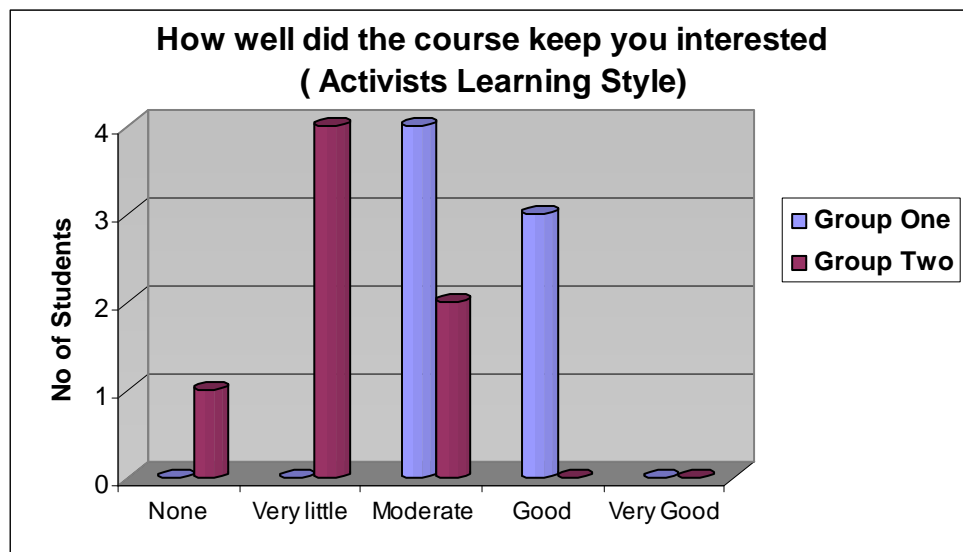


Figure 7.11: Students level of interested in material accessed on the online course.

There was a significant difference between the Activist learners in the two groups ($P < 0.01$) in the mean level of interest in the course material, see Table 7.12. The activist students in Group one were more interested ($N=7$, $M=3.43$, $SD=0.54$), than the activist students in Group two ($N=7$, $M=2.14$, $SD=0.69$). The full results are presented in Appendix G.

Group	Sample Size, N	Mean Score in level of interested	Standard Deviation, SD	Mann-Whitney U	Asymp. Sig. (2-tailed)
Group one (matched)	7	3.43	0.54	4.00	0.006
Group two (non-matched)	7	2.14	0.69		

Table 7.12: Activist learning style - differences between students' level of interest in the course material

7.3.5 Difference in Level of Comfort with Course Material between Matched and Non-Matched Activist Students

All seven Activist students in Group one answered, Yes, they were comfortable using the online course. In Group two only two Activist learners said they were comfortable with the course material, see Figure 7.12

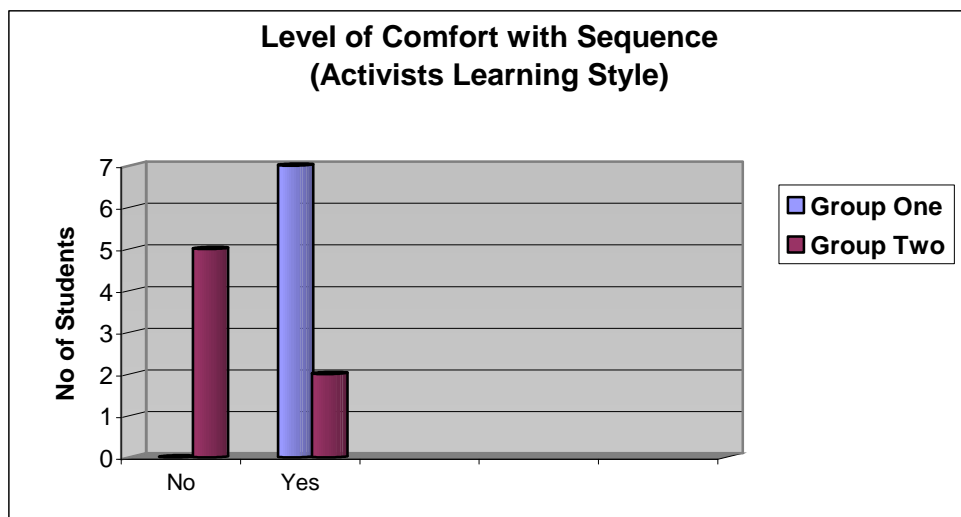


Figure 7.12: Students' level of comfort with sequence that was presented to them

There was a significant difference between the two groups of Activist learners ($P < 0.01$) see Table 7.13 in whether or not they were comfortable with the online course material. The Activist learners in Group one were more comfortable using the online course, ($N=7$, $M=2$, $SD= 0$), than the Activist learners in Group two ($N=7$, $M=1.29$, $SD=0.49$), see Table 7.13. The full results are presented in Appendix G.

Group	Sample Size, N	Mean Score in level of comfortable	Standard Deviation, SD	Mann-Whitney U	Asymp . Sig. (2-tailed)
Group one (matched)	7	2.00*	-	7.00	0.007
Group two (non-matched)	7	1.29	.49		

* all student in group 1 where answered YES to the question.

Table 7.13 Activist learning style - differences between matched and non-matched students in whether or not they felt comfortable with the course material

7.4 Conclusions and Discussion

7.4.1 Conclusions

- There were no significant differences between the two groups of students in their self-assessed levels of knowledge either before or after accessing the online course.
- According to the Wilcoxon Signed Ranks Test the increase in mean rank of self-assessed level of knowledge was not significant at a 95% confidence level for either the 11 students in Group one, or the 8 students in Group two.
- The results showed no significant difference between the two groups ($P > 0.05$) in their level of knowledge after they completing the online course.
- The results showed no significant difference ($P > 0.05$) between the two groups in the level of confidence that they understood the course material.
- There was significant difference ($P < 0.01$) between the two groups in the level of interest in the online course. Students of Group one were significantly more interested than the students in Group two.
- There was significant difference ($P < 0.01$) between the two groups in whether or not they felt comfortable with the online course. Group one was significantly more comfortable than Group two.
- The result showed that the student who used a learning sequence that matched his/her learning style found the online course significantly more interesting, and a student who used the learning sequence that matches his/her learning style was more likely to feel comfortable with the online course.

- Because of the group sample was very small the researcher tested only the Activists learning style. The results showed that Activists learners in group one were more interest and comfortable than the activists learners in Group two.

7.4.2 Discussion

The results show there was no significant difference between the students in Groups one and two in their self-assessed level of knowledge before they accessed the online course. This was confirmed when no significant differences were found between the mean marks for the two groups in the Pre-test.

The results show there was no significant difference between the students in Groups one and two in their self-assessed level of knowledge after completing the online course.

The student in both groups and, Activist learners made no significant progress in their self-assessed level of learning after completing the online course.

Generally, students who used the learning sequence that matched their learning styles found the course more interesting.

Generally students whose learning style matched the delivery sequence were comfortable with the online course, whereas students whose learning style did not match the delivery sequence were not comfortable

Unfortunately, the size of the cohort in the third experiment was only 19. It was only because nearly three-quarters of the cohort were Activists that any meaningful results were obtained for a particular learning style.

Chapter Eight

Comparison of Data for the Three Experiments

8.1 Introduction

This chapter compares the results obtained from the three experiments and on this basis concludes that the use of online technologies in higher education can improve the effectiveness of student learning by allowing the matching of the order of the delivery of taught material to the user's learning style. The essential research question was to find whether any correlation existed between student learning styles and the order in which the component parts of the course material was presented to them, this has been answered affirmatively.

8.2 Hypotheses Tested by the Three Experiments

This chapter answers the following hypotheses:

Hypothesis 1: Matching a student's learning style to the sequence in which the course material is delivered will have a significant effect on the student's test score or on their appreciation of the course. Null hypothesis: There will be no significant difference between the mean scores for matched and non-matched students in their level of knowledge either before beginning or after completing the online course, nor in the Pre- and Post-test marks obtained.

Conclusion 1: Table 8.1 summarises the results of the measured levels of significance for the differences in student level of knowledge Pre and Post-test, and mean scores in the Pre and Post-tests, between matched and non-matched groups in the three experiments. Note: Pre- and Post-test comparison was included only in experiment two.

The results for the first and final experiments showed that no significant difference between the two groups in the students' level of knowledge before beginning or after completing the online course. According to these experiments the relevant null hypothesis can be accepted. Clearly, one would expect no significant differences between the groups in the mean Pre-test score, nor in the level of understanding prior to commencing the course. Indeed, a repeated pattern of significant differences arose in this aspect that would be surprising and worthy of investigation. However, the lack of a significant difference between the two groups after completing the course is – in the opinion of the researcher – due to all the students in these experiments obtaining 100% in the Post-test. In experiment this was due to using the same questions for both Pre and Post test, and was one aspect of the research that was corrected for the second and third experiments. It should also be noted that in experiment three all the students had some knowledge of the subject matter before the course started.

In experiment two a significant difference between the groups was obtained in their levels of knowledge after completing the online course, and in the mean Post-test marks. The student group who used the learning sequence that matched their learning styles (N=30, M=4.20 between Good and Very Good, SD=0.71) considered their knowledge of logic gates to be significantly better than the group (N=34, M=2.24 between Very little and Moderate, SD=1.01) who's learning sequence did not match their learning styles. According to the result of experiment two the null hypothesis can be rejected.

Here, the findings from experiment two do not agree with those from experiments one and three. Of course these results do not contradict each other, but which is the more reliable – in the sense of which is generally applicable. The results from experiments one and three have serious question marks over them (see above), but experiment two had the great strength that the sample was large enough to provide a statistically significant difference. It should also be mentioned that, unlike the sample of students in experiment three, the students in experiment two started with little or no background knowledge about logic gates, and showed a significant improvement in their mean level of knowledge after completing the online course. The latter seems intuitively correct!

Test Type	Experiment one 22 students	Experiment Two 64 students	Experiment three 19 students
Level of knowledge before	$P > 0.05$	$P > 0.05$	$P > 0.05$
Level of knowledge after	$P > 0.05$	$P < 0.001$	$P > 0.05$
Pre-Test	*	$P > 0.05$	*
Post-Test	*	$P < 0.001$	*

*The Test cannot be performed on empty groups.

Table 8.1: Levels of significance for the differences in student achievements (level of knowledge Pre and Post-test, and mean scores in the Pre and Post-tests) between matched and non-matched groups in the three experiments

On balance, then, it appears that hypothesis one is disproved.

Hypothesis 2: Matching a student's learning style to the sequence in which the course material is delivered will have a significant effect on the student's level of confidence, level of interest and level of comfort. Null hypothesis: there will be no significant difference in student ranking of preferred learning sequence.

Conclusion 2: Table 8.2 summarises the results of the measured levels of significance for the differences in students' level of confidence in the course material, how well the online course held their interest, and how comfortable they felt while using the online material. As can be seen, experiment one showed no significant difference between the two groups in terms of the students' levels of confidence, interest and comfort. According to this experiment the null hypothesis can be accepted.

Experiment two showed that there was significant difference ($P < 0.001$) between the groups in the level of confidence, interest and comfortable. Group one was, on average, significantly more confident and interested in the course material, and more comfortable with the course material than Group two. According to experiment two the null hypothesis can be rejected.

Experiment three found a significant difference ($P < 0.01$) between the groups in the level of interest in the course and comfort with the course. Group one was, on average, significantly more interested and comfortable with the course than Group two. According to experiment three the null hypothesis can be rejected.

Test Type	Experiment one	Experiment Two	Experiment three
Level of confidence	$P > 0.05$	$P < 0.001$	$P > 0.05$
Level of Interest	$P > 0.05$	$P < 0.001$	$P < 0.01$
Level of comfort	*	$P < 0.001$	$P < 0.01$

*The Test cannot be performed on empty groups.

Table 8.2: The comparison the difference in students' level of confident, Interest and comfortable the three experiments.

Given that experiment two, with its larger sample size, appears the most reliable then, on balance, it appears that hypothesis two is disproved.

8.2.1 Comparison between Learning Styles

This section examines and compares the relative achievements of the four student learning styles (Activist, Pragmatist, Reflector and Theorist). Student achievement was measured by the rankings given for the self-assessed level of knowledge after completing the online course, the level of interest in the course material, the level of confidence in the course material, the level of comfort with the online course, and the marks awarded in the Post-test. In first or third experiments all students answered all the questions in the Post-test correctly and so no valid comparisons can be drawn (especially as in experiment one the Pre- and Post-test were the same). Also in the third experiment the sample was too small to obtain any useful comparisons for the Pragmatist, Reflector and Theorist learning styles.

Hypothesis 3 Matching a student's learning style to the sequence in which the course material is delivered will offers an equal balance of learning opportunity to all students no matter what their learning style. Null hypothesis: there will be no significant difference in the performance of students with different learning styles, as measured by their achievement in any of the assessments (student ranking their level of knowledge after completing the online course, and Post-test scores).

Conclusion 3 Table 8.3 summarises the results obtained from the three experiments. The results from experiment one show that there was no significant difference in student achievement between learners with the same learning style in the two groups. The null hypothesis in this case cannot be rejected.

In experiment two the Activists, Pragmatists and Theorist learners appear to learn significantly better if they use a learning sequence that matches their learning style. There was no significant difference between the achievements of those Reflectors whose course matched their learning style and those reflectors whose course did not match their learning style. This result is most likely due to the small number of Reflectors in the sample, but the possibility exists that Reflectors are more flexible than other learning styles. According to this result the null hypothesis can be rejected.

In experiment three the sample was too small. The learning style of the Students in this group was only activist. Experiment three showed no significant difference between the learners with the same learning styles in the two groups in students' achievements when using different learning sequences. The null hypothesis in this case cannot be rejected.

Learning Style	Test Type	Experiment one	Experiment Two	Experiment three
Activist	Level of knowledge after completing the online course	$P > 0.05$	$P < 0.001$	$P > 0.05$
	Post-test score	*	$P < 0.001$	$P > 0.05$
Pragmatist	Level of knowledge after	$P > 0.05$	$P < 0.01$	*
	Post-test score	*	$P < 0.05$	*
Reflectors	Level of knowledge after	$P > 0.05$	$P > 0.05$	*
	Post-test score	*	$P > 0.05$	*
Theorist	Level of knowledge	$P > 0.05$	$P < 0.05$	*
	Post-test score	*	$P < 0.001$	*

*The Test cannot be performed on empty groups.

Table 8.3: The comparison of students' learning achievements in the three experiments according to students' learning styles.

Hypothesis 4: It is expected that students with different learning styles will differ in their confidence with the course material, their level of interest in the course, and their comfort level when using different learning sequences. Null hypothesis: there will be no significant difference in student ranking of preferred learning sequence according to learning style.

Conclusion 4: In experiment one there was no significant difference between the students with the same learning styles when using different learning sequence, see Table 8.4. The result showed that the null hypothesis can be accepted.

Experiment two showed that there was a significant difference between Activist learners in their level of interest, confidence and comfort when they used different learning sequence. Activists who used the learning sequence that matched their learning styles did better than those who did not. Pragmatist learners were significantly different in their levels of interest and comfort when using different learning sequences. Pragmatist, learners who used the learning sequence that matched their learning styles did better than those who did not. Theorist learners showed significant differences only in their comfort level when using the online course when using different learning sequence, but this was a relatively small sample. Reflector learners showed no significant difference in their levels of interest, confidence and comfort when using different learning sequences, however this was because of the very small number of responses received. On balance, it appears that the null hypothesis can be rejected.

In experiment three the only significant difference was found with Activist learners because there were so few Pragmatists, Reflectors and Theorists no significant results could be obtained. The Activist students were significantly more interested in the course and comfortable with their way of learning if the learning sequence matched their learning. Thus the null hypothesis cannot be accepted, at least with the Activist learning style.

Learning Style	Test Type	Experiment one	Experiment Two	Experiment three
Activist	Interest	$P > 0.05$	$P < 0.01$	$P < 0.01$
	Confidence	$P > 0.05$	$P < 0.01$	$P > 0.05$
	Comfortable	*	$P < 0.05$	$P < 0.01$
Pragmatist	Interest	$P > 0.05$	$P < 0.05$	*
	Confidence	$P > 0.05$	*	*
	Comfortable	*	$P < 0.01$	*
Reflectors	Interest	$P > 0.05$	$P > 0.05$	*
	Confidence	$P > 0.05$	$P > 0.05$	*
	Comfortable	*	$P > 0.05$	*
Theorist	Interest	$P > 0.05$	$P > 0.05$	*
	Confidence	$P > 0.05$	$P > 0.05$	*
	Comfortable	*	$P < 0.05$	*

*The Test cannot be performed on empty groups.

Table 8.4: The comparison the difference in students' level of confident, interest and comfortable the two experiments according students learning styles.

Chapter Nine

Contribution and Recommendations

9.1 Introduction

This chapter summarizes the outcomes of this investigation to find whether any correlation existed between student learning styles, the order in which the component parts of the course material was presented, and the learning outcomes as determined by a Post-test score and the students' self assessed level of knowledge of the course material.

This research was intended to investigate the student's online learning environment to first confirm that the environment itself significantly affected learning outcomes and, secondly, to provide useful information for course designers and educators on how they can get the best outcome when using this new high technology learning environment. The specific issue tested was whether, in this learning environment, the sequence of in which the course material was presented to the student had a significant effect on the learning outcomes: in particular the relative improvement in student test scores, the students' relative interest and confidence in the course material, how comfortable the students felt while studying the course material as a function of whether the order of presentation of the course material matched or did not match the students learning style as defined by Honey and Mumford.

The researcher was planned to do more than one experiment which aimed to confirm the results. There was difference in results of experiment two and there and that due to the difference in time of experiment and background level of students.

9.2 Contributions.

1. The first finding from his research is that it is possible to deliver the course material to be studied in different learning sequences. This is a confirmation of the work of previous researchers created a flexible system (AHA) that allowed them to integrate into it as many variation as they liked, of the learning styles of Kolb, and Honey and Mumford (Stash, et al. 2004).
2. The second, finding is that the learning sequence can have a significant effect on student outcome. The results show that it is important that the course contents should be presented in a sequence that matches the student's learning style. This confirms the work of Bajraktarevic, et al (2003) "learning outcomes can be improved if designers of hypermedia courseware provide a different sequence and presentation of materials to accommodate individual learning style differences" and Honey (2006, p22) "where individual preferences and activities match, learning is more likely. If there is a mismatch you are less likely to learn and will find learning a struggle".
3. A third, important, result is that Activist learners are the student who most prefer to follow the learning contents in a sequence that matches their learning style.
4. Reflectors showed no significant difference between the two groups in any test, almost certainly due to the small sample size, but there is the suggestion that these learners are more flexible and adapt more readily to a delivery pattern. The researcher did not find any other work in the literature to conform this point.
5. The research confirmed that the differences in student learning styles should be considering when designing online learning system. Another study was argues that when students' learning styles are identified, it is possible to define an appropriate context of learning. This study had confirmed that the differences in student learning styles should be considering when designing online learning system (Zapalska and Brozik, 2006).
6. By designing online material instruction according to Kolb learning cycle, the students achieved higher scores compared to students across Kolb learning

cycle. Kolb model divided to four learning sessions this can be implemented in online learning and can offer an equal balance of learning opportunity to all students no matter what their learning style.

This kind of designing eLearning material can offer high structured which can be more beneficial to match many learning styles (Wang., et al, 2006).

9.3 Recommendation for Future Research

The researcher recommends to repeat the same experiments with the following changes:

- Replication of this study be conducted within a higher education institution with an increased sample population, the number of students in each learning type/style at least 40 – 20 in each of Group one and two.
- Additional research into modules in other subjects in different academic fields.
- Researchers should use different instruments in determining learning styles and also implement aspects of learning styles into hypermedia systems in order to confirm the important of using the learning sequences, and it effect on students' achievements.

References:

- Alexander, S., and Boud, D. (2001). Learners Still Learn from Experience when Online? In J. Stephenson (Ed.), Teaching and Learning Online: Pedagogy for New Technologies: Kogan Page Ltd.
- Allen, E. and Seaman, J. (2006). "Making the Grade", BABSON Survey Research Group, Nov 2006.
- Bajraktarevic, N., Hall, W. and Fullick, P. (2003). Incorporating Learning Styles in Hypermedia Environment: Empirical Evaluation. Proc. 2003 ED-MEDIA World Conf. on Educational Multimedia and Hypermedia, Boston, USA, available on line at <http://www.wis.win.tue.nl/ah2003/proceedings/paper4.pdf> (Downloaded 9/02/2008).
- Becta {Report}, (2005) Learning Styles – an Introduction to the Research Literature, Report by Becta, Version 1.1, September 2005, URL: <http://industry.becta.org.uk/display.cfm?resID=15472>. (Downloaded 15/012/2007)
- Brown, E., Cristea, A., Stewart, C., and Brailsford, T. (2005). Patterns in Authoring of Adaptive Educational Hypermedia: A Taxonomy of Learning Styles. Educational Technology and Society, 8 (3), 77-90
- Campbell, J. and Oblinger, D. (2007) "Top-Ten Teaching and Learning Issues", Educause Quarterly, No. 3.
- Carver, C. A., Howard, R.A., and Lavelle, E. (1996). Enhancing Student Learning by Incorporating Learning Styles into Adaptive Hypermedia. In Proc ED-MEDIA '96, Association for the Advancement of Computing in Education, Charlottesville, Virginia, 118-123.
- Clark, D. (2001). eLearning and the Psychology of Learning (No. 1.1): CEO, ESPIC Group PLC.
- Clarke, A. (1999). Evaluation Research: An Introduction to Principles Methods and Practice. London.: SAGE Publications.
- Coffield, F., Moseley, D., Hall, E. and Ecclestone, K. (2004), Should We Be Using Learning Styles? What Research Has to Say to Practice, Learning and Skills Development Agency, London. [online] <http://www.lsd.org.uk/files/PDF/1540.pdf>. (Downloaded 6/2/2008)

- Cox, K., and Walker, D. (1993), *User Interface Design*, 2nd Edition, London: Prentice Hall.
- Dunn R. (1993), 'Learning Styles in the Multicultural Diverse', *Emergency Librarian*, vol. 20 (4)
- Felder R.M., and Solomon, B. (2006) Online Index of learning styles questionnaire. [online],
<http://www2.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/ilsweb.html>.
(Downloaded 01/12/2007)
- Felder, R.M. and Silverman, L.K. (1988) Learning Styles and Teaching Styles in Engineering Education. *Journal of Engineering Education*, 78 (7), 674-681
- Fraenkel, J., and Wallen, N. (1991). *Quantitative Research in Social Studies Education*. In J. Shaver (Ed.), *Handbook of Research on Social Studies Teaching and Learning: A project of the National Council for the Social Studies* (pp. 67-82). New York: Macmillan Publishing Company.
- Franklin, S. and Peat, M. (2001). *Managing Change: The Use of Mixed Delivery Modes to Increase Learning Opportunities*. *Australian Journal of Education Technology (AJET)*, 17(1), 37-49.
- Gagne, R. (1965). *The Conditions of Learning*. New York: Holt: Rinehart and Winston.
- Garrison, D., and Anderson, T. (2003). *eLearning in the 21st Century: A Framework for Research and Practice*. London: RoutledgeFalmer.
- Hall, E. and Moseley, D. (2005) "Is there a role for learning styles in personalised education and training?", *INT.J. of Lifelong Education*, Vol. 24, No. 3, May-June, pp. 243-255.
- Hilgard, E. R., and Bower, B. H. (1966). *Theories of Learning*. New York: Appleton century crofts.
- Honey , P. and Mumford A. (2000), *The Learning Styles Questionnaire: 80 Item Version* Peter Honey Publications Ltd., Maidenhead, Berkshire, UK
- Honey, P. (2006), *The Learning Styles Questionnaire: 40Item Version* Peter Honey Publications Ltd., Maidenhead, Berkshire, UK
- Honey, P. and Mumford A. (1986), *The Manual of Learning Styles*, Second ed. Peter Honey Publications Ltd., Maidenhead, Berkshire, UK
- Honey, P. and Mumford, A. (1992) *The Manual of Learning Styles*, 3rd edition, Published and distributed by Peter Honey.

- Jayaratna, N. (1994) . Understanding and Evaluating Methodologies NIMSAD: A Systemic Framework: McGraw-Hill Int.
- Karuppan, C. (2001). Web-based Teaching Materials: a User's Profile, Electronic Network Applications and Policy, Vol.11/2, pp.138-148.
- Kellogg, O. and Bhatnagar, V. (2003). Macromedia Authorware7: Using Authorware7. 1st edition May 2003.
- Kettanurak, V. (2001). User Attitude as a Mediator of Learning Performance Improvement in an Interactive Multimedia Environment: an Empirical Investigation of the Degree of Interactivity and Learning Styles”, Int. J. Human-Computer Studies, Vol. 54/4, April 2001, pp.541-583.
- Knowles, M. (1990). The Adult Learner a Neglected Species (4th ed.)Gulf Publishing company.
- Kolb, D. A. (1984). Experiential Learning: Experience as the source of Learning and Development. Englewood Cliffs NJ: Prentice-Hall.
- Kottegoda, N. T., and Rosso, R. (1997). Statistics, Probability and Reliability. London.: McGraw-Hill.
- Krichen, J. (2007) "Investigating Learning Styles in the Online Educational Environment", SIGITE'07, Oct 18-20, 2007, USA, pp. 127-134.
- Lee, E. T., & Wang, J. W. (2003). Statistical Methods for Survival Data Analysis. US: Hoboken, N.J. John Wiley & Sons, Inc.
- Liegle J. & Janicki T, (2006) "The Effect of Learning Styles on the Navigation Needs of Web-Based Learners", *Computers and Human Behavior*, , V22, N5, pp-885-898.
- Massy, J. (2002, May, 2002). Quality and eLearning in Europe Survey Report. eLearning age Magazine.
- McCarthy, B. (1980). The 4MAT System: Teaching to Learning Styles with Right/Left Mode Techniques, Barrington IL: Excel, Inc.
- McLoughlin, C. 1999, 'The Implications of the Research Literature on Learning Styles for the Design of Instructional Material'. Australian Journal of Educational Technology 15 (3), 222-241.
- Miller, M., Rainer, K., and Corley, K. (2003). Predictors of Engagement and Participation in an Online Course. Online Journal of Distance Learning Administration, 6(1).

- Morgan, G., Griego, O., and Gloeckner, G. (2001). *SPSS for Windows: An Introduction to Use and Interpretation in Research*. London.: Lawrence Erlbaum Associates Publishers.
- Nigel, F. and Sherry, C. (2001). *Matching/Mismatching Revisited: an Empirical Study of Learning and Teaching Styles*. *British Journal of Educational Technology*. Vol 32 No 1 2001.
- Papanikolaou, K., Grigoriadou, M., Kornilakis, H., and Magoulas, G. (2001). *INSPIRE: An Intelligent System for Personalized Instruction in a Remote Environment*, retrieved July 23, 2005, from <http://www.wis.win.tue.nl/ah2001/papers/papanikolaou.pdf>. (Downloaded 05/03/2008)
- Papanikolaou, K.A., Magoulas, G.D and Grigoriadou, M. (2000) A Connectionist Approach for Supporting Personalized Learning in a Web-based Learning Environment. In: P. Brusilovsky, O. Stock and C. Strapparava (eds.): 'Adaptive Hypermedia and Adaptive Web-based Systems. Lecture Notes in Computer Science, Vol. 1892. Springer-Verlag, Berlin, pp. 189-201.
- Paredes, P. and Rodriguez, P. (2002). *A Mixed Approach to Modelling Learning Styles in Adaptive Educational Hypermedia*. Madrid Spain.
- Pfeiffer, G. Holley, D. and Andrew, D. (2005). *Developing thoughtful students: using learning styles in an HE context*, *Journal of Education + Training*, Vol. 47, Issue:6, pp. 422-431
- Roger, S. (1997). *Virtual Learning*: McGraw-Hill Inc.
- Roger, S. (2002). *Designing World-Class E-Learning: How IBM, GE, Harvard Business School, and Columbia University Are Succeeding at e-Learning*: McGraw-Hill.
- Serdiukov, P. (2001). *Models of Distance Higher Education: Fully Automated or Partially Human*. *AACE Journal, formerly Educational Technology Review*, 9(1), 15-25.
- Sidman, C. and Jones, D. (2007) "Addressing Students' Learning Styles through Skeletal PowerPoint Slides: A Case Study", *Journal of Online Learning and Teaching* Vol. 3, No.4, December 2007, pp. 448-459
- Stash, N., Cristea, A., and De Bra, P. (2004) *Authoring of Learning Style in Adaptive Hypermedia Problems and Solutions WWW'04 Education Track*, ACM, New York.

- Stephenson, J. (2001). *Teaching and Learning Online: Pedagogy for new Technologies*. London.: Kogan Page Ltd.
- Tilley, A. (1996). *An Introduction to Psychological Research and Statistics* (3rd ed.): Pineapple Press Brisbane.
- Villaverde, E. Godoy, D. and Amandi A. (2006), "Learning styles' recognition in e-learning environments with feed-forward neural networks", *Journal of Computer Assisted Learning*, Vol. 22, pp197–206.
- Wang, K., Wang, T. and Wang, W. (2006), " Learning styles and formative assessment strategy: enhancing student achievement in Web-based learning", *Journal of Computer Assisted Learning*, Vol.22, pp. 207-217.
- Wenger, E. (1987) *AI and Tutoring Systems. Computational and Cognitive Approaches to the Communication Knowledge*. M. Kaufmann Publishers, California.
- Zapalska, A. and Brozik, D. (2007) "Learning Styles and Online Education", *Campus-Wide Information Systems*, Vol.24, No.1, pp. 6-16.
- Zmud, R., Olson, M., and Hauser, R. (1989). *Field Experimentation in M IS Research*. In I. Benbasat, J. Cash and J. Nunamaker (Eds.), *The Information Systems Research Challenge: Experimental Research Methods: The President and Fellows of Harvard*.

Appendix (A): Screenshots of the Online Material.

A	B
0	0
0	0
0	1
0	1
1	0
1	0
1	1
1	1

Any combination that satisfies the specification results in a 1 in the P column, otherwise a 0 is entered. Go through the above table line by line and satisfy yourself that it meets all the requirements.

The transition screen from left to right

Figure A3.4: Screenshot of online course transaction on the screen.

A	B	C	P
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

Any combination that satisfies the specification results in a 1 in the P column, otherwise a 0 is entered. Go through the above table line by line and satisfy yourself that it meets all the requirements.

Figure A3.5: Screenshot of online course transaction on the screen

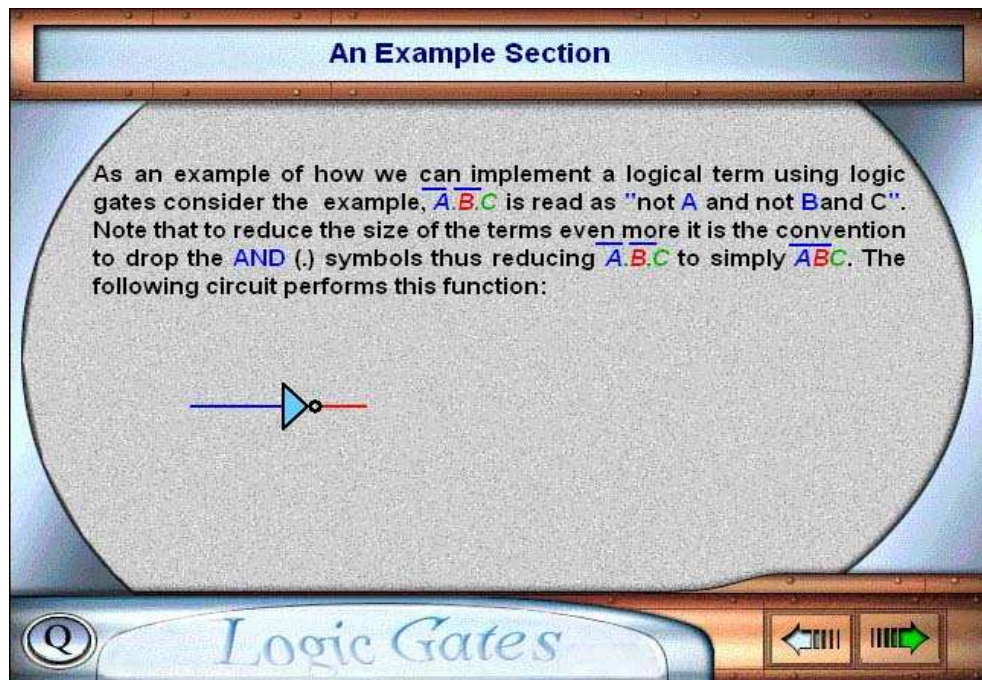


Figure A3.7: Screenshot of online course from the An Example Section.

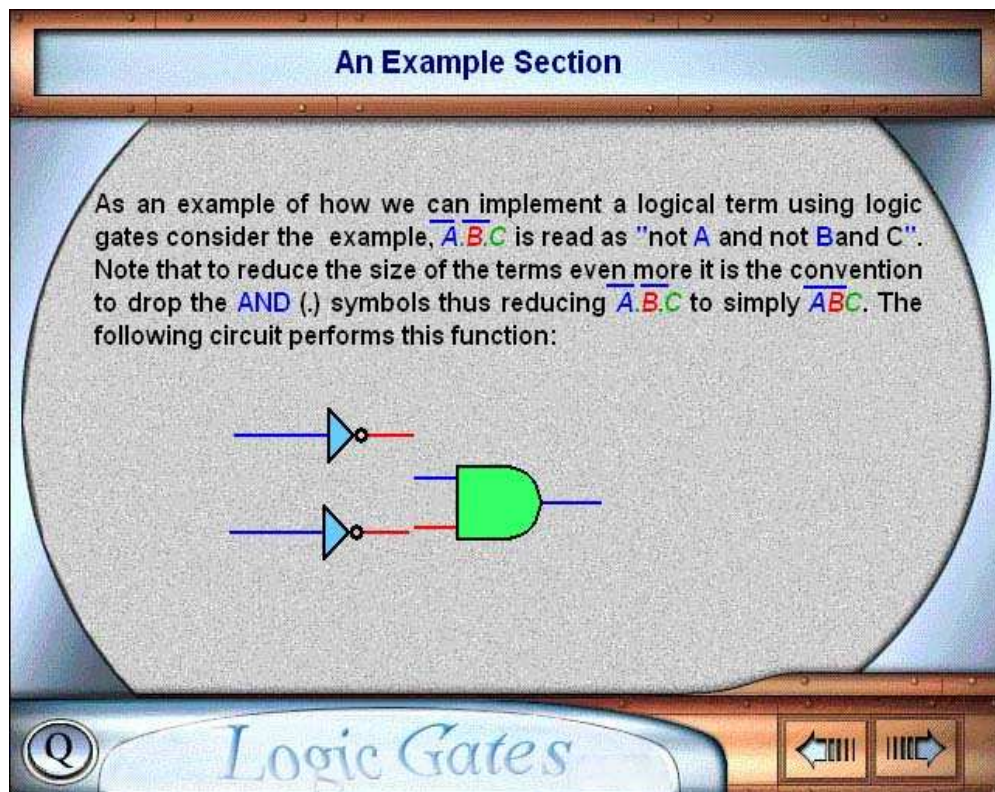


Figure A3.8: Screenshot of online course from the An Example Section.

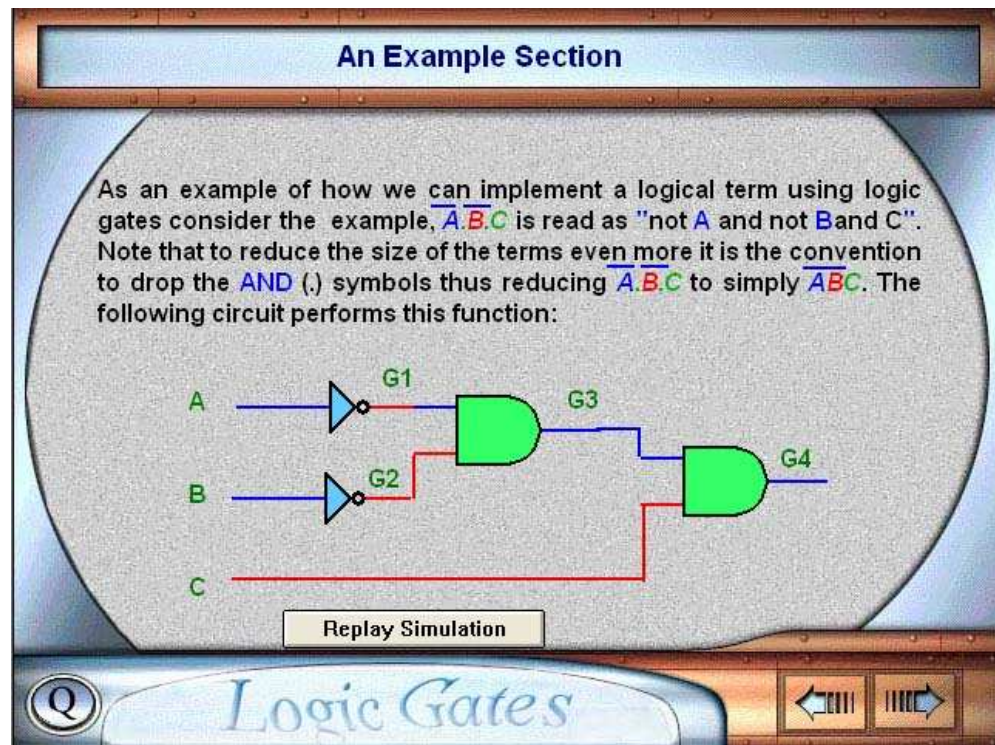
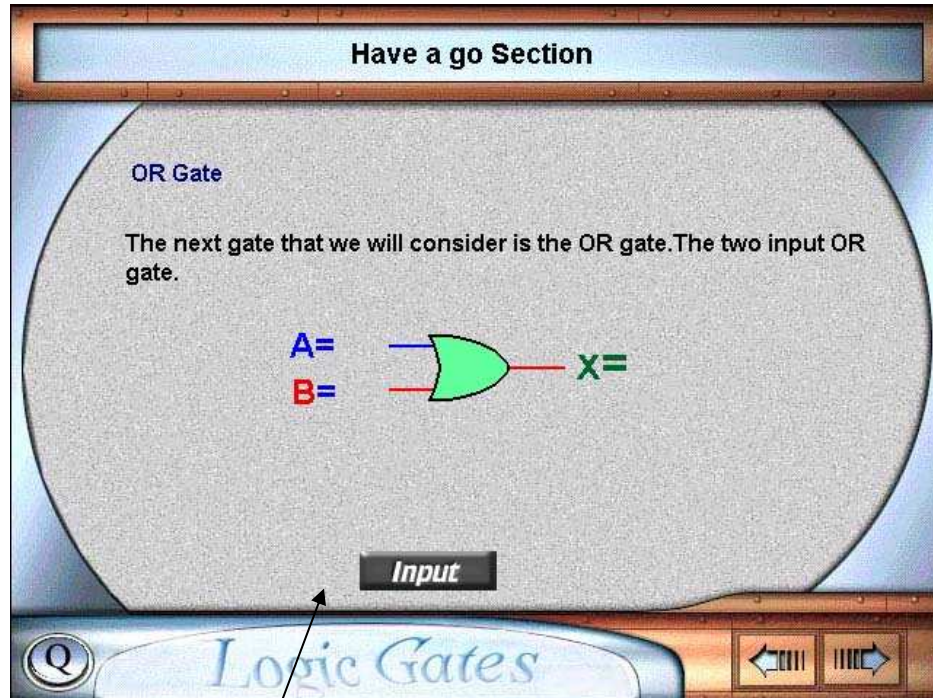


Figure A3.9: Screenshot of online course from the An Example Section.



Input data button to logic gate

Figure A3.11: Screenshot of online course from the Have-a-Go Section.

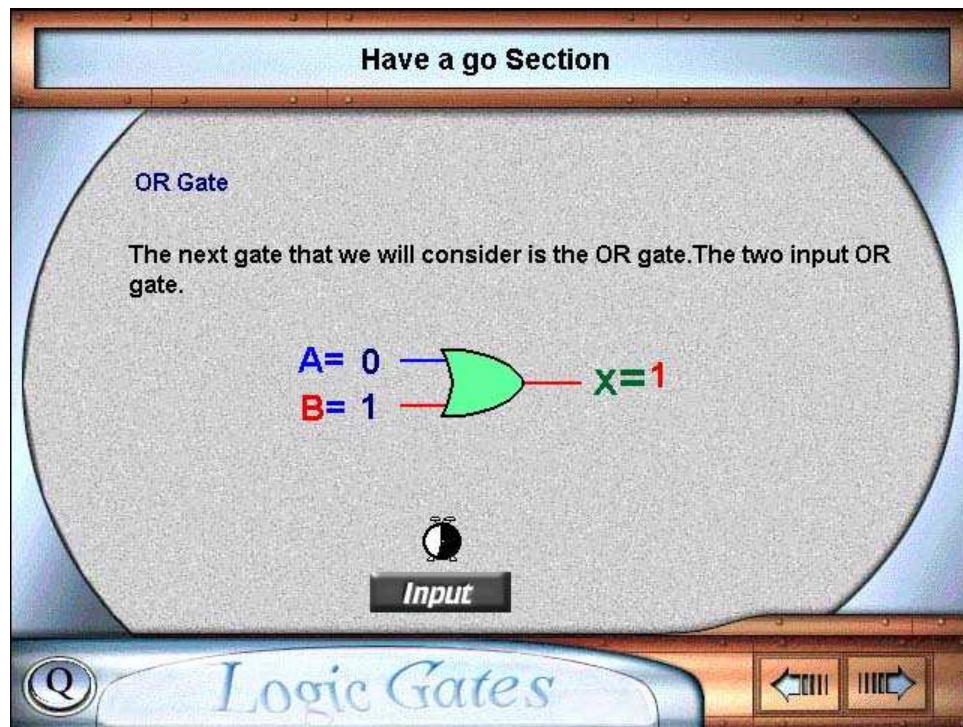

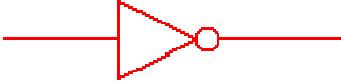







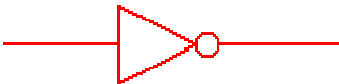






Figure A3.12: Screenshot of online course from the Have-a-Go Section.

Appendix B: Pre-test .

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Q2		The electrical symbol illustrated below represent ?																																																						
																																																								
Answer	No answer																																																							
		1- OR Gate	2- NOR Gate	3- NOT Gate																																																				
Q3		Which of the following symbols represents a NOR gate?																																																						
																																																								
Answer	No answer	1-	2-	3-																																																				
																																																								
Q4		Which one of the following truth tables represents the behaviour a AND gate?																																																						
Answer	No answer																																																							
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Appendix C: Evaluation Form: Post Evaluation Form

This form is to be used to provide feedback on the Logic Gates online course you have recently completed. Please be as honest as you can, as your feedback may be used as a basis to make future improvements and will not influence any marks that you receive for this course.

Q1	How well did the course keep you interested? (please give your reasons)				
Your answer					
	Not at all	Badly	Ok	Good	Very Good
Q2	What level of knowledge would you say that you had before using the Logic Gates material?				
Your answer					
	Not at all	Badly	Ok	Good	Very Good
Q3	What level of knowledge would you say that you now have on the subject of Logic Gates?				
Your answer					
	Not at all	Badly	Ok	Good	Very Good
Q4	What level of confidence do you have that you understood the course material? (please add any comments)				
Your answer					
	None	Very little	Moderate	Confident	Very Confident
Q5	Did you feel comfortable completing the Logic Gates material in the order that it was presented to you? (please add any comments)				
Your answer					
	No			Yes	
Q6	What did you like/dislike about the look and feel of the tool? (eg, Colour schemes, layout, navigation)?				
Q7	What did you like/dislike about the way the material was presented (text, animation, interactivity)?				
Q8	What other learning activity or media do you think would be helpful if it was included? (eg, Audio , Video Clips)?				

APPENDIX D: Full Results of First Experiment.

Student self-assessment of their level of knowledge before accessing the online course, all six groups.

The Chi-Square value obtained in the Kruskal-Wallis test showed no significant difference between any of the six groups in how students assessed their own level of knowledge before they commenced the online course (Chi-Square = 1.01, $P > 0.05$).

Kruskal-Wallis Test**Test Statistics (b)**

	Level of knowledge before course
Chi-Square	1.010
df	5
Asymp. Sig.	.962 (a)

a Kruskal Wallis Test

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error
Level of knowledge before course	Group 1	Mean		2.45	.390
		95% Confidence Interval for Mean	Lower Bound	1.59	
			Upper Bound	3.32	
		5% Trimmed Mean		2.45	
		Median		3.00	
		Variance		1.673	
		Std. Deviation		1.293	
	Minimum		1		
	Maximum		4		
	Range		3		
	Interquartile Range		3.00		
	Group 2	Mean		2.14	.404
		95% Confidence Interval for Mean	Lower Bound	1.15	
			Upper Bound	3.13	
5% Trimmed Mean			2.10		
Median			2.00		
Variance			1.143		
Std. Deviation			1.069		
Minimum		1			
Maximum		4			
Range		3			
Interquartile Range		2.00			

Level of knowledge before course	Group 3	Mean		2.20	.735
		95% Confidence Interval for Mean	Lower Bound	.16	
			Upper Bound	4.24	
		5% Trimmed Mean		2.17	
		Median		1.00	
		Variance		2.700	
		Std. Deviation		1.643	
		Minimum		1	
		Maximum		4	
		Range		3	
		Interquartile Range		3.00	
	Group 4	Mean		3.00	1.000
		95% Confidence Interval for Mean	Lower Bound	-9.71	
			Upper Bound	15.71	
		5% Trimmed Mean		.	
		Median		3.00	
		Variance		2.000	
		Std. Deviation		1.414	
		Minimum		2	
		Maximum		4	
		Range		2	
		Interquartile Range		.	
	Group 5	Mean		2.33	.333
		95% Confidence Interval for Mean	Lower Bound	.90	
			Upper Bound	3.77	
		5% Trimmed Mean		.	
		Median		2.00	
		Variance		.333	
		Std. Deviation		.577	
		Minimum		2	
		Maximum		3	
		Range		1	
		Interquartile Range		.	
	Group 6	Mean		2.40	.600
		95% Confidence Interval for Mean	Lower Bound	.73	
			Upper Bound	4.07	
		5% Trimmed Mean		2.39	
		Median		3.00	
		Variance		1.800	
		Std. Deviation		1.342	
		Minimum		1	
		Maximum		4	
		Range		3	
		Interquartile Range		2.50	

Student self-assessment of their level of knowledge after completing the online course, all six groups.

The Chi-Square value for the the Kruskal-Wallis test showed no significant difference between any of the six groups in how students assessed their own level of knowledge after completing the online course.

Kruskal-Wallis Test

Test Statistics (b)

Level of knowledge after course	
Chi-Square	8.566
df	5
Asymp. Sig.	.128(a)

a Kruskal Wallis Test

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error
Level of knowledge after course	Group 1	Mean		4.18	.182
		95% Confidence Interval for Mean	Lower Bound	3.78	
			Upper Bound	4.59	
		5% Trimmed Mean		4.20	
		Median		4.00	
		Variance		.364	
		Std. Deviation		.603	
		Minimum		3	
		Maximum		5	
		Range		2	
	Interquartile Range		1.00		
	Group 3	Mean		4.40	.245
		95% Confidence Interval for Mean	Lower Bound	3.72	
			Upper Bound	5.08	
		5% Trimmed Mean		4.39	
		Median		4.00	
Variance			.300		
Std. Deviation		.548			
		Minimum		4	
		Maximum		5	
		Range		1	
		Interquartile Range		1.00	

a Level of knowledge after course is constant when Sequence Type = Group 2. It has been omitted. (the value was 4 as Good)

	Sequence Type			Statistic	Std. Error
Level of knowledge after course	Group 4	Mean		3.50	.500
		95% Confidence Interval for Mean	Lower Bound	-2.85	
			Upper Bound	9.85	
		5% Trimmed Mean		.	
		Median		3.50	
		Variance		.500	
		Std. Deviation		.707	
		Minimum		3	
		Maximum		4	
		Range		1	
		Interquartile Range		.	
	Group 5	Mean		4.33	.333
		95% Confidence Interval for Mean	Lower Bound	2.90	
			Upper Bound	5.77	
		5% Trimmed Mean		.	
		Median		4.00	
		Variance		.333	
		Std. Deviation		.577	
		Minimum		4	
		Maximum		5	
		Range		1	
		Interquartile Range		.	
	Group 6	Mean		3.60	.245
		95% Confidence Interval for Mean	Lower Bound	2.92	
			Upper Bound	4.28	
		5% Trimmed Mean		3.61	
		Median		4.00	
		Variance		.300	
		Std. Deviation		.548	
		Minimum		3	
		Maximum		4	
		Range		1	
		Interquartile Range		1.00	

Student levels of confidence that they understood the taught material of the online course, all groups.

The Chi-Square value showed that there is no significant difference (at the 0.05 level) between any of the six groups in the students' level of confidence that they had understood the material accessed on the online course.

Kruskal-Wallis Test

Test Statistics

	Level of confidence
Chi-Square	4.551
df	5
Asymp. Sig.	.473

a Kruskal Wallis Test

b Grouping Variable: Sequence Type

Descriptives

Level of confidence	Sequence Type			Statistic	Std. Error
Level of confidence	Group 1	Mean		3.64	.244
		95% Confidence Interval for Mean	Lower Bound	3.09	
			Upper Bound	4.18	
		5% Trimmed Mean		3.65	
		Median		4.00	
		Variance		.655	
		Std. Deviation		.809	
	Minimum		2		
	Maximum		5		
	Range		3		
	Interquartile Range		1.00		
	Group 2	Mean		3.71	.184
		95% Confidence Interval for Mean	Lower Bound	3.26	
			Upper Bound	4.17	
5% Trimmed Mean			3.74		
Median			4.00		
Variance			.238		
Std. Deviation			.488		
Minimum		3			
Maximum		4			
Range		1			
Interquartile Range		1.00			

a Level of confidence is constant when Sequence Type = Group 3. It has been omitted. (The Value was 4 as confident)

	Sequence Type			Statistic	Std. Error
Level of confidence	Group 4	Mean		3.50	.500
		95% Confidence Interval for Mean	Lower Bound	-2.85	
			Upper Bound	9.85	
		5% Trimmed Mean		.	
		Median		3.50	
		Variance		.500	
		Std. Deviation		.707	
		Minimum		3	
		Maximum		4	
		Range		1	
		Interquartile Range		.	
	Group 5	Mean		4.33	.333
		95% Confidence Interval for Mean	Lower Bound	2.90	
			Upper Bound	5.77	
		5% Trimmed Mean		.	
		Median		4.00	
		Variance		.333	
		Std. Deviation		.577	
		Minimum		4	
		Maximum		5	
		Range		1	
		Interquartile Range		.	
	Group 6	Mean		3.40	.510
		95% Confidence Interval for Mean	Lower Bound	1.98	
			Upper Bound	4.82	
		5% Trimmed Mean		3.39	
		Median		3.00	
		Variance		1.300	
		Std. Deviation		1.140	
		Minimum		2	
		Maximum		5	
		Range		3	
		Interquartile Range		2.00	

Student's level of interest in course material, all groups.

The Chi-Square test showed no significant differences in the interest expressed in the course between any of the six groups.

**Kruskal-Wallis Test
Test Statistics (b)**

	Level of interest
Chi-Square	1.083
df	5
Asymp. Sig.	.956 (a)

a Kruskal Wallis Test

b Grouping Variable: Sequence Type

Descriptives

Level of interest	Sequence Type			Statistic	Std. Error		
Level of interest	Group 1	Mean		3.82	.182		
		95% Confidence Interval for Mean	Lower Bound	3.41			
			Upper Bound	4.22			
		5% Trimmed Mean		3.80			
		Median		4.00			
		Variance		.364			
		Std. Deviation		.603			
		Minimum		3			
		Maximum		5			
		Range		2			
		Interquartile Range		1.00			
		Level of interest	Group 2	Mean		3.71	.184
				95% Confidence Interval for Mean	Lower Bound	3.26	
					Upper Bound	4.17	
5% Trimmed Mean				3.74			
Median				4.00			
Variance				.238			
Std. Deviation				.488			
Minimum				3			
Maximum				4			
Range				1			
Interquartile Range				1.00			
Level of interest	Group 3			Mean		3.80	.200
				95% Confidence Interval for Mean	Lower Bound	3.24	
					Upper Bound	4.36	
		5% Trimmed Mean		3.83			
		Median		4.00			
		Variance		.200			
		Std. Deviation		.447			
		Minimum		3			
		Maximum		4			
		Range		1			
		Interquartile Range		.50			
		Level of interest	Group 4	Mean		3.50	.500
				95% Confidence Interval for Mean	Lower Bound	-2.85	
					Upper Bound	9.85	
5% Trimmed Mean				.			
Median				3.50			
Variance				.500			
Std. Deviation				.707			
Minimum				3			
Maximum				4			
Range				1			
Interquartile Range				.			

	Sequence Type			Statistic	Std. Error
Level of interest	Group 5	Mean		3.67	.333
		95% Confidence Interval for Mean	Lower Bound	2.23	
			Upper Bound	5.10	
		5% Trimmed Mean		.	
		Median		4.00	
		Variance		.333	
		Std. Deviation		.577	
		Minimum		3	
		Maximum		4	
		Range		1	
		Interquartile Range		.	
	Group 6	Mean		3.60	.245
		95% Confidence Interval for Mean	Lower Bound	2.92	
			Upper Bound	4.28	
		5% Trimmed Mean		3.61	
		Median		4.00	
		Variance		.300	
		Std. Deviation		.548	
		Minimum		3	
		Maximum		4	
		Range		1	
		Interquartile Range		1.00	

Evaluation by Learning styles

Because there were only five matched students it was not possible to carry out meaningful comparisons between matched and unmatched students for each of the three learning styles in this sample. Thus the following is, necessarily, confined to examining the students in each learning style as a single unit.

Students' level of knowledge before accessing the online course.

There was significant difference between the three learning styles in the level of how knowledgeable the students considered themselves before they started the course. Those students classified as Theorists considered themselves significantly more knowledgeable about logic gates than did either of the other two learning styles.

Kruskal-Wallis Test

Test Statistics (b)

	Level of knowledge before course
Chi-Square	6.266
df	2
Asymp. Sig.	.044(a)

a Kruskal Wallis Test

b Grouping Variable: Student Learning style

Descriptives

Level of knowledge before course	Student Learning style	Statistic	Std. Error			
Level of knowledge before course	ACTIVIST	Mean	1.91	.315		
		95% Confidence Interval for Mean	Lower Bound	1.21		
			Upper Bound	2.61		
		5% Trimmed Mean	1.84			
		Median	2.00			
		Variance	1.091			
		Std. Deviation	1.044			
		Minimum	1			
		Maximum	4			
		Range	3			
		Interquartile Range	2.00			
		Level of knowledge before course	REFLECTOR	Mean	1.75	.479
				95% Confidence Interval for Mean	Lower Bound	.23
Upper Bound	3.27					
5% Trimmed Mean	1.72					
Median	1.50					
Variance	.917					
Std. Deviation	.957					
Minimum	1					
Maximum	3					
Range	2					
Interquartile Range	1.75					
Level of knowledge before course	THEORIST			Mean	3.29	.421
				95% Confidence Interval for Mean	Lower Bound	2.26

		Upper Bound	4.31	
		5% Trimmed Mean	3.37	
		Median	4.00	
		Variance	1.238	
		Std. Deviation	1.113	
		Minimum	1	
		Maximum	4	
		Range	3	
		Interquartile Range	1.00	

Students' level of knowledge after completing the online course.

The Chi-square test showed no significant difference between the three learning styles in student self-assessment of their own level of knowledge after completing the online course.

Kruskal-Wallis Test

Test Statistics b

	Level of knowledge after course
Chi-Square	1.820
df	2
Asymp. Sig.	.403 a

a Kruskal Wallis Test

b Grouping Variable: Student Learning style

Descriptives(a,b)

	Student Learning style		Statistic	Std. Error	
Level of knowledge after course	ACTIVIST	Mean	3.91	.211	
		95% Confidence Interval for Mean	Lower Bound	3.44	
			Upper Bound	4.38	
	5% Trimmed Mean	3.90			
	Median	4.00			
	Variance	.491			
	Std. Deviation	.701			
	Minimum	3			
	Maximum	5			
	Range	2			
	Interquartile Range	1.00			
	REFLECTOR	REFLECTOR	Mean	4.25	.250
			95% Confidence Interval for Mean	Lower Bound	3.45
Upper Bound				5.05	
5% Trimmed Mean		4.22			
Median		4.00			
Variance		.250			
Std. Deviation		.500			
Minimum		4			
Maximum		5			
Range		1			

		Interquartile Range		.75	
	THEORIST	Mean		4.29	.184
		95% Confidence Interval for Mean	Lower bound	3.83	
			Upper bound	4.74	
		5% Trimmed Mean		4.26	
		Median		4.00	
		Variance		.238	
		Std. Deviation		.488	
		Minimum		4	
		Maximum		5	
		Range		1	

Students' level of confidence after completing the online course.

The Chi-square test showed no significant difference between the three learning styles in student confidence in the material contained in the online course.

**Kruskal-Wallis Test
Test Statistics b**

	Level of confidence
Chi-Square	1.469
df	2
Asymp. Sig.	.480 a

a Kruskal Wallis Test

b Grouping Variable: Student Learning style

Descriptives

	Student Learning style			Statistic	Std. Error
Level of confident	ACTIVIST	Mean		3.55	.247
		95% Confidence Interval for Mean	Lower Bound	2.99	
			Upper Bound	4.10	
		5% Trimmed Mean		3.55	
		Median		4.00	
		Variance		.673	
		Std. Deviation		.820	
		Minimum		2	
		Maximum		5	
		Range		3	
		Interquartile Range		1.00	
	THEORIST	Mean		3.86	.404
		95% Confidence Interval for Mean	Lower Bound	2.87	
			Upper Bound	4.85	
		5% Trimmed Mean		3.90	
		Median		4.00	
		Variance		1.143	
		Std. Deviation		1.069	
		Minimum		2	
		Maximum		5	
		Range		3	
		Interquartile Range		2.00	

a Level of confident is constant when Student Learning style = REFLECTOR. It has been omitted.

Students' level of interest in the online course material.

There was a significant difference between the learning styles in level of interest in the online course. Reflector type learners and Theorist type learners found the online course significantly more interesting than did Activist type learners.

**Kruskal-Wallis Test
Test Statistics (b)**

Level of interest	
Chi-Square	8.302
df	2
Asymp. Sig.	.016 (a)


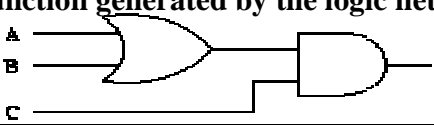
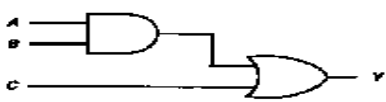
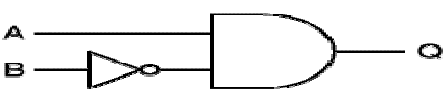
a Kruskal Wallis Test

b Grouping Variable: Student Learning style

Descriptives

	Student Learning style			Statistic	Std. Error	
Level of interest	ACTIVIST	Mean		3.45	.157	
		95% Confidence Interval for Mean	Lower Bound	3.10		
			Upper Bound	3.81		
		5% Trimmed Mean		3.45		
		Median		3.00		
		Variance		.273		
		Std. Deviation		.522		
		Minimum		3		
		Maximum		4		
		Range		1		
		Interquartile Range		1.00		
		THEORIST	Mean		4.14	.143
		95% Confidence Interval for Mean	Lower Bound	3.79		
	Upper Bound	4.49				
	5% Trimmed Mean	4.10				
	Median	4.00				
	Variance	.143				
	Std. Deviation	.378				
	Minimum	4				
	Maximum	5				

a Level of interest is constant when Student Learning style = REFLECTOR. It has been omitted. (the Value was 4 as Good)

Post-Course Test																																																	
\salamander\logic																																																	
Name:																																																	
Group:																																																	
Date:																																																	
This is a multiple choice quiz. Please answer each question by make your choice																																																	
Q1		What are the values of the inputs to make the output equals to one?																																															
Answer	No answer																																																
		1- A=0, B=0	2- A=1, B=0	3- A=0, B=1																																													
				4- A=1, B=1																																													
Q2		Identify the function generated by the logic network illustrated?																																															
Answer	No answer																																																
		1- (A + B)C	2- C(A.B)	3- A(C+B)																																													
				4- B(A+C)																																													
Q3		In order for output 'Y' to be a '1', inputs A, B, and C must be:																																															
Answer	No answer																																																
		1- A=1, B=0, C=0	2- A=0, B=0, C=0	3- A=1, B=0, C=1																																													
				4- A=0, B=1, C=0																																													
Q4		Which one of the following truth tables represents the output for this circuit?																																															
Answer	No answer																																																
		1-	2-	3-																																													
		<table border="1" style="margin: auto;"> <thead> <tr><th>Input A</th><th>Input B</th><th>Output Q</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>1</td></tr> </tbody> </table>	Input A	Input B	Output Q	0	0	0	0	1	0	1	0	0	1	1	1	<table border="1" style="margin: auto;"> <thead> <tr><th>Input A</th><th>Input B</th><th>Output Q</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>0</td></tr> </tbody> </table>	Input A	Input B	Output Q	0	0	1	0	1	1	1	0	1	1	1	0	<table border="1" style="margin: auto;"> <thead> <tr><th>Input A</th><th>Input B</th><th>Output Q</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>0</td></tr> </tbody> </table>	Input A	Input B	Output Q	0	0	0	0	1	0	1	0	1	1	1	0
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APPENDIX E: Evaluation Form for Second Experiment

Post Evaluation Form

This form is to be used to provide feedback on the Logic Gates online course you have recently completed. Please be as honest as you can, as your feedback may be used as a basis to make future improvements and will not influence any marks that you receive for this course.

<u>Q1</u>	How well did the course keep you interested and motivated? (please give your reasons)				
Your answer					
	None	Very little	Moderate	Good	<u>Very Good</u>
<u>Q2</u>	What level of knowledge would you say that you have before using the Logic Gates material?				
Your answer					
	None	Very little	Moderate	Good	<u>Very Good</u>
<u>Q3</u>	What level of knowledge would you say that you now have on the subject of Logic Gates?				
Your answer					
	None	Very little	Moderate	Good	<u>Very Good</u>
<u>Q4</u>	What level of confidence do you have that you understood the course material? (please add any comments)				
<u>Your answer</u>					
	None	Very little	Moderate	Confident	<u>Very Confident</u>
<u>Q5</u>	Did you feel comfortable completing the Logic Gates material in the order that it was presented to you? (please add any comments)				
<u>Your answer</u>					
	No		Yes		

APPENDIX F: Full Results for Second Experiment.**Differences in marks awarded in the Pre- and Post-tests for both groups.**

The t-test (equal variances not assumed) showed no significant difference in the marks awarded for the Pre-test, but there was a significant difference between the two groups ($t=8.44$, $P < 0.001$) in the Post-test marks.

**T-test
Group Statistics**

	Sequence Type	N	Mean	Std. Deviation	Std. Error Mean
Pre-test marks	Group 1	30	2.0667	1.63861	.29917
	Group 2	33	1.4848	1.50252	.26156
Post-test marks	Group 1	30	2.7000	.46609	.08510
	Group 2	34	1.0882	.99598	.17081

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre-test Marks	Equal variances assumed	.816	.370	1.470	61	.147	.58	.400	-2.09	1.373
	Equal variances not assumed			1.464	59.02	.148	.58	.397	-2.13	1.377
Post-test marks	Equal variances assumed	14.54	.000	8.109	62	.000	1.61	.199	1.214	2.009
	Equal variances not assumed			8.446	48.05	.000	1.61	.191	1.228	1.995

Change in level of knowledge before and after completing the online course, matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of students' self-assessed level of knowledge, for the 30 matched students in Group one (learning style matching learning sequence), was significant at a level of confidence of 99.9%.

Wilcoxon Signed Ranks Test

	Level of knowledge before course – Level of knowledge after course
Z	-4.826 a
Asymp. Sig. (2-tailed)	.000

a Based on negative ranks.

Ranks

		N	Mean rank
Level of knowledge before course – Level of knowledge after course	Negative ranks	0	.00
	Positive ranks	29	15.00
	Ties	1	
	Total	30	

Change in level of knowledge before and after completing the online course, non-matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of how students assessed their own level of knowledge, for the 34 students in Group two (learning style not matching learning sequence), was not significant at a level of confidence of 95%.

Wilcoxon Signed Ranks Test

	Level of knowledge before course – Level of knowledge after course
Z	-4.185a
Asymp. Sig. (2-tailed)	.000

a Based on negative ranks.

Ranks

		N	Mean rank
Level of knowledge before course - Level of knowledge after course	Negative ranks	0	.00
	Positive ranks	19	10.00
	Ties	15	
	Total	34	

Student self-assessment of their level of knowledge before accessing the online course, both groups.

The non-parametric test (Mann-Whitney U) was used because the scores given by the students were ordinal data. There was no significant difference between mean scores of the two groups at ($P > 0.05$).

Mann-Whitney Test

Level of knowledge before course	
Mann-Whitney U	466.000
Wilcoxon W	931.000
Z	-.763
Asymp. Sig. (2-tailed)	.445

Descriptives

Level of knowledge before course	Sequence Type		Statistic	Std. Error	
Level of knowledge before course	Group 1	Mean	1.37	.155	
		95% Confidence Interval for Mean	Lower Bound	1.05	
			Upper Bound	1.68	
		5% Trimmed Mean	1.22		
		Median	1.00		
		Variance	.723		
		Std. Deviation	.850		
		Minimum	1		
		Maximum	5		
	Range	4			
	Group 2	Interquartile Range	.25		
		Mean	1.62	.189	
		95% Confidence Interval for Mean	Lower Bound	1.23	
			Upper Bound	2.00	
		5% Trimmed Mean	1.49		
		Median	1.00		
		Variance	1.213		
Std. Deviation		1.101			
Minimum	1				
Maximum	5				
Range	4				
Interquartile Range	1.00				

Student self-assessment of their level of knowledge after completing the online course, both groups.

The Mann-Whitney U test was again used to analyse the ordinal data obtained. A significant difference between the two groups was found in their mean self-assessed level of knowledge after completing the online course ($P < 0.001$).

**Mann-Whitney Test
Test Statistics a**

	Level of knowledge after course
Mann-Whitney U	78.00
Wilcoxon W	673.0
Z	-5.952
Asymp. Sig. (2-tailed)	.000

a Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error	
Level of knowledge after course	Group 1	Mean		4.20	.130	
		95% Confidence Interval for Mean	Lower Bound	3.93		
			Upper Bound	4.47		
		5% Trimmed Mean		4.22		
		Median		4.00		
		Variance		.510		
		Std. Deviation		.714		
		Minimum		3		
		Maximum		5		
		Range		2		
		Interquartile Range		1.00		
		Group 2	Mean		2.24	.174
			95% Confidence Interval for Mean	Lower Bound	1.88	
				Upper Bound	2.59	
5% Trimmed Mean			2.17			
Median			2.00			
Variance			1.034			
Std. Deviation			1.017			
Minimum			1			
Maximum			5			
Range			4			
Interquartile Range			1.25			

Student levels of confidence that they understood the taught material of the online course, both groups.

The Mann-Whitney U test was used to analyse the ordinal data obtained. The result showed that there is significant difference ($P < 0.001$) between the two groups in their levels of confidence in the online course material.

**Mann-Whitney Test
Test Statistics b**

	Level of confidence
Mann-Whitney U	65.500
Wilcoxon W	443.500
Z	-3.526
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000 a

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

Level of confidence	Sequence Type			Statistic	Std. Error
Level of confidence	Group 1	Mean		3.93	.267
		95% Confidence Interval for Mean	Lower Bound	3.35	
			Upper Bound	4.50	
		5% Trimmed Mean		3.98	
		Median		4.00	
		Variance		.995	
	Std. Deviation		.997		
	Minimum		2		
	Maximum		5		
	Range		3		
	Interquartile Range		2.00		
	Group 2	Mean		2.59	.171
		95% Confidence Interval for Mean	Lower Bound	2.24	
Upper Bound			2.94		
5% Trimmed Mean			2.60		
Median			3.00		
Variance			.789		
Std. Deviation		.888			

Student's level of interest in course material, both groups.

The Mann-Whitney U test was again used to analyse the ordinal data obtained. The results showed that there was significant difference between the two groups in their self-perceived level of interest in the course ($P < 0.001$).

**Mann-Whitney Test
Test Statistics (a)**

	Level of interest
Mann-Whitney U	156.500
Wilcoxon W	652.500
Z	-4.200
Asymp. Sig. (2-tailed)	.000

a Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error	
Level of interest	Group 1	Mean		3.72	.108	
		95% Confidence Interval for Mean	Lower Bound	3.50		
			Upper Bound	3.94		
		5% Trimmed Mean		3.70		
		Median		4.00		
		Variance		.293		
		Std. Deviation		.542		
		Minimum		3		
		Maximum		5		
		Range		2		
		Interquartile Range		1.00		
		Group 2	Mean		2.84	.161
			95% Confidence Interval for Mean	Lower Bound	2.51	
				Upper Bound	3.17	
5% Trimmed Mean			2.84			
Median			3.00			
Variance			.806			
Std. Deviation			.898			
Minimum			1			
Maximum			5			
Range			4			
Interquartile Range			.00			

Differences between matched and non-matched students in whether or not they felt comfortable with the way of the material was presented.

The Mann-Whitney U test was used to analyse the ordinal data obtained. There was significant difference between the two groups ($P < 0.001$) in how comfortable they felt with the material of the online course.

Mann-Whitney Test

Test Statistics a

	"Did you feel comfortable?"
Mann-Whitney U	225.000
Wilcoxon W	690.000
Z	-4.261
Asymp. Sig. (2-tailed)	.000

a Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error
"Did you feel comfortable?"	Group 1	Mean		1.9667	.03333
		95% Confidence Interval for Mean	Lower Bound	1.8985	
			Upper Bound	2.0348	
		5% Trimmed Mean		2.0000	
		Median		2.0000	
		Variance		.033	
		Std. Deviation		.18257	
		Minimum		1.00	
		Maximum		2.00	
		Range		1.00	
		Interquartile Range		.0000	
	Group 2	Mean		1.4667	.09264
		95% Confidence Interval for Mean	Lower Bound	1.2772	
			Upper Bound	1.6561	
		5% Trimmed Mean		1.4630	
		Median		1.0000	
		Variance		.257	
		Std. Deviation		.50742	
		Minimum		1.00	
		Maximum		2.00	
		Range		1.00	
	Interquartile Range		1.0000		

ACTIVIST STUDENTS

Differences in marks awarded in the Pre- and Post-tests for both groups of Activist students.

The t-test (equal variances not assumed) showed no significant difference in the marks awarded for the Pre-test, but there was a significant difference between the two Activist groups ($t=8.12$, $P < 0.001$) in the Post-test marks

Group Statistics

	Sequence Type	N	Mean	Std. Deviation	Std. Error Mean
Pre-test marks	Group 1	10	2.20	1.814	.573
	Group 2	12	1.08	1.505	.434
Post-test marks	Group 1	10	3.00	.000	.000
	Group 2	12	1.00	.853	.246

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre-test Marks	Equal variances assumed	1.215	.283	1.580	20	.130	1.117	.707	-.358	2.591
	Equal variances not assumed			1.552	17.56	.138	1.117	.719	-.398	2.631
Post-test marks	Equal variances assumed	18.18	.000	7.385	20	.000	2.000	.271	1.435	2.565
	Equal variances not assumed			8.124	11.00	.000	2.000	.246	1.458	2.542

Change in level of knowledge before and after completing the online course, matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of students' self-assessed level of knowledge, for the 10 activist students in Group one (learning style matching learning sequence).

Wilcoxon Signed Ranks Test

Test Statistics (b)

	Level of knowledge after course - Level of knowledge before course
Z	-2.850(a)
Asymp. Sig. (2-tailed)	.004

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0(a)	.00	.00
	Positive Ranks	10(b)	5.50	55.00
	Ties	0(c)		
	Total	10		

a Level of knowledge after course < Level of knowledge before course
b Level of knowledge after course > Level of knowledge before course
c Level of knowledge after course = Level of knowledge before course

Change in level of knowledge before and after completing the online course, non-matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of how students assessed their own level of knowledge, for the 12 activist students in Group two (learning style not matching learning sequence), was not significant at a level of confidence of 50%.

Wilcoxon Signed Ranks Test

Test Statistics (b)

	Level of knowledge after course - Level of knowledge before course
Z	-2.333(a)
Asymp. Sig. (2-tailed)	.020

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0(a)	.00	.00
	Positive Ranks	6(b)	3.50	21.00
	Ties	6(c)		
	Total	12		

a Level of knowledge after course < Level of knowledge before course
b Level of knowledge after course > Level of knowledge before course
c Level of knowledge after course = Level of knowledge before course

Activist student self-assessment of their level of knowledge before accessing the online course.

The Mann-Whitney U test showed that there was no significant difference in the level of student self-assessment ($P > 0.05$) between the matched and non-matched Activist groups before accessing the online course.

**Mann-Whitney Test
Test Statistics b**

	Level of knowledge before course
Mann-Whitney U	50.500
Wilcoxon W	105.500
Z	-.933
Asymp. Sig. (2-tailed)	.351
Exact Sig. [2*(1-tailed Sig.)]	.539a

a Not corrected for ties.

b Grouping Variable: Sequence Type

	Sequence Type			Statistic	Std. Error	
Level of knowledge before course	Group 1	Mean		1.10	.100	
		95% Confidence Interval for Mean	Lower Bound	.87		
			Upper Bound	1.33		
		5% Trimmed Mean		1.06		
		Median		1.00		
		Variance		.100		
		Std. Deviation		.316		
		Minimum		1		
		Maximum		2		
		Range		1		
		Interquartile Range		.00		
		Group 2	Mean		1.33	.188
			95% Confidence Interval for Mean	Lower Bound	.92	
				Upper Bound	1.75	
5% Trimmed Mean			1.26			
Median			1.00			
Variance			.424			
Std. Deviation			.651			
Minimum			1			
Maximum			3			
Range			2			

Activist Student self-assessment of their level of knowledge after completing the online course.

The Mann-Whitney U test shows a significant difference between Activist learners in the two Activist groups in their level of knowledge after completing the online course, ($P < 0.001$).

**Mann-Whitney Test
Test Statistics**

	Level of knowledge after course
Mann-Whitney U	3.000
Wilcoxon W	81.000
Z	-3.835
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000 a

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

Level of knowledge after course	Sequence Type			Statistic	Std. Error
Level of knowledge after course	Group 1	Mean		4.20	.249
		95% Confidence Interval for Mean	Lower Bound	3.64	
			Upper Bound	4.76	
		5% Trimmed Mean		4.22	
		Median		4.00	
		Variance		.622	
		Std. Deviation		.789	
	Minimum		3		
	Maximum		5		
	Range		2		
	Interquartile Range		1.25		
	Group 2	Mean		1.92	.229
		95% Confidence Interval for Mean	Lower Bound	1.41	
			Upper Bound	2.42	
5% Trimmed Mean			1.91		
Median			2.00		
Variance			.629		
Std. Deviation			.793		
Minimum		1			
Maximum		3			
Range		2			
Interquartile Range		1.75			

Activist Students' level of confidence in taught material after completing the online course, both groups.

The Mann-Whitney U test shows there is significant difference in the mean levels of confidence between the Activist learners in the two groups ($P < 0.01$).

Mann-Whitney Test

Test Statistics(b)

	Level of confidence
Mann-Whitney U	4.000
Wilcoxon W	49.000
Z	-3.184
Asymp. Sig. (2-tailed)	.001
Exact Sig. [2*(1-tailed Sig.)]	.001(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type		Statistic	Std. Error			
Level of confident	Group 1	Mean		4.13	.295		
		95% Confidence Interval for Mean	Lower Bound	3.43			
			Upper Bound	4.82			
		5% Trimmed Mean		4.14			
		Median		4.00			
		Variance		.696			
		Std. Deviation		.835			
		Minimum		3			
		Maximum		5			
		Range		2			
		Interquartile Range		1.75			
		Group 2	Group 2	Mean		2.33	.236
				95% Confidence Interval for Mean	Lower Bound	1.79	
					Upper Bound	2.88	
5% Trimmed Mean				2.37			
Median				2.00			
Variance				.500			
Std. Deviation				.707			
Minimum				1			
Maximum				3			
Range				2			
Interquartile Range		1.00					

Activist students' level of interest in course material, both groups.

The Mann-Whitney U test shows that there is significant difference between the levels of interest in the online course material of the Activist learners in the two groups ($P < 0.01$).

Mann-Whitney Test**Test Statistics(b)**

	Level of interest
Mann-Whitney U	18.000
Wilcoxon W	84.000
Z	-2.877
Asymp. Sig. (2-tailed)	.004
Exact Sig. [2*(1-tailed Sig.)]	.008(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error
Level of interest	Group 1	Mean		3.88	.227
		95% Confidence Interval for Mean	Lower Bound	3.34	
			Upper Bound	4.41	
		5% Trimmed Mean		3.86	
		Median		4.00	
		Variance		.411	
		Std. Deviation		.632	
		Minimum		3	
		Maximum		5	
		Range		2	
		Interquartile Range		.75	
	Group 2	Mean		2.73	.273
		95% Confidence Interval for Mean	Lower Bound	1.90	
			Upper Bound	3.44	
		5% Trimmed Mean		2.69	
		Median		3.00	
		Variance		1.000	
		Std. Deviation		.905	
		Minimum		1	
		Maximum		4	
		Range		3	
		Interquartile Range		1.00	

Differences between matched and non-matched Activist students in whether or not they felt comfortable with the way of the material was presented.

The Activist students were asked whether or not they felt comfortable with the material of the online course. The response was either Yes or No. There was significant difference at ($P < 0.05$). All students in Group one answered Yes.

Mann-Whitney Test

Test Statistics(b)

	"Did you feel comfortable?"
Mann-Whitney U	30.000
Wilcoxon W	96.000
Z	-2.384
Asymp. Sig. (2-tailed)	.017
Exact Sig. [2*(1-tailed Sig.)]	.085(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives(a)

	Sequence Type			Statistic	Std. Error
"Did you feel comfortable?"	Group 2	Mean		1.55	.16
		95% Confidence Interval for Mean		1.19	
			Lower Bound	1.19	
			Upper Bound	1.90	
		5% Trimmed Mean		1.55	
		Median		2.00	
		Variance		.27	
		Std. Deviation		.52	
		Minimum		1.00	
		Maximum		2.00	
		Range		1.00	
		Interquartile Range		1.00	
		Skewness		-.213	.661
		Kurtosis		-2.44	1.28

a All ten students in Group 1 answered Yes, and it has been omitted.

PRAGMATIST STUDENTS**Differences in marks awarded in the Pre- and Post-tests for both groups of Pragmatist students.**

The t-test (equal variances not assumed) showed no significant difference in the marks awarded for the Pre-test, but there was a significant difference between the two groups ($t=3.45$, $P < 0.05$) in the Post-test marks.

T-Test**Group Statistics**

	Sequence Type	N	Mean	Std. Deviation	Std. Error Mean
Pre-test marks	Group 1	6	2.167	1.472	.601
	Group 2	9	1.556	1.740	.580
Post-test marks	Group 1	6	2.500	.548	.224
	Group 2	9	1.000	1.118	.373

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre-test marks	Equal variances assumed	.665	.430	.706	13	.493	.611	.865	-1.259	2.481
	Equal variances not assumed			.732	12.10	.478	.611	.835	-1.207	2.429
Post-test marks	Equal variances assumed	2.450	.142	3.026	13	.010	1.500	.496	.429	2.571
	Equal variances not assumed			3.451	12.26	.005	1.500	.435	.555	2.445

Change in level of knowledge before and after completing the online course, matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of students' self-assessed level of knowledge, for the 6 pragmatist students in Group one (learning style matching learning sequence).

Wilcoxon Signed Ranks Test

Test Statistics(b)

	Level of knowledge after course - Level of knowledge before course
Z	-2.333(a)
Asymp. Sig. (2-tailed)	0.020

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0(a)	.00	.00
	Positive Ranks	6(b)	3.50	21.00
	Ties	0(c)		
	Total	6		

a Level of knowledge after course < Level of knowledge before course
b Level of knowledge after course > Level of knowledge before course
c Level of knowledge after course = Level of knowledge before course

Change in level of knowledge before and after completing the online course, non-matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of how students assessed their own level of knowledge, for the 9 pragmatist students in Group two (learning style not matching learning sequence).

Wilcoxon Signed Ranks Test

Test Statistics(b)

	Level of knowledge after course - Level of knowledge before course
Z	-2.121(a)
Asymp. Sig. (2-tailed)	.034

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0(a)	.00	0.00
	Positive Ranks	5(b)	3.00	15.00
	Ties	4(c)		
	Total	9		

a Level of knowledge after course < Level of knowledge before course
b Level of knowledge after course > Level of knowledge before course
c Level of knowledge after course = Level of knowledge before course

Pragmatist student self-assessment of their level of knowledge before accessing the online course.

The Mann-Whitney U test showed that there was no significant difference in the level of student self-assessment ($P > 0.05$) between the matched and non-matched Pragmatist groups before accessing the online course.

Mann-Whitney Test Test Statistics(b)

	Level of knowledge before course
Mann-Whitney U	18.00
Wilcoxon W	39.00
Z	-1.266
Asymp. Sig. (2-tailed)	.205
Exact Sig. [2*(1-tailed Sig.)]	.328(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type		Statistic	Std. Error	
Level of knowledge before course	Group 1	Mean	1.17	.167	
		95% Confidence Interval for Mean	Lower Bound	.74	
			Upper Bound	1.60	
		5% Trimmed Mean	1.13		
		Median	1.00		
		Variance	.167		
		Std. Deviation	.408		
	Minimum	1			
	Maximum	2			
	Range	1			
	Interquartile Range	0			
	Group 2	Mean	1.89	.389	
		95% Confidence Interval for Mean	Lower Bound	.99	
			Upper Bound	2.79	
5% Trimmed Mean		1.82			
Median		1.00			
Variance		1.361			
Std. Deviation		1.167			
Minimum	1				

Pragmatist student self-assessment of their level of knowledge after completing the online course.

The Mann-Whitney U test shows a significant difference between the Post-test scores of the Pragmatist learners in Groups one and two ($P < 0.001$).

**Mann-Whitney Test
Test Statistics (b)**

	Level of knowledge after course
Mann-Whitney U	4.000
Wilcoxon W	49.000
Z	-2.818
Asymp. Sig. (2-tailed)	.005
Exact Sig. [2*(1-tailed Sig.)]	.005(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type		Statistic	Std. Error	
Level of knowledge after course	Group 1	Mean	4.33	.211	
		95% Confidence Interval for Mean	Lower Bound	3.79	
			Upper Bound	4.88	
		5% Trimmed Mean	4.31		
		Median	4.00		
		Variance	.267		
		Std. Deviation	.516		
		Minimum	4		
		Maximum	5		
		Range	1		
	Interquartile Range	1			
	Group 2	Mean	2.56	.377	
		95% Confidence Interval for Mean	Lower Bound	1.69	
Upper Bound			3.42		
5% Trimmed Mean		2.56			
Median		3.00			
Variance		1.278			
Std. Deviation		1.130			
Minimum	1				

Pragmatist students' level of confidence in taught material after completing the online course, both groups.

No Pragmatist student in Group one (matched) answered this question so no comparison can be made.

**Mann-Whitney Test
Descriptives**

	Sequence Type			Statistic	Std. Error
Level of confidence	Group 2	Mean		2.67	.333
		95% Confidence Interval for Mean	Lower Bound	1.90	
			Upper Bound	3.44	
		5% Trimmed Mean		2.69	
		Median		3.00	
		Variance		1.00	
		Std. Deviation		1.00	
		Minimum		1	
		Maximum		4	
		Range		3	
		Interquartile Range		1.00	
		Skewness		.000	.752
		Kurtosis		.000	1.481

a There are no valid cases for Level of confidence. Statistics cannot be computed.

Pragmatist students' level of interest in course material, both groups.

The results show that there is significant difference between the levels of interest of the Pragmatist learners in the two groups ($P < 0.05$).

Mann-Whitney Test**Test Statistics(b)**

	Level of interest
Mann-Whitney U	3.000
Wilcoxon W	48.000
Z	-2.093
Asymp. Sig. (2-tailed)	.036
Exact Sig. [2*(1-tailed Sig.)]	0.064(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

Level of interest	Sequence Type			Statistic	Std. Error
	Group 2	Mean		2.89	.309
		95% Confidence Interval for Mean		2.18	
			Lower Bound		
			Upper Bound	3.60	
		5% Trimmed Mean		2.93	
		Median		3.00	
		Variance		.861	
		Std. Deviation		.928	
		Minimum		1	
		Maximum		4	
		Range		3	
		Interquartile Range		1	
		Skewness		-.944	.717
		Kurtosis		1.354	1.400

All three students in Group 1 answered Good, so it has been omitted.

Differences between matched and non-matched Pragmatist students in whether or not they felt comfortable with the way of the material was presented

There was significant difference in how comfortable the Pragmatist learners in the two groups felt while they used the online course ($P < 0.01$).

Mann-Whitney Test

Test Statistics(b)

	"Did you feel comfortable?"
Mann-Whitney U	6.000
Wilcoxon W	42.000
Z	-2.704
Asymp. Sig. (2-tailed)	.007
Exact Sig. [2*(1-tailed Sig.)]	.020 a

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type		Statistic	Std. Error
"Did you feel comfortable?"	Group 2	Mean	1.250	.1637
		95% Confidence Interval for Mean	Lower Bound	.8630
			Upper Bound	1.637
		5% Trimmed Mean	1.222	
		Median	1.000	
		Variance	.214	
		Std. Deviation	.463	
		Minimum	1.00	
		Maximum	2.000	
		Range	1.000	
		Interquartile Range	.750	
		Skewness	1.440	.752
		Kurtosis	.000	1.481

All six students in Group 1 answered Yes, and so it has been omitted.

REFLECTOR STUDENTS**Differences in marks awarded in the Pre- and Post-tests for both groups of Reflector students.**

The t-test (equal variances not assumed) showed no significant difference in the mean marks awarded to the two Reflector groups for either the Pre-test or the Post-test.

Group Statistics

	Sequence Type	N	Mean	Std. Deviation	Std. Error Mean
Pre-test marks	Group 1	5	1.000	1.414	.632
	Group 2	4	1.500	1.915	.957
Post-test marks	Group 1	5	2.400	.548	.245
	Group 2	4	2.250	.500	.250

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre-test marks	Equal variances assumed	.500	.502	-.452	7	.665	-.500	1.105	-3.113	2.113
	Equal variances not assumed			-.436	5.416	.680	-.500	1.147	-3.383	2.383
Post-test marks	Equal variances assumed	.728	.422	.424	7	.685	.150	.354	-.687	.987
	Equal variances not assumed			.429	6.815	.681	.150	.350	-.682	.982

Change in level of knowledge before and after completing the online course, matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of students' self-assessed level of knowledge, for the 5 Reflectors students in Group one (learning style matching learning sequence).

Wilcoxon Signed Ranks Test

Test Statistics(b)	
	Level of knowledge after course - Level of knowledge before course
Z	-2.060(a)
Asymp. Sig. (2-tailed)	.039

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks				
		N	Mean Rank	Sum of Ranks
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0(a)	.00	.00
	Positive Ranks	5(b)	3.00	15.00
	Ties	0(c)		
	Total	5		

a Level of knowledge after course < Level of knowledge before course
b Level of knowledge after course > Level of knowledge before course
c Level of knowledge after course = Level of knowledge before course

Change in level of knowledge before and after completing the online course, non-matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of how students assessed their own level of knowledge, for the 2 Reflectors students in Group two (learning style not matching learning sequence).

Wilcoxon Signed Ranks Test

Test Statistics(b)	
	Level of knowledge after course - Level of knowledge before course
Z	-1.414(a)
Asymp. Sig. (2-tailed)	.157

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks				
		N	Mean Rank	Sum of Ranks
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0(a)	.00	.00
	Positive Ranks	2(b)	1.50	3.00
	Ties	2(c)		
	Total	4		

a Level of knowledge after course < Level of knowledge before course
b Level of knowledge after course > Level of knowledge before course
c Level of knowledge after course = Level of knowledge before course

Reflector student self-assessment of their level of knowledge before accessing the online course.

The Mann-Whitney U test showed that there was no significant difference in the level of student self-assessment ($P > 0.05$) between the matched and non-matched Reflector groups before accessing the online course.

**Mann-Whitney Test
Test Statistics (b)**

	Level of knowledge before course
Mann-Whitney U	7.000
Wilcoxon W	22.000
Z	-.809
Asymp. Sig. (2-tailed)	.418
Exact Sig. [2*(1-tailed Sig.)]	.556 a

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

Level of knowledge before course	Sequence Type			Statistic	Std. Error	
Level of knowledge before course	Group 1	Mean		1.40	.245	
		95% Confidence Interval for Mean	Lower Bound	.72		
			Upper Bound	2.08		
		5% Trimmed Mean		1.39		
		Median		1.00		
		Variance		.300		
		Std. Deviation		.548		
		Minimum		1		
		Maximum		2		
		Range		1		
		Interquartile Range		1.00		
		Group 2	Mean		2.25	.750
			95% Confidence Interval for Mean	Lower Bound	-.14	
				Upper Bound	4.64	
5% Trimmed Mean			2.22			
Median			2.00			
Variance			2.250			
Std. Deviation			1.500			
Minimum			1			
Maximum		4				

Reflector student self-assessment of their level of knowledge after completing the online course.

The Mann-Whitney U test shows no significant difference between the Post-test scores of the Reflector learners in Groups one and two ($P > 0.05$).

Mann-Whitney Test Test Statistics (b)

	Level of knowledge after course
Mann-Whitney U	4.000
Wilcoxon W	14.000
Z	-1.528
Asymp. Sig. (2-tailed)	.126
Exact Sig. [2*(1-tailed Sig.)]	.190 a

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error		
Level of knowledge after course	Group 1	Mean		3.80	.374		
		95% Confidence Interval for Mean	Lower Bound	2.76			
			Upper Bound	4.84			
		5% Trimmed Mean		3.78			
		Median		4.00			
		Variance		.700			
		Std. Deviation		.837			
		Minimum		3			
		Maximum		5			
		Range		2			
		Interquartile Range		1.50			
		Group 2	Group 2	Mean		2.75	.479
				95% Confidence Interval for Mean	Lower Bound	1.23	
					Upper Bound	4.27	
5% Trimmed Mean				2.72			
Median				2.50			
Variance				.917			
Std. Deviation				.957			
Minimum				2			
Maximum				4			
Range				2			
Interquartile Range				1.75			

Reflector students' level of confidence in taught material after completing the online course, both groups.

No significant difference was found between Reflector type learners in the two student groups in their level of confidence in the course material ($P > 0.05$).

**Mann-Whitney Test
Test Statistics(b)**

	Level of confidence
Mann-Whitney U	4.500
Wilcoxon W	10.500
Z	.000
Asymp. Sig. (2-tailed)	1.000
Exact Sig. [2*(1-tailed Sig.)]	1.000(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error
Level of confidence	Group 1	Mean		3.00	.577
		95% Confidence Interval for Mean	Lower Bound	.52	
			Upper Bound	5.48	
			5% Trimmed Mean	.	
		Median	3.00		
		Variance	1.000		
	Std. Deviation	1.000			
	Minimum	2			
	Maximum	4			
	Range	2			
	Interquartile Range	.			
	Group 2	Mean		3.00	.577
		95% Confidence Interval for Mean	Lower Bound	.52	
Upper Bound			5.48		
5% Trimmed Mean			.		
Median		3.00			
Variance		1.000			
Std. Deviation		1.000			
Minimum	2				

Reflector students' level of interest in course material, both groups.

The results shows that there was no significant difference between the levels of interest of the Reflector learners in the two groups ($P > 0.05$).

**Mann-Whitney Test
Test Statistics(b)**

	Level of interest
Mann-Whitney U	2.000
Wilcoxon W	8.000
Z	-1.291
Asymp. Sig. (2-tailed)	.197
Exact Sig. [2*(1-tailed Sig.)]	.400(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error
Level of interest	Group 1	Mean		3.33	.333
		95% Confidence Interval for Mean	Lower Bound	1.90	
			Upper Bound	4.77	
		5% Trimmed Mean		.	
		Median		3.00	
		Variance		.333	
		Std. Deviation		.577	
		Minimum		3	
		Maximum		4	
		Range		1	
		Interquartile Range		.	
	Group 2	Mean		2.67	.333
		95% Confidence Interval for Mean	Lower Bound	1.23	
			Upper Bound	4.10	
		5% Trimmed Mean		.	
		Median		3.00	
		Variance		.333	
		Std. Deviation		.577	
		Minimum		2	
		Maximum		3	
		Range		1	
		Interquartile Range		.	

Differences between matched and non-matched Reflector students in whether or not they felt comfortable with the way of the material was presented

There was no significant difference in how comfortable the Reflector learners in the two groups felt while they used the online course.

Mann-Whitney Test

Test Statistics

	"Did you feel comfortable?"
Mann-Whitney U	7.500
Wilcoxon W	13.500
Z	.000
Asymp. Sig. (2-tailed)	1.000
Exact Sig. [2*(1-tailed Sig.)]	1.000 a

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

All students, both matched and non-matched gave a Yes answer to this question.

THEORIST STUDENTS**Differences in marks awarded in the Pre- and Post-tests for both groups of Theorist students.**

The t-test (equal variances not assumed) showed no significant difference in the mean marks awarded to the two Reflector groups for the Pre-test, but there was significant difference between mean marks for Theorist learners in the two groups in the Post-test ($t=5.18$, $P < 0.001$).

Group Statistics

	Sequence Type	N	Mean	Std. Deviation	Std. Error Mean
Pre-test marks	Group 1	9	2.444	1.667	.5556
	Group 2	9	1.778	1.202	.4006
Post-test marks	Group 1	9	2.667	.5000	.1667
	Group 2	9	.7778	.9718	.3239

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre-test marks	Equal variances assumed	2.081	.168	.973	16	.345	.6667	.6849	-.7853	2.119
	Equal variances not assumed			.973	14.55	.346	.6667	.6849	-.7972	2.131
Post-test marks	Equal variances assumed	1.263	.278	5.185	16	.000	1.889	.3643	1.117	2.661
	Equal variances not assumed			5.185	11.96	.000	1.889	.3643	1.095	2.683

Change in level of knowledge before and after completing the online course, matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of students' self-assessed level of knowledge, for the 9 matched students in Group one (learning style matching learning sequence).

Wilcoxon Signed Ranks Test

Test Statistics(b)

	Level of knowledge before course - Level of knowledge after course
Z	-2.555(a)
Asymp. Sig. (2-tailed)	.011

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0(a)	.00	.00
	Positive Ranks	8(b)	4.50	36.00
	Ties	1(c)		
	Total	9		

a Level of knowledge after course < Level of knowledge before course

b Level of knowledge after course > Level of knowledge before course

c Level of knowledge after course = Level of knowledge before course

Change in level of knowledge before and after completing the online course, non-matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of how students assessed their own level of knowledge, for the 9 students in Group two (learning style not matching learning sequence).

Test Statistics(b)

	Level of knowledge before course - Level of knowledge before course
Z	-2.449(a)
Asymp. Sig. (2-tailed)	.014

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Level of knowledge before course - Level of knowledge after course	Negative Ranks	0(a)	.00	.00
	Positive Ranks	6(b)	3.50	21.00
	Ties	3(c)		
	Total	9		

a Level of knowledge after course < Level of knowledge before course

b Level of knowledge after course > Level of knowledge before course

c Level of knowledge after course = Level of knowledge before course

Theorist student self-assessment of their level of knowledge before accessing the online course.

The Mann-Whitney U test showed that there was no significant difference in the level of student self-assessment ($P > 0.05$) between the matched and non-matched Theorist groups before accessing the online course.

Mann-Whitney Test Test Statistics(b)

	Level of knowledge before course
Mann-Whitney U	32.500
Wilcoxon W	77.500
Z	-.971
Asymp. Sig. (2-tailed)	.332
Exact Sig. [2*(1-tailed Sig.)]	.489(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error
Level of knowledge before course	Group 1	Mean		1.78	.465
		95% Confidence Interval for Mean	Lower Bound	.71	
			Upper Bound	2.85	
		5% Trimmed Mean		1.64	
		Median		1.00	
		Variance		1.944	
	Std. Deviation		1.394		
	Minimum		1		
	Maximum		5		
	Range		4		
	Interquartile Range		2		
	Group 2	Mean		1.44	.444
		95% Confidence Interval for Mean	Lower Bound	.42	
Upper Bound			2.47		
5% Trimmed Mean		1.27			
Median		1.00			
Variance		1.778			
Std. Deviation		1.333			
Minimum		1			

Theorist student self-assessment of their level of knowledge after completing the online course.

The Mann-Whitney U test shows a significant difference between the Post-test scores of the Theorist learners in Groups one and two ($P < 0.05$).

Mann-Whitney Test

Test Statistics(b)

	Level of knowledge after course
Mann-Whitney U	7.000
Wilcoxon W	52.000
Z	-3.064
Asymp. Sig. (2-tailed)	.002
Exact Sig. [2*(1-tailed Sig.)]	.002(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type		Statistic	Std. Error		
Level of knowledge after course	Group 1	Mean	4.33	.236		
		95% Confidence Interval for Mean	Lower Bound	3.79		
			Upper Bound	4.88		
		5% Trimmed Mean	4.37			
		Median	4.00			
		Variance	.500			
		Std. Deviation	.707			
		Minimum	3			
		Maximum	5			
		Range	2			
		Interquartile Range	1			
		Group 2	Mean	2.11	.389	
			95% Confidence Interval for Mean	Lower Bound	1.21	
				Upper Bound	3.01	
5% Trimmed Mean	2.01					
Median	2.00					
Variance	1.361					
Std. Deviation	1.167					
Minimum	1					
Maximum	5					

Theorist students' level of confidence in taught material after completing the online course, both groups.

No significant difference was found between Theorist type learners in the two student groups in their level of confidence in the course material ($P > 0.05$).

**Mann-Whitney Test
Test Statistics(b)**

	Level of confidence
Mann-Whitney U	2.500
Wilcoxon W	23.500
Z	-1.761
Asymp. Sig. (2-tailed)	.078
Exact Sig. [2*(1-tailed Sig.)]	.095(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type		Statistic	Std. Error
Level of confidence	Group 1	Mean	4.33	.667
		95% Confidence Interval for Mean	Lower Bound	1.46
			Upper Bound	7.20
		5% Trimmed Mean		.
		Median	5.00	
		Variance	1.333	
		Std. Deviation	1.155	
		Minimum	3	
		Maximum	5	
		Range	2	
		Interquartile Range		.
	Group 2	Mean	2.67	.422
		95% Confidence Interval for Mean	Lower Bound	1.58
			Upper Bound	3.75
		5% Trimmed Mean	2.69	
		Median	3.00	
		Variance	1.067	
		Std. Deviation	1.033	
		Minimum	1	
		Maximum	4	

Theorist students' level of interest in course material, both groups.

The results shows that there was no significant difference between the levels of interest of the Theorist learners in the two groups ($P > 0.05$).

**Mann-Whitney Test
Test Statistics(b)**

	Level of interest
Mann-Whitney U	18.00
Wilcoxon W	54.00
Z	-1.924
Asymp. Sig. (2-tailed)	.054
Exact Sig. [2*(1-tailed Sig.)]	.093(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type		Statistic	Std. Error			
Level of interest	Group 1	Mean		3.67	.167		
		95% Confidence Interval for Mean	Lower Bound	3.28			
			Upper Bound	4.05			
		5% Trimmed Mean		3.69			
		Median		4.00			
		Variance		.250			
		Std. Deviation		.500			
		Minimum		3			
		Maximum		4			
		Range		1			
		Interquartile Range		1			
		Level of interest	Group 2	Mean		3.00	.378
				95% Confidence Interval for Mean	Lower Bound	2.11	
					Upper Bound	3.89	
5% Trimmed Mean				3.00			
Median				3.00			
Variance				1.143			
Std. Deviation				1.069			
Minimum				1			

Differences between matched and non-matched Theorist students in whether or not they felt comfortable with the way of the material was presented.

The results show there was significant difference in how comfortable the Theorist learners in two groups felt while they used the online course ($P < 0.05$).

**Mann-Whitney Test
Test Statistics(b)**

	"Did you feel comfortable?"
Mann-Whitney U	17.500
Wilcoxon W	53.500
Z	-2.147
Asymp. Sig. (2-tailed)	.032
Exact Sig. [2*(1-tailed Sig.)]	.074(a)

a Not corrected for ties.

b Grouping Variable: Sequence Type

Descriptives

	Sequence Type			Statistic	Std. Error		
"Did you feel comfortable?"	Group 1	Mean		1.8889	.11111		
		95% Confidence Interval for Mean					
			Lower Bound	1.6327			
			Upper Bound	2.1451			
		5% Trimmed Mean		1.9321			
		Median		2.0000			
		Variance		.111			
		Std. Deviation		.33333			
		Minimum		1.00			
		Maximum		2.00			
		Range		1.00			
		Interquartile Range		.00			
		Group 2	Group 2	Mean		1.3750	.18298
				95% Confidence Interval for Mean			
	Lower Bound			.9423			
	Upper Bound			1.8077			
5% Trimmed Mean				1.3611			
Median				1.0000			
Variance				.268			
Std. Deviation				.51755			
Minimum				1.00			
Maximum				2.00			

Appendix G: Full Results for Third Experiment

Differences in marks awarded in the Pre- and Post-tests for both groups.

The t-test (equal variances not assumed) showed significant difference in the marks awarded for the Pre-test, but there was no significant difference between the two groups ($t=1.53$, $P > 0.05$) in the Post-test marks.

Group Statistics

	Sequence Type	N	Mean	Std. Deviation	Std. Error Mean
Marks of Pre-Test	Group 1	11	4.0000	.00000	.00000
	Group 2	8	3.2500	.88641	.31339
Marks of Post-Test	Group 1	11	4.0000	.00000	.00000
	Group 2	8	3.7500	.46291	.16366

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Marks of Pre-Test	Equal variances assumed	44.289	.000	2.838	17	.011	.7500	.26430	.19238	1.30762
	Equal variances not assumed			2.393	7.000	.048	.7500	.31339	.00895	1.49105
Marks of Post-Test	Equal variances assumed	29.526	.000	1.811	17	.088	.2500	.13802	-.04121	.54121
	Equal variances not assumed			1.528	7.000	.170	.2500	.16366	-.13700	.63700

Change in level of knowledge before and after completing the online course, matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score, of how students assessed their own level of knowledge, for the 11 matched students in Group one was not significant.

**Wilcoxon Signed Ranks Test
Group 1**

Test Statistics(b)

	Level of knowledge before course – Level of knowledge after course
Z	-1.890(a)
Asymp. Sig. (2-tailed)	.059

- a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Level of knowledge after course - Level of knowledge before course	Negative Ranks	0(a)	.00	.00
	Positive Ranks	4(b)	2.50	10.00
	Ties	7(c)		
	Total	11		

- a Level of knowledge after course < Level of knowledge before course
b Level of knowledge after course > Level of knowledge before course
c Level of knowledge after course = Level of knowledge before course

Change in level of knowledge before and after completing the online course, non-matched students.

A Wilcoxon Signed Ranks Test showed that the increase in mean score of how students assessed their own level of knowledge, for the 8 non-matched students in Group two was not significant.

Wilcoxon Signed Ranks Test group 2

Test Statistics(b)

	Level of knowledge before course - Level of knowledge after course
Z	-1.414(a)
Asymp. Sig. (2-tailed)	.157

- a Based on negative ranks.
b Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Level of knowledge before course - Level of knowledge after course	Negative Ranks	1(a)	2.50	2.50
	Positive Ranks	4(b)	3.13	12.50
	Ties	3(c)		
	Total	8		

a Level of knowledge after course < Level of knowledge before course

b Level of knowledge after course > Level of knowledge before course

c Level of knowledge after course = Level of knowledge before course

Student self-assessment of their level of knowledge before accessing the online course, both groups.

The non-parametric test (Mann-Whitney U) was used because the scores given by the students were ordinal data. There was no significant difference in the mean levels of knowledge, prior to accessing the online course, between the two groups (matched and non-matched, $P > 0.05$).

**Mann-Whitney Test
Test Statistics(b)**

	Level of knowledge before course
Mann-Whitney U	33.500
Wilcoxon W	69.500
Z	-.897
Asymp. Sig. (2-tailed)	.369
Exact Sig. [2*(1-tailed Sig.)]	.395(a)

a Not corrected for ties.

b Grouping Variable: Group No

Descriptives				Statistic	Std. Error
Group No					
Level of knowledge before course	Group 1	Mean		3.36	.279
		95% Confidence Interval for Mean	Lower Bound	2.74	
			Upper Bound	3.98	
		5% Trimmed Mean		3.35	
		Median		3.00	
		Variance		.855	
		Std. Deviation		.924	
		Minimum		2	
		Maximum		5	
		Range		3	
		Interquartile Range		1	
		Skewness		.023	.661
		Kurtosis		-.448	1.279
	Group 2	Mean		2.88	.479
		95% Confidence Interval for Mean	Lower Bound	1.74	
			Upper Bound	4.01	
		5% Trimmed Mean		2.86	
		Median		2.50	
		Variance		1.839	
		Std. Deviation		1.356	
		Minimum		1	
		Maximum		5	
		Range		4	
		Interquartile Range		2	
		Skewness		.294	.752
		Kurtosis		-1.078	1.481

Student self-assessment of their level of knowledge after completing the online course, both groups.

The Mann-Whitney U test was again used to analyse the ordinal data obtained. There was significant difference between the two groups in the mean levels of knowledge after completing the online course, $P > 0.05$.

**Mann-Whitney Test
Test Statistics(b)**

	Level of knowledge after course
Mann-Whitney U	30.500
Wilcoxon W	66.500
Z	-1.181
Asymp. Sig. (2-tailed)	.238
Exact Sig. [2*(1-tailed Sig.)]	.272(a)

a Not corrected for ties.

b Grouping Variable: Group No

Descriptives

Group No			Statistic	Std. Error
Level of knowledge after course	Group 1	Mean	3.82	.263
		95% Confidence Interval for Mean		
		Lower Bound	3.23	
		Upper Bound	4.41	
		5% Trimmed Mean	3.85	
		Median	4.00	
		Variance	.764	
		Std. Deviation	.874	
		Minimum	2	
		Maximum	5	
		Range	3	
		Interquartile Range	1	
		Skewness	-.690	.661
		Kurtosis	.779	1.279
	Group 2	Mean	3.38	.324
		95% Confidence Interval for Mean		
		Lower Bound	2.61	
		Upper Bound	4.14	
		5% Trimmed Mean	3.36	
		Median	3.00	
		Variance	.839	
		Std. Deviation	.916	
		Minimum	2	
		Maximum	5	
		Range	3	
		Interquartile Range	1	
		Skewness	.488	.752
		Kurtosis	.421	1.481

Student levels of confidence that they understood the taught material of the online course, both groups.

The Mann-Whitney U test was again used to analyse the ordinal data obtained. There was no significant difference ($P > 0.05$) between the two groups in their levels of confidence in the online course material.

**Mann-Whitney Test
Test Statistics(b)**

	Level of confident
Mann-Whitney U	25.500
Wilcoxon W	61.500
Z	-1.589
Asymp. Sig. (2-tailed)	.112
Exact Sig. [2*(1-tailed Sig.)]	.129(a)

a Not corrected for ties.

b Grouping Variable: Group No

Descriptives

Group No				Statistic	Std. Error
Level of confident	Group 1	Mean		3.36	.279
		95% Confidence Interval for Mean	Lower Bound	2.74	
			Upper Bound	3.98	
		5% Trimmed Mean		3.35	
		Median		3.00	
		Variance		.855	
		Std. Deviation		.924	
		Minimum		2	
		Maximum		5	
		Range		3	
		Interquartile Range		1.00	
		Skewness		.023	.661
		Kurtosis		-.448	1.279
	Group 2	Mean		2.63	.420
		95% Confidence Interval for Mean	Lower Bound	1.63	
			Upper Bound	3.62	
		5% Trimmed Mean		2.58	
		Median		2.50	
		Variance		1.411	
		Std. Deviation		1.188	
		Minimum		1	
		Maximum		5	
		Range		4	
		Interquartile Range		1.00	
		Skewness		.970	.752
		Kurtosis		1.872	1.481

Student's level of interest in course material, both groups.

The Mann-Whitney U test was again used to analyse the ordinal data obtained. A significant difference ($P < 0.01$) was detected between the two groups in their self-perceived level of interest in the course.

**Mann-Whitney Test
Test Statistics(b)**

	Level of interest
Mann-Whitney U	9.000
Wilcoxon W	45.000
Z	-3.101
Asymp. Sig. (2-tailed)	.002
Exact Sig. [2*(1-tailed Sig.)]	.003(a)

a Not corrected for ties.

b Grouping Variable: Group No

Descriptives

Group No				Statistic	Std. Error
Level of interest	Group 1	Mean		3.45	.157
		95% Confidence Interval for Mean	Lower Bound	3.10	
			Upper Bound	3.81	
		5% Trimmed Mean		3.45	
		Median		3.00	
		Variance		.273	
		Std. Deviation		.522	
		Minimum		3	
		Maximum		4	
		Range		1	
		Interquartile Range		1.00	
		Skewness		.213	.661
		Kurtosis		-2.444	1.279
	Group 2	Mean		2.25	.250
		95% Confidence Interval for Mean	Lower Bound	1.66	
			Upper Bound	2.84	
		5% Trimmed Mean		2.28	
		Median		2.00	
		Variance		.500	
		Std. Deviation		.707	
		Minimum		1	
		Maximum		3	
		Range		2	
		Interquartile Range		1.00	
		Skewness		-.404	.752
		Kurtosis		-.229	1.481

Differences between matched and non-matched students in whether or not they felt comfortable with the way of the material was presented.

The Mann-Whitney U test showed a significant difference between the two groups ($P < 0.01$) in how comfortable they felt with the material of the online course. The matched students were, on average, significantly more comfortable than the non-matched students.

Mann-Whitney Test

Test Statistics(b)

	Did you feel comfortable with sequence was presented
Mann-Whitney U	16.500
Wilcoxon W	52.500
Z	-2.973
Asymp. Sig. (2-tailed)	.003
Exact Sig. [2*(1-tailed Sig.)]	.020(a)

a Not corrected for ties.

b Grouping Variable: Group No

Descriptives(a)

Group No			Statistic	Std. Error
Did you feel comfortable with sequence was presented	Group 2	Mean	1.38	.183
		95% Confidence Interval for Mean		
		Lower Bound	.94	
		Upper Bound	1.81	
		5% Trimmed Mean	1.36	
		Median	1.00	
		Variance	.268	
		Std. Deviation	.518	
		Minimum	1	
		Maximum	2	
		Range	1	
		Interquartile Range	1.00	
		Skewness	.644	.752
		Kurtosis	-2.240	1.481

a Did you feel comfortable with sequence was presented is constant when Group No = Group 1. It has been omitted.

Evaluation by learning styles.**ACTIVIST STUDENTS**

Activist student self-assessment of their level of knowledge before accessing the online course.

The Mann-Whitney U test showed that there was no significant difference in the mean levels of student self-assessment ($P > 0.05$) between the seven matched students and seven non-matched students before accessing the online course.

**Mann-Whitney Test
Test Statistics(b)**

	Level of knowledge before course
Mann-Whitney U	23.000
Wilcoxon W	51.000
Z	-.197
Asymp. Sig. (2-tailed)	.844
Exact Sig. [2*(1-tailed Sig.)]	.902(a)

a Not corrected for ties.

b Grouping Variable: Group No

Descriptives				Statistic	Std. Error
Group No					
Level of knowledge before course	Group 1	Mean		3.14	.404
		95% Confidence Interval for Mean	Lower Bound	2.15	
			Upper Bound	4.13	
		5% Trimmed Mean		3.10	
		Median		3.00	
		Variance		1.143	
		Std. Deviation		1.069	
		Minimum		2	
		Maximum		5	
		Range		3	
		Interquartile Range		2.00	
		Skewness		.772	.794
		Kurtosis		.263	1.587
	Group 2	Mean		3.00	.535
		95% Confidence Interval for Mean	Lower Bound	1.69	
			Upper Bound	4.31	
		5% Trimmed Mean		3.00	
		Median		3.00	
		Variance		2.000	
		Std. Deviation		1.414	
		Minimum		1	
		Maximum		5	
		Range		4	
		Interquartile Range		2.00	
		Skewness		.000	.794
		Kurtosis		-1.200	1.587

Student self-assessment of their level of knowledge after completing the online course.

The Mann-Whitney U test shows a significant difference between Activist learners in the two Activist groups in their level of knowledge after completing the online course, ($P > 0.05$).

**Mann-Whitney Test
Test Statistics(b)**

	Level of knowledge after course
Mann-Whitney U	22.000
Wilcoxon W	50.000
Z	-.335
Asymp. Sig. (2-tailed)	.737
Exact Sig. [2*(1-tailed Sig.)]	.805(a)

a Not corrected for ties.

b Grouping Variable: Group No

Descriptives

Group No				Statistic	Std. Error
Level of knowledge after course	Group 1	Mean		3.57	.369
		95% Confidence Interval for Mean		2.67	
			Lower Bound	2.67	
			Upper Bound	4.47	
		5% Trimmed Mean		3.58	
		Median		4.00	
		Variance		.952	
		Std. Deviation		.976	
		Minimum		2	
		Maximum		5	
		Range		3	
		Interquartile Range		1.00	
		Skewness		-.277	.794
		Kurtosis		.042	1.587
	Group 2	Mean		3.43	.369
		95% Confidence Interval for Mean		2.53	
			Lower Bound	2.53	
			Upper Bound	4.33	
		5% Trimmed Mean		3.42	
		Median		3.00	
		Variance		.952	
		Std. Deviation		.976	
		Minimum		2	
		Maximum		5	
		Range		3	
		Interquartile Range		1.00	
		Skewness		.277	.794
		Kurtosis		.042	1.587

Students' level of confidence in taught material after completing the online course, both groups.

The Mann-Whitney U test shows there was no significant difference in the mean levels of confidence between the Activist learners in the two groups ($P > 0.05$).

**Mann-Whitney Test
Test Statistics(b)**

	Level of confident
Mann-Whitney U	16.500
Wilcoxon W	44.500
Z	-1.072
Asymp. Sig. (2-tailed)	.284
Exact Sig. [2*(1-tailed Sig.)]	.318(a)

- a Not corrected for ties.
b Grouping Variable: Group No

Descriptives

Group No			Statistic	Std. Error
Level of confident	Group 1	Mean	3.14	.404
		95% Confidence Interval for Mean		
		Lower Bound	2.15	
		Upper Bound	4.13	
		5% Trimmed Mean	3.10	
		Median	3.00	
		Variance	1.143	
		Std. Deviation	1.069	
		Minimum	2	
		Maximum	5	
		Range	3	
		Interquartile Range	2.00	
		Skewness	.772	.794
		Kurtosis	.263	1.587
	Group 2	Mean	2.57	.481
		95% Confidence Interval for Mean		
		Lower Bound	1.39	
		Upper Bound	3.75	
		5% Trimmed Mean	2.52	
		Median	2.00	
		Variance	1.619	
		Std. Deviation	1.272	
		Minimum	1	
		Maximum	5	
		Range	4	
		Interquartile Range	1.00	
		Skewness	1.137	.794
		Kurtosis	1.947	1.587

Students' level of interest in course material, both groups.

The Mann-Whitney U test shows that there is significant difference between the levels of interest in the online course material of the Activist learners in the two groups ($P < 0.01$).

**Mann-Whitney Test
Test Statistics(b)**

	Level of interest
Mann-Whitney U	4.000
Wilcoxon W	32.000
Z	-2.773
Asymp. Sig. (2-tailed)	.006
Exact Sig. [2*(1-tailed Sig.)]	.007(a)

a Not corrected for ties.
b Grouping Variable: Group No

Descriptives

Group No		Statistic		Std. Error
Level of interest	Group 1	Mean	3.43	.202
		95% Confidence Interval for Mean	Lower Bound	2.93
			Upper Bound	3.92
		5% Trimmed Mean	3.42	
		Median	3.00	
		Variance	.286	
		Std. Deviation	.535	
		Minimum	3	
		Maximum	4	
		Range	1	
		Interquartile Range	1.00	
		Skewness	.374	.794
		Kurtosis	-2.800	1.587
	Group 2	Mean	2.14	.261
		95% Confidence Interval for Mean	Lower Bound	1.50
			Upper Bound	2.78
		5% Trimmed Mean	2.16	
		Median	2.00	
		Variance	.476	
		Std. Deviation	.690	
		Minimum	1	
		Maximum	3	
		Range	2	
		Interquartile Range	1.00	
		Skewness	-.174	.794
		Kurtosis	.336	1.587

Differences between matched and non-matched students in whether or not they felt comfortable with the way of the material was presented.

The Activist students were asked whether or not they felt comfortable with the material of the online course. The response was either Yes or No. There was significant difference at ($P < 0.01$).

Mann-Whitney Test

Test Statistics(b)

	Did you feel comfortable with sequence was presented
Mann-Whitney U	7.000
Wilcoxon W	35.000
Z	-2.687
Asymp. Sig. (2-tailed)	.007
Exact Sig. [2*(1-tailed Sig.)]	.026(a)

a Not corrected for ties.

b Grouping Variable: Group No

Descriptives(a)

Group No			Statistic	Std. Error
Did you feel comfortable with sequence was presented	Group 2	Mean	1.29	.184
		95% Confidence Interval for Mean		
		Lower Bound	.83	
		Upper Bound	1.74	
		5% Trimmed Mean	1.26	
		Median	1.00	
		Variance	.238	
		Std. Deviation	.488	
		Minimum	1	
		Maximum	2	
		Range	1	
		Interquartile Range	1.00	
		Skewness	1.230	.794
		Kurtosis	-.840	1.587

a Did you feel comfortable with sequence was presented is constant when Group No = Group 1. It has been omitted.

