Integrative Evaluation of Computer Assisted Learning in Geography in Schools and University

by

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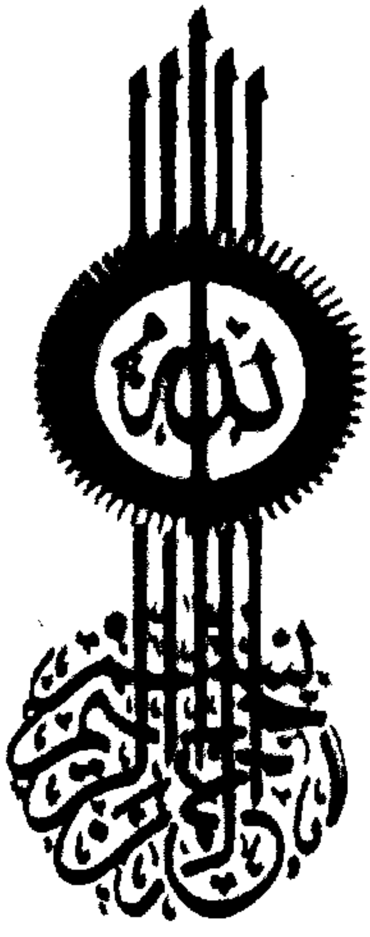
الله
بسم الله الرحمن الرحيم

I dedicate this piece of work to
my mother, my brothers and
sisters, my wife and my
beloved children

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ABSTRACT

Evaluating CAL as part of an overall teaching and learning situation, can help school and university teachers to recognise strengths and weaknesses in their use and delivery of teaching method. This approach is called "integrative evaluation"

This research extends the application of integrative evaluation methods to Computer Assisted Learning (CAL) in three ways: (1) to use the integrative approach at the secondary school level for the first time; (2) to investigate deep vs. surface learning in university students using CAL in conjunction with other resources; (3) to apply integrative evaluation to the field of CAL in Geography teaching for the first time.

The research comprises four studies, each dealing with a different CAL package. Two of the studies were conducted in two secondary schools in the city of Glasgow, and two were carried out in the Geography Department at the University of Glasgow. The total sample population was 238 (74 school pupils and 164 university students). Various instruments besides classroom observation were used for evaluation purposes, including tests designed to measure learning outcomes, questionnaires designed to gauge pupils'/students' reactions, opinions and confidence levels and interviews.

The software studied in this research comprised: (1) A database-like dealing with the geography of Japan. (2) An interactive CAL package related to the subject of the Weather. (3) A university-level CAL package on the subject of Glaciation which related theory to practical labs. (4) Five different application programs (including GIS and Minitab) being taught to university students in an IT course.

In the 3 studies that measured learning, the evaluations showed definite gain due to the CAL, although with interesting variations from objective to objective. Among the other findings of the research are: (1) Two distinct patterns of correlation between CAL gains and pupils' geographical ability were detected in each of the school-based studies. It was concluded that low ability pupils gained more from a stimulating, interactive CAL package, but benefited less than more able pupils from a database-type package. (2) Students found the scheduled computer lab the most useful learning resource for learning about the five applications covered in the IT course. This finding clearly demonstrated that each resource had a specific role to play within the course, and that each resource is more suited to the achievement of certain learning objectives and less suitable for others. (3) Only a small shift from surface to deep learning was found by the end of the Glaciation course, even though the CAL package was specifically designed to link theoretical and practical knowledge. However, doubts raised about the design of questions used to determine the shift suggest that the shift may have been underestimated.

CHAPTER ONE

Introduction

Computers have become an important part of daily life in many, if not most, societies. As they become ever more available, accessible and affordable, they are found more commonly in almost all sites of activity, from industrial and commercial centres to small business premises and high street outlets. Computers are now frequently used in the home and, of course, they have become an important tool in many aspects of education.

From an educational point of view, the most important issue at the moment is how both learners and teachers can benefit more fully from this technology. In other words, how can this technology be made more effective, or be used more effectively, in order to achieve teaching and learning objectives.

The following sections of this introductory chapter outline the background to this research, the general aim of the study, and the specific research questions that it will answer.

1.1 Background to the research

Since computers were first introduced into the educational environment, many different Computer Assisted Learning (CAL) packages have been produced for use in specific subject areas, including Geography. The most common types of package available are drill and practice, simulation and databases. As far as the quality of these packages is concerned, there is a fair degree of variability. While most are generally well-designed and make good use of the computer's unique ability to employ extensive branching, curricular-oriented sound, animation and graphics, others are poorly-written, educationally unsound and, in most cases, are little more than electronic page-turners.

Despite this variability in quality, CAL is already being used fairly widely. Naturally, the main reason for using computers in the classroom is to help students learn more effectively. However, the extent to which this happens in practice depends almost entirely on the way teachers use this technology.

In their eagerness to use CAL, teachers and lecturers sometimes forget to ask themselves basic questions about the most effective ways of organising the time students spend using the packages and the role of CAL in relation to more traditional learning methods. In order to help teachers identify strengths and weaknesses in the way they use CAL, and to help ensure that students benefit fully from CAL, an appropriate method of evaluation is required.

Many attempts have been made to evaluate CAL and its effectiveness in the teaching of academic subjects. Researchers have employed a range of different approaches to evaluate the effectiveness of CAL. Among these approaches is one which evaluates CAL in isolation - comparing CAL with traditional methods of teaching - neglecting other factors that might influence learner performances.

The limitations of this approach to evaluation are discussed in chapter three of this thesis. The present research, however, adopts a different approach, which evaluates CAL as part of the overall teaching and learning situation in what is known as "integrative evaluation" (Draper et al, 1996).

Integrative evaluation was originally developed in a higher education context, where it proved useful in helping university teachers to adjust the overall delivery of teaching where CAL was an element, in order to improve learning outcomes. The approach is described more fully in chapter three.

1. 2 Aim of the research

The main aim of the research is to extend the application of the method of integrative evaluation in three ways. First, this approach is employed in a secondary school context for the first time (all the previous studies had been conducted in the university context). Second, the approach is applied in a university context to investigate deep vs. surface learning in students using CAL in conjunction with other methods. Finally, the approach is applied to the field of Geography teaching for the first time. In common with all integrative evaluation studies, the present research also aims to help school and university teachers recognise the strengths and weaknesses of their teaching methods when CAL is one of the methods employed so they can make necessary improvements and changes.

1.3 Research questions

Integrative evaluation lies somewhere between the extremes of purely quantitative and purely qualitative approaches to the evaluation of CAL. In other words, integrative evaluation is concerned not only with the objective measurement and analysis of learning outcomes, but also with drawing conclusions from the more subjective reactions and opinions of students. Consequently, a wide range of research questions are addressed in this thesis. Before these questions are listed, however, it should be pointed that the use of four separate Geography-related CAL packages was evaluated, two of which are in use in secondary education and two at the university level. Consequently, the research is divided into four studies: studies 1 and 2 conducted in secondary schools and studies 3 and 4 carried out at the University of Glasgow. The studies are defined and described in more detail in chapter four (the methodology chapter).

The full list of research questions is provided below.

1. To what extent does CAL influence pupil achievement in schools? (*studies 1&2*)

2. Is there any correlation between CAL gain and pupil's Geographical ability? (*studies 1&2*)

3. How do pupils react to the use of CAL in the teaching of Geography in particular, and to the computer as a medium of learning in general? (*Studies 1&2*)

4. Which learning resource is perceived as being the most useful for learning about the weather? (*Study 1*)

5. Which learning resource is perceived by students (who studying the IT course in the current year, 1995-96 and those who studied it in the previous year, 1994-95) as the most useful for learning about each of the five applications covered in the course? (*Study 3*)

6. What difficulties are encountered in accessing resources? (*Study 3*).

7. Is there a statistically significant difference in students' confidence of meeting the IT course objectives between those students studying in the current year (1995-96) and those who studied it in the previous year (1994-95)? (*Study 3*)

8. Is there a statistically significant difference between university students' pre-course and post-course performances, and to what extent does CAL contribute to the difference? (*study 4*)

9. Are there any significant differences between the degree to which students value the three methods used to teach them about Glaciation (lecture, physical lab and CAL)? (*Study 4*)

10. To what extent does the course on Glaciation (which includes a CAL package) help students develop deeper understanding of the subject? (*Study 4*)

1.4 Organisation of the thesis.

This thesis comprises eight chapters, the first of which is this introductory chapter. In chapter two, there follows a review of some of the psychological factors that can influence student learning and achievement. Two kinds of cognition-experiential and reflective cognition- are also discussed, particularly in relation to the computer as a medium of learning. Chapter three is a review of the literature pertaining to the field of CAL and the evaluation of its effectiveness. Chapter four is devoted to a discussion of the methods and instruments used in the four studies. The results of the school-based and university-based studies are presented and discussed in chapters five and six respectively. Chapter seven is a discussion of the difficulties encountered during the field work. It also includes a discussion of the feedback provided by teachers regarding the findings of the studies. Finally, in chapter eight, the findings are summarised, recommendations are provided, and suggestions for further research are put forward. The chapter also contains a short message to educational authorities in Saudi Arabia.

CHAPTER TWO

LITERATURE REVIEW OF RELEVANT PSYCHOLOGY

CHAPTER TWO

Literature Review of Relevant Psychology

2.1 Introduction

It has been argued through various studies related to educational psychology that a number of factors can play a role in the effectiveness of learning. Among these factors is working space capacity. Research into this field has indicated that working space capacity varies between individuals, but is always limited (Al-Naeme, 1991). Perceptual ability was also considered as another factor that influences learning.

Although this study was not designed specifically to measure these factors, such factors are considered to be pertinent to the present study. The argument is that working space capacity and usage becomes a crucial factor in the effectiveness of learning when a large amount of information is being processed. Perceiving a three dimensional object on a two dimensional surface is also considered to be a problem for the learners. These two factors are held to be important regardless of the learning environment and material used. Hence, the computer learning environment is no exception. Based on these arguments, this chapter aims to review the literature related to these issues. In addition, the chapter discusses two kinds of cognition: experiential cognition and reflective cognition and how these are related to the computer as a learning aid.

2.2 Memory

One loose definition of the term memory could be something like 'being able to remember some information'. But the fact is that the term memory has many definitions, which represent more than one system. Baddeley (1990), for example, argued that the systems range in storage duration from fractions of a second up to a life time and in storage capacity from a tiny buffer store to the long term memory system that appears to exceed the capacity and flexibility of the largest available computer. Ashcraft (1994) was in agreement with Baddeley's view of the memory. He claimed that "memory means the mental processes of acquiring and retaining information for later retrieval and the mental storage system that enable these processes"

The above definitions of memory indicate that the memory is not a single entity, but rather comprises a range of different systems, the main characteristic of which is the capacity for storing information. It is also clear that memory involves three main kinds of mental activities namely: initial acquisition of information, subsequent retention of the information, and then retrieval of the information.

2.3 Working memory

Working memory and short term memory are terms widely used by researchers. Baddeley and Hitch (1977), Anderson (1983), and Johnstone (1988) prefer the term 'working memory', to denote a memory with a number of sub-systems rather than a single unitary store. Those who use the term 'short term memory' (Atkinson and Shiffrin, 1968), for example, assume that the short term memory store functions as a working memory which is a system for temporarily holding and manipulating information as part of a wide range of essential cognitive tasks such as learning, reasoning and comprehending.

Johnstone (1984) has made a very clear distinction between short term memory and working memory. He said, if someone is asked to memorize a set of numbers such as new telephone numbers and give them back in the same order within seconds, there is no processing and the space is used completely as a short term memory. But in another case if someone is subjected to receive input in the form of numbers and then asked to sum the first and the last and multiply by the middle number, processing now begins to operate and the space is called in this case not short term memory but a working memory and according to him this space " is a part of the brain where we hold information, work upon it, and shape it, before storing it in the long term memory for further use"

2.4 Overload of working memory

As argued previously, the working space is limited and because of this it is possible for this part of the brain to be overloaded. Any overload of it leaves us no space for thought and organization and so faulty learning or no learning takes place (Johnstone, 1984). In any given learning situation, whether in the lab or the classroom, there are a number of variables which cause such overload of working memory, with resultant effects upon students' performance.

In a laboratory situation for example, Johnstone and Wham (1982) argued that if a large amount of information is given at once, the working memory is overloaded. They go further in their argument by indicating that the overload also occurs when the learner is unable to distinguish between the 'noise' and the 'signal' information. Uz-Zaman (1996) cites Johnstone and Letton (1987) to provide one good example to illustrate the overload of working memory during laboratory work in terms of signal and noise, with reference to teacher thinking. They showed that in the laboratory manual, statements were presented in a form with more noise than signal. There was often no clear distinction between some synonyms used in the lab manual, and hence the students were not in a position to distinguish their precise meaning.

Overload can also be influenced by the language used, whether it be the language of the instruction or the actual language of the quizzes. The argument is that any unfamiliar vocabulary or even an unnecessarily long sentence takes up valuable working space. As a result, the performance of the students will be affected. The way the questions are asked or written is also believed to influence the thought processes. If for example the question is written in the negative form, then it would require more working space and, as a consequence, it would impair performance (Cassels and Johnstone, 1984).

From the above studies it appears that there are a number of factors which can increase the load of working memory. Minimizing the load is very important in facilitating the teaching and learning processes as Talbi (1990) has argued. He suggested a number of steps to achieve such a purpose:

- the information content should be kept low.
- redundant and irrelevant information kept out.
- the employment of language should be kept simple and familiar.

As regard the effects of language on working memory, Ziane (1990) has pointed out that "it could be possible to avoid the language load on working memory by using both familiar vocabulary, familiar equipment and short sentences in the experimental notes which could contain added diagrams to enhance the grasp of the physical understanding".

As mentioned earlier, the noise information in practical work was considered as one of the problems causing the overload of working memory. However, it is possible to reduce the effects of noise information. Johnstone and Wham (1982) suggest four steps which could be taken. These are :

- enhance the signal by giving a clear statement of the main points involved in an experiment,
- suppress the noise by stating clearly what is preliminary, peripheral and preparatory.
- redesign of the experiment.
- teach the important manipulative and interpretive skill before using them.

The other factor which may influence the thinking processes is perception i.e. the problems students may encounter when perceiving a 3D object in a 2D surface. These problems may contribute to overload of the working memory space. This issue of perception will be discussed in detail in the coming sections of this chapter.

2.5 Long Term Memory

According to Ashcraft (1994) the long term memory (LTM) is the ultimate destination for information we want to learn and remember. Rather than being a single entity, Tulving (in Bruning et al 1990) argued that LTM has two distinguishable components: episodic and semantic memory. Episodic memory is a record of one person's past experience, while semantic memory holds one's knowledge of language, rules and concepts.

Johnstone et al (1994) on the other hand, have pointed out that the long term memory acts as a storage centre where factual information is held, concepts are developed and attitudes are formed. They further argued that long term memory controls perception as it directs information chosen by the perceptive filter and supplies information for working memory space. Hence learning is the movement of information flowing from the perceptive processes, into working memory and then to LTM.

The above findings on the relationship between the kind of information and language and overload in students' working memory space can easily be applied to the use of the computer as a learning aid. This is particularly true when a large amount of information is displayed on the screen at the same time (information that can include both text and images). The students' attention is inevitably divided and their working memory overloaded, which has a negative effect on performance.

2.6 PERCEPTION

2.6.1. WHAT IS PERCEPTION?

Perception has been described as an active process (Hilgard, 1979). Between sensory input to the visual system and the experience of seeing or reading, our mind actively processes and transforms the information to make the stimulus meaningful. Others have viewed perception as a hypothesis testing process (Goldstein, 1989). Bruning et al (1995) on the other hand described perception as "the assignment of meaning to incoming stimuli".

Perception has been described in a number of learning models. According to the information processing model (Johnstone et al, 1994) that event, observation and instruction which is mainly called 'environment input' comes first of all through the perception (see Fig.2.1).The model also indicated that the perceptive filter is seen as driven by the long term memory in order to select the important information.

On the other hand, perception in Atkinson's and Shifrin's (1968) multi store model of memory was proposed as a sensory register. This model assumed that input information is initially received by sensory stores which hold information in a relatively uninterpreted form for very short periods of time.

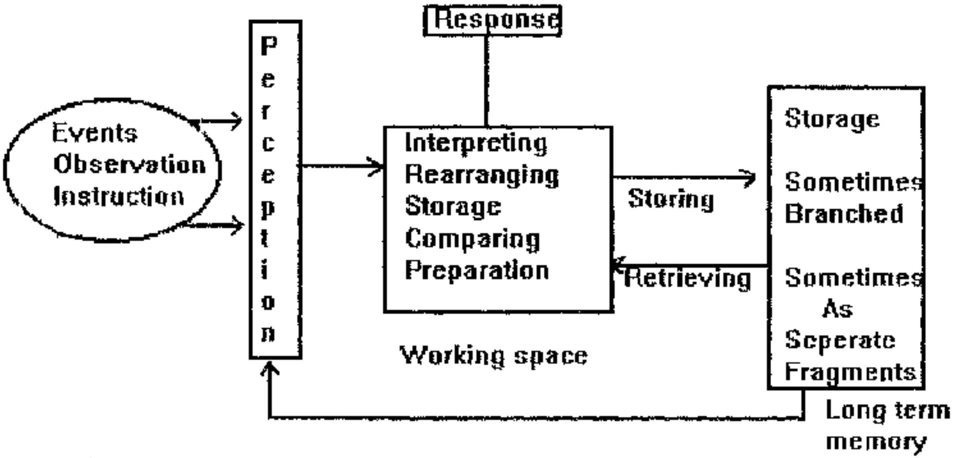


Fig. 2.1. Information Processing Model

Perception has also been described from a constructivist standpoint by Hochberg in (Goldstein 1989) where "the observer takes an active role in perception by making a series of fixations on different parts of an object or scene". This information from the various fixations is combined to produce the resultant perception of the image. Thus we conduct a 'bottom up' processing of information where the sum of the parts combine, leading to recognition of the whole (Salso, 1995).

2.6.2. Perception and Knowledge.

Knowledge has been considered as a fundamental factor that can play a part in perception and as White (1988) argued, "what you know determines what you can see". Bruning et al (1995) also agreed with this view and maintained that "knowing what we see (or hear) and even how to look or (listen) depends on the knowledge we have". So, perception depends on our taking into account meaning and familiarity with any object gleaned from our past experiences and knowledge. This leads to 'top-down' processing of information where recognition of the whole results is recognition of the respective components.

Craik (1952) maintained that our brain functions like a computer, holding a model of external reality then matching external events with this model in order to ascertain the most appropriate response. If somebody is familiar with an object and has had previous experience of it then this helps his perception interpretation. It could be argued that learning will be more effective if the process of perception is helped by past knowledge of the objects. Johnstone (1992) declared that "interest, previous training and culture play a part in the process of perception and it is driven by long term memory, which helps to recognise the familiar and unfamiliar".

In addition to knowledge, skills can also play an important role in perception. The argument is that if the person has some skill, he/she can perceive more easily. Science subjects including Geography, often require certain technical skills from the students. Particularly relevant to this research is the highly technical field of

Geographical Information Systems (GIS) where mapping skills might improve a student's perception of computer models and therefore result in faster learning.

2.6.3. Perceiving three dimensional object on a two dimensional surface.

Hilgard (1979) considered perceiving the third dimension in objects as a problem because the retina is essentially a two-dimensional surface. Researchers believe that there are a number of cues available to aid the observer in the perception of 3D objects on a 2D surface. These are the depth and distance cues which affect our perception of the relative size of a particular object. Marr (1982) in Sekuler and Blake 1994, states that "depth serves to define objects relative to their background, helping the viewer distinguish those objects and appreciate their shape".

According to Hilgard (1979), there are four types of cues used in depth perception on a two dimensional surface. These are:

superposition if one object partially superimposes another, we usually perceive the unobscured object as nearer.

relative size if there are objects of varying size, the smaller ones are perceived as the more distant.

height on the horizontal plane, objects further away appear to be higher.

texture there is a gradient of texture with distance - the more open texture is perceived as in the foreground with finer textures being more distant.

Depth and distance cues lead to size constancy and also illusions of size (Sekuler and Blake, 1994). Gregory (1966) maintains that "size constancy normally helps us to maintain a stable perception of objects by taking distance into account". However, he goes on to say that when applied on a two dimensional surface size constancy sometimes creates illusions. The Muller-Lyer illusion is an example of misapplied size constancy (see Fig.2.2). The arrowheads give perspective cues - the outward pointing arrowheads make the line appear shorter than the inward pointing arrowheads.

It could be concluded that depth and distance cues are essential to our 3D perception, but cannot always be relied upon, resulting in illusions. For learning to be effective, perception must be clear.

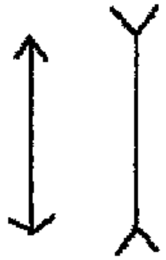


Fig. 2. 2. **The Muller- Lyer Illusion**
[After Goldstein, 1989]

2.6.4. Computer as a medium of learning and perception.

As has been discussed above perceiving a third dimension is quite difficult for a person unless he/she has some experience of the objects, and of depth and distance cues. As a medium of learning, computers like text books, TV and blackboard have only a two dimensional surface. So, any problems students may have perceiving a 3D object on a text book page should be no different from difficulty recognising an object on a computer screen .

So, in considering the use of computers in any kind of subject especially a science, one must take into consideration the issue of perception. There are of course inherent difficulties in transforming the third dimension into two dimensional surface in such a way that the students actually perceive the image or object as intended, coupled with the question of how do we know that all students are perceiving the image or object in the same way. Goldstein (1989) describes a number of areas of difficulties when transforming 3D images into 2D figures for use on a computer.

- a 2D representation can be caused by more than one 3D object. Thus, the active nature of our perception causes us to search for meaning in a figure and, if more than one perceptual image of a figure is possible, once we have seen the 2 or more alternatives, our perception constantly switches between the two.
- intersecting lines could be part of the same objects or two different ones e.g. in Fig. 2.3, line AB is created by both objects.
- we cannot ascertain the shape of objects that are partly obscured, e.g. in

(Fig.2.3), object 2 may or may not be a solid cuboid since we cannot see most of its lower half.

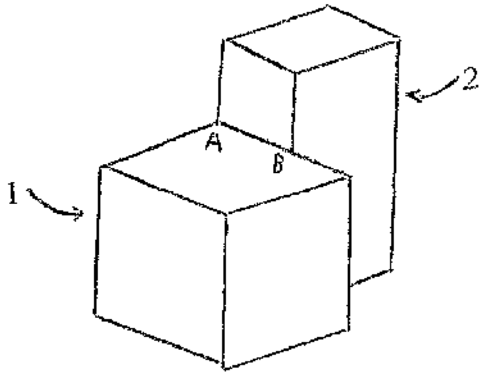


Fig.2.3

In addition to these three difficulties, actual perception of images for example is subject to varying influences , such as cultural familiarity with an object some of which may differ from one individual to another.

However, as has been argued above, the pre-knowledge and the familiarity can influence the perception. Preece et al (1994) indicate "our ability to perceive objects on a screen, be they text, graphics, two dimensional or three dimensional representations is a result of our prior knowledge and expectations as to what should appear and the images that fall on our retinas".

It could be concluded that despite the potential of the computer to show images, and graphics in a way that can stimulate students' learning, students may still encounter some difficulties in perceiving three dimensional objects.

2.7. Experiential and reflective cognition.

The learning process relies heavily on two modes of cognition: experiential cognition and reflective cognition. Through experiential cognition, humans perceive and react to events and thereby become efficient in some form of behaviour. It is the way in which information is acquired and skills learnt with relatively little mental effort (Norman, 1993). Reflective cognition, on the other hand, involves comparison, contrast, active thinking and decision making. It is this mode that results in new ideas and new solutions.

Both modes of cognition are essential for human performance. Experiential cognition is required for expert behaviour, for example, the almost automatic responses of sports players and pilots who have little time for reflection. Reflective cognition, on the other hand, is required for the activities of planning, conceptualisation and consideration. The reflective mode is slower and demands more effort than the experiential mode. Performance in this mode is enhanced by an environment free from distractions.

Both experiential and reflective cognition have roles to play in a learning situation, and they may in fact, complement each other. Melaine, cited in Norman (1993) argues that although experiential learning by itself is not enough, it is a good motivator and therefore a good starting point.

For the purpose of using computers as a learning aid, it is important to consider to what extent the computer is an experiential medium and to what extent it facilitates reflective cognition. This issue will be discussed in the following section.

2.7.1. Experiential and reflective cognition and the computer as learning tool.

As has been indicated, in the experiential mode, thinking and reasoning are not required and may not even be possible due to time constraints. The exploration of new ideas can only be achieved in the reflective mode. Since it can be argued that new ideas are the eventual goal of any educational system, any learning medium should create the conditions necessary for reflection. Before assessing to what extent the computer creates these two conditions, it is useful to look briefly at TV and printed media.

An important feature of TV is the speed at which information is delivered; images 'come at their own speed' (Mander cited in Norman, 1993). The viewer is unable to control this stream, cannot pull out and contemplate the images (at least not without paying less attention to the next image). Therefore, according to the previous definitions, TV mainly facilitates experiential cognition; the viewer is passive both mentally and physically.

In contrast, printed media encourages much greater activity on the part of the reader. On the most basic level, readers are forced to move their eyes across the page. But reading also involves selection (i.e. the reader can choose where to begin, what to skip over, what to skim and what to re-read). The reader also determines the pace at which he/she takes in information. Clearly, printed media can create a better opportunity for reflection than TV.

Returning to the issue of the extent to which the computer creates the conditions for experiential and reflective learning, it could be argued that the computer is still at the stage of an 'experiential medium'(i.e. opportunities similar to those available to the reader of the printed media do not often exist for the student using the computer). On the other hand, it could be argued that the extent to which the computer encourages experiential or reflective learning depends entirely on the design of the software.

Many computer programs, particularly those designed for educational purposes, tend to encourage experiential learning. One reason may be that the programmers are not aware that students have different learning styles. One example of this type of program is 'drill and practice' where students have little or no opportunity to reflect, to make comparisons or to formulate new ideas. As a consequence, there are negative implications for students, as they are encouraged to become passive rather than active learners. Other programs balance experiential and reflective learning. Simulation programs do just this since reflection is required in making decisions and the feedback provides opportunities for experiential learning.

From the above example of simulation, it could be argued that the computer has the potential to be a reflective medium, but for this to be the case, information needs to be well-organized and structured in a such a way that the student is forced to make decisions and given the freedom to move backwards and forwards within the learning situation, i.e. to refer back, make changes and try again.

At the same time, however, there are characteristics of the computer environment that make reflective activity difficult. As was previously mentioned, distractions have a negative effect on reflective cognition. The design of many programs is such that many distractions are built in, dialog boxes, warning notices etc., which are often unnecessary, and can seriously interrupt the train of concentration that is essential to completing the task.

One might argue, however, that the computer, even when used as a primarily experiential medium, is an important motivator for students, allowing them to acquire information and skills at their own pace. At the same time, the computer should be seen as more than a motivational tool; appropriate software can turn it into a powerful medium to encourage more reflective learning. Here, the motivational aspects can be seen as a first step to reflection.

It is through reflection that students are able to think in depth about subjects, analyse situations and make evaluations. Yet, it is these activities that historically have not been encouraged in our education systems even prior to the introduction of computers. Norman (1993) makes a clear distinction between the learning that takes place in schools and informal learning. He points out that in the classroom topics are fixed, the time and place is predetermined and activities are forced and paced with frequent interruptions. He contrasts this with the informal learning situation where activities are self-paced, the individual is free to choose the subject, interruptions are minimised and group or joint activities can be arranged.

Clearly, the former type of learning environment can lead to highly experiential learning, while the latter can result in much more reflective learning. The computer, in fact, lends itself to the informal learning situation if careful planning is implemented.

In conclusion, both experiential and reflective learning are vital in education and are, in fact, mutually beneficial. As far as the computer is concerned, it has the potential to create situations for experiential learning which is important for student motivation, but at the same time, it can be a powerful means of forcing students to reflect. The computer has not yet fulfilled its potential as a reflective medium.

2.8. Summary

This chapter mainly discussed some of the psychological issues which can play a part in the learning process, namely working memory and long term memory. A number of studies concerning the overload of working memory have been highlighted. Overload of the working memory can be caused by several variables, e.g. noise information, language, and negative questions. The ways of minimizing this overload have also been reflected upon.

The issue of perception has also been examined. Perceiving a three dimensional object on a two dimensional surface was found to be the main problem which could face the learner. The use of cues such as those of depth and distance, and the effects of past experience on perception were discussed as ways of helping in the perceptive process.

Finally, the differences between experiential and reflective learning have been highlighted. The issue of the computer as a medium of learning incorporating both types of learning is also discussed.

CHAPTER THREE
LITERATURE REVIEW RELATED TO CAL AND EVALUATION

CHAPTER THREE

REVIEW OF LITERATURE RELATED TO CAL AND EVALUATION

3.1 INTRODUCTION

The area of Computer Assisted Learning (CAL) is one that many researchers believe holds great promise in helping to improve student performance. Many see CAL as a valuable tool for overcoming the drawbacks of teaching methods currently in use. In particular, it is seen as a way of encouraging students to become more active in the learning process.

Despite positive signs that suggest that CAL may well fulfill its potential, there are those that warn against its being viewed as the solution to all educational problems (Draper, in press). CAL, like any other medium of learning, has both advantages and shortcomings. The evaluation of the effectiveness of CAL, therefore becomes an important issue to address.

The main purpose of this chapter is to discuss one of the more recent approaches to evaluating CAL, namely, "integrative evaluation". This is the approach that has been adopted in the current study. At the same time, other issues related to CAL will also be discussed, including its history, the types of software used in schools, the claims made for the effectiveness of CAL, and other techniques commonly used to evaluate the effectiveness of CAL. In addition, the important distinction between deep and surface approaches to learning and Ausubel's theory of learning, will be discussed.

3.2 A brief history of the computer and its use in education

Computers in their present day form can be seen as the sophisticated descendent of much simpler devices that first appeared hundreds if not thousands of years ago (Bitter and Comuse, 1988).

As early as 1642, the French mathematician and philosopher, Blaise Pascal, invented a mechanical calculator (Brownwell, 1987). Later in the 17th century, Gottfried Willhelm developed a machine capable of not only multiplication and division, but also more the complex function of square roots. Despite these early advances, it is perhaps Charles Babbage's analytical engine, invented in the 19th century, that is closest in concept to today's computer (Brownwell, 1987).

From an educational point of view, significant development took place between 1959 and 1964. Not only was there a reduction in the physical size of computers, but for the first time authoring languages became available which allowed educators to write their own courseware. One such language was "tutor" designed for use in the University of Illinois' PLATO project (Hallworth and Brehner, 1980). However, according to Tashner (1991) it was still difficult to incorporate computer technology into classroom activities. Various experiments in Computer Assisted Instruction (CAI) identified several obstacles including high material costs, high student to terminal ratios, and the generally poor instructional quality of programs.

Meanwhile, in Britain, it was not until the 1970s that a major attempt was made to introduce computers into schools. The National Development Program in Computer Assisted Learning (NDPCAL) lasted for five years, and in the final report published in 1977, Hooper argued that the effectiveness of CAL depended on two main factors: the level of commitment shown by the institution in terms of staff and resources; and the commitment of the institution itself to the value of CAL.

Even while the NDPCAL was under way, changes were taking place in the hardware available to schools, with a general shift from large central computers accessible through data terminals to the first generation of microcomputers. In Scotland, these changes prompted the setting up of the Scottish Microelectronics Development Program (SMDP) in 1980 to raise awareness of microelectronics in education, to develop a software library and in-service training, and to liaise between interested parties and provide programming support.

3.3 The use of computers in education.

Computer usage in the educational environment can be broadly divided into three main categories: when computing or computer science is studied as a subject in its own right i.e. when the goal is to teach students computer skills and computer literacy; when the computer is used for administrative purposes such as record-keeping and performance monitoring (CML); and when the computer is used to assist the learning of other subjects (CAL). This thesis is mainly concerned with the last of these categories.

3.3.1 What is CAL ?

The term CAL (Computer Assisted Learning) is used in a very specific sense in the U.K. CAL is similar in some respects to what in the U.S.A., is called CAI (Computer Assisted Instruction). However, there are important differences between CAL and CAI.

CAL is seen as placing much greater emphasis on the student rather than the subject matter (MacDonald et al, 1977). Furthermore, CAL is usually applied within the broader context of a teaching programme and in the U.K., at least, is usualy used as an enrichment medium rather than an initial teaching medium. CAI, on the other hand, is used almost exclusively in programmed instruction and as such is more suited to industrial and military training.

3.3.2 Types of software used in schools

The successful integration of computer technology into an educational setting depends not only on hardware capabilities, but also on the availability of suitable software. The issue of software use in education has been addressed in a number of studies (e.g. Allen, 1984, Bitter, 1984, Norton and Resta, 1986, Bialo et al, 1987, Taylor, 1987, Hartley, 1987, Kinze and Sullivan, 1989, Khan, 1989, Blow, 1991).

The most common types of software used in schools are drill and practice, simulation and databases programs. In the following section, drill and practice and simulation programs will be discussed as well as their effect on students.

Drill and Practice.

This mode of CAL assumes previous learning of concept, skills or process. Programs of this type usually present students with a set of questions to be answered. In this application, the computer works in much the same way as a workbook (Rooze and Northup, 1986). In this type of task, the learner does nothing more than single recognition of the previously presented material. No productive response is required since the response format is usually yes/no or true/false. These tasks do not allow us to infer that the learners comprehend the material, only that they recognise it (Blomeyer, 1989).

This passive role, which the student is forced into by drill and practice programs, has been criticised. The learner for example, does not engage actively with the material in the program, but is merely programmed (Papert, 1980). In addition, the mechanistic nature of drill and practice does not offer the learner the chance to air an opinion, discuss or challenge the data they are presented with. Instead, it leaves room for only one right answer.

Drill and practice programs are also criticised for assuming that all students have the same style of learning. No allowance is made for different abilities among students. The same data is presented to all students and, as mentioned above, there is only one right answer. This obviously mean certain students will be left behind while others find the task easy. It also gives the impression that knowledge is made up of "answers".

This is not to suggest, however, that drill and practice programs are without advantage. Drill and practice programs offer immediate feedback, which either reinforces the learner's responses or direct him/her to a remedial section in the program. In this important although incomplete way, learning is seen as individualised.

Simulation

In this mode of CAL, the computer is more of a learning resource than a direct instructional tool. Simulations are based on a set of concepts and generalisations called constructs or models and are designed to describe real-world phenomena. Students using simulations learn by interacting in a manner similar to the way they would react in a real situation (Alessi and Trollip, 1991).

They are also able be to ask important questions like "What would happen if ....?". Students may then become more involved in problem solving, decision making and the most important they become more active participants.

Simulation programs are, however, not without their problems, particularly when students are using them independently. If students are left to work with the program on their own, without help or guidance from the teacher, there is a chance that they may overlook its significance or not concentrate on the desired purpose of the exercise. There is also the danger that students will work through the simulation without really reflecting on what they are doing. In order to overcome such a problem, the software can be designed to force students into solving problems or answering questions before they are allowed to proceed. Alternatively, teachers themselves can be on hand to ensure students understand what they are doing and make good use of the data.

Clearly, the issue of software quality is very important. It would be argued again that the successful integration of computers into a curriculum does not merely depend on the availability of software, but on the availability of good quality software. The quality of software depends, in turn, on the degree to which it is interactive, i.e. to what extent students feel involved and are able to interact with the package. Interactivity is the feature of an educational program that transforms the role of the student from passive to active participant. More specifically, Lyall (1995) argues that it is the level of interactivity that is important, i.e. the degree of control that the learner has over the presentation of information within the package.

3.4. Evaluating computer assisted learning

The term "evaluation" is used widely in the educational context. However, there is no universally accepted approach to evaluation available. Instead, there are numerous styles and types of evaluation practiced, each of which has its inherent problems. Difficulties arise because the attachment of value judgments is usually necessary in the evaluation process, yet the philosophical values of the evaluator are inevitably reflected in these judgments.

It is also important to remember that evaluation does not take place in a vacuum. Evaluations are generally conducted for a specific purpose, with a particular audience in mind, and in a specific environment. Before considering any evaluation of CAL, these three factors must be borne in mind.

The evaluation of CAL has always followed close on the heels of advances in CAL itself. According to Jones et al (1996), "the emergence and convergence of new technologies that can be used for educational purposes leads to a need to consider methods for judging the effectiveness of educational innovation". They also point out that the need for evaluation is particularly great given the ambitious claims made for computers in education. These claims will be discussed shortly.

There are various approaches to the evaluation of CAL. The choice of approach depends to a large extent to the goals of the evaluation. Draper (1995) identifies three different purposes for which evaluation is carried out: to help improve the design of CAL (formative evaluation); to help users select which piece of CAL to use and for what purposes (summative evaluation); and to help users make the most of a given piece of CAL (integrative evaluation). For the purposes of this research, integrative evaluation is the most relevant approach, and therefore the discussion in the later sections of this chapter will focus on that method.

3.5. Claims made about the effectiveness of CAL.

Since the introduction of the computer into education, there have been numerous claims made regarding the positive role that computers can play in learning and teaching. The most common claims concern the ability of the computer to motivate students to learn, the interactive environment that the computer creates, the way the computer individualises the process of learning, and the encouragement the computer provides to students to participate actively (Bork, 1984, Jonassen, 1985, Kinze and Sullivan, 1989, Hativa and Lesgold, 1991, Niemiec and Walburg, 1992, Swann, 1992, Johnson et al, 1994).

The assumption behind all the claims listed above is that the computer is used in conjunction with other teaching methods. However, there have been predictions made recently about the computer replacing most if not all current teaching practices in the future. MacFarlane et al (1992) claim that "In the long term, changes at the individual level will be profound. Students will have to be taught how to manage their own learning to an unprecedented degree. They will have to....self-pace and self-structure their programmes of learning....to choose from a spectrum of virtual self-instruction under support to group working of various types". As a consequence, they see the format of the lecture changing, with the role of freely accessible supplementary material becoming increasingly important. A further benefit of the new format would be that valuable contact time could be used for ensuring real understanding rather than transmitting information.

MacFarlane et al have also identified two categories of potential benefits arising from the use of CAL: the effectiveness benefits, and the efficiency benefits. The effectiveness benefits relate to gains made from access to quality information, to experiences gained from multimedia and simulation, and to gains in speed of access to information. The efficiency benefits include increased student turnover, reduced failure rates, and reduced production costs for learning resources.

While some of these benefits may well prove to be the true, Lyall (1995) warns against the more speculative ideas contained within this report. He suggests that the proposals for the future role of the computer go beyond the computer's capabilities into areas that are better dealt with in other ways.

Although there is no doubt that CAL has a significant role to play, the suggestion that it should replace teaching is not practical. Computers, like all teaching tools, have weaknesses as well as strengths. Furthermore, problems may arise as a consequence of replacing the teacher by CAL, including the students' loss of the contact with the teacher and the lack of interaction between students, both of which are considered among the primary benefits of any teaching programme. Learning must be ultimately the interaction of lively and flexible minds. The computer cannot match the human interaction, hence its limitation.

Therefore, it could be argued that the true potential of CAL lies not in its replacing the teacher but in its use as part of an integrated course where the teacher decides how best to use it (see section, 3.8.2).

3.6 Techniques used to measure the effectiveness of CAL on students' achievement.

The issue of student performance in relation to the use of computers has been raised in much research studies. There is general agreement that central to the evaluation of CAL is the measurement of learning that should result from the educational programs (Jolicoeur and Berger, 1988). In other words, learning is the ultimate criterion for success; the main justification for using the computer in education is to help students learn more effectively.

Most studies that attempt to measure the effectiveness of computers on student achievement employ a comparative approach i.e. comparing CAL with conventional or alternative teaching methods.

A study by Nelson et al (1989) compared the effectiveness of an interactive videodisc presentation of a science lesson on sea mammals with a traditional oral presentation with still pictures. The videodisc software, controlled by Apple Computer's Hypercard, allowed pupils to navigate through a database of visuals, text and sounds. The study showed that pupils using the interactive videodisc significantly outscored those receiving the lecture.

An earlier study by Carrier et al (1985) into the effectiveness of computers versus traditional worksheets as delivery systems found mixed results. The two systems were designed to reinforce arithmetic skills within three areas: symbolic algorithms, multiplication facts and division facts. Those using the computer made significant gains on tests of basic fact. However, the test on algorithms revealed that pupils using the computer performed no better than those using worksheets.

In a study comparing the use of CAL in teaching chemistry formulae and the balancing of equations with the use of traditional pencil and paper methods, it was found that the students instructed in a traditional manner actually did better than those using computers (Wainwright, 1985).

From the three example studies cited above, it appears that there is evidence of situations in which computers do improve student performance but at the same time, there are examples of traditional methods giving better results. However it should be pointed out that the reliable measurement of learning is a very difficult task. The task is even more difficult when computer based learning is being evaluated for their effectiveness in relation to the other methods of teaching. The comparative techniques used in the aforementioned studies may not, therefore, have been wholly appropriate in evaluating the effectiveness of

CAL. Indeed, a number of researchers have criticised the use of such techniques. These criticisms will be discussed in the following section.

3.7 Criticisms of the comparative approach to evaluation

According to Jones et al (1996) the problem with making comparative studies lies in the fact that if a particularly innovative piece of software is being evaluated, there is unlikely to be any similar material available with which it can be compared. They also argued that while such studies may be good at evaluating what has been learned, they do not explain how this learning has occurred.

Draper et al (1996) warn against general comparisons of textbook, lectures and CAL. They argue that it is more meaningful to look at the merits of a particular book, a particular lecture, or a particular CAL package. Furthermore, they express doubts about the predictive value of carefully controlled experiments. In a real situation, external factors are likely to have a significant influence on student performance.

Jonassen (1985) supports this view, pointing out that there is invariably a problem with studies that attempt to compare CAL with conventional instruction in that " the nature of the learning tasks, the characteristics of the learners and the characteristics of the media (are) largely ignored" when the research is designed and interpreted.

Another danger of using comparative approaches results from the specific nature of some CAL packages. Software designed to prompt, help and provide feedback to the student cannot be fairly compared to some traditional teaching methods. Furthermore, the novelty of computer based learning can itself motivate students, again making fair comparisons sometimes impossible.

Thus, for example, in the study mentioned above comparing a videodisc with an illustrated lecture, students using the videodisc (who learned more than those receiving the lecture) had more control, could learn at their own pace, and may have been excited by the noval technology - the experiment could not measure those factors separately. Conversely, in the study where pencil and paper methods did better than the computer for teaching chemical formulae, pencil and paper may have allowed more learner control, and been more interactive and flexible than the computer.

It is clear that a more appropriate method of evaluating the effectiveness of computer assisted learning is required. For any such method to be valid it must avoid evaluating CAL in isolation. This issue will be discussed in the following section.

3.8 Different approaches to the evaluation of CAL

As has been mentioned earlier, CAL evaluation can be carried out for several purposes: to improve the design of the CAL (formative); to help users select which piece of CAL to use (summative); and to help users make the most of a given piece of CAL (integrative). Before discussing the integrative approach to evaluation in detail, it may be useful to look briefly at the other two approaches to evaluation : formative and summative.

3.8.1 Formative and summative evaluation.

The term "formative" and "summative" evaluation were first used by Scriven (1967). The distinction has been drawn by Bloom (1971) in the hope of bringing the evaluation process closer to the teaching and learning process. Formative evaluation is typically carried out during the early stages in the development of an instructional program. Its purpose is to identify amendments and revisions that are required before the program reaches a finished state. It is usually carried out with a limited number of individuals who provide feedback on changes that may be necessary.

Summative evaluation, on the other hand, is concerned with the finished program. Its purpose is to provide objective external criticism and to make judgments regarding the value of the program to potential users. This type of evaluation is designed to help users decide whether or not to use the program, and may include direct comparisons with similar products (Draper, 1997).

3.8.2 Integrative evaluation

The integrative approach to evaluation was developed by an evaluation group within the TILT (Teaching with Independent Learning Technologies) project at the University of Glasgow. The TILT group has conducted many studies into the use of CAL in university courses. In their experience, the main issue for university teachers is no longer whether to use CAL or even which CAL package is the best. Instead, most teachers need to know how best to use existing CAL resources that they are committed to using. Therefore, integrative evaluation aims at improving teaching and learning by better integrating CAL material into the overall teaching strategy (Draper et al, 1996).

In essence, the approach formalises the common process of feedback and remedial action that occurs quite naturally in higher education. For example, when many students voluntarily complain about some aspect of the course, or the majority score badly on a certain test question, the teacher responds by making adjustments to the way the material is presented. What integrative evaluation does is to ensure that data relating to the performances and opinions of all students is gathered systematically and taken into consideration. The methods used in integrative evaluation not only provide detailed descriptive data, but also have diagnostic value: making it easier for teachers to identify necessary changes to the course and its delivery.

A defining feature of integrative evaluation is that it is conducted in a real classroom situation, and that the evaluation findings are designed to be of practical use to the teacher involved. Consequently, the teacher's own definitions of learning objectives, and tests designed by the teacher are central to the methods employed. The advantage of using a real classroom situation is that it allows the teacher to respond to complaints, comments and performance data highlighted in the evaluation report. The report can on the one hand provide confirmation that certain objectives are indeed being satisfactorily achieved, and on the other hand that other objectives are only being partially met or not met at all. Armed with this information, teachers can consider ways of tackling such weaknesses by fine-tuning aspects of teaching delivery, which is a relatively low-cost activity in terms of effort and resources. Because teachers are closely involved in the evaluation process, they are more likely to accept the findings and then to take remedial action in order to improve the way CAL is used. In this way, the teaching situation is more likely to be improved and the learner has a better chance of benefiting from CAL.

Another important characteristic of integrative evaluation is that it always studies CAL in the context of the overall teaching and learning situation (as opposed to an experimental situation in which CAL is evaluated in isolation) in recognition of the fact that learning outcomes are never the direct result of a single causal factor, but rather a combination of factors e.g. students generally use CAL under the guidance of a human teacher, and often use the software in conjunction with worksheets that define the tasks to be achieved.

Integrative evaluation differs from traditional formative evaluation of the software in that what is studied and modified is not only the software itself, but all the associated teaching materials and activities.

The methods employed in integrative evaluation rely on a mixture of fixed and open-ended measures. Fixed measures, such as quizzes and confidence logs, being directly related to learning objectives, are powerful diagnostic tools. At the same time, open-ended measures are useful in allowing respondents to raise unexpected issues. These methods are described and discussed more fully in the following section.

3.9. Methods involved in the integrative approach to evaluation

According to Draper et al (1996), the integrative evaluation approach is carried out at two different levels, which they term the "outer method" and the "inner method". The outer method concerns the collaboration and the interaction with the teachers and lecturers involved. This is central and any failure at this level can seriously affect the evaluation process. Teachers play several important roles in the evaluation process: they often set the tests used in the evaluation, and are also responsible for providing answers and marking schemes. Their involvement is vital because they are the only ones completely familiar with the course and its objectives. Furthermore, they are often needed to arrange classroom observation and help administer questionnaires. Finally, their interpretations of the data are often crucial, as they know both the subject matter and the learners better than the evaluator.

The "inner method", on the other hand, refers to the actual instruments used to collect data for the evaluation. The choice of the instruments depends on the design of the study. In the following section, the instruments relevant to the present studies will be discussed.

Knowledge Quizzes

When quizzes are used, they are generally designed by the teachers themselves and administered both immediately before and after the intervention under evaluation. Each question would usually correspond to a distinct learning objective.

Learning Resources Questionnaire

This type of questionnaire takes the form of checklist of the learning resources provided by the teachers and lectures involved. Students are asked to indicate which resources they used, how useful they found them and how easily they were accessed. The main argument for using such an instrument is so that CAL material is evaluated in the context of other teaching resources, rather than in isolation. As Brown et al, (1996) point out "Learning gains from a CAL package are important, but .... acquisition and retention of knowledge is really what is ultimately important and will depend on other learning experiences in the course ......". They also cite Blondel et al (1990) as asserting that "since computers are not used in isolation, CALL should not be evaluated in isolation"

Confidence Logs

This type of questionnaire uses a checklist of the specific learning objectives for a courseware package, as provided by the teacher. Students are asked to rate their confidence in terms of their grasp of underlying principles and their ability to perform certain tasks. A higher score for a particular objective after exposure to an activity indicates that students at least believe they have learned from it. If a score does not rise, the activity is unlikely to have been of benefit.

Post Task Questionnaire

This type of questionnaire is usually administered to students immediately after they have completed the class session in which the courseware was used. Its main aim is to elicit personal reactions to the experience, and to find out the relative value individual students place on the various teaching resources (Doughty et al, 1995).

Focus Group

A focus group consists of a small number of students and an evaluator who has a few set questions with which to initiate a discussion. Thereafter, the students' responses and comments act as prompts to continue the discussion. The main function of a focus group is as an open-ended instrument which is able to elicit views that were not covered in the questionnaire, using participants' responses as prompts for the other participants. In this way, students are able to provide further feedback to the evaluator which is ultimately valuable to the teacher.

3.10 Approaches to learning

Researchers investigating learning processes, particularly learning at the university level, have often distinguished two different ways in which learning may be approached. Ausubel (1968) made a distinction between *meaningful* and *rote* learning and subsequent studies have followed similar lines (i.e., the difference between *understanding* and *reproductive* learning (Entwistle, Hanley and Hounsell, 1979); *generic* and *surface coding* (Biggs and Telfer, 1981); *deep* and *surface* learning (Marton and Salsjo, 1976).

For the purpose of this study, the last of these learning approaches is of particular interest. There follows an explanation of the distinction between *deep* and *surface* learning. First, however, it may be useful to review Ausubel's theory of learning briefly.

3.10.1 Ausubel Theory of meaningful learning

Central to Ausubel's theory of learning is his precise definition of meaningful learning. According to Ausubel (1966), "meaningful learning takes place if the learning task is related in a non-arbitrary and non-verbatim fashion to the learner's existing structure of knowledge". Furthermore, Ausubel and Robinson (1969) identify a number of pre-requisites to meaningful learning which relate both to the teaching material and to the experience and motivation of the learner.

Ausubel makes the important distinction between meaningful and rote learning. He claims that meaningful learning results in the assimilation of new knowledge in the learner's mind whereas rote learning results in the arbitrary and verbatim incorporation of new knowledge. This is knowledge taken in without attachment to existing knowledge. However, Ausubel (1973) does not view meaningful and rote learning as pure dichotomies; rather they represent two poles. He does indicate, though, that learning becomes increasingly rote in nature when the teaching materials lack logical meaningfulness, when the learner lacks relevant ideas in his own cognitive structure, and when the learner lacks a meaningful learning context.

3.10.2 Deep and surface approaches to learning

The difference between deep and surface approaches to learning has been the subject of a number of studies. The basic argument is that there is an important difference between merely learning (a surface approach) and attempting to understand (a deep approach).

In their original study, Marton and Saljo (1976), focused on what university students learned from reading an academic text. The study revealed two very different approaches adopted by the students, which Marton and Saljo termed "deep and surface approaches", and which resulted in very different learning outcomes in terms of understanding. The deep approach was characterised by an attempt on the student's part to understand the significance of the author's argument in the text. The surface approach, on the other hand, was characterised by the student's attempt to recall isolated facts and concepts presented in the text.

Ramsden (1988) cited in Morgan (1993) provides a useful summary of the ways in which the deep approach differs from the surface approach. In particular, he emphasises the importance of organising and structuring the content of teaching materials, and focusing on the meaning of information rather than the information itself, if greater understanding is to be achieved.

It is important to remember that between the extremes of completely deep and completely surface approaches are a range of approaches to understanding that are deep and surface to varying degrees. In general, however, the deep approach is linked to an attempt to understand, whereas the surface approach is often linked to a desire to do well in a test, and to a focus of the learning on the kind of the task they will be tested.

Clearly, there are similarities between deep and meaningful learning, on the one hand, and surface and rote learning, on the other hand. The former refer to situations where students look beyond the information provided and seek to understand underlying principles and patterns. The latter, in contrast, refer to memorisation, where facts are learned but not necessarily understood.

However, despite these similarities, deep and surface approaches are not synonymous with Ausubel's meaningful and rote learning. The significant difference is that whether meaningful or rote learning occurs depends mainly on the style of teaching provided for the student. The difference between deep and surface learning, on the other hand, depends more on the individual differences that exist between learners with respect to their attitude to learning.

3. 11 Summary

Experience has shown that computers perform a number of different roles in the educational environment. One of these roles is as a teaching medium within a wider teaching programme. In this role, computers sometimes offer unique advantages over both traditional mediums and other technological mediums.

The computer's effectiveness as a teaching medium both in schools and higher education depends not only on the way it is introduced, but also on the way it is evaluated once in use. While several different approaches could be used to evaluate the effectiveness of CAL, integrative evaluation is thought to be the most appropriate. Integrative evaluation has the advantage that it allows CAL to be assessed within the context of the overall learning situation, rather than in isolation.

CHAPTER FOUR
RESEARCH METHOD

CHAPTER FOUR

RESEARCH METHOD

4.1 Introduction

In this chapter, the method that has been adopted in this research will be outlined. The chapter begins with a description of the initial procedures undertaken prior to the CAL evaluation study. These include the initial visits to the schools, the meetings held with the teachers, and the selection of schools to be used in the study. Then, the methods used to collect data for the evaluation will be discussed. Reasons for the choice of methods will be provided for both the University and school context.

4.2 Initial procedures undertaken before conducting the study both in the University and schools.

In this type of research, a number of initial procedures need to be carried out and, as discussed earlier (see chapter three, section 3.9), these procedures are crucial to any study involving integrative evaluation.

4.2.1 Initial visit to schools

The researcher made an initial visit to three schools in the city of Glasgow: St. Thomas Aquinas Secondary School, Holyrood Secondary School and Garhthamlock Secondary School. These three schools were recommended by the Social Studies Adviser of the Strathclyde Education Department as those who were actively using computers to teach geography. The main aim of this visit was to obtain a general idea of the CAL programs available in the Geography departments of these schools, as well as the types and numbers of machines used. Another important objective of this visit was to assess the extent to which teachers were willing to cooperate.

4.2.2 Selection of schools

Based on the initial visit made to the three schools listed above, two schools, namely, St. Thomas Aquinas Secondary School (1) and Holyrood Secondary School (2) were selected for the following reasons:

- both schools have CAL programs which are relevant to the subject of Geography, and these programs were going to be used during the period of the proposed research. In the case of school (1), the CAL program dealt with the subject of the weather, while in school (2), it dealt with the Geography of Japan.

- the Geography teachers at both schools were prepared to cooperate with the evaluator. It should be noted, however, that while the teacher at school (1) was particularly keen to take part in the research, the teacher at school (2) was much less enthusiastic although he did agree to cooperate.

4.2.3 Further meetings with teachers in schools

After selecting the schools, further meetings with the Geography teachers were arranged. Various issues were discussed, including the design of the tests to measure learning outcomes, the number of pupils in each class, suitable times for administering the test and other instruments, and the procedures for marking the test.

4.2.4 Meetings with the lecturer at the Geography Department at Glasgow University

Two meetings took place with a lecturer in Geography at Glasgow University. The first meeting concentrated on the types of CAL packages available, the reasons for using them, the aims of these packages, the courses into which these packages would be incorporated, the level of the courses (i.e. in which of the four years of the undergraduate course), number and type of machines available etc. From the first meeting, it became clear that two packages were particularly relevant to the study. The first package "Analysis of Glacial Sediments" was to be used by second year students and the other package related to IT techniques was to be used by third year students.

These initial meetings provided an overall picture of the type of packages which were going to be used in the Geography Departments of the two schools and the University. On the basis of this information, the research can be divided into four studies as follows:

- study one. *the use of the weather package in school (1).*

- study two. *the use of the Japan package in school (2).*

- study three. *the use of the package related to IT techniques in the University (level 3).*
- study four. *the use of Glacial Sediments package in the University (level 2).*

4.3 The study samples

Each of the four studies mentioned above involved a specific group of participants. In the case of study 1, all 24 pupils in the class using the Weather package during the period of the study took part. In study 2, two classes provided 50 participants. In the two studies conducted at the university, 94 students took part in study 3 and 70 participated in study 4. Included in the former group were students who had been taught the IT course in the previous year (1994-95). The number of participants are summarised in table 4.1.

Table 4.1 Number of participants in each study.

Studies	Participants
study 1	24
study 2	50
study 3	94
study 4	70

Total ——————— 238

4.4 Methods used to collect the data

Three main methods were used to collect the data for this research, namely,

- Tests (quizzes)
- Questionnaires
- Focus group

Some of these methods were used in both the University and schools studies, while others were employed exclusively in the University studies as is explained in the following sections.

4.4.1 Methods used in the school studies

The Tests

These tests were used to measure learning outcomes in both the schools. The test used included multiple-choice and open-ended questions. Separate tests were designed for each school in order to reflect differences in the objectives of each subject and in the content of the CAL packages. In each school the same test was administered three times:

- prior to human teaching (pretest)

- after human teaching and before the CAL package (post 1)

- after the completion of the CAL package (post 2)

The order in which the tests were administered was dictated by the way CAL was used in the schools (i.e. Computer teaching followed by human teaching). Since the whole process was under the control of the teachers, it was impossible for the evaluator to study the effect of computer teaching preceding human teaching in an actual teaching situation.

Using the same test does allow the possibility of memorising answers, but it provides a more exact comparison of learning outcomes. In order to minimise the effect of memorisation, pupils were given no feedback on their test performance. In addition, they were not told in advance that they were going to be tested three times, neither were they warned of post1 or post 2.

Post task questionnaire

This questionnaire aimed to look at pupils' reaction to the computer as a tool for learning about the "weather" and "Japan" as well as their reaction to the packages themselves. It consisted of four fixed response questions with some opportunity for pupils to give reasons for their answers. This questionnaire was administered to pupils one week after the completion of the CAL packages.

Learning resources questionnaire

A Learning resources questionnaire is useful for finding out to what extent pupils consider CAL to be useful. It is particularly suited to situations in which CAL is to be evaluated in relation to other resources, and not in isolation. For this reason, it was only administered in school (1) because only here were a variety of learning resources available. The questionnaire was based on the different resources which were made known to the researcher by the teacher of the subject and are eight in number. In each case, pupils can indicate their responses on a five point scale ranging from "not at all useful" to "extremely useful". The questionnaire also had additional questions related to the resources (e.g. the resources which increased and decreased pupils' interest on learning about the weather subject and the resources which they had difficulty in accessing). This questionnaire was administered to pupils on the same day as the post task questionnaire.

4.4.2 Methods used in the university studies.

4.4.2.1 Methods used in study 3

Ideally, objective test would also have been used to measure learning outcomes in this study, however it was difficult to get a test format from the lecturer involved in teaching this course. So, 3 instruments had to be used: a learning resources questionnaire, a confidence log questionnaire and a focus group.

Learning resources questionnaire

A version of this questionnaire had been used in previous studies at the University of Glasgow by Group E of TILT (Brown et al, 1996). The questionnaire covers all the five techniques used in the third year IT course. These five techniques are : GIS (Geographical Information System), Excel, Minitab, Netscape and Write. Eight resources were provided by the lecturer and were listed for each technique. The questionnaire allowed students to indicate which resources they used and how useful they found each resource to be. In each case, students indicated their responses on a five point scale ranging from "not at all useful" to "extremely useful". The questionnaire also included open-ended questions (e.g. asking about the resources which students had difficulty accessing). The questionnaire was administered to both third year students studying the IT course in 1995-96 and fourth year students who had studied the same course in the previous academic year 1994-95. This was to see if there were any differences in students' perceptions of the usefulness of the IT course between those who had just completed the course and those who had completed it one year previously.

Confidence log.

A version of this questionnaire has also been used by group E of TILT. It consisted of a checklist of specific learning objectives provided by the lecturer. Students were required to rank their feeling of confidence about being able to meet each objective on a 5 point scale from "no confidence at all" to "very confident". As with the learning resources questionnaire, the confidence log was administered to third year students studying the IT course in 1995-96 and fourth year students who studied the course in 1994-95.

Focus group

From the third year group, 6 students volunteered to be interviewed. The method used with these students was a "focus group" discussion. The main idea behind using such method was to obtain more probing comments from students involved. Some issues that had not been covered in the learning resources questionnaires and confidence log, were discussed. Among these issues were: lectures and how they related to the practical work, staff support, time available to finish the practical work and students' confidence in being able to apply the techniques covered in the IT course to their dissertation work.

4.4.2.2 Methods used in study 4

The Test

One test was administered to the second year students studying Glacial sediments. Its aim was to measure the learning gain resulting from the course where CAL package was a part of the course. The CAL package itself brings together information from lectures about sedimentary deposit formation processes and from practical work on the appearance of the resulting sedimentary deposits to help students make connections between the information they received from these two resources.

The test consisted of nine questions. The first seven questions were multiple-choice questions. Of these, questions 1 to 5 covered material presented by all three teaching methods (lectures, physical lab and CAL), whereas questions 6 and 7 relied heavily on material presented by the CAL package. Questions 8 and 9 were open-ended questions designed to show the extent to which the CAL package helped students to make connections. In other words, it was hoped that these two questions would be able to distinguish deep learning from surface learning. The test was administered to students twice: immediately before they started the course and using CAL (pre course) and immediately after they finished it (post course).

Post task questionnaire

This questionnaire was designed to find out how students reacted to three main methods used to teach them about Glacial Sediments.(i.e. the lecture, the lab and the CAL package). In the first question, students were asked to rate each of the three teaching methods on a five point scale ranging from "worthless" to "outstanding". Students who considered the lecture, lab or CAL package "worthless", "of little value", "very valuable" or "outstanding" were required to give reasons. In another question, they were requested to indicate what they found most useful about each of the methods. The questionnaire was administered to students immediately after teaching and CAL.

4.5 Reports to the teachers involved.

Reports based on the results of the studies conducted both in the schools and the university were submitted to the teachers for their comments.

4.6 Meetings with the teacher

Meetings were held with the teachers to discuss the results contained in these reports and to allow them to provide feedback. Several issues were raised during these meetings including the variability within the test results, their opinions of the usefulness of the method employed (i.e. the evaluation), and any changes they intend to make to the way they use CAL as a result of these findings.

4.7 Summary

A summary of the instruments used in this study and the time of their use is provided in table 4.2

Table 4.2 Summary of the instruments used in the studies

Studies							
Study	(1)	Study	(2)	Study	(3)	Study	(4)
Instrument	**Time**	**Instrument**	**Time**	**Instrument**	**Time**	**Instrument**	**Time**
Quiz (pretest)	Immediately before human teaching	Quiz (pretest)	Immediately before human teaching	Learning resources and conf. log	During term 2 (1995-96)	Quiz (pre-course)	Immediately before teaching and (CAL)
Quiz (posttest1)	Immediately after human teaching	Quiz (posttest1)	Immediately after human teaching	Focus group	During term 2 (1995-96	Quiz (post-course)	Immediately after teaching and (CAL)
Quiz (posttest2)	Immediately after CAL	Quiz (posttest2)	Immediately after CAL			Post task questionnaire	Immediately after teaching and (CAL)
Post task and resource questionnaires	One week after posttest 2	Post task questionnaire	One week after posttest 2				

From the methods outlined and summarised in this chapter, it can be seen that different approaches and methods have been employed in this research to evaluate computer assisted learning (CAL) as part of the overall teaching and learning situation. Each method used in this research was designed and chosen to achieve certain purposes, ranging from measuring the learning outcomes to looking at students'/pupils' reactions and opinions of the use, value and usefulness of CAL in the Geography. In addition, the chapter outlined the initial procedures that were essential to the successful implementation of the evaluation approach used in this study.

CHAPTER FIVE
RESULTS AND DISCUSSION

(SCHOOLS RESULTS)

CHAPTER FIVE

RESULTS AND DISCUSSION

(Schools results)

5.1 Introduction

In this chapter, the results of studies one and two (the two schools based studies) will be presented and discussed. In the case of study one, the results of the three instruments - the tests, the post-task questionnaire and the learning resources questionnaire will be presented. In the second part of the chapter, the result of study two, for which only the tests and the post task questionnaire were involved, will be presented.

5.2 Study one results

5.2.1 Test results

As indicated in the previous chapter on methods used (section 4.4.1) the test designed by the teacher to measure learning outcomes was administered to pupils on three occasions: immediately before human teaching (pretest), after human teaching and prior to CAL (post1) and after the use of CAL (post2). The test itself consisted of eight questions. For comparison purposes, the mean score for each question in each of the three tests is shown in table (5.1) and appears in graphical form in Appendix B .

Table 5.1 Initial analysis of mean pretest, post1 and post2 scores

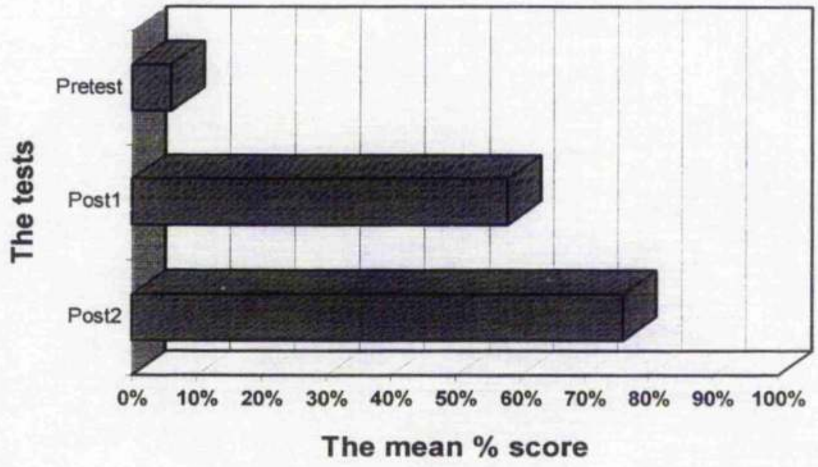
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Maximum mark	**12**	**1**	**1**	**1**	**8**	**8**	**4**	**5**
Pretest (before teaching)	**1.1**	**0**	**0**	**0**	**0.8**	**0.6**	**0.8**	**0.1**
Pretest mean score as % of maximum mark	9%	0%	0%	0%	10%	8%	20%	2%
Post1 (after teaching)	**9.8**	**0.4**	**0.3**	**0.7**	**2.4**	**4.2**	**3.3**	**3.9**
Post1 mean score as % of maximum mark	82%	40%	30%	70%	30%	53%	83%	78%
Post2 (after CAL)	**11.5**	**0.7**	**0.6**	**0.9**	**3.7**	**5.3**	**3.7**	**4.3**
Post2 mean score as % of maximum mark	96%	70%	60%	90%	46%	66%	93%	86%

The above table clearly indicates that in post2 pupils performed very well in certain questions, notably questions 1, 4, 7, and 8. Their performance in questions 2 and 6 was also good, though not as good as in the case of questions 1, 4, 7 and 8. On the other hand, pupils scored badly on question 5, achieving less than 50% of the maximum mark.

There are two possible explanations for variation in test scores. First, the different scores could indicate real differences in the achievement of learning objectives i.e. differences in the effectiveness of the teaching material and methods. The other explanation is that the form of the questions themselves influences test scores, i.e. the wording of the questions, the kind of response required from the pupils and the scoring system, could have a significant bearing on performance.

In order to provide a more general picture of pupils' performance over all eight questions, the mean percentage scores for each test are given in figure (5.1).

Figure 5.1 mean % score for all eight questions



There would appear to be a very large increase in performance following human teaching: the mean score increased from 6% to 58%. There would also appear to be a marked, though much smaller, increase in scores following the use of CAL: the mean score rose from 58% to 76%.

5.2.1.1 Teaching gain

In order to calculate teaching gain for each question, the average score of pretest was subtracted from the average score of post1 (see table 5.2).

Table 5.2 Full analysis of mean pretest, post1, and post2 scores

A	Questions	1	2	3	4	5	6	7	8
B	**Maximum mark**	12	1	1	1	8	8	4	5
C	**Pretest** (before teaching)	1.1	0	0	0	0.8	0.6	0.8	0.1
D	**Post1** (after teaching)	9.8	0.4	0.3	0.7	2.4	4.2	3.3	3.9
E	**Post2** (after CAL)	11.5	0.7	0.6	0.9	3.7	5.3	3.7	4.3
F	**Teaching gain** = D-C	8.7	0.4	0.3	0.7	1.6	3.6	2.5	3.8
G	**Teaching gain as % of max. mark. =F/B*100**	73%	40%	30%	70%	20%	45%	63%	76%
H	**Possible teaching gain =B-C**	10.9	1	1	1	7.2	7.4	3.2	4.9
I	**Teaching efficiency** =F/H*100	80%	40%	30%	70%	22%	49%	78%	78%
J	**CAL gain =E-D**	1.7	0.3	0.3	0.2	1.3	1.1	0.4	0.4
K	**CAL gain as % of max. mark. =J/B*100**	14%	30%	30%	20%	16%	14%	10%	8%
L	**Possible CAL gain =B-D**	2.2	0.6	0.7	0.3	5.6	3.8	0.7	1.7
M	**CAL efficiency =J/L*100**	77%	50%	43%	67%	23%	29%	57%	24%
N	**Overall gain** =E-C	10.4	0.7	0.6	0.9	2.9	4.7	2.9	4.2
O	**Overall gain as % of max. mark =N/B*100**	87%	70%	60%	90%	36%	59%	73%	84%
P	**Possible overall gain =B-C**	10.9	1	1	1	7.2	7.4	3.2	4.9
Q	**Overall efficiency =N/P*100**	95%	70%	60%	90%	40%	64%	91%	86%

When teaching gain is expressed as a percentage of the maximum mark, it can be seen that pupils gained more than 50% as a consequence of the human teaching in questions 1, 4, 7, and 8, but less than 50% in the remaining questions. The possible reasons for this variation have already been given in section 5.2.1.

5.2.1.2 Teaching efficiency

In order to find out the extent to which human teaching was effective, teaching gain was divided by the maximum possible teaching gain that could have been achieved to give a new value: teaching efficiency (see table 5.2). The table shows that the human teaching efficiency was again greater for questions 1, 4, 7, and 8 than for questions 2, 3, 5 and 6. The value of teaching efficiency would thus seem to confirm that the performances for certain questions are significantly different from the others.

5.2.1.3 CAL gain

CAL gain is one of the main measurements used to find out to what extent pupils gained as a result of using the package. The CAL gain is the difference between the mean score of post1 and the mean score of post2 i.e. (post2-post1). The CAL gain obtained in each question is shown in table (5.2). The table illustrated that pupils gained from the use of CAL. There were positive CAL gains for all questions and it is interesting to note that some of the largest percentage gains occurred in questions 2, 3, and 5 for which teaching gains were relatively low. It is possible that the special facilities provided by the CAL package e.g. animation and a huge database of climate information helped to clarify certain points that were not well understood after human teaching.

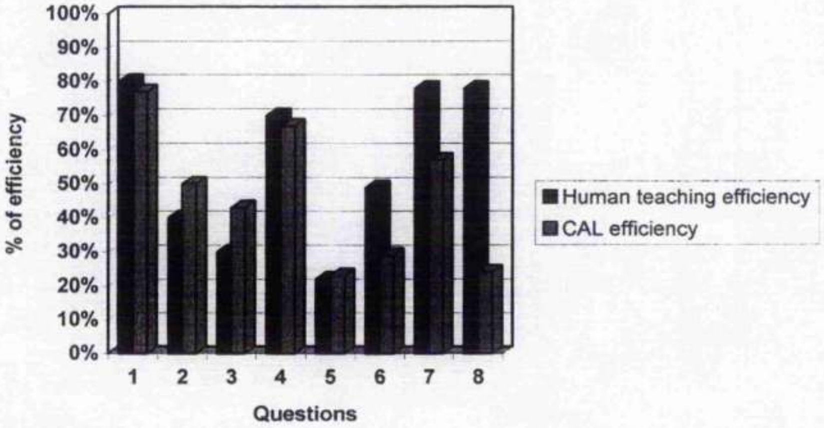
5.2.1.4 CAL efficiency

The other measurement used to look at the effectiveness of CAL was the amount gained by pupils relative to the maximum they could gain (see table 5.2). It is clear that CAL was effective in achieving objectives 1, 4, and 7 for which pupils achieved 50% or more of the maximum, while it was less effective in achieving the other objectives.

Whether it is actually fair to compare CAL efficiency and human teaching efficiency is somewhat debatable. The fact that CAL followed human teaching can lead to two possible conclusions, depending on what assumptions are made about the pattern of learning within the class. If one assumes that the best pupils contributed most to the post1 scores, then high CAL efficiencies would be harder to achieve than high human teaching efficiencies. If, however, one assumes that CAL performed more as a revision tool, providing pupils with a second exposure to similar topics, then CAL may have had an easier job to perform than the teacher who introduced the topic. In this case, CAL efficiency might be expected to be higher than human teaching efficiency.

The results obtained, in fact, do not suggest any clear pattern: CAL efficiency was higher than human teaching efficiency for objectives 2, 3 and 5, whereas for all the other objectives, the opposite was true (see figure 5.2). It seems likely that some points were presented better than other by the CAL package.

figure 5.2 Comparsion of human teaching efficiency and CAL efficiency.



5.2.1.5 Overall gain

It was argued in chapter three (section 3.9) that, in the integrative approach to evaluation, CAL should be evaluated as part of the overall teaching situation rather than be evaluated in isolation. Thus it is important to look at the overall gain achieved from the combination of CAL and human teaching. In order to calculate the overall gain, the mean pretest score was subtracted from the mean post2 score. From table 5.2, it can be seen that in all questions except number 5 the combination of teaching approaches resulted in large gains.

5.2.1.6 Overall efficiency

Similarly, from the point of view of integrative evaluation, it is useful to look at the overall efficiency. Overall efficiency was calculated by dividing overall gain by the maximum possible gain. The results are shown in table 5.2.

It would seem that the overall efficiency of three learning objectives was high i.e. objectives 1, 4 and 7. The efficiency for objectives 8 and 2 was also fairly high, whereas for objectives 3, 5 and 6 it was low.

So, it can be concluded that CAL needs to be evaluated for its effectiveness in combination with other teaching methods, notably human teaching. The most useful measure in this respect is overall efficiency and for all but one learning objective CAL contributed to high scores (well in excess of 50%).

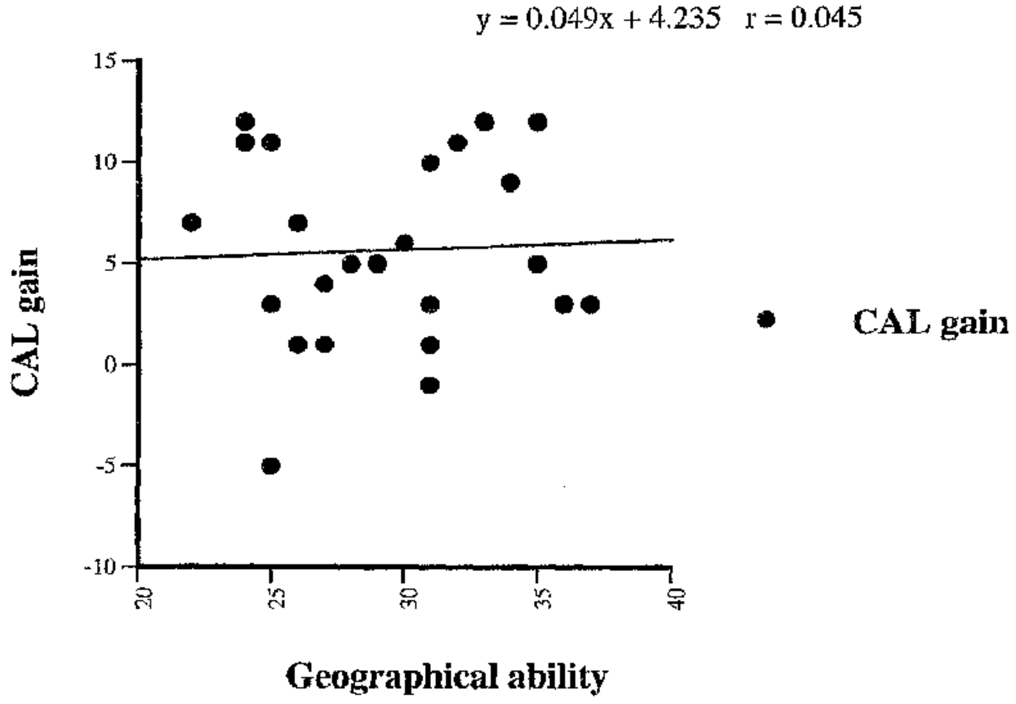
The fairly wide range of values for overall efficiencies can be explained in the same way as the variability in individual test scores i.e. shortcomings in the combined teaching approach and/ or differences between test questions with respect to their wording and the type of response required.

5.2.1.7 CAL gain versus pupils' geographical ability

In order to investigate further any possible trends in the CAL gains recorded by pupils, it was decided to see if a correlation existed between pupils' CAL gain and their "geographical ability". In other words, the question posed was whether high and low ability pupils benefited equally or differently from using the CAL package.

The term "geographical ability" in this context is defined as a measure of pupils' achievement in Geography. In practice, each of the teachers in the school studies was asked to provide the evaluator with test scores from a more comprehensive geography test used for normal academic assessment purposes. These were normal class tests used for pupil record purposes. They allowed the researcher to place pupils in order of merit and hence into groups based on ability. These should not be confused with the tests used in this research which were designed for integrative evaluation purposes. No details of the test questions were available, but both teachers were able to confirm that the distribution of test scores within the class was representative of the geography abilities of individual pupils. In order to investigate the existence and strength of the correlation between CAL gain and geographical ability, two sets of correlation coefficient tests were conducted. The first test looked at the Direct Product Moment Correlation between gain from the use of the CAL package and the geographical ability for each number of the whole sample of pupils. In this case, no correlation at all was found as **r** = *0.045* (see figure 5.3).

Figure 5. 3 CAL gain versus Geographical ability (all pupils, N=24)



In the second test, the sample of pupils was divided into three categories according to their geographical ability (as obtained from the school records)

- low ability pupils, whose school test scores placed them in the bottom third of the class.
- average ability pupils, whose school test scores placed them in the middle third of the class.
- high ability pupils, whose school test scores placed them in the top third of the class.

The result revealed the following:

1- there is only a tendency towards an inverse relationship between the achievement of low ability pupils on the school test and their CAL gain as **r** = - *0.3* (see figure 5.4).

2- there is no correlation at all between the achievement of average ability pupils and their CAL gain as **r** = *0.041* (see figure 5.5).

3- there is a fairly strong negative correlation between the achievement of high ability pupils and their CAL gain as **r** = - *0.791* (see figure 5.6).

Figure 5.4 CAL gain versus Geographical ability (low ability pupils)

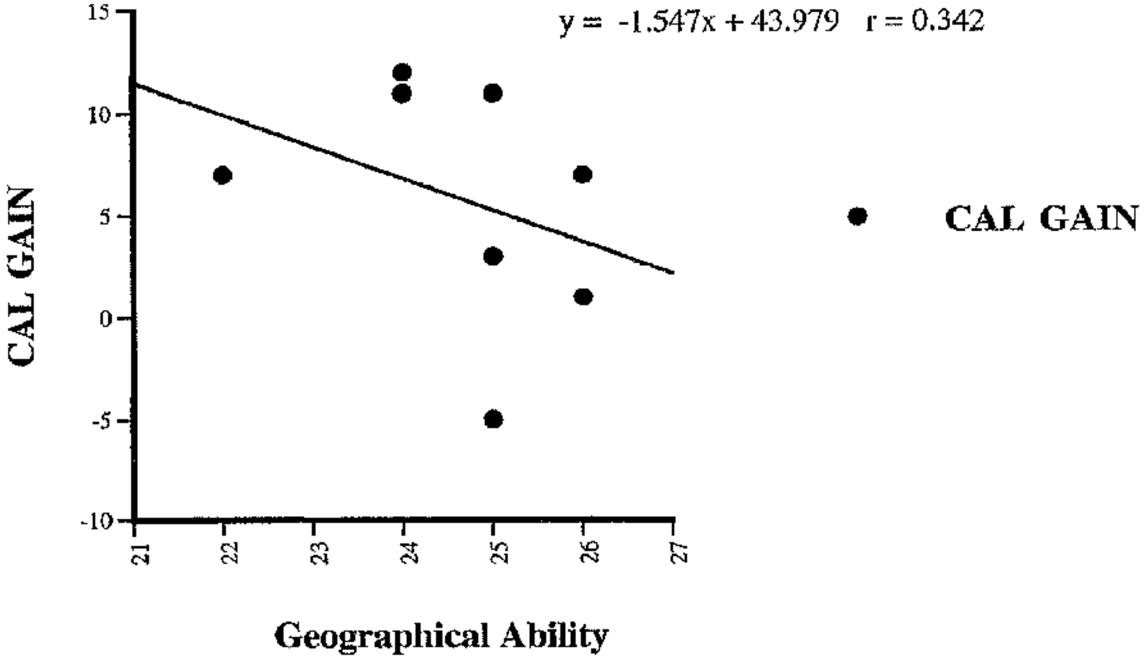


Figure 5.5 CAL gain versus Geographical ability (average pupils)

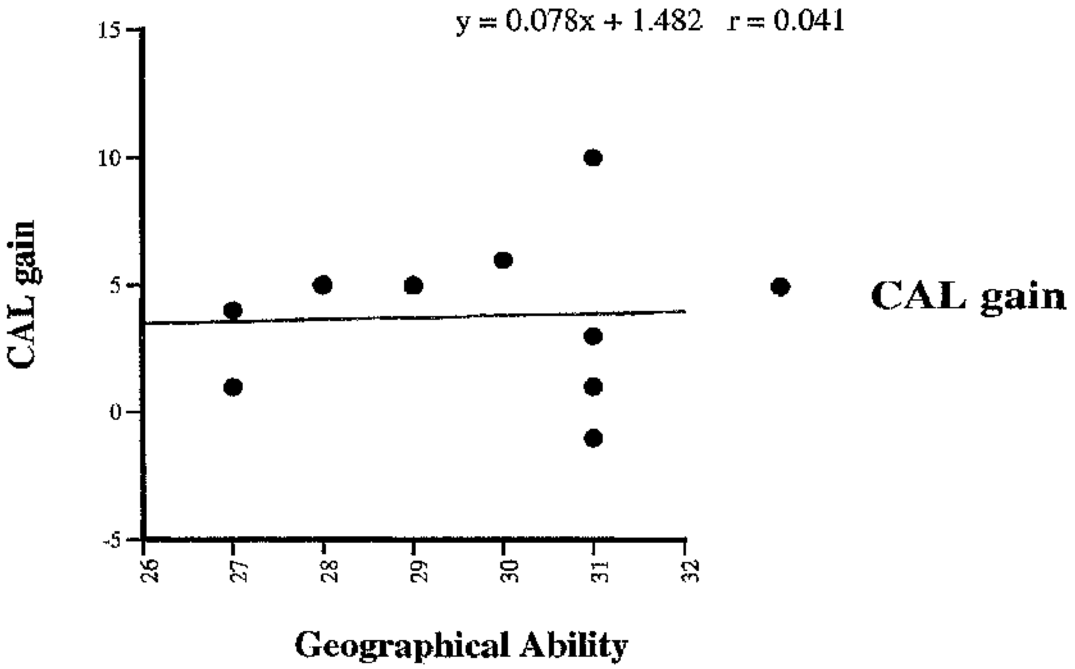
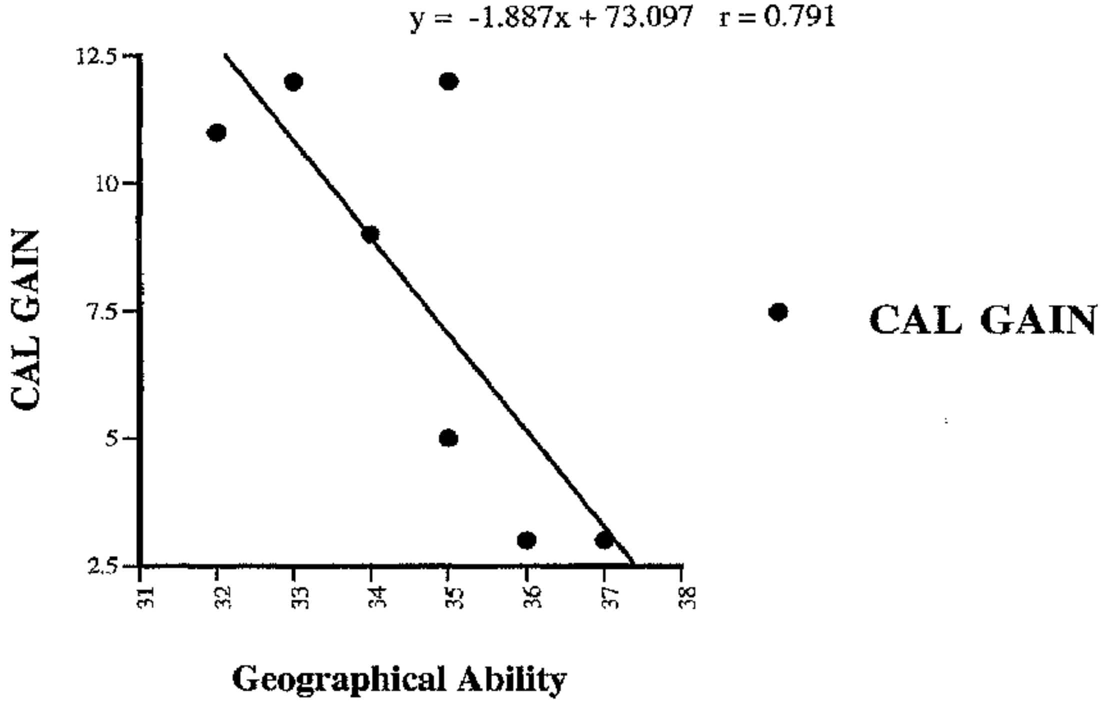


Figure 5.6 CAL gain versus Geographical ability (high ability pupils)



The results of the correlation test for the low ability pupils is interesting. It suggests that CAL has something of an equalizing effect on the group, benefiting pupils with lower ability *within the group* more than those with higher abilities *within the group.*

An even stronger effect of this kind was found within the pupils of high geographical ability, although the fact that CAL gain rather than CAL efficiency was used means that the effect may be exaggerated in this case by some pupils approaching or even achieving the maximum possible mark. In other words, the higher ability pupils had already attained highly so that there was little room for further gain.

In retrospect it may have been better to investigate the correlation between CAL gain and some independent variable (since there was a degree of overlap between the tests used for evaluation purposes and the test used to determine "geographical ability", the latter is not an independent variable). For example, a more general intelligence test might have been used to measure more general "ability". However, intelligence tests scores are not available in Glasgow schools. Also, the fact that already - available geography test results were used was mainly due to practical considerations, namely that no extra time was available for pupil involvement in the study.

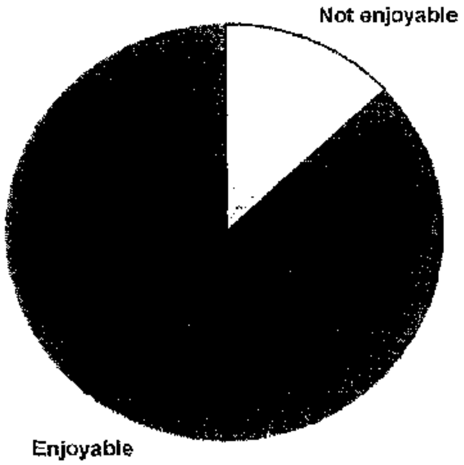
5.3 Post task questionnaire results

As indicated in the previous chapter (section 4.4.1), pupils were asked to complete a post task questionnaire one week after they had finished using the CAL package. The questionnaire consisted of four questions that sought to assess pupils' reactions to the computer as a learning medium. The pupils' responses are outlined below.

5.3.1 Question one result

In this question, pupils were asked they if found the experience of using the computer enjoyable or not. The analysis indicates that the vast majority of the pupils responded that it was enjoyable (87%). Only a minority responded negatively (13%) (see figure 5.7).

Figure 5.7 Pupil ratings of the learning experience of using computers in terms of enjoyment



5.3.2 Question two result

In this question, pupils were asked to indicate if the CAL package had helped them to learn about subject of the weather. Again the majority (87%) thought that they had benefited from the CAL package. The remainder (13%) felt that they had not benefited (see figure 5.8).

Figure 5.8 Pupil ratings of the helpfulness of the CAL package in learning about the weather

Pupils were asked to provide reasons for their responses if they responded positively to this question. Similar reasons to this open-ended prompt were grouped, and six kind of reason were identified. Table 5.3 lists these reasons and shows the number of pupils who provided each reason.

Table 5.3 Reasons given by pupils who thought CAL helped them to learn about the weather. (N=21)

Reasons	**No. of pupils**
- it helped me to understand certain aspects of the weather by putting them in picture form.	4
- it showed how fronts moved and how the weather changed.	4
- the CAL was not boring as some resources (textbook) because you are more involved.	4
- it simulated different type of weather that we would not see normally.	3
- I could make up my own weather forecast.	3
- it enabled me to learn about the weather in more detail.	3

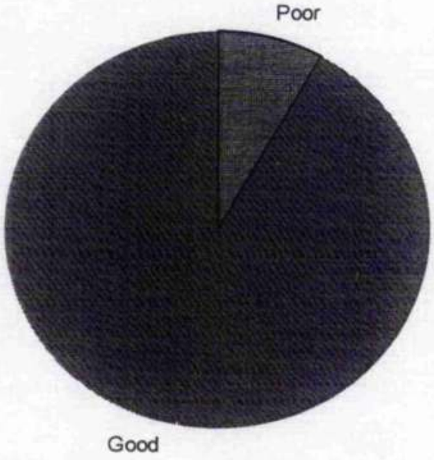
The various reasons cited by pupils for finding the CAL package beneficial are consistent with the benefits often attributed to the computer as a learning tool e.g. the stimulating and motivating effect that graphics can have on learners, and the increased sense of involvement that learners experience with interactive packages.

Those pupils who did not feel CAL was beneficial gave reasons such as "*I felt that CAL was boring and I didn't know what to do*" and "*It was not enjoyable*". Such responses are a reminder that computers can present learners with problems, e.g. detailed information which can sometimes become noise information and unfamiliarity with the technical aspects of the computer.

5.3.3 Question three result

In this particular question, pupils were asked whether they thought the computer was a good tool to learn about the subject. The vast majority (92%) responded positively. Only (8%) considered it a poor tool (see figure 5.9). These findings seem consistent with the responses to question two.

Figure 5.9 Pupil ratings of the computer as a tool for learning



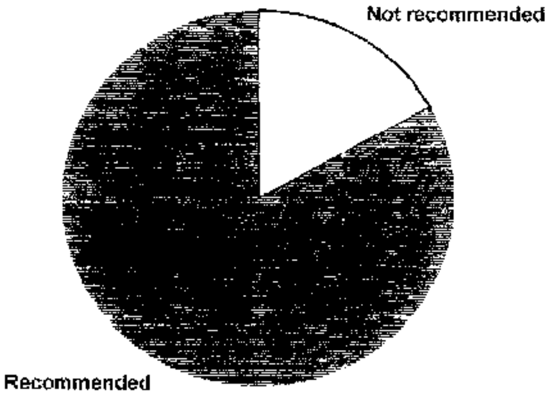
5.3.4 Question four result

In this final question, pupils were asked whether they would recommend the CAL package to other pupils in their school. Again the majority of pupils (83%) reported that they would recommend it to other pupils, while only (17%) said they would not (see figure 5.10).

The pupils who responded negatively gave the following reasons :

> *"Although I learned from it, I think the teacher was much better"*
>
> " *I felt it was too boring*"
>
> " *It was hard to understand*"

Figure 5.10 Pupils' responses when asked whether they would recommend the CAL package to other pupils in the school



It could be concluded that the pupils' responses to CAL as well as the computer as a learning tool are in most cases extremely positive. The findings confirm the benefits often attributed to CAL in the literature. However, despite the positive reactions from the overwhelming majority of pupils, for the purposes of integrative evaluation, the smaller number of negative reactions are also important and have to be taken into account.

5.4 Learning resources questionnaire results

As stated in chapter four on methods used (section 4.4.1), the purpose of the learning resources questionnaire is to see how pupils perceive the usefulness of learning resources used to teach them about the weather. The questionnaire consisted of four questions. The pupils' responses to these questions are outlined below.

5.4.1 Question one results

In this question, pupils were asked to rate the usefulness of each resource on a five point scale ranging from "not at all useful" to "extremely useful". The picture that emerged from the pupils' responses is summarised in table 5.4.

Table 5.4 Pupil responses to learning resources.

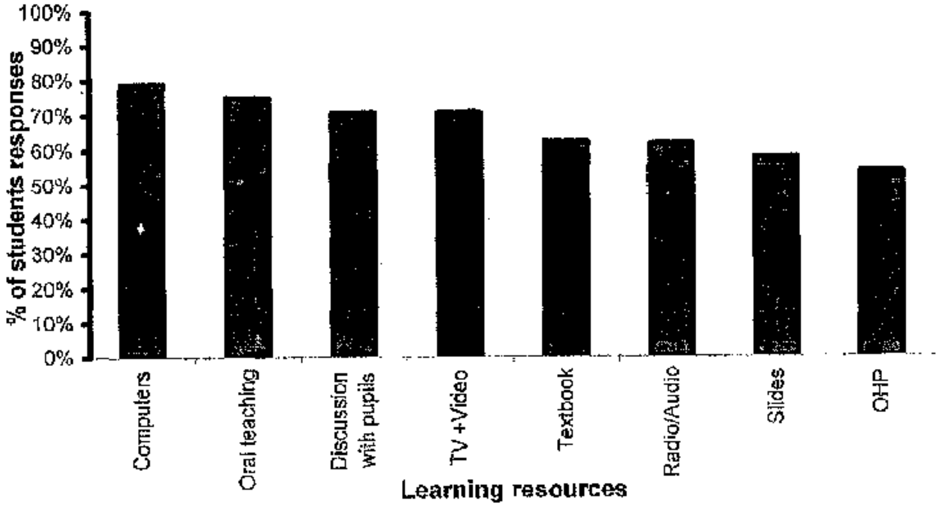
Resource	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**
TV +Video	2	5	10	7	0
Computers	1	4	9	8	2
Radio/Audio	1	8	10	4	1
Textbook	3	6	9	6	0
Oral teaching	2	4	9	7	2
Slides	1	9	9	4	1
Discussion with pupils	1	6	10	6	1
OHP	3	8	8	5	0

Since the main reason for asking the first question was merely to establish which resources the pupils considered most useful in teaching them about the weather subject, the "not at all useful" and "not very useful" responses were combined into a single category: " not useful". Similarly, the "useful", "very useful" and extremely useful" responses were grouped into a single category: "useful". The responses are tabulated in percentage form in table 5.6 and the ranking of useful responses is shown graphically in figure 5.11.

Table 5.6 Pupil ratings the usefulness of learning resources

Resource	**Useful**	**Not useful**
TV +Video	71%	29%
Computers	79%	21%
Radio/Audio	62%	37.5%
Textbook	62.5%	37.5%
Oral teaching	75%	25%
Slides	58%	42%
Discussion with pupils	71%	29%
OHP	54%	46%

Figure 5.11 pupil ratings of the usefulness of the learning resources used to teach them about the Weather.



It is clear from the responses given by the pupils that they rate the computer as the most useful resource for learning about the weather - 79% considered it useful. Oral teaching was considered the second most useful resource (75%), followed closely by TV and video, and discussion with other pupils (71%). Of the remaining resources, OHP was rated as the least useful.

There are a number of reasons which might explain why pupils rate the computer more highly than other resources. First, the computer offers opportunities for interactive learning, e.g. pupils can make their own weather forecast reports with accompanying maps. Second, computer animation and computer generated sound might make the learning experience more stimulating. Finally, the computer gives pupils access to a huge database of information on weather patterns throughout the world which means that pupils are less likely to become bored and, in fact, may motivate them to compare the weather conditions in different cities and even different countries.

The fact that the pupils considered oral teaching the second most useful resource emphasizes the importance of the teacher in any learning situation. Indeed, it lends support to the argument that technology cannot and will not completely replace the teacher.

5.4.2 Question two results

In this question, pupils were asked to mention which resources they used to compensate for those resources they considered not useful. The pupils' responses are summarized in table 5.7.

Table 5.7 Resources considered non useful and the compensation made by pupils.

Non useful resources	Compensation	No. of pupils
TV+Video	*the teacher*	5
Computers	*the teacher*	2
Radio/audio	*computers*	4
textbook	*computers*	5
Oral teaching	*discussion with pupils*	3
Slides	*The teacher*	3
disc. with pupils	*The teacher*	2
OHP	*The textbook*	2

It can be seen from table 5.7 that the teacher was the resource most commonly used as a compensatory resource. This finding is hardly surprising given that the teacher is the most accessible resource, always available to respond to difficulties pupils might experience with other resources. Once again, the central role that the teacher plays in the learning process is emphasised. It is interesting to note, however, the computer was the only machine-based resource used in compensation. In addition, the results show that discussion among pupils is essential to the understanding of the subject ; once again this resource is rated third after the computer and the teacher.

5.4.3 Question three results

In this question, pupils were asked to indicate whether the various resources increased or decreased their interest in learning about the subject.Their responses are summarised in table 5.8.

Table 5.8 Resources which increased and decreased pupils' interest in learning about the subject

Resources	**% of pupils who said the resource increased their interest**	**% of pupils who said the resource decreased their interest**
Computers	**83%**	**17%**
Oral teaching	**75%**	**25%**
Disc. with pupils	**67%**	**33%**
The textbook	**50%**	**50%**
OHP	**46%**	**54%**

It can be seen from the table that the computer was the resource that most increased pupils' interest in learning about the weather. Again, oral teaching was rated second, while discussion with other pupils was rated third. In contrast, the textbook decreased pupils' interest in as many cases as it increased it, and OHP was again rated last with the majority of pupils reporting that it had decreased their interest in learning about the weather.

The features of CAL that increase pupils' interest in this subject are probably the same features that make it more useful to them. These features were discussed in the previous section (5.4.1). The importance of the teacher, this time as a motivator, is again emphasised. It is also interesting to note that discussion with other pupils is again rated highly as a learning resource.

The low rating of the textbook can perhaps be explained by the irrelevance of some of the material, and the less than stimulating style of presentation. As far as the OHP is concerned, its low rating would be due to the way the teacher has used this resource or the fact that information presented in this form is not always very easy to read.

5.4.4 Question four result

In this final question, pupils were asked if there were any resources which they found difficult to access. Almost all pupils responded by indicating that they had equal access to all the resources available to them during the school hours. It is worth mentioning that in a university context access to using computers is often problematic, for reasons such as limited numbers of computers available to students and time constraints. However, it is clearly not a problem in this school.

The pupils' responses to the learning resources questionnaire clearly indicate that they consider the computer to be the best resource in most respects. However, it is interesting to note that oral teaching was also rated consistently highly and that discussion with other pupils was considered very important. The result, therefore, suggests that pupils probably prefer to use the computer in conjunction with other resources.

5.5. Study two results

5.5.1 Test results

The procedures for administering the three tests for study two were the same as those for study one (see section 5.2.1). However, on this occasion, the test only consisted of six questions. The mean score for each question in each of the three school tests is shown in table 5.9, and is illustrated graphically in appendix C .

Table 5.9 Initial analysis of mean pretest, post1 and post2 scores

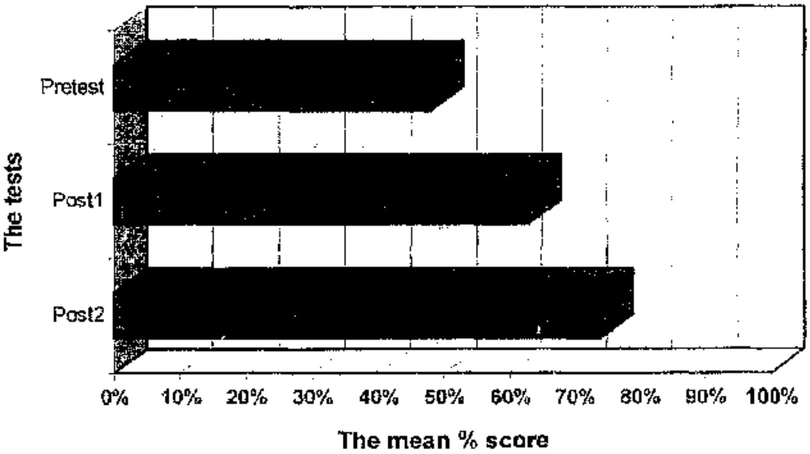
Questions	**1**	**2**	**3**	**4**	**5**	**6**
Maximum mark	**3**	**1**	**2**	**1**	**1**	**3**
Pretest (before teaching)	**0.9**	**0.86**	**0.2**	**0.48**	**0.94**	**0.58**
pretest mean score as % of maximum mark	**30%**	**86%**	**10%**	**48%**	**94%**	**19%**
Post1 (after teaching)	**1.88**	**0.92**	**0.3**	**0.82**	**0.96**	**0.96**
post1 mean score as % of maximum mark	**63%**	**92%**	**15%**	**82%**	**96%**	**32%**
Post2 (after CAL)	**1.88**	**1**	**0.7**	**0.88**	**1**	**1.84**
post2 mean score as % of maximum mark	**63%**	**100%**	**35%**	**88%**	**100%**	**61%**

It is clear from the table that pupils performed exceptionally well in post2 on questions 2 and 5 (scoring the maximum mark in both) and very well on question 4 (88%). The scores for questions 1 and 6 were somewhat lower(averaging 63% and 61% respectively), whereas the mean score for question 3 was only 35%.

The great variability in test scores can be interpreted in several ways. First, as was the case in study one, the scores could represent real differences in the achievement of the learning objectives. However, there seem to be two overriding explanations: First, the pupils involved in this study were given very little guidance in how to use the CAL package: no worksheets were provided so that pupils could become involved more deeply with the material and the teacher was not available to answer queries. Second, some of the questions were either too simple or too easy to answer correctly by guessing. The questions in the test ranged from "which" questions, that the pupils had a 50% of getting right even if they didn't actually know the answer, to fairly open-ended "why" questions.

In order to provide a more general picture of pupils' performance over all six questions, the mean percentage scores for each test are given in figure 5.12.

Figure 5.12 mean % score for all six questions



The above figure indicates that the mean scores increased modestly following human teaching: from 48% to 63%, and there was a similar increase following the use of CAL from 63% to 74%.

5.5.2 Teaching gain

Teaching gain was calculated in the same way as in study one (see section 5.2.1.1). The teaching gains for each question are shown in table 5.10.

Table 5.10 Full analysis of mean pretest, post1 and post2 scores

A	**Questions**	1	2	3	4	5	6
B	**Maximum mark**	3	1	2	1	1	3
C	**Pretest** (before teaching)	0.9	0.86	0.2	0.48	0.94	0.58
D	**Post1** (after teaching)	1.88	0.92	0.3	0.82	0.96	0.96
E	**Post2** (after CAL)	1.88	1	0.7	0.88	1	1.84
F	**Teaching gain** = D-C	0.98	0.06	0.1	0.34	0.02	0.38
G	**Teaching gain as % of max. mark.** =F/B*100	33%	6%	5%	34%	2%	13%
H	**Possible teaching gain** =B-C	2.1	0.14	1.8	0.52	0.06	2.42
I	**Teaching efficiency** =F/H*100	47%	43%	6%	65%	33%	16%
J	**CAL gain** =E-D	0	0.08	0.4	0.06	0.04	0.88
K	**CAL gain as % of max. mark.** =J/B*100	0%	8%	20%	6%	4%	29%
L	**Possible CAL gain** =B-D	1.12	0.08	1.7	0.18	0.04	2.04
M	**CAL efficiency** =J/L*100	0%	100%	24%	33%	100%	43%
N	**Overall gain** =E-C	0.98	0.14	0.5	0.4	0.06	1.26
O	**Overall gain as % of max. mark** =N/B*100	33%	14%	25%	40%	6%	42%
P	**Possible overall gain** =B-C	2.1	0.14	1.8	0.52	0.06	2.42
Q	**Overall efficiency** =N/P*100	47%	100%	28%	77%	100%	52%

When teaching gain is expressed as a percentage of the maximum mark, it can be seen that the gains are generally low (the maximum gains were 33% and 34%), and in some cases extremely low (the gains of half the questions were less than 10%).

One reason for such small gains could be significant pre-knowledge of the subject (pupils are likely to have quite a lot of general knowledge about Japan). This Pre-knowledge combined with the simplicity of the questions and the high probability of merely guessing the correct answers is likely to have resulted in high pretest scores and, therefore, less scope for teaching gain.

5.5.4 Teaching efficiency

Teaching efficiency is a particularly useful measure in this study since it takes into account the fact that only small gains are possible due to the high pretest scores. This is most notable in the cases of questions 2 and 5, where teaching gains of only 6% and 2% translate into teaching efficiencies of 43% and 33% respectively (see table 5.10).

5.5.5 CAL gain

The CAL gains achieved in each question are shown in table 5.10. Not surprisingly, very low gains were achieved in questions that pupils had scored highly on pretest and post1 (in fact, there was no gain at all on question 1). Conversely, significant gains were made on questions 3 and 6 which had remained low-scoring even after human teaching.

5.5.6 CAL efficiency

The values of CAL efficiency were highly variable (see table 5.10). The relatively small gains for questions 2 and 5 in fact fully realised the potential gains and, therefore, resulted in 100% CAL efficiency.

Comparing CAL efficiency to human teaching efficiency, it can be seen that CAL efficiency was higher in all questions except question 1 (where efficiency was 0%) and question 4 (where efficiency was only 33%). For questions 5 and 6 the higher efficiencies can probably be directly attributed to the graphic representations of population differences that make it easy to remember that Japan has a higher population than the UK, while in the case of question 6, it is the computer- generated, interactive map of the region that stimulates interest in the information.

5.5.7 Overall Gain

The importance of measuring overall gains has already been mentioned in section 5.2.1.5. However, it is important to re-emphasise that this measurement (the differences between the mean scores from post2 and the pretest) is particularly valuable for integrative evaluation. From table 5.10 it can be seen that while the overall gains for questions 2 and 5 were understandably very small (because of the high pretest scores), modest gains between 25% and 42% of the maximum mark were made on the other questions.

5.5.8 Overall efficiency

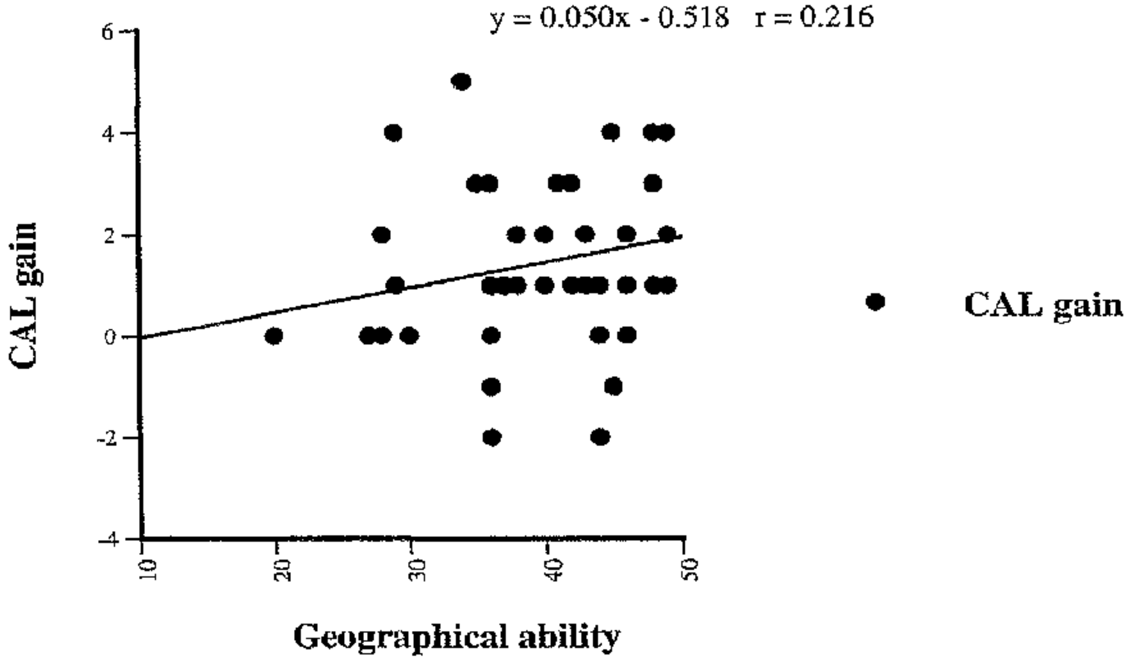
In terms of the overall efficiency, it can be seen from table 5.10 that there is a great variability between questions. As far as the 100% efficiencies for questions 2 and 5 are concerned, it is important to remember that they are the result of the small improvements to already high pretest scores. In addition, the 47% efficiency of question 1 was entirely due to teaching gain; no CAL gain occurred. The overall efficiency for question 3 was particularly low (28%).

It can be concluded that there is a huge variability in both teaching and CAL gain, and their corresponding efficiencies. This variability could be due to the type of questions asked. The lack of any gain for question one suggest problems with either the package or the way it was used. The comment recorded in section 5.5.1 concerning a lack of proper guidance, strongly suggest it was the latter.

5.5.9 CAL gain versus pupils' geographical ability

As with a study one, two sets of correlation coefficient tests were used to find whether there is a relationship between the two variables (i.e.CAL gain and pupils' geographical ability). The first test looks at the relationship between the geographical ability of the all participants and their CAL gain. The result reveals that there is only a tendency towards a positive relationship between the two variables as **r** = *0.216* (see figure 5.13).

Figure 5. 13 CAL gain versus Geographical ability (all pupils, N=50)



In the second test, the participants were divided into three categories according to their geographical ability:

- low ability pupils whose school test scores placed them in the bottom third of the class.

- average ability pupils whose school test scores placed them in the middle third of the class.

- high ability pupils whose school test scores placed then in the top third of the class

The result revealed the following:

1- there is a very small tendency towards a positive correlation between the achievement of low ability pupils on the school test and their CAL gain as **r** =0.116 (see figure 5.14).

2- there is only a tendency towards an inverse relationship between the achievement of average ability pupils on the school test and their CAL gain as **r** =- 0.319 (see figure 5.15).

3- there is a tendency towards a positive relationship between the achievement of high ability pupils on the school test and their CAL gain as **r** = 0.420 (see figure 5.16).

Figure 5. 14 CAL gain versus Geographical ability
(low ability pupils)

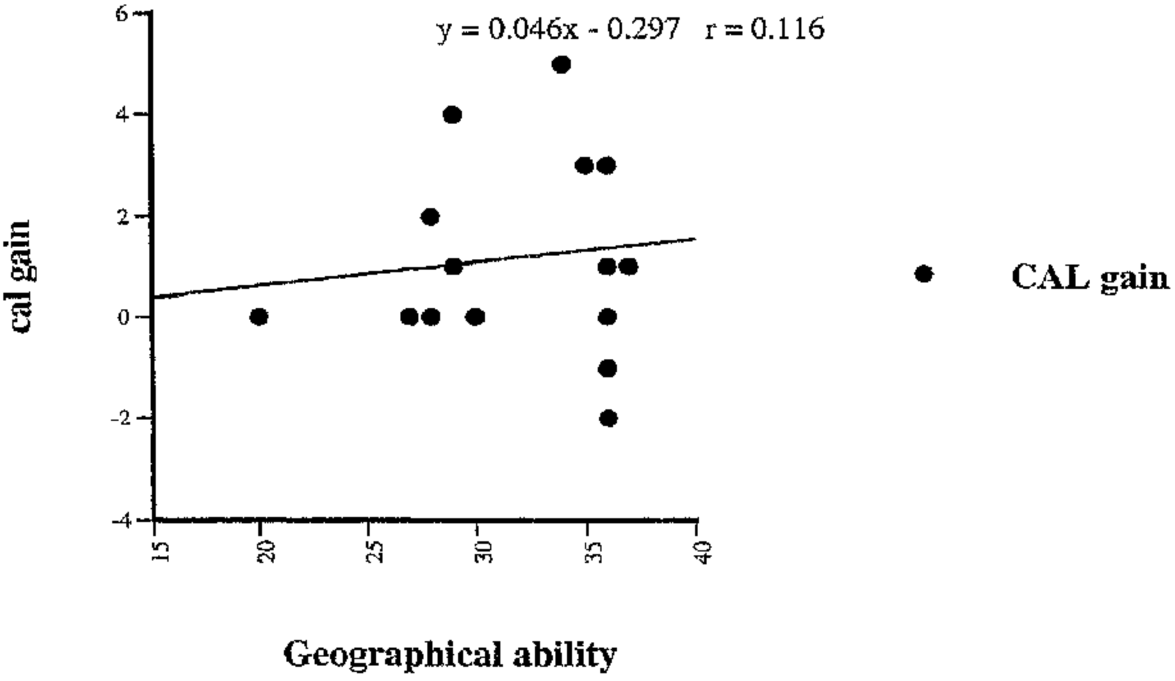


Figure 5.15 CAL Gain Versus Geographical ability (average ability)

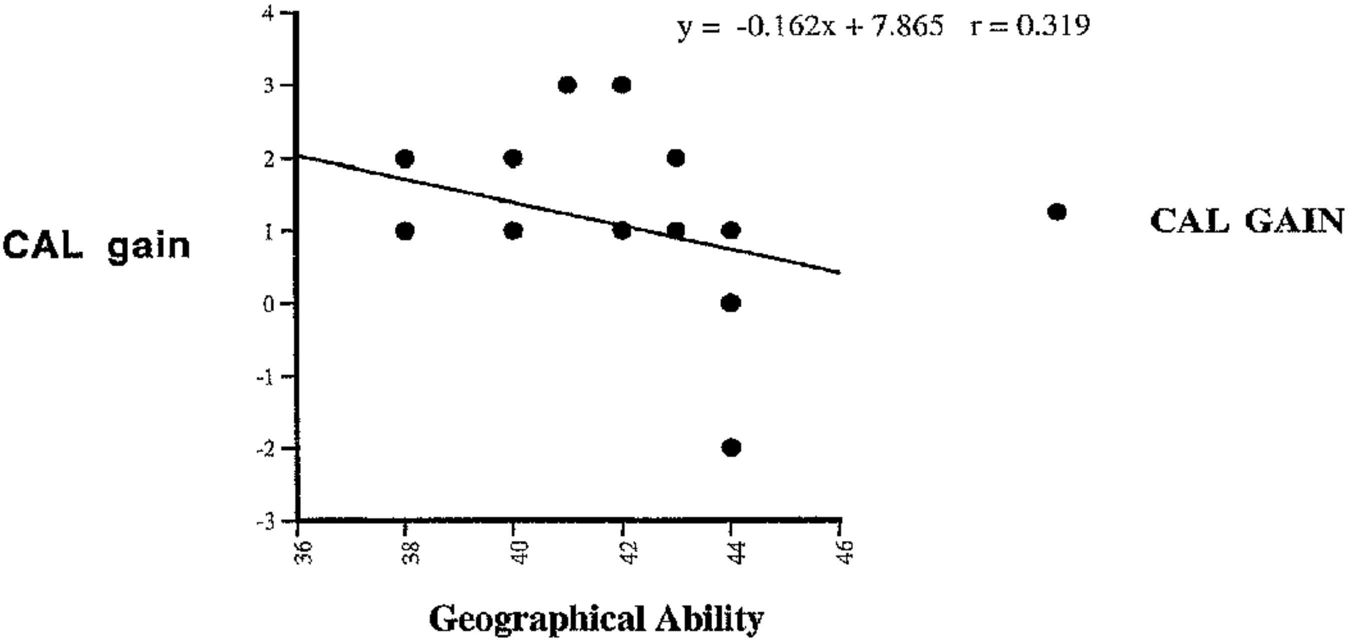
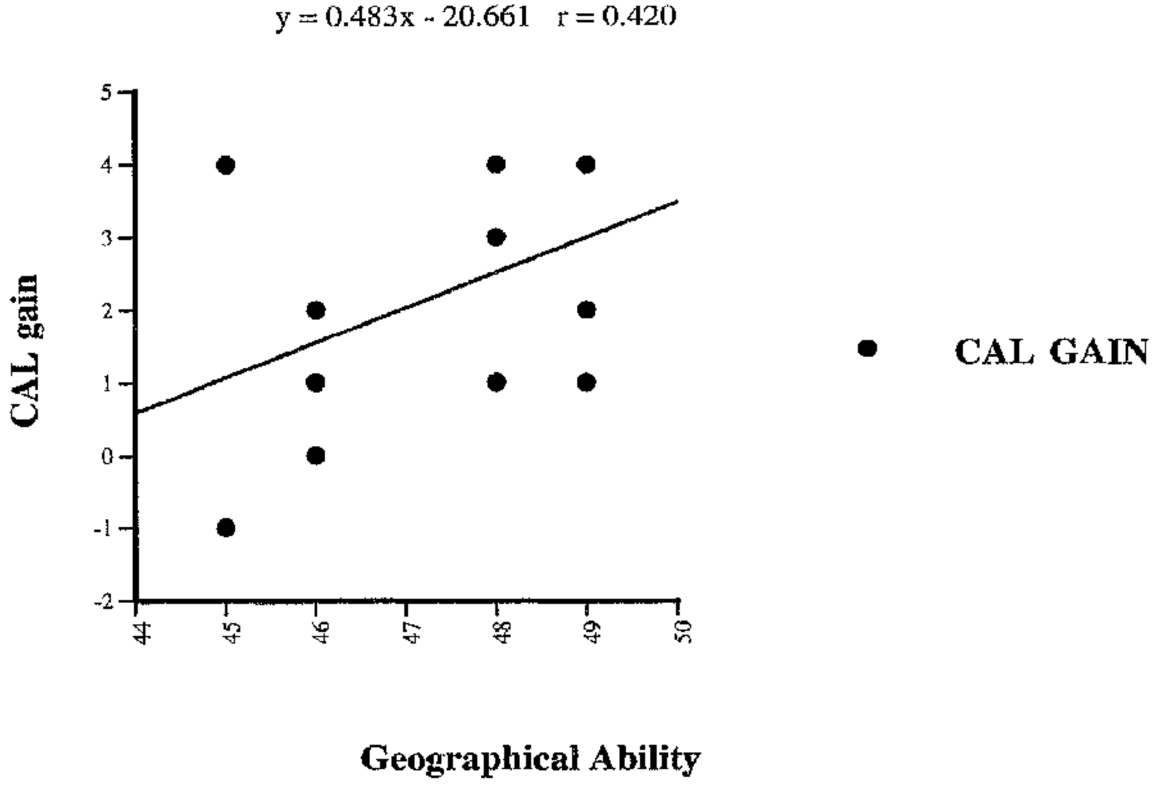


Figure 5.16 CAL Gain Versus Geographical Ability (high ability pupils)



Comparing these correlation tests with corresponding tests in study 1, it is apparent that the overall pattern is different: in study 1, there was evidence of an inverse relationship between CAL and geographical ability (at least with two of the ability groups), whereas the results of study 2 generally point to a positive relationship (the exception being the medium ability pupils).

This finding suggest that different CAL packages, may, as a result of their differing styles of presentation, benefit different kinds of pupils. The package used in study 1 was interactive and made good use of graphics. It seems likely that this contributed to the equalizing effect witnessed in the two of the ability groups. These features are known to have a motivating effect and probably explain why higher gains were found for less able pupils who require more motivation. It should also be noted that worksheets were used in conjunction with this package, which again would help to motivate pupils. The package used in study 2, on the other hand, was a quite straight forward database. Not surprisingly, lower ability pupils do not seem to have benefited so much from this style of presentation. On the contrary, the more able pupils, building on a greater store of general knowledge in Geography, got more out of the package and made greater gains.

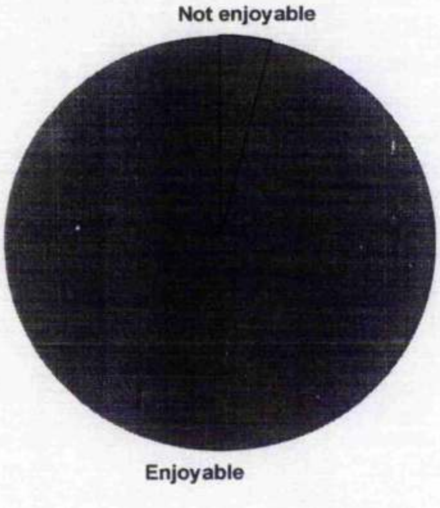
5.6 Post task questionnaire results

As indicated in the previous chapter, pupils completed a post task questionnaire one week after finishing with the CAL package. The four questions asked were essentially the same as those used in study one. The aim again being to find out about the pupils' reactions to the CAL package as well as to the computer as a learning medium. The pupils' responses to each question are shown below.

5.6.1 Question one results

When asked to rate their experience of using the computer in terms of enjoyment, the fast majority of pupils (96%) indicated that they found it enjoyable (see figure 5.17).

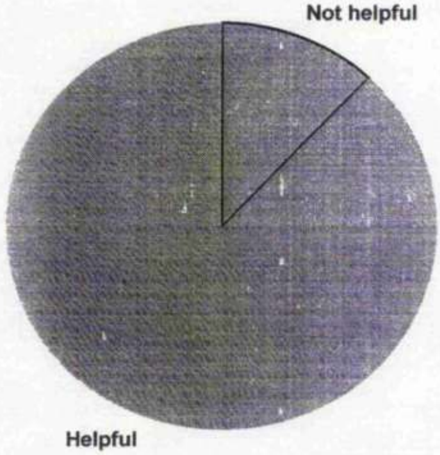
Figure 5.17 Pupil ratings of the learning experience of using computers in terms of enjoyment



5.6.2 Question two results

In this question, pupils were asked whether the CAL package had helped them to learn about Japan. 92% of the pupils affirmed that it had been helpful (see figure 5. 18).

Figure 5.18 Pupil ratings of the helpfulness of the CAL Package in learning about Japan



Pupils were also asked to give reasons for their responses to question two. Table 5.11 shows the reasons given by pupils who felt that CAL helped them to learn about Japan.

Table 5.11 Reasons given by pupils who thought CAL helped them to learn about Japan. (N=31)

Reasons	No. of pupils
It was easier than flicking through the pages of a textbook	12
The graphics made it easier to understand the subject	9
The package had a lot of information about Japan	6
It helped me to learn things I had not learned in the class	4

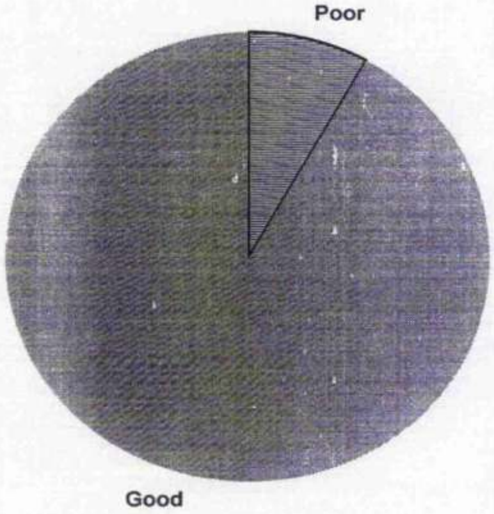
From these comments, it seems clear that ease of access to information was the benefit most appreciated by pupils. They appear to have found that the wealth of information available to them was helpful. Again, as in study one, pupils found the graphics helpful, confirming perhaps that many of them are "visual learners".

Those pupils who didn't feel that CAL was beneficial provided reasons such as "It was too boring" and "It was not enjoyable". Again, as indicated in study one, negative responses are a reminder computer packages can sometimes present learners with problems. In the case of this particular package, the observation cited in section 5.5.1 might suggest that the lack of clear instructions were responsible for the negative reactions.

5.6.3 Question three results

In this particular question, pupils were asked whether they thought the computer was a good tool to learn about Japan. Again the vast majority (92%) responded positively. Only (8%) felt that it was a poor tool (see figure 5.19).

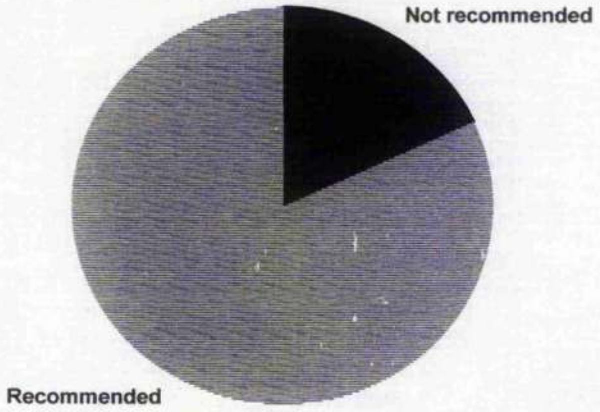
Figure 5.19 Pupil ratings the computer as a tool for learning



5.6.4 Question four results

In this question, pupils were asked whether they would recommend the CAL package to other pupils in their school. The majority of pupils (82%) reported that they would recommend it, while only (18%) said they would not (see figure 5.20).

Figure 5.20 Pupils' responses when asked whether they would recommend the CAL package to other pupils in the school



The pupils who responded negatively to this question provided reasons such as "I did not enjoy learning using the package. I think learning from the textbook is easier" and "It was too boring". The first of these reasons suggest that some pupils found the package difficult to use, and underlines the need for clear instructions and a certain degree of supervision. The second reason suggests that the information may not have been presented in a stimulating way, making full use of graphics and interactive tasks.

It could be concluded that the responses to post task questionnaire are for the most part very positive, showing that the pupils generally found the package to be useful and enjoyable to use. Nevertheless, the minority of pupils who responded negatively provide a clear warning that improvement would be made both in the design of the package itself and the way it is used in the school.

5.7 Summary

In this chapter the result of studies one and two have been presented. In the case of study one, three instruments were used to obtain the results: tests, the post task questionnaire and the learning resources questionnaire. In study two, only the first two of the instruments were used.

In study one, not only was there a high degree of variability between questions in terms of their teaching and CAL gains and their teaching and CAL efficiencies, but there were also different patterns of improvement. In other words, for some questions CAL was greater than teaching efficiency and vice versa. The variability can be partly explained by real differences in the achievement of learning objectives, but is compounded by differences in the way questions were formulated and scored.

In study two, the measurements of gain and efficiency were also characterised by a very high degree of variability. Possible reasons for this variability have been suggested, but the dominant reasons would appear to be the differences in the type of the questions asked and the high degree of pre-knowledge that the pupils had for some questions.

Different patterns of correlation between pupils' CAL gains and their geographical ability were found in each of the studies. It is possible that this was due to the fact that different kinds of CAL package results in disproportionately large gains for pupils with certain abilities.

In the post task questionnaire, pupils gave an overwhelmingly positive response to CAL as well as to the computer as a learning tool. Similarly, the results obtained from the learning resources questionnaire show that pupils find the computer to be the most useful resource, the resource that most increases their interest in learning.

CHAPTER SIX
RESULTS AND DISCUSSION

(UNIVERSITY RESULTS)

CHAPTER SIX
RESULTS AND DISCUSSION

(University results)

6.1 Introduction

In this chapter, the results of studies three and four (the two university based-studies) are presented and discussed. The first part of the chapter deals with the three instruments used in study three, namely the learning resources questionnaire, the confidence log questionnaire and the focus group. The second part is devoted to the two instruments used in study four: the test and the post task questionnaire.

6.2 Study three

Study three involved two groups of students who were studying or who had studied, five computer applications as part of an IT course in the Geography Department at the University of Glasgow. One group was studying these applications in the 1995-96 academic year, while the other group had studied them in the previous year (1994-95), and were asked during 1996 about their experience a year before. The five applications in question were GIS (Geographical Information System), Minitab, Excel, Write and Netscape.

6.2.1 Learning resources results

As indicated in chapter four (section 4.4.2.1), the aim of the learning resources questionnaire is to investigate how useful students perceive their learning resources to be. The questionnaire consisted of two parts. In the first part, students were asked whether they had used each resource and, if so, they were asked to rate it under one of the five categories of usefulness which ranged from "not at all useful" to "extremely useful". In the second part, students were asked open-ended questions relating to the learning resources. Each of the five parts of the IT course were investigated separately i.e. the learning resources questionnaire was divided into five separate sections dealing with GIS, Minitab, Excel, Write, and Netscape respectively. Each section followed the same format.

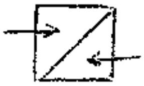
In each one of the five applications, eight learning resources were available to the students: lectures, handouts, scheduled computer lab, unscheduled computer lab, discussion with tutors, discussion with the lecturer, discussion with students, and discussion with the technician. The first three of these resources were the main learning resources for the course. The other resources were optional. The results of part one of the questionnaire are presented in the following sections.

6.2.1.1 Student ratings of the usefulness of learning resources for GIS

As indicated earlier, students were required to rate the usefulness of each learning resource on a five-point scale. The number of the students who used each resource as well as their responses are illustrated in table 6.1.

Table 6.1 Number of students who used each resource and their rating of the usefulness of the resources for GIS (1994-95 and 1995-96)

Learning resources	***No. of students used the resource***	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**
Lecture	47 47	9 6	18 10	10 16	6 10	4 5
Handout	47 47	2 0	8 3	23 20	12 15	2 9
Scheduled Computer lab	47 47	3 0	10 4	15 22	13 16	6 5
Unscheduled Computer lab	29 16	8 3	10 5	8 7	3 1	0 0
Discussion with tutor	26 24	6 1	7 9	11 8	3 5	0 1
Discussion with lecturer	18 19	0 2	8 5	7 8	3 4	0 0
Discussion with students	30 33	3 2	6 7	8 10	10 9	3 5
Discussion with technician	13 16	1 0	5 6	6 8	1 2	0 0

1994-95  1995-96

Since the essential aim of this part of the questionnaire was to find out which resource students considered most useful, responses under categories: "useful", "very useful" and "extremely useful" were combined into a new category, namely " useful". The combined results are presented in percentage form in table 6.2 and illustrated graphically in Appendix A.

Table 6.2 Number and percentage of students who used and considered resources useful in learning about GIS (1994-95 and 1995-96, N=47 in both cases)

Learning resources	**No. of students who used the resource**		**% of students who considered the resource useful**	
	1994-95	1995-96	1994-95	1995-96
Lecture	47	47	43%	66%
Handout	47	47	79%	94%
Scheduled Computer lab	47	47	72%	91%
Unscheduled Computer lab	29	16	38%	50%
Discussion with tutor	26	24	50%	58%
Discussion with lecturer	18	19	56%	63%
Discussion with students	30	33	70%	73%
Discussion with technician	13	16	54%	63%

It is clear from the table that of the three main resources used by all students, handouts were found most useful (79% from 1994-95 and 94% from 1995-96 considered it useful). When asked in the questionnaire why they found it useful, students most commonly commented that "*The GIS handouts were very easy to follow which turned the lab into something more enjoyable*" and "*The GIS handouts were well presented and gave clear instructions*". The scheduled computer lab was considered the next most useful resource for learning about GIS (72% from 1994-95 and 91% from 1995-96). The most common comments were "*Computer lab for GIS allowed me to put theory into practice*" and "*Computer lab* *increased my interest in learning about GIS as it gives experience and skills of things I previously knew little or nothing about*".

Lectures were considered the least useful of the three main learning resources. This can perhaps be explained by the amount of new scientific terminology used in the lectures. The difficulties students faced in understanding the language used would affect their understanding of the lectures as a whole, and hence decrease the usefulness of these lectures. In addition, since the use of computer programs is a practical subject, practice rather than information presented in a lecture is likely to be more helpful.

Comparing the responses of the 1994-95 students with the responses of the 1995-96 students, it is notable that the latter group rated all three of the main learning resources more highly. There are a number of explanations for this trend. As far as the lectures were concerned, their content was broader in 1995-96 than it was in 1994-95. The same could also be said for the content of the handouts. With regards to the computers, it would seem that the number of computers available to students was higher in 1995-96 than the previous year, which probably explains the increase in students ratings for this resource. This supports the argument that the successful integration of the computer into the curriculum depends to a large extent on a high computer-to-student ratio.

The optional resources were unsurprisingly not fully used. However, since the questionnaire did not ask for reasons for non-use of resources, it is impossible to say whether the fact students did not use a resource implies that they anticipated that it would not be useful. Indeed, students often do not realise that a resource is useful until they have used it. For this reason, it was decided not to calculate percentages using the total number of students, but rather the number of students who actually used the resource. Another reason for only taking into account students who used resources was that it was noted that the optional resources were not always easy to access. For example, to use the unscheduled computer lab, students had to arrange to borrow the GIS package from their teacher. They then faced potential difficulties using the package on their own: certain skills were required to use the package, yet no technician was on hand to provide guidance. Students lacking skills and needing guidance would be discouraged from using this particular resource.

Closer examination of the responses to the five optional resources reveals that not only was discussion with students used more frequently than the other resources, but it was also the resource that the highest proportion of students found useful (70% from 1994-95, and 73% from 1995-96).

However, it should be pointed out that comparisons between optional resources and between optional and main resources can only be tentative because, as indicated above, it is impossible to tell how many students did not use the optional resources because they anticipated that they would not be useful. In future, it might be useful to ask students why they decided not to use a particular resource.

6.2.1.2 Student ratings the usefulness of learning resources for Minitab

In the learning resources questionnaire for the Minitab part of the IT course, students were, as with the GIS, asked to rate the usefulness of the learning resources. Their responses are summarised in table 6.3

Table 6.3 Number of students who used each resource and their rating of the usefulness of the resources for Minitab (1994-95 and 1995-96).

Learning resources	***No. of students used the resource***	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**
Lecture	47 47	12 5	20 25	11 13	3 4	1 0
Handout	47 47	3 1	9 8	17 18	15 16	3 4
Scheduled Computer lab	47 47	3 0	7 6	19 17	13 17	5 7
Unscheduled Computer lab	25 19	1 0	5 1	5 6	2 3	0 0
Discussion with tutor	23 25	0 0	7 8	12 11	3 5	1 1
Discussion with lecturer	15 19	1 2	9 8	5 7	0 2	0 0
Discussion with students	30 26	2 0	6 6	14 11	5 7	3 2
Discussion with technician	16 17	0 0	7 6	7 6	2 4	0 1

1994-95 → ⧄ ← 1995-96

Again "useful", "very useful" and "extremely useful" responses were combined, and these totals are presented in percentage form in table 6.4 and shown graphically in Appendix A.

Table 6.4 Number and percentage of students who used and considered resources useful in learning about Minitab (1994-95 and 1995-96, N=47 in both cases).

Learning resources	**No. of students who used the resource**		**% of students who considered the resource useful**	
	1994-95	1995-96	1994-95	1995-96
Lecture	47	47	32%	36%
Handout	47	47	74%	81%
Scheduled Computer lab	47	47	79%	87%
Unscheduled Computer lab	25	19	28%	47%
Discussion with tutor	23	25	70%	68%
Discussion with lecturer	15	19	33%	47%
Discussion with students	30	26	73%	77%
Discussion with technician	16	17	56%	65%

It is clear from the table that of the three main resources used, the scheduled computer lab was the one that students found most useful (79% and 87% from the first and second groups respectively). The most common comment made by students was "*Using Minitab on computer made me aware of the way statistical* *analysis can be enhanced, especially for the purposes of a dissertation*". Handouts were considered the second most useful for learning about Minitab (74% and 81%). The fact that lectures were considered the least useful of the three main resources can perhaps be explained by the fact that Minitab does not require much in the way of theoretical background, but rather practical experience. In other words, while lecture may be useful for teaching students *about* a subject, they are not the best means of teaching them *how to do* something.

Comparing the responses of the two groups, it can be seen that the second group rated all three main resources more highly. The reasons for this are probably the same as those put forward in the previous discussion of GIS i.e. the improvement in the availability of computers and the increased breadth of the handout and lectures.

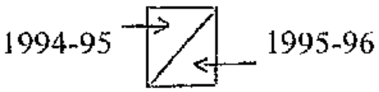
Again closer examination of the responses to the five optional resources reveals that not only was discussion with students used more frequently than the other resources, but it was also the resource that the highest proportion of students found useful (73% from the 1994-95 and 77% from 1995-96). However, as was pointed out in the previous discussion on GIS, these comparisons did not take into account students who did not use the optional resources.

6.2.1.3 student ratings of the usefulness of learning resources for Excel

The number of students who used each of the resources of learning about Excel, and their ratings of the usefulness of these resources, are shown in table 6.5

Table 6.5 Number of students who used each resource and their rating of the usefulness of the resources for Excel (1994-95 and 1995-96.

Learning resources	***No. of students used the resource***	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**
Lecture	47 47	6 4	21 19	14 19	6 5	0 0
Handout	47 47	3 1	13 11	17 22	10 8	4 5
Scheduled Computer lab	47 47	0 0	6 5	23 21	10 15	8 6
Unscheduled Computer lab	21 19	3 0	8 7	9 10	1 2	0 0
Discussion with tutor	27 24	1 0	8 7	16 12	1 5	1 0
Discussion with lecturer	18 18	0 0	8 7	7 9	3 1	0 1
Discussion with students	29 23	0 0	8 5	14 10	6 6	1 2
Discussion with technician	19 19	1 0	7 6	6 9	5 3	0 1



The procedure for grouping the positive responses into a single "useful" category was carried out in the same way as for GIS and Minitab. The results are presented in percentage form in table 6.6. and shown graphically in Appendix A.

Table 6.6 Number and percentage of students who used and considered resources useful in learning about Excel (1994-95 and 1995-96, N=47 in both cases).

Learning resources	**No. of students who used the resource**		**% of students who considered the resource useful**	
	1994-95	**1995-96**	**1994-95**	**1995-96**
Lecture	**47**	**47**	**43%**	**51%**
Handout	**47**	**47**	**66%**	**74%**
Scheduled Computer lab	**47**	**47**	**87%**	**89%**
Unscheduled Computer lab	**21**	**19**	**48%**	**63%**
Discussion with tutor	**27**	**24**	**67%**	**71%**
Discussion with lecturer	**18**	**18**	**56%**	**61%**
Discussion with students	**29**	**23**	**72%**	**78%**
Discussion with technician	**19**	**19**	**58%**	**68%**

The scheduled computer lab was found to be the most useful of the three main resources (87% and 89% of the students in each year group considered this resource to be useful). As was the case with Minitab, students rated handouts second and lectures third. The same reasons also apply. The extent to which the two groups found the three main learning resources useful was the same as for GIS, Minitab, i.e. the students from 1995-96 consistently rated their more highly, and probably for the same reasons.

The two year groups differed as far as which optional resource they used the most. The 1994-95 group used discussion with students most frequently, and discussion with tutor came a close second. The ranking was reversed for the 1995-96 students. A high proportion of all students considered these two resources useful.

6.2.1.4. Student ratings the usefulness of learning resources for Write.

The number of students using each of the eight learning resources to learn about Write are presented in table 6.7, as their ratings of the usefulness of these resources.

Table 6.7 Number of students who used each resource and their rating of the usefulness of the resources for Write (1994-95 and 1995-96).

Learning resources	***No. of students used the resource***	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**
Lecture	47 47	11 9	25 22	11 14	0 2	0 0
Handout	47 47	4 1	20 16	15 16	7 11	1 3
Scheduled Computer lab	47 47	0 0	2 7	25 22	15 12	5 6
Unscheduled Computer lab	25 20	1 1	12 8	10 7	2 4	0 0
Discussion with tutor	13 19	0 1	3 6	9 8	1 4	0 0
Discussion with lecturer	14 8	0 0	6 2	6 5	2 1	0 0
Discussion with students	25 16	3 0	3 3	16 11	2 1	1 1
Discussion with technician	16 9	0 0	7 3	7 6	2 0	0 0

Following the previous normal procedure, all positive responses were combined to give a total number of "useful" ratings. The results are provided in table 6.8 and illustrated graphically in Appendix A.

Table 6.8 Number and percentage of students who used and considered resources useful in learning about Write (1994-95 and 1995-96, N=47 in both cases)

Learning resources	**No. of students who used the resource**		**% of students who considered the resource useful**	
	1994-95	1995-96	1994-95	1995-96
Lecture	47	47	23%	34%
Handout	47	47	49%	64%
Scheduled Computer lab	47	47	96%	85%
Unscheduled Computer lab	25	20	48%	55%
Discussion with tutor	13	19	77%	63%
Discussion with lecturer	14	8	57%	75%
Discussion with students	25	16	67%	81%
Discussion with technician	16	9	56%	67%

The above table shows that of the three main resources, scheduled computer lab was considered most useful by both groups (96% and 85% respectively). Handouts were rated second and lectures third. Again, the reason that lectures are rated least useful is probably the lack of any need for intensive theoretical explanations; the more practical labs and handouts are no doubt considered more relevant.

When the responses of the two groups are compared, it can be seen that, as with the three previous applications, the second group rate the lectures and handouts more highly. The likely reasons for this have already been discussed. However, Write is the first application for which students in 1994-59 group rated scheduled computer lab more highly (96%). A possible explanation for this reversal could be that the benefits of the lab are only realised after a certain time. In other words, the 1994-95 students may appreciate the computer lab more with the benefit of one year's further experience than the current students do having only recently completed the learning experience.

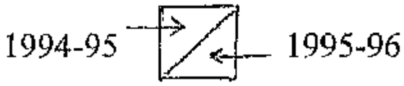
For the first time, the unscheduled lab was the optional resource used most frequently. More than half of the 1994-95 group used the unscheduled lab making it, along with discussion with students, the resource used the most. A slightly smaller number of 1995-96 students used the lab, but it was still the most-used resource. It is significant, however, that a low percentage of students who used the unscheduled lab actually found it useful (48% and 55%). This contrasts sharply with the corresponding figures for the scheduled lab (96% and 85%) and probably points to problems of inadequate guidance during the unscheduled lab.

6.2.1.5 Student ratings the usefulness of learning resources for Netscape

Student responses to the first part of the questionnaire for Netscape are summarised in table 6.9.

Table 6.9 Number of students who used each resource and their rating of the usefulness of the resources for Netscape (1994-95 and 1995-96).

Learning resources	***No. of students used the resource***	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**
Lecture	**47** **47**	**5** **6**	**35** **31**	**7** **10**	**0** **0**	**0** **0**
Handout	**47** **47**	**4** **2**	**26** **20**	**15** **21**	**2** **2**	**1** **2**
Scheduled Computer lab	**47** **47**	**0** **1**	**22** **14**	**17** **20**	**8** **10**	**0** **2**
Unscheduled Computer lab	**23** **26**	**2** **1**	**13** **15**	**7** **7**	**1** **2**	**0** **1**
Discussion with tutor	**9** **15**	**0** **1**	**6** **6**	**3** **7**	**0** **1**	**0** **0**
Discussion with lecturer	**13** **8**	**1** **0**	**5** **3**	**5** **4**	**2** **1**	**0** **0**
Discussion with students	**26** **21**	**0** **1**	**14** **7**	**8** **8**	**3** **3**	**1** **2**
Discussion with technician	**13** **11**	**0** **1**	**8** **4**	**4** **4**	**1** **2**	**0** **0**



Again, all positive responses were combined to give a total number of "useful" ratings. The results are presented in percentage form in table 6.10 and illustrated graphically in Appendix A.

Table 6.10 Number and percentage of students who used and considered resources useful in learning about Netscape (1994-95 and 1995-96, N=47 in both cases).

Learning resources	**No. of students who used the resource**		**% of students who considered the resource useful**	
	1994-95	1995-96	1994-95	1995-96
Lecture	47	47	15%	21%
Handout	47	47	36%	53%
Scheduled Computer lab	47	47	53%	68%
Unscheduled Computer lab	23	26	35%	38%
Discussion with tutor	9	15	33%	53%
Discussion with lecturer	13	8	54%	63%
Discussion with students	26	21	46%	62%
Discussion with technician	13	11	38%	55%

The scheduled computer lab was the main resource that students considered most useful (53% and 68%). Handouts came second and lectures third. Again, all three of these resources were rated more highly by the 1995-96 group than those of 1994-95. The same trend was observed with GIS , Minitab, and Excel, and the reasons put forward in section 6.2.1.1 probably also apply to Netscape.

It is interesting to note from the results shown in the above table it does not always follow that a resource used frequently is also considered useful.

Closer examination of the responses to the optional resources reveals that while both unscheduled computer lab and discussion with students were frequently used by both year groups, the former was rated fairly low in terms of usefulness. In contrast, discussion with the lecturer was rated highly by both year, yet this resource was only used by a small number of students in each year group. Lectures on Netscape received extremely poor ratings from the students in both year groups, lower than for any other application, in fact (only 15% and 21% of students considered them useful). Clearly, the students found theoretical explanations of very limited use, and found greater benefit from more "hands-on" resources.

6.2.1.6 Resources used to compensate for non useful resources.

In the learning resources questionnaire, students were asked to indicate which resources they used to compensate for those they considered not useful. The students responses are summarised in table 6.11.

Table 6. 11 Resources considered non-useful and the compensation made by students.

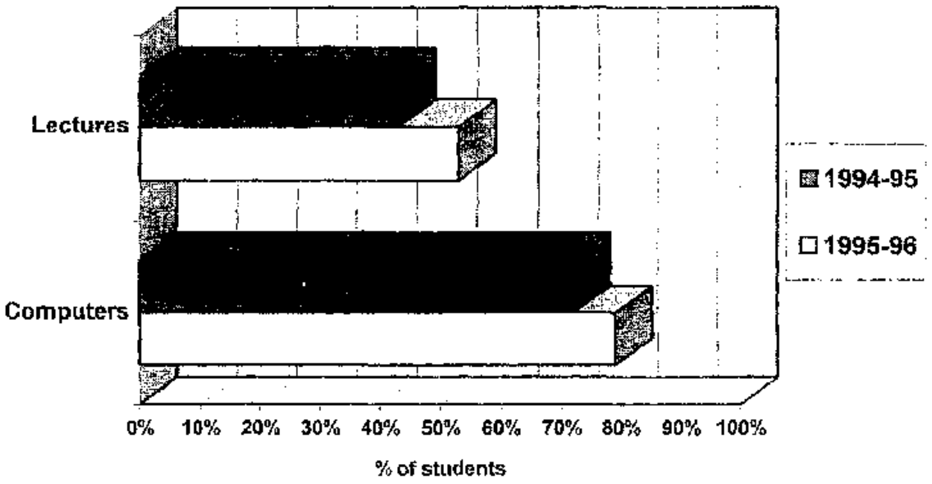
Non useful resources	Compensation	No. of students	
		1994-95	1995-96
Lectures (Excel)	Computer labs	11	15
Lectures (GIS)	handouts	14	18
Lectures (Minitab)	Discussion with student	3	6
Handouts	Discussion with student	4	2
Handouts	Discussion with tutor	5	2
Discussion with tutor	Discussion with student	2	5
Discussion with students	Computer labs	7	4

From the above table, it would appear that lectures are the most problematic resource. This was the only resource which significant proportions of the two year groups reported as being non-useful. However, it is important to note that this was only the case for two particular packages: Excel and GIS. Also interesting to note is that the compensation in these two cases was different: computer lab in the case of Excel and handout in the case of GIS. Finally, it would appear that improvements in the quality of handouts are reflected in student responses: fewer students from 1995-96 found them non-useful.

6.2.1.7 Resources which increased and decreased students' interest in learning about the five applications.

In the second part of the learning resources questionnaire, students were asked which of the eight learning resources available to them had increased their interest in learning about the five applications covered in the IT course. Interestingly, in both year groups, students only reported two resources as having increased their interest in learning about IT techniques: the lectures and the scheduled computer lab. In the case of lectures, 43% of 1994-95 students and 53% of those from 1995-96 said this resource had increased their interest. With regard to the scheduled computer lab, 72% and 79% of students in the respective year groups reported that that this resource had increased their interest (see figure 6.1).

Figure 6.1 Resources which increased students' interest to learn about the five techniques



The fact that handouts were not mentioned at all in students' responses to this part of the questionnaire is fairly interesting. Handouts were consistently rated more useful than lectures by both year groups and for all five applications, yet students seem to make a clear distinction between what is useful and what is stimulating. In other words, handouts were valued as a useful reference resource, and lectures were valued more for their ability to motivate than their capacity for imparting information.

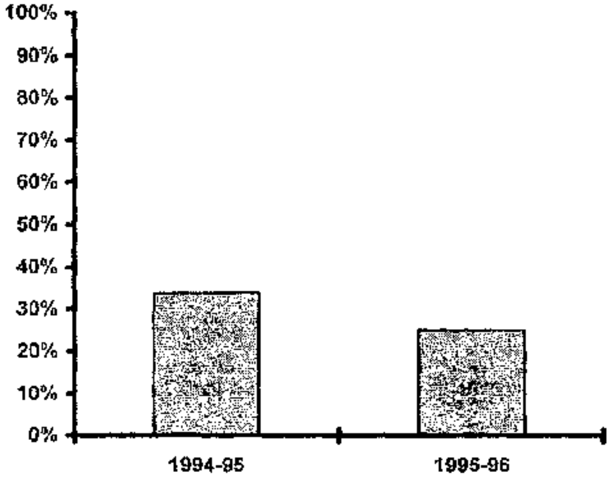
Of the various reasons students gave for why the scheduled computer lab had increased their interest, the most common were, *"Through the computer you have the ability to solve problems very quickly"* and *"Computers have many facilities, like graphics, which make learning more interesting"*

In contrast, the unscheduled computer lab was the only resource that both year groups reported as having decreased their interest. 68% and 51% of students in the respective year groups said this was the case. The most likely explanation for this demotivating effect would seem to be the lack of supervision and guidance provided for students in the unscheduled lab.

6.2.1.8 Resources which were difficult to access.

When asked in the learning resources questionnaire which resources they had found difficulties in accessing, both year groups indicated that the computer was the only resource that posed this problem. 34% of students from group one (the 1994-95 students) had encountered difficulties accessing computers, while 25% of those from group two indicated computer access was a problem (see figure 6.2). Two types of difficulty were reported: shortage of computers and time constraints (i.e. restrictions arising from booking procedures and lab opening hours).

Figure 6.2 Percentage of students who found computers difficult to access (1994-95 and 1995-96)



The decrease in the percentage of students reporting access difficulties between 1994-95 and 1995-96 can no doubt be explained by the increase in the number of machines available to students that occurred in the intervening year.

It can be concluded that student responses in the learning resources questionnaire suggest that the scheduled computer lab was not only the most useful resource but also the one that most increased their interest. In this particular study, this finding is hardly surprising for the simple reason that the objectives of the course could not have been achieved without the students gaining practical experience of computer applications. In the other three studies students used computers to learn about another subject - the Weather, Japan and Glaciation. These subjects can be, and indeed have been for many years, learned without the use of computer technology. It is impossible, however, to envisage gaining a full understanding of Minitab, for example, without hands on experience of the application.

Although lectures consistently received low ratings in terms of usefulness - again hardly surprising giving the practical rather than theoretical nature of the course- they do seem capable of playing a motivational role and perhaps influencing student attitudes to the course.

6.2.2 Confidence log results

As indicated in chapter four (section 4.4.2.1), students from each of the year groups involved in study three (i.e. students from 1994-95 and 1995-96 academic years) were asked to report how confident they felt about meeting the learning objectives of the IT course. Against the list of the eleven learning objectives provided by the lecturer, students categorised their confidence on a five-point scale ranging from "no confidence at all" to "very confident". The frequency of responses in each category of each year group is shown in table 6.12.

Table 6.12 Student confidence ratings for achieving learning objectives of the IT course (1994-95 and 1995-96, N=47)

learning objectives	*Year of study*	No confidence at all	Little confidence	Some confidence	Confident	Very confident
transfer data between statistical and word processing packages	1994-95	3	10	15	17	2
	1995-96	1	2	8	30	6
generate graphs using Minitab	1994-95	0	4	5	31	7
	1995-96	2	7	11	21	6
access on-line resource material from the WWW	1994-95	1	5	10	28	3
	1995-96	2	6	15	20	4
describe the main features of (GIS)	1994-95	5	7	12	19	4
	1995-96	7	9	14	14	3
using GIS plus to explore spatial data sets	1994-95	2	7	10	21	7
	1995-96	0	8	18	16	5
produce draft quality summary reports using a basic word-processing	1994-95	0	0	2	30	15
	1995-96	0	2	8	33	4
develop a simple numerical simulation using Excel	1994-95	4	8	18	11	6
	1995-96	3	4	26	11	3
perform a multivariate regression analysis using Minitab	1994-95	5	15	20	7	0
	1995-96	2	12	23	8	2
run pre-programmed numerical simulation programs under Basic	1994-95	4	6	29	8	0
	1995-96	5	12	21	7	2
run computer packages operating on a PC using Windows based software	1994-95	0	1	5	32	9
	1995-96	1	2	9	28	7
input, summarize and graph data using the Excel package	1994-95	3	4	10	26	4
	1995-96	2	8	16	16	5

In order to investigate whether the responses of the two year groups were significantly different, a Chi-square test was performed for each learning objective. However, since some categories of responses had frequencies of less than five, similar categories first had to be combined in order to carry out the test (Robson,1994, Clegg, 1993). Thus, the "no confidence at all", "little confidence" and "some confidence" responses were combined into a single category: "less confident". Similarly, the "confident" and "very confident" were combined to give a single "confident" category. The combined frequencies of response to each learning objective are given in table 6.13.

Table 6.13 Statistical analysis of combined confidence ratings.

Learning objectives	**Year of study**	**Less confident**	**Confident**	χ^2
1- transfer data between statistical and word-processing packages	1994-95	28	19	Sig.
	1995-96	11	36	(1% level)
2- generate graphs using Minitab	1994-95	9	38	Sig.
	1995-96	20	27	(5% level)
3- access on-line resource material from the WWW	1994-95	16	31	Not sig.
	1995-96	23	24	
4- describe the main features of (GIS)	1994-95	24	23	Not sig.
	1995-96	30	17	
5- using GIS plus to explore spatial data sets	1994-95	19	28	Not sig.
	1995-96	26	21	
6- produce draft quality summary reports using a basic word-processing	1994-95	2	45	Sig.
	1995-96	10	37	(5% level)
7- develop a simple numerical simulation using Excel	1994-95	30	17	Not sig.
	1995-96	33	14	
8- perform a multivariate regression analysis using Minitab	1994-95	40	7	Not sig.
	1995-96	37	10	
9- run pre-programmed numerical simulation programs under Basic	1994-95	39	8	Not sig.
	1995-96	38	9	
10-run computer packages operating on a PC using Windows based software	1994-95	5	42	Sig.
	1995-96	12	35	(10% level)
11- input, summarize and graph data using the Excel package	1994-95	17	30	Sig.
	1995-96	26	21	(10% level)

Critical value at *1%* level of significance and *1 d.f.* is (6.63)
Critical value at *5%* level of significance and *1 d.f.* is (3.84)
Critical value at *10%* level of significance and *1 d.f.* is (2.70)

From table 6.13 it can be seen that there are a number of learning objectives for which there are significant differences between the responses of 1994-95 and 1995-96 students. At the same time, however, there are some learning objectives for which no significant differences were found.

For learning objective I, there was a significant differences between the responses of the two year groups ($\chi 2$ = 12.66; 1 d.f at 1% level of significance), with the frequencies indicating that the 1995-96 students were more confident in achieving the objective in question. This result is contrary to expectations - the 1994-95 group might have been expected to be more confident because of their extra year's experience. However, the result seems to suggest that this particular objective was not reinforced in the following year.

Significant differences were also found between the responses of the two groups for objective 2 ($\chi 2$ = 6.037; 1 d.f. at 5% level of significance). However, in this case and as the frequencies indicate, the 1994-95 students were more confident, suggesting that they had benefited from experience gained in the third year. Similar results were obtained for objective 6 ($\chi 2$ = 6.114;1 d.f at 5% level of significance).

Table 6.13 also shows that there were only slight differences between the responses of the two groups for objective 10 and 11. This was reflected in the Chi-square results ($\chi 2$ = 3.519; 1 d.f. for objective 10 and $\chi 2$ = 3.472, 1 d.f. for objective 11), giving statistical differences between the responses of the two groups at the 10% level.

On the other hand, no significant differences were found between the responses of 1994-95 and 1995-6 students for any of the remaining objectives:
(objective 3: $\chi2 = 2.147$, 1 d.f.; objective 4: $\chi2 = 1.567$, 1 d.f.; objective 5: $\chi2 = 2.089$, 1 d.f.; objective 7: $\chi2 = 0.433$,1 d.f.; objective 8: $\chi2 = 0.646$, 1 d.f. and objective 9: $\chi2 = 0.072$, 1 d.f.).

Closer examination of the frequencies of response for objectives 7, 8, and 9 for which no significant differences were detected at all by the chi-square test reveals an interesting trend. It is clear that the lack of significant differences in these cases was due to a similarly low level of confidence in *both* year groups. This finding suggests a possible problem with the way the objectives were addressed in the course, an inherent difficulty in achieving these particular objectives, or possibly problems relating to students supervision and guidance.

6.2.3 Focus group results

As indicated in chapter four (section 4.4.2.1), six students who completed the learning resources questionnaire and confidence log also volunteered to participate in the focus group. These volunteers are referred to in the following discussion as students A, B, C, D, E, and F. It should be noted that, due to time constraints, all six volunteers were drawn from the 1995-96 year group. The main reason for using the focus group method was to obtain additional comments on issues not covered in the written questionnaire. The main issues discussed in the focus group were:

. *lectures and their relevance to practical work*

. *time available to complete practical work*

. *staff support*

. *student' confidence in being able to apply the techniques covered in the IT course to their dissertation work.*

6.2.3.1 Lectures and their relevance to practical work

From the focus group discussion, it emerged that all six students had found one lecture particularly relevant to practical work. As student E commented, "*There was actually one lecture that I can remember was interesting, and that was the regression one*". However, apart from the regression lecture, students agreed that the lectures were not sufficiently relevant to practical work. Again student E pointed out that " *All other lectures were just so detached from real life and their relevance to the labs was not always clear*". Student C explained " *I don't think they would tell us much about how we were going to use the computers in the labs* *because they would have had to spend so much time explaining to us how to do things that they wouldn't be able to explain the statistics, the results and the interpretations that were needed*".

6.2.3.2 Time available to complete practical work

The majority of students indicated that shortage of time was the main problem during practical work. As student E commented "*There were too many separate things to be done in too little time*". Student B pointed out that it was mainly in the first few weeks that time was a problem, "*Sometimes I only got half of it done, but then, once you got more used to them, it did get a lot easier and I started finishing 20 minutes early*".

6.2.3.3 Staff support

From the discussion, it emerged that all six students agreed that there was insufficient staff support (i.e. help from technicians). This was particularly the case at the beginning of the lab work when students encountered difficulties finding out how to use the packages. Often, students were forced to resort to a process of trial and error. On this subject, student C stated "*The* way *you got a result was through trying lots of different ways of doing it*".

6.2.3.4 Student' confidence in being able to apply the techniques covered in the IT course to their dissertation work.

From the students' discussion, it emerged that none of the six students was confident in using the Excel package. For example student D admitted, "*I am not confident at all. I really don't know what I am doing. I think I have proved this in my exam by not being able to answer any of the Excel questions*". Student E, on the other hand, did feel slightly confident, though he added, "*only with some of the exercises*".

The issues raised by the students in the focus group are a reminder of the factors that need to be taken into account when the computer is to be integrated into the teaching of a subject. Clearly, lectures can be useful in providing background information on techniques (e.g. statistics), but their relevance to practical work always needs to be carefully considered. As far as practical work itself is concerned, the availability of technician need to be ensured, especially when new material is being introduced, and the amount of time that students are given to complete practical work needs to be carefully considered.

6.3 Study four results

6.3.1 The test results

As indicated in chapter four (section 4.4.2.2), the aim of the test was to measure learning gain resulting from a university course on Glaciation in which CAL was used in parallel with two other teaching resources i.e. lectures and a physical lab. The test was administered twice: immediately before students started the course and again at the end of teaching. The test itself consisted two parts. In the first part, questions covered information presented in the lectures, the physical lab and the CAL package, while in the second part, two additional questions were included to distinguish between deep and surface learning. These two questions that most directly designed to measure students' ability and willingness to make connections between the two aspects of the topic (i.e. the appearance and description of samples as they occur in the physical lab and the theoretical lectures on the deposition). The test results of the two parts are presented and discussed below.

6.3.1.1 Student performance on part one of the test

Part one of the test comprised seven questions. The maximum score over all seven questions was 20. The mean student scores on both pre-course and post-course tests are given in table 6.14 along with their standard deviations. The difference between the two means (the learning gain) is also shown in the table.

Table 6.14 Mean and SD of pre- course, post- course and learning gain. N=70

	Mean	SD
Pre-course	8.5	2.7
Post-course	11.1	2.7
Learning gain	2.6	2.2

In order to determine whether the learning gain (i.e. the difference between post-course and pre-course score) was significant, a matched sample t-test was employed. This test is the most appropriate because the two student samples were identical and individual student scores would be identified (Howell, 1992). In the matched sample t-test, difference scores (in this case learning gain) are treated as a population. The null hypothesis is that the mean score of this population is zero:

Ho: learning gain= post course-pre course = 0

The formula for calculating *t* is:

$$t = \frac{\overline{D} - 0}{SD / \sqrt{N}}$$

Where $\overline{\text{D}}$ and SD are the mean and standard deviation of the difference score (learning gain) and N is the number of students.

The calculated value of *t* is (9.9) which is greater than the critical value of *2.000* (two-tailed test at 5% level of significance, 69 d.f). Thus the null hypothesis is rejected. In other words, there is a strong evidence to suggest that students' performance was positively affected by the course. However, since the test covered all aspects of the course, it is impossible from the overall results to prove whether the specific contribution made by CAL was significant or not.

6.3.1.2 Student performance on individual test questions

In order to obtain further insight into the improvements in student performance resulting from the course and to see whether gains attributable to CAL were significant, a comparison of pre-course and post-course test scores was made *for each question.* (in section 6.3.1.1 *overall* test scores were considered). The results of this comparison are shown in table 6.15.

Table 6.15 Analysis of mean student scores on individual questions

	Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**
A	**Maximum mark**	*2*	*2*	*2*	*4*	*2*	*4*	*4*
B	**Pre-course**	**1.2**	**1.7**	**1.3**	**2.3**	**0.3**	**1.4**	**0.4**
C	**Pre-course mean as % of maximum mark** = B/A*100	**60%**	**85%**	**65%**	**58%**	**15%**	**35%**	**10%**
D	**Post course**	**1.6**	**1.8**	**1.8**	**2.5**	**0.4**	**1.9**	**1**
E	**Post-course mean as % of maximum mark** = D/A*100	**80%**	**90%**	**90%**	**63%**	**20%**	**48%**	**25%**
F	**Learning gain** = D-B	**0.4**	**0.1**	**0.5**	**0.2**	**0.1**	**0.5**	**0.6**
G	**Learning gain as % of max. mark** =F/A*100	**20%**	**5%**	**25%**	**5%**	**5%**	**13%**	**15%**

From the above table, it can be seen that pre-course mean scores were highly variable, ranging from 10% to 85%. Post-course mean scores were almost as variable, ranging from 20% to 90%. As far as learning gains are concerned, the highest percentage gains occurred on questions 1, 3, 6, and 7 (with gains ranging from 13% to 25%). More modest gains of 5% were observed in the remaining questions. Of particular interest are the gains in questions 6 and 7. These two questions most specifically test students' knowledge of material presented in the CAL package and, therefore, are a measure of CAL gain. In order to test the significance of these gains, the matched sample t-test was again employed (see section 6.3.1.1 for explanation). The results of this analysis are summarised in table 6.16.

Table 6. 16 Mean, SD and t- values for gains on individual questions. N=70

Questions	**Mean gain**	**SD**	**t. Value ***
1	**0.4**	**1.2**	**2.8**
2	**0.1**	**0.9**	**1.0**
3	**0.5**	**1.1**	**3.8**
4	**0.2**	**1.7**	**1.0**
5	**0.1**	**1.0**	**0.8**
6	**0.5**	**1.2**	**3.5**
7	**0.6**	**1.3**	**3.7**

*** Critical value for *t* at 5% of significance, 69 d.f. = 2.000**

Perhaps, not surprisingly, the large gains for questions 1, 3, 6, and 7 did indeed prove significant using a two-tailed test at the 5% level of significance. Therefore, there is fairly strong evidence to suggest that the course helped to increase students performance on these particular questions and that CAL, in particular, contributed to significant gains on questions 6 and 7.

The explanation for the fact that the smaller gains for questions 2, 4, and 5 did not prove significant is difficult to pinpoint with any certainty. It could be that the CAL package was not effective with respect to certain learning objectives, or equally, there could have been problems with the way the package was used (e.g. lack of guidance). On the other hand, failure to meet learning objectives could have been due to shortcomings in other areas of teaching: the lectures and the physical lab. Alternatively, performance may well have been enhanced with respect of these learning objectives, but the improvements might not have been detected because of the question design or because they were too small to be statistically significant.

6.3.1.3 Part two of the test

Questions 8 and 9 on the test were open-ended questions designed to see if they could apply general principles to real situations and so exhibit a degree of deep learning of the subject of Glaciation. The two questions were:

Question 8: You are given a sample of well rounded particles of a wide range of sizes, mostly aligned in one direction. Why does the sample look like this?

Question 9: A 10m deep hole is to be dug outside the university library.
Explain what materials you would expect to find in this hole.

Analysis of student responses to these two questions is provided below.

6.3.1.3.1 Question 8 results

Students were expected to make a connection between the three components of the questions:

- roundness
- wide range of sizes
- alignment

Students were given a score between 0 and 2 according to the following marking schedule.

0 those students who showed no understanding of the question.

1 those students who gave a correct short answer but who failed to make any connections between the three components (i.e. students who demonstrated surface learning only).

2 those students who succeeded in making connections (i.e. students who demonstrated deep learning).

In order to obtain some measures of how the course had influenced deep and surface learning, students were placed into one of six categories based on their respective pre-course and post-course scores. The frequency and proportion of students falling into these categories are summarised in table 6.17.

Table 6.17 Frequency and percentage distribution of pre- course ➡ post- course scores. N=70.

Pre-course➡ Post-course	**No. Of students**	**% of students**
0 ➡ 0	**16**	**23**
0 ➡ 1	**15**	**21**
0 ➡ 2	**3**	**4**
1 ➡ 1	**29**	**41**
1 ➡ 2	**2**	**3**
2 ➡ 2	**5**	**7**

The above table reveals that the majority of students showed no improvement in score post-course with 23% repeating their 0 pre-course score, and 41% remaining on a score of 1. In addition, 7% of students scored 2 both in pre-course and post-course, but here there was no possibility of improvement. A total of 28% of students did achieve a positive shift in score. However, the vast majority of these went from 0 to 1 (21% of the total), which is indicative of an improvement in surface learning only. The 0-2 and 1-2 shifts, which indicate improvements in deep learning, account for only 4% and 3% of students respectively. It should be noted that no students were observed to decrease their score.

The relatively small shift to deep learning (from 7% pre-course to 14% post-course) suggests that the course as a whole did not succeed in encouraging *many* students to understand rather than merely recall. This finding is somewhat surprising given that the CAL element of the course was specifically designed to show students the link between the practical and the theoretical parts of the course. However, the fault may not lie on the software, but in the way it was used e.g. if students used it to gain specific information they thought might be useful in their exams. Another explanation is that the wording of the question itself did not make it sufficiently clear that a longer answer was required. In this case, some students may have had a greater understanding of the subject of Glaciation than they demonstrated in their responses.

6.3.1.3.2 Question 9 results

In order to demonstrate a deep understanding of this question, students first had to identify the geological material on which the university library stands and then make a connection between the appearance of the material in the hole (a poorly sorted diamicton with subrounded/subangular clasts and a strong fabric) and its origin (drumlin).

Student scores were obtained according to the following marking schedule:

0 those students who showed no understanding of the question.

1 those students who mentioned at least some of the keywords listed above relating to either the appearance of the material or its origin but who failed

to mention both (i.e. students who demonstrated surface learning only).

2 students who successfully linked the appearance of the material to its origin (i.e. students who demonstrated deep learning).

As with question 8, students were placed into one of the six possible categories of pre-course and post-course scores combinations. The frequency and percentage of students falling into those categories are summarised in table 6.18.

Table 6.18 Frequency and percentage distribution of pre- course→ post- course scores N=70.

Pre-course→Post-course	No. Of students	% of students
0 → 0	0	0
0 → 1	0	0
0 → 2	0	0
1 → 1	58	83
1 → 2	12	17
2 → 2	0	0

The above table reveals a pattern of scores very different from that found for question 8. First, no students had a pre-course score of 0 which would suggest significant pre-knowledge of the subject. Indeed, it emerged that the students had already studied this subject, albeit at a lower level, in the previous year. Second, no students had a pre-course score of 2 which meant that all participants had the opportunity of improving their score. A total of 12 students (17%) did achieve a positive shift in score from 1 to 2, while 58 (83%) remained on a score of 1.

Although the shift to deeper learning in this question (17%) was greater than for question 8 (7%), the shift was still low given that the CAL package was specifically designed to help students link lectures material and lab work. However, it is possible that the magnitude of the shift for question 9 is underestimated due to the wording of the question itself. Although mention of both appearance and origin is expected, the question emphasises the former (.......what material.....) without specifically asking *how* materials got there or *why* they look like this. Another possibility is that students did not, or were not able to, exploit the full potential of the CAL package because not enough guidance or instruction was provided in how they should use the software.

6.3.2 Post task results

As indicated in chapter four (section 4.4.2), the post task questionnaire was designed to find out how students reacted to the three methods used to teach them about Glacial Sediments (i.e. the lecture, the physical lab and the CAL package). The questionnaire consisted of four questions. The results of these questions are presented and discussed below.

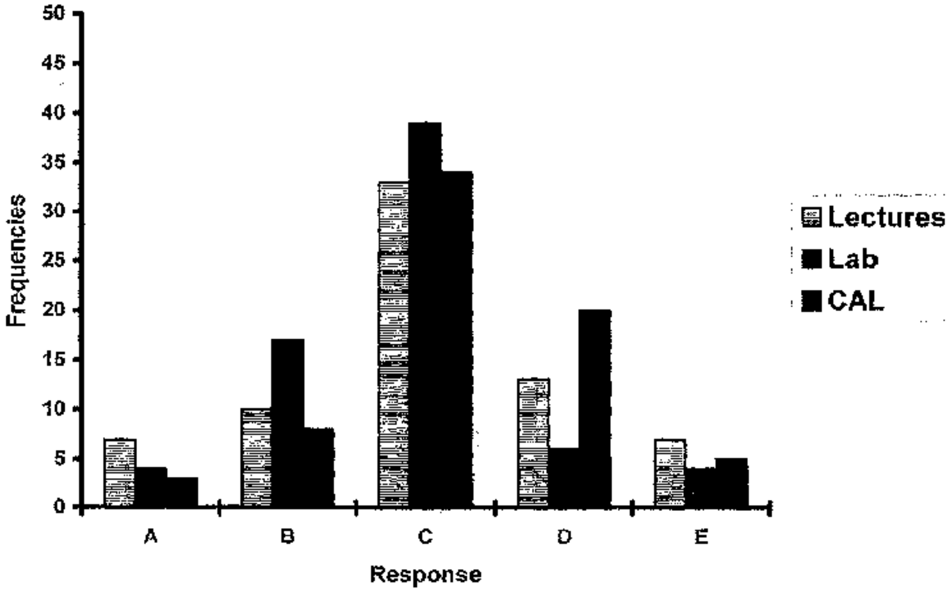
6.3.2.1 Question one results

In question one of the post task questionnaire, students were asked to rate the value of the three teaching methods mentioned above. Five categories of responses were available to them, which ranged from "worthless" to "outstanding". The frequency of student responses under each category is shown in table 6.19 and illustrated graphically in figure 6.3.

Table 6.19 Student ratings of the value of the three teaching/learning methods used in the course on Glaciation. N= 70

	Worthless	**Of little value**	**Worthwhile**	**Very valuable**	**Outstanding**
Lectures	**7**	**10**	**33**	**13**	**7**
Lab	**4**	**17**	**39**	**6**	**4**
CAL package	**3**	**8**	**34**	**20**	**5**

Figure 6.3. Student ratings of the value of the three methods used in the course on Glaciation



A= worthless, B= of little value, C= worthwhile, D= very valuable, E= outstanding

In order to find out whether students ratings for the three methods were significantly different, 3 Chi-square tests were performed on the three possible pairs of methods (*lectures v lab, lectures v CAL and lab v CAL)*. However, as was the case in study three (section 6.2.2.), some of the categories first had to be combined to ensure that all frequencies were greater than or equal to five. Thus, the "worthless" and "of little value" were combined into a single category: "not valuable". Similarly, "very valuable" and "outstanding" were combined to give a new "valuable" category. The "worthwhile" category remained unchanged. The frequencies of response under these three categories are shown in table 6.20.

Table 6.20 Combined student ratings of the value of the three teaching/learning methods used in the course on Glaciation. N= 70

	Not valuable	**Worthwhile**	**Valuable**
Lectures	**17**	**33**	**20**
Lab	**21**	**39**	**10**
CAL package	**11**	**34**	**25**

With all three pairs of methods, the null hypothesis is that there is no significant difference between the frequencies of student responses.

The critical value of χ^2 at 1% level of significance ,(2 d.f.) is 9.21. and, at 5% level of significance is 5.99. The values of χ^2 obtained for the lecture v lab and lecture v CAL tests (4.254 and 1.856 respectively) were smaller than the critical values and, therefore, there is no reason to reject the null hypothesis. However, a $\chi 2$ value of (9.896) for the lab v CAL test is significant at 1% level and, therefore, there is strong evidence to suggest that the CAL package was found to be more "valuable" than the physical lab.

6.3.2.2 Question two results

In this question, students were asked to explain why they had rated the three teaching methods "very valuable" or "outstanding". The most common reason for the finding the lectures valuable was that "*In the lecture you were be able to ask questions*", suggesting that interaction was an important feature of lectures. Another common reason was that "*The oral explanation and slides make the lectures very useful*".

For the physical lab, the most common reason was that "*The physical lab gave introduction to techniques used in the field*", while the next most common one was "*Material was well explained*". With regards to the CAL package, the most common reasons given were "*The CAL package displays images of what happens in Glaciation*" and "*the CAL package taught a lot of things about glaciation by examples*". Students explanations as to why CAL had been valuable suggest that the graphic capabilities of the computer helped them to understand phenomena that occur in space or over time.

6.3.2.3 Question three results

In this question, students were also asked to explain why they had rated teaching/learning methods "worthless" or "of little value". The most common reason given for the lecture was, "*The lectures had too much information*". The next most common reason was, " *The lectures had unclear list of terminologies.*"

With regards to the physical lab, the most common reason was that "*In the physical lab there was too much time emphasis on measuring/ calculating instead of analysing*", while the next most common was that "*Notes given in the lab did not explain ideas and processes very well*"

As far as the CAL package is concerned the most common reasons given by students were "*In the CAL package there is too much information to take in at one time*" *and* "*No assistance available*".

The above examples of reasons given by students clearly indicate how too much information given either in the lectures or in CAL package can prevent learners getting full benefit from these methods. This is particularly true of information that students do not really need to know(i.e. noise information). The students responses also provide strong evidence of how instruction and guidance in the labs, particularly the computer lab, are important, especially for those students who have not previously used the computer let alone the CAL packages themselves.

6.3.2.4 Question four results

In this question, students were asked to say what they had found each of the three teaching/learning methods most useful for. Their responses to each of the methods are presented below.

6.3.2.4.1 Student responses to lectures

Student responses fell into one of three categories. The number and percentage of students responding under each category are summarised in table 6.21.

Table 6.21 Usefulness of lectures as perceived by students. N= 70

Responses	No. Of students	% of students
Providing general facts	**37**	**53%**
Explaining basic concepts about Glaciation	**21**	**30%**
Explaining Glacial processes	**12**	**17%**

The above responses suggest that lectures were most useful for introducing new material and for explaining concepts and processes that are at first difficult to grasp.

6.3.2.4.2 Student responses to the physical lab

Only 55 of the 70 students participating explained how the physical lab had been useful. The responses of those who did explain fell into one of the three categories. The number and percentage of students responding under each category are shown in table 6.22.

Table 6.22 Usefulness of the physical lab as perceived by students. N= 55

Responses	No. Of students	% of students
Learning field work techniques	**42**	76%
Putting theory into practice	**8**	**15%**
Measuring sediments	**5**	**9%**

6.3.2.4.3 Student responses to the CAL package

Only 60 of the 70 students participating explained how the CAL package had been useful. The responses of those who did explain fell into one of the three categories. The number and percentage of students responding under each category are illustrated in table 6.23.

Table 6.23 Usefulness of the CAL package as perceived by students. N=60

Responses	No. Of students	% of students
Linking lectures and the physical lab	**32**	**53%**
Providing visual representation of Glacial processes	**19**	**32%**
Giving clear definitions of the terms relating to Glaciation	**9**	**15%**

The above responses to CAL suggest that the CAL package has succeeded in fulfilling its main aim, i.e. linking information presented in lectures with the more practical tasks of the physical lab. 53% of students cited this as its most useful function. A high proportion of students emphasised the usefulness of the visual presentations. 32% suggesting that computer graphics are not only useful for stimulating and motivating students, but also, for explaining processes.

Taken as a whole, the student responses to the teaching/learning methods available to them during the course on Glaciation provide a clear picture of how the methods complement each other and how CAL played a central role in supporting and linking other methods. Students appeared to find lectures most useful for introducing a new subject, providing facts and concepts. As far as explaining complex processes is concerned, the CAL package would appear to complement the lectures: 17% found lectures useful in this respect, while 32% found computer animation of the processes useful. It is possible that, in this case, CAL is helping students who failed to understand these processes fully after the lecture presentation.

Not surprisingly, the vast majority (76%) of students found the physical lab most useful for learning field work techniques. It is interesting to note that "putting theory into practice" was another useful function cited by several students (15%). This suggested that the lab helped students to understand the relevance of what they had learned in the lectures. CAL also performed this linking role to great effect. The majority of students (53%) reported that CAL had helped to link lectures and the physical lab.

6.4 General conclusions from studies three and four

Studies three and four, when taken together, provide compelling evidence for the need to match teaching/learning methods with specific objectives. Study four, for example, showed that lectures are an effective way of presenting general facts and concepts. In contrast, lectures proved ineffective, even irrelevant, as far as more practical subjects are concerned e.g. the computer applications of study three.

When two or more methods are used to teach the same subject, it would seem to make sense to ensure that their objectives complement each other. Common complaints about the lectures in study four were that there was too much information and that terminology was unclear. Perhaps a lesson could be learned here from study three, where handouts were highly rated as a reference resource. By putting supplementary information and definitions in handouts, the lecturer has more time to spend on those aspects of the lecture format that make it particularly useful, including the possibility of providing instant feedback, and to use the lecture as a means of stimulating student interest in a new subject.

As a complementary method of learning, CAL would seem to have a great potential. Not only has it proved useful as a direct complement to lectures, e.g. illustrating processes that are more difficult to explain through animation sequences, but it is also credited with providing a useful link between lectures and labs. Taking this role further, one might envisage taking certain topics out of the lecture altogether and leaving them entirely to the CAL part of the course. Again, this would free up lecture time and allow greater emphasis on more theoretical or conceptual topics.

Labs are clearly the most effective way of learning techniques, whether they be scientific or computer-related. However, a healthy balance between lectures and labs is frequently hard to achieve. In study three, the students complained about the introduction of difficult terminology that did not appear particularly useful in achieving their main objective in the computer lab. In study four, the complaint was that the labs were too quantitative and thus did not allow students to apply their theoretical knowledge in a more analytical way.

Bringing together all the ideas put forward above, one might envisage, for example, a complementary set of methods for teaching the subject of Glaciation whereby the lectures were used to first stimulate interest and then impart specific information (including new terminology) could be contained in handouts, and complex processes could be illustrated in a CAL package used with adequate staff supervision. The CAL package could also link the lecture (theory) to the physical lab (practice). Finally, the physical lab itself could concentrate on teaching specific techniques that were related back to the lectures.

6.5 Summary

In this chapter, the quantitative and qualitative data obtained for study three and four have been presented, analysed and discussed. The data itself was gathered using a variety of instruments: tests, learning resources questionnaire, confidence log, a focus group and post task questionnaire.

In the responses to study three, the learning resources questionnaire showed that students found the scheduled computer lab the most useful resource for learning about all techniques covered in the IT course except GIS, for which handouts were found most useful. This finding was true for both year groups involved in the study. However, the 1995-96 year group appear to have found the scheduled computer lab even more useful than students from 1994-95, reflecting improvements in the number of machines available.

As far as the confidence log is concerned, significant differences emerged between the two year groups in terms of their confidence in achieving certain learning objectives. As predicted, the 1994-95 students were generally more confident after their year's experience using the techniques. However, no significant differences were found between the two year groups with respect to some learning objectives.

The focus group discussion revealed a number of factors that can prevent students from gaining the full benefit of the computer as a medium of learning. They include insufficient relevance of lecture material to practical work, insufficient time to finish practical work and insufficient staff support to guide students while they are working in the computer lab.

In study four, the tests revealed significant improvements in overall student performance at the end of the course. However, closer examination of student performances on individual questions showed that overall improvement was due to improved performances on certain questions only. The improvements observed in other questions proved statistically insignificant. Interestingly, the learning gains on the two questions closely related to the CAL package proved significant. Results of the second part of the test designed to distinguish between deep and surface learning, suggest that there was only a small shift to deeper learning by the end of the course.

The result of the post task questionnaire for study four showed that students have both positive and negative views of the teaching/learning methods used. CAL was found useful for visualising the Glaciation processes and for linking the lectures and labs.

CHAPTER SEVEN

DISCUSSION OF DIFFICULTIES ENCOUNTERED DURING FIELDWORK

CHAPTER SEVEN

Discussion Of Difficulties Encountered During Fieldwork

7.1 Introduction

Fieldwork can very rarely be carried out exactly according to the researcher's original aims and intentions. Unexpected situations arise and unforeseen factors come into play in the course of collecting data and gathering information. Sometimes the unexpected can be positive, leading to additional and more meaningful findings. On the other occasions, the consequences are more negative, making interpretation more difficult and findings less conclusive.

This study was no exception. Although the evaluation of CAL is a relatively well-established area of research, it still requires a great deal of decision-making, ranging from the selection of sample groups to the choice of instruments and their specific design. The consequences of these decisions, the compromises that were required, and the problems arising from unforeseen circumstances are all discussed in this chapter. The two school-based studies were particularly problematic, with difficulties arising from inadequate resources, lack of teacher co-operation and small sample sizes. Problems were also encountered in the university context.

In the following sections, the various problems that arose are discussed in greater detail. The chapter ends with a discussion of the feedback obtained from the teachers on the results of this evaluation.

7.2 Difficulties encountered during fieldwork

7.2.1 Teachers' cooperation

Of fundamental importance to the integrative evaluation approach is the extent to which teachers are willing to become involved in the evaluation process. The involvement of teachers is vital at all stages of evaluation: making CAL available, providing support, designing tests, granting permission to administer questionnaires, and discussing results with the researcher.

In conducting this research, two kinds of teachers were encountered: those who were extremely positive about the evaluation, who were willing to participate and enthusiastic about getting involved, and those who only co-operated reluctantly. The enthusiastic teachers, by becoming involved before, during and after the evaluation process, made the evaluation easier to conduct and gave it a sounder base. For example, they made the effort to design and correct tests, afforded the evaluator access to administer tests and questionnaires, took time to discuss the results of the evaluation with evaluator and provided general comments on student performance, the CAL package itself, and the overall teaching environment.

Those teachers who were less enthusiastic, provided reasons for their negative attitude: they were too busy with the rest of the curriculum and they lacked sufficient hardware resources. It was observed that some teachers themselves lacked the confidence in using the computers properly. Similar reasons have been identified in previous studies of the computer in education (Heywood and Norman, 1988, Reiser and Dick, 1990, Zammit, 1992).

The absence of full cooperation gave rise to several problems: tests in general were poorly designed, making student performance and improvement more difficult to assess; students were not adequately supervised, which meant that the students were not getting the full benefit of the CAL package.

Part of the solution to these problems is demonstrating to the teachers how their involvement would benefit both them and their students. At the same time, however, other requirements need to be fulfilled, including adequate provision of hardware, good quality CAL packages, and teachers having sufficient knowledge of how to apply computers to their subject. Only by satisfying all the demands will teachers fully appreciate the potential role that the computer can play in teaching their subject, and the important role that evaluation plays in improving the effectiveness of computers in education.

7.2.2 Student cooperation

The main difficulty that arose concerning student cooperation in the university was students not returning all the two questionnaires i.e. learning resources questionnaire and confidence log questionnaire. Of the nearly 70 students who were supposed to complete the questionnaires, only 47 did so, and then only after considerable effort from members of the Geography Department.

A likely reason for this problem was the fact that students did not complete the questionnaires in the lecture theatre. Because the questionnaire was too long for students to complete during or after the lecture, they were asked instead to take it home and return it to the department. This problem did not arise with the fourth year students who studied the IT course in the previous year i.e. 1994-95, as it proved easier to have them to remain for 20 to 30 minutes necessary to complete the questionnaires.

7.2.3 Sample size

Another problem faced during fieldwork, particularly in the schools, was the limited number of students available for inclusion in the sample. Since not all classes in a given year study the same units at the same time, samples were restricted to those classes studying the unit related to the CAL package in use at the time of the evaluation study. As a consequence, sample sizes were fairly small, the main disadvantage of which was the difficulty encountered obtaining statistically significant findings. Larger samples would have made the results of the evaluation more meaningful and convincing.

7.2.4 The type and quality of CAL packages

One of the problems faced in the two school-based studies was that different CAL packages were used in each school. If the same package had been used in both schools, it would have been possible to isolate and quantify other factors that influence student achievement (guidance, hardware availability etc.) and thereby obtain a more accurate assessment of the contribution made by CAL to overall gain. It would also have been preferable to have had packages of similarly good quality, however, the interactive package used in study (1) was superior to the overly-detailed database used in study (2).

7.2.5 Computer availability and access.

A serious yet common problem encountered in studies concerned with the evaluation of CAL is the inadequacy of computer facilities. This was a problem in both the university and school contexts.

During this study the consequences of poor computer availability were clear to see, with students and pupils often forced to work in pairs on a single computer. While some students do benefit from working with a partner, the disadvantages of the arrangement are overwhelming: since only one student can control the input devices, the other student is forced to assume the role of more passive observer. Furthermore, many students prefer to work alone so they can experiment and make mistakes without fear of embarrassment. From an evaluation point of view, it would obviously be better if all students had an equal opportunity to benefit from CAL.

A related problem to computer availability is access to computer facilities. This problem only occurred in the university-based studies where students were required to spend time in unscheduled labs. A common complaint was that there was insufficient time to complete tasks, or even find an available time to book, within the opening hours of the computer lab. Restrictions on access to these facilities prevented many students from gaining the full benefit of CAL.

7.2.6 The timing of CAL use within school and university environments and its effect on study design.

One of the major factors that lay outwith the control of the researcher was the time that CAL was used in relation to other teaching methods. In the two school-based studies the teachers decided to use CAL after traditional human teaching. Ideally, from a researcher point of view, it would probably the interesting to study the use of CAL before any other forms of teaching in order to obtain a useful measurement of the effectiveness of CAL. However, the teachers thought that it would be difficult to modify their curriculum plans in this way, explaining that this timing would not be conducive to their teaching goals. Nevertheless, the fact that CAL was used exclusively for a certain time meant that its effectiveness could be measured by administering three tests: pre-test (pre-human teaching), post-test1 (after human teaching and before CAL) and post-test2 (after CAL).

Unfortunately, this was not the case in study four at the university. Here, CAL was used alongside two other teaching methods - lectures and physical lab. It was not possible to have CAL concentrated either at the beginning of the course or at the end as it would lead to an undesirable "peak demand" for computers which would not only affect students involved in the study, but also students from other courses. In addition, delaying CAL use to the end of the course would lead to time conflicts with exam revision. As a consequence of not being able to isolate CAL, it is not possible to measure the effectiveness of CAL alone. Instead, learning gains had to be attributed to a combination of the three methods.

There was one advantage offered by these circumstances, namely, that the evaluation was more consistent with the idea of an integrative evaluation, which stresses the importance of not viewing CAL in isolation. The specific contributions made by CAL are, perhaps, better understood with reference to the post-task questionnaire where students indicate the ways in which they found CAL particularly helpful. However, a tentative quantification of CAL's contribution to learning gains was obtained from closer examination of some questions on the test that relied heavily on the content of the CAL package.

7.3 Discussion on teachers feedback on evaluation result

One of the fundamental aims of integrative evaluation is to help the teachers involved improve the way they apply CAL packages to their subjects. In this respect, test scores and comments made by the students are a very useful starting point for getting feedback from the teachers. This section outlines the reaction of teachers to the test results and the results of the questionnaires administered to students.

One of the issues raised in meetings with teachers and lecturers was the high degree of variability in the test scores for individual questions. Unusually low scores were generally explained by poor wording of the questions themselves. In some cases, it was argued that students should have been given stronger prompts to encourage them to think more and give fuller answers. At the other extreme, one teacher conceded that some questions had been too easy to answer correctly merely by guessing. Both types of problem almost certainly led to an underestimation of CAL gains, and this finding demonstrates the importance of well-designed tests.

Another factor that the university lecturer believed had led to low learning gains was the fact that there were a numbers of obstacles that students faced before they could get maximum benefit from the package (study 4). Many students did not even manage to work their way through the whole package because they ran out of lab time or got stuck due to technical difficulties. The latter case was not helped by the fact that the package did not come with the a user manual. On a related theme, one teacher believed that the problem of computer availability had probably played a part in student performances. He predicted that, had there been one computer per student, the results would have been very different.

As far as the views expressed by students in the questionnaire was concerned, the teachers were generally encouraged by the number of positive comments. In particular, the teachers considered the perceived usefulness of computer graphics and animation to be a significant finding. One teacher firmly believed that learning would not only be made more enjoyable but also more effective, by further incorporating graphics packages.

Not all pupil comments were positive, however. For example, one pupil complained that CAL was "boring" and that he "didn't know what to do". The teacher explained that this reaction was not uncommon among pupils who had not gained a basic familiarity with computers at the primary level. However, he admitted that it was the teacher's responsibility to be on hand while pupils are working with a CAL package in order to increase their confidence and ensure they get the maximum benefit.

Another issue raised was the lack of communication between schools and between similar departments regarding their experience of the various CAL packages available. In the opinion of one teacher, such communication is important for identifying both good and poor packages and therefore helping the selection of suitable packages.

It appears from the teacher feedback to the evaluation results that a number of factors may have affected student/pupil performances. These factors include the type of questions asked and their wording, insufficient instructions provided to students, and a general shortage of computers. It is interesting to note that the teachers did not appear critical of the CAL packages themselves. Instead, they acknowledged that the central problem is probably the way in which the packages are used.

7.4 Summary

This chapter has mainly focused on the difficulties encountered during the fieldwork of this evaluation study. Difficulties detailed in this chapter range from poor teacher co-operation to the timing of CAL use.

Also presented in this chapter is the feedback given by teachers to the results of the study. It became apparent that they found the analysis of students' performances useful for identifying strengths and weaknesses in the delivery of learning objectives. Teachers also found the student comments on CAL encouraging and evidence of the potential value in schools and the University.

Finally, it is hoped that by highlighting the kind of problems that are likely to be faced during CAL evaluation that such problems can be avoided or, at least, minimised in future studies.

CHAPTER EIGHT
DISCUSSION AND CONCLUSION

CHAPTER EIGHT

Discussion and Conclusion

8.1 Introduction

This research has employed an integrative evaluation approach in order to assess the benefits of CAL use in Geography teaching. The research was conducted at the University of Glasgow and in two Secondary Schools in the Strathclyde region. In addition to the comparative measurement of learning outcomes using tests (Quizzes), information on other aspects of CAL use was gathered through questionnaires. The research is divided into four studies corresponding to the four CAL packages that were used: two at the University and one in each of the schools.

This chapter contains a summary of the findings of the research, recommendations, suggestions for further research, and a short message to the educational authorities in Saudi Arabia.

8.2 list of Findings

1. In both the school-based studies, the patterns of improvement varied greatly. For some learning objectives, CAL efficiency was greater than human teaching efficiency while for others the pattern was reversed.

   It is important to distinguish this finding from the findings cited in section 3.6. The latter were obtained from comparative studies in which CAL was compared with conventional teaching methods through the use of a control group. No such control group was used in the present study: all the pupils participating in the study used CAL as a following-up to conventional teaching. In other words, it is a real class room situation study. However, it is interesting to note that the results of the present study are similar to the results of the studies by Carrier et al (1985), Wainwright (1985) and Nelson et al (1989) when taken as a whole i.e. there is no conclusive evidence to suggest that CAL is more or less effective than conventional teaching methods overall. The important difference in the case of this study is that this inconclusiveness is not problematic; it merely reinforces the assumption upon which integrative evaluation is based i.e. that learning is the result of more than one factor and that these factors can complement each other.

2. The relationship between CAL gain and pupils' geographical ability (as determined by their performance on a school test) was investigated in studies 1 and 2. Two very different patterns of correlation were found; evidence of an inverse relation within certain groups of pupils in study 1, and an indication of a slight positive correlation in study 2. It was concluded that low ability pupils gained more from a stimulating, interactive CAL package (study 1), but benefited less than more able pupils from database type packages (study 2). This conclusion would be consistent with the claims made by Lyall (1995) (see section 3.3.2) regarding the benefits of interactive software. If it is assumed that pupils defined in this study as being of lower ability have a tendency to be more passive learners than those of higher ability, then it makes sense that the CAL gains achieved by the lower ability pupils would be greater. The interactive nature of the simulation software would tend to

make them more active and hence better - performing pupils.

3. The majority of pupils involved in the two school-based studies reacted positively to the use of CAL in teaching them about the Weather and Japan.

4. In study 1, pupils narrowly rated computers more useful than the teacher as a resource for learning about the Weather. Computers were also rated more highly than the textbook, slides, and OHP.

5. The university students taking part in study 3 found the scheduled computer lab the most useful learning resource for learning about the five applications covered in IT course. This was true for both year groups (1994-95 and 1995-96). This study provided clear evidence that each resource is more suited to the achievement of certain teaching objectives and less suited to the achievement for others. Although these findings are predictable, no literature was available to show the usefulness of these resources in such a comparison.

6. Of the two year groups in study 3, those from 1995-96 generally rated the three main learning resources (lectures, handouts, scheduled computer lab) more useful than those from 1994-95. This difference reflects improvements in the quality and quantity of resources that were made in the intervening year.

7. Computer labs were the only main learning resource that university students experienced difficulty in accessing. However, computer access was not found to be a problem in schools.

8. Statistically significant differences were found between the confidence levels of 1994-95 and 1995-96 university groups as far as meeting certain learning objectives of the IT course was concerned. In the majority of cases, the former group was more confident. It could be that, since they were reporting in retrospect, the 1994-95 students were more confident after a year's further experience

9. In study 4, the difference between student scores in the post course test and the pre course test proved to be statistically significant when scores for all questions were totalled. However, when the gains on individual questions were analysed, most, but not all, of the gains proved statistically significant. Since CAL was used in parallel with two other teaching methods (lectures and the physical lab) the gains cannot be attributed to CAL alone. However, closer examination of questions that specifically tested knowledge of the CAL package revealed that these gains were indeed significant.

The study of the effectiveness of the three methods employed in the teaching of Glaciation could be considered new as no literature was found to link a CAL package with theoretical and practical part of a course.

10. In study 4, analysis of the responses to questions designed to distinguish between deep and surface learning reveals a small shift from surface to deep learning by the end of the course. A larger shift had been expected, particularly since the CAL package used was specifically designed to link theoretical and practical knowledge. However, doubts about the design of the questions used to determine deep vs. surface learning (doubts which are shared by the lecturers involved) suggest that the shift may have been underestimated in this study. The potential problems that can a rise from certain kinds of language used in quizzes were highlighted in section 2.4 in the discussion of the overloading students' working memory. Research carried out by Cassels and Johnstone (1984) predicts that performance will be adversely affected by the wording of questions e.g. long sentences and unfamiliar vocabulary. The problem with the wording of questions used to distinguish deep and surface learning in Study 4 of this research was that it was not clear exactly what length of question was required or the kind of response expected.

11. Analysis of the way in which students categorised the value of each of the methods used to teach Glaciation revealed that there were no significant differences between their ratings of lectures and CAL or lectures and physical lab. However, the difference in their assessment of CAL and the physical lab was statistically significant and suggests that students consider CAL more valuable than the physical lab in teaching them about Glaciation. (Study 4)

8.3 Usefulness of the Method

When the secondary school teachers were asked to comment on the usefulness of the integrative evaluation approach being used, they said that the method had been useful in two respects. First, the method had helped to identify some of the weaknesses in the way CAL was being used. From this, they concluded that more careful planning and improved delivery would be necessary in the future in order to make better use of CAL within the context of other teaching resources. Second, the teachers mentioned that the method had helped to highlight the difficulties they faced in matching the learning objectives of the subject with the teaching resources available. This, they pointed out, was particularly true of resources bought in (such as CAL packages) rather than those designed by the teachers themselves.

The comments above would seem to suggest that integrative evaluation has indeed proved to be useful in a secondary school context. This was by no means a foregone conclusion at the beginning of the research for the simple reason that the secondary school context is so different from the university context (in which all previous studies have been conducted). However, while the current research shows that this kind of evaluation is useful in the school context, the full potential of the approach can only be achieved through further research, suggestions for which are listed in section 8.6.

8.4 Summary of the main findings

It was stated in the original aim of this research that the extension of the integrative evaluation approach to the secondary school context was to be one of the main contributions of this research. From the comments documented in the previous section (8.3.), the integrative approach would appear to be as useful at the secondary school level as it is at the university level. This research demonstrated, therefore, that performance, comments and complaints of younger learners are equally valid in attempts to improve the overall learning situation.

One of the most significant findings to emerge from this research is the fact that the type of CAL software being employed seems to have a bearing on the kind of pupils who benefit most. The results of this study suggest that low ability pupils may benefit from interactive CAL packages but the opposite may be true when the CAL package is not particularly interactive.

The CAL package designed to link theoretical and practical knowledge (study 4) seemed to help in creating a shift, albeit a small one, towards deeper learning. This kind of information is not available in the existing literature which is based on comparative studies that do not address differences in learning styles.

8.5 Recommendations

The researcher would like to stress that the recommendations made in this chapter are in no way meant to constitute criticisms of the teachers' existing methods. They are designed to help teachers improve the overall delivery of a combination of teaching methods of which CAL is only one element, and they are based both on the findings of this research and on existing literature.

1. Teachers intending to use a CAL package should first become familiar with all aspects of the software in order to assess its suitability for student use. In particular, they should ask themselves whether the kind of information provided is such that "noise" is avoided, and whether graphic representations, especially those that simulate three dimensions, are unambiguous and readily understood. These initial checks are all designed to avoid problems related to the overloading of working memory.

2. Students will always benefit more fully from a CAL package if they are given proper guidance and instruction. This is particularly true for students with limited computer skills. By easing the difficulties that students face with the "mechanics" of the package, teachers and technicians can free students' working memory so that they are able to devote more time and energy to to understanding the subject itself.

3. Discussion with teachers involved in this research revealed that some were keen to develop their own CAL packages. They indicated that commercially available packages were not always entirely suitable for their particular needs

or geared towards their own specific subject areas. However, if teachers are to get involved in software development, they will undoubtedly require considerable support at a departmental or institutional level. Assuming that this is forthcoming, they would then need to ensure that their packages incorporate those feature that characterise an effective CAL package, including good use of graphics in relation to text, the avoidance of unnecessary information and language, the provision of clearly defined objectives for the user, and the incorporation of interactive task.

4. A common complaint made by students at the university was that insufficient time was allowed for them to work through the whole of the CAL package. Clearly, if students are to exploit the full potential of a package, careful planning is required to ensure that there is enough time during the course or the term for them to complete all the tasks without any undue pressure.

5. Teachers should remember that every teaching method is useful for achieving certain goals and not so useful for achieving others. It is therefore important for teachers to employ a combination of methods each matched to a teaching goal well-suited to that method. For example, one of the teaching goals in one of the university studies was to equip students with scientific terminology that would help them in their CAL labs and in the physical lab. This terminology was introduced in the lectures where students found it difficult to grasp.
   In this case, it way well have been preferable to introduce the new terminology in a manual that student could refer to during their labs. Not only would this minimise confusion, but it would also provide more time in the lectures for

imparting facts and information - the teaching goals best suited to the lecture format.

6. The problem of unnecessary information is possible with any teaching method. Therefore, teachers should guard against including too much information, whether it be in the form of lectures, practical labs or CAL.

7. Results obtained in the school-based studies suggest there may be a link between the gain low ability pupils achieved from using the CAL and the type and quality of the CAL packages used. It was found that low ability pupils benefited more from well-designed, interactive software than they did from software that merely functioned as a database. Therefore, teachers should be careful to select and integrate packages that encourage learners to be active and involved with the material being presented, rather than software that allows them to remain passive.

8. It become apparent during this research that a major obstacle to students getting the full benefit of CAL was the general shortage of computers in schools and the university. This reduces the amount of time that individual students can spend using the CAL packages. A similar problem can arise when access to computers is restricted, for example, by the opening hours of the computer lab. Greater departmental co-operation between lecturers and technicians could, in some cases, alleviate such problem.

8.6 Suggestions for further research.

During any research project, unforeseen questions and issues are raised which cannot be answered or addressed immediately, but which point to future research. In addition, recognition of the necessary limitations of a research project can help to suggest gaps that need to be filled and areas that a merit expanding upon. The suggestions made below originate from the experiences gained in the current research.

1. The findings of the present research are based on only five samples (two at secondary schools and three at the University of Glasgow). Further studies would be useful in order to gather more information and data. More studies conducted in secondary schools would be particularly valuable.

2. In order to demonstrate the particular value of integrative evaluation, it would be interesting to conduct further studies in secondary schools into subjects other than Geography.

3. In this research, the deep approach to learning has only been investigated with university students. Similar investigations are required in secondary schools to assess the extent to which pupils adopt such an approach.

4. The present research has not investigated a possible correlation between student ratings of the usefulness of learning resources and their learning outcomes. Research to investigate such a correlation would be valuable.

5. It may be useful to investigate a possible correlation between students' confidence in meeting the learning objectives of the course and their actual performance.

6. Further research is required into the impact of psychological factors, especially visual perception, on student performance. Of a particular importance is the way three- dimensional objects are represented within CAL packages.
7. It was noted in chapter seven that some teachers were reluctant to co-operate fully in conducting this integrative evaluation study. It might be useful to identify the reasons for such reluctance in order to make future evaluation study easier to conduct and more beneficial to the teachers involved.

8. Further research into the impact that different types of CAL package have on pupils of different abilities is needed. This might provide supporting evidence for the findings of this research.

9 . It has been argued throughout this research that inadequate instruction given to students using CAL packages is likely to have a negative effect on their learning outcomes. In order to quantify the benefits of providing proper instruction, some sort of comparative study would be useful.

8.7 The Research's Message to the Educational Authorities in Saudi Arabia

In common with educational authorities throughout the world, the authorities in Saudi Arabia are keen to introduce computer technology into their schools and universities. Indeed, computer science has already been introduced into secondary education as a subject in its own right, with pupils achieving basic computer literacy and awareness, and being introduced to programming. As a result, pupils are now leaving schools equipped with skills that will help them in all aspects of contemporary life. However, perhaps the greatest benefit from introducing computer technology into education lies in integrating computers into the teaching of other subjects.

In addition, it is important to bear in mind that the benefits of using the computer as a medium for learning depend not only on having the hardware and software available. It has been argued in this research that the *way* in which these resources are employed is equally important. The issues raised in this research, its findings and recommendations should be relevant to the concerns of the educational authorities in Saudi Arabia.

Educators planning to introduce CAL into their teaching should benefit from the experience gained in this research and thus make the computer a more effective learning medium in the services of their teaching objectives. It is important for teachers and lecturers to realise that in order to monitor the degree to which CAL packages are effective, detailed evaluation of the kind employed in the current study is required. Furthermore, for evaluation to be successful, both teachers and authorities need to understand the nature of such evaluation, and all parties must be willing to co-operate fully and to work flexibly.

The successful integration and use of CAL into teaching depends on both teachers and students being familiar with computers. Therefore, intensive teacher training should be anticipated where teachers lack necessary computer skills. There is also a strong argument for ensuring pupils are computer literate before they leave primary school so that they are able to cope with CAL when they reach secondary school.

The research supports previous studies that have employed the integrative approach to evaluation in that it identifies inadequacy of student supervision and guidance as a major problem. The message is clear: if the full potential of CAL is to be realised, steps must be made to ensure that sufficient staff support - either in the form of teachers or technicians- is provided to students using CAL packages.

Finally, it is important to say that the amount of time that is allotted to CAL and the arrangements for access to computer facilities are also important factors governing the effectiveness of CAL's integration into a teaching programme. Educators in Saudi Arabia, therefore need to strike a healthy balance between the time students spend in the classroom and the time they spend in the computer lab. They also need to consider to what extent extra hours of access are required to allow students sufficient time to complete CAL assignments.

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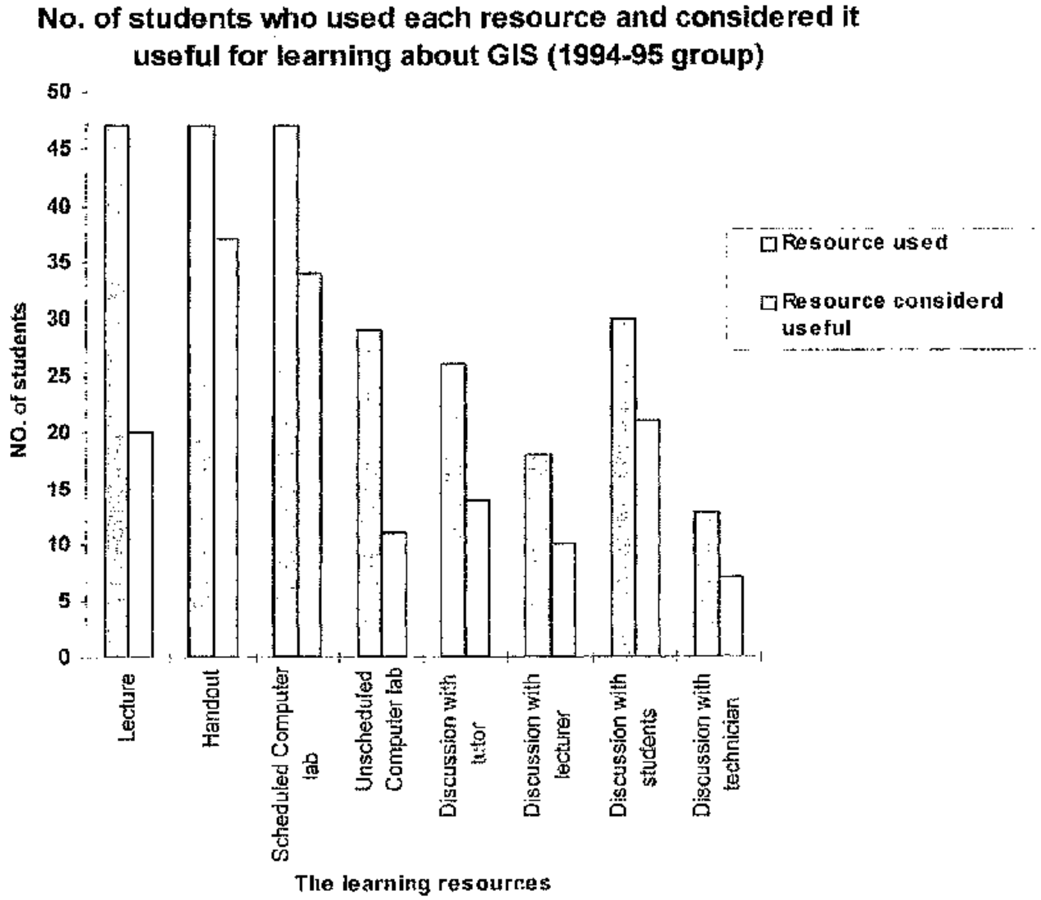
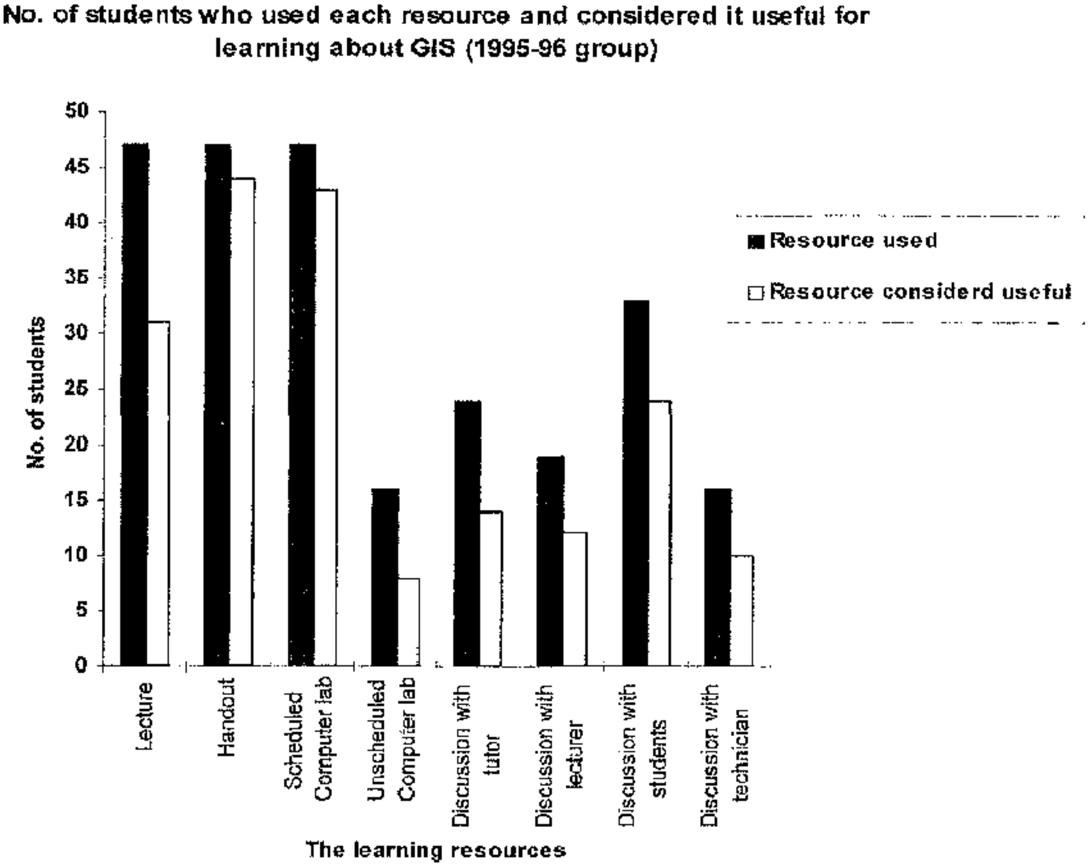
APPENDICES

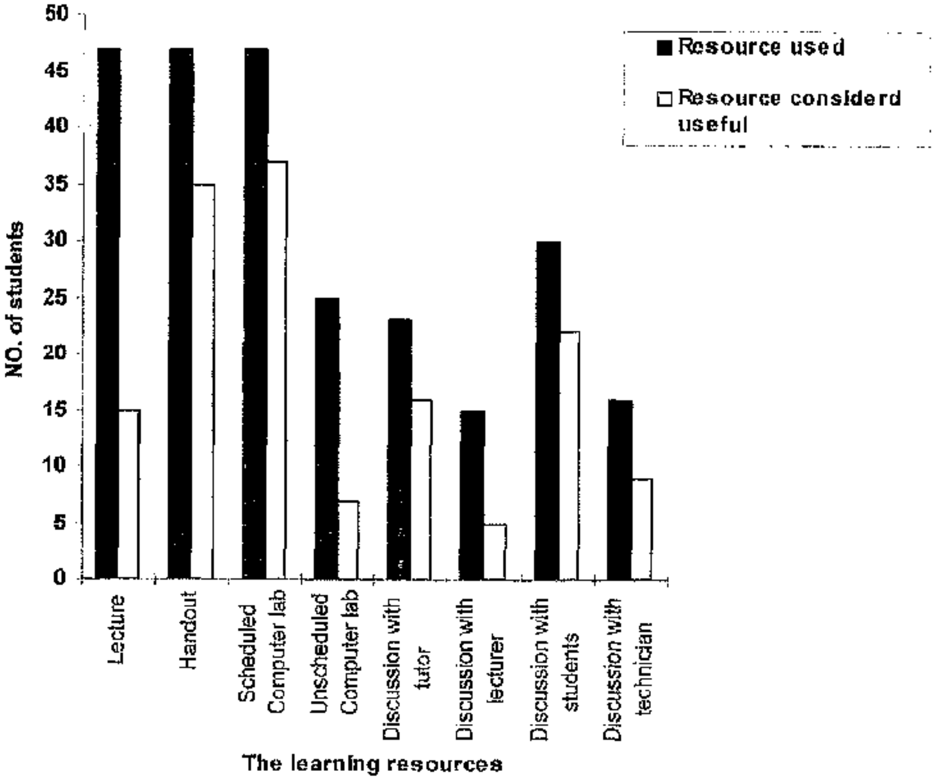
APPENDIX A

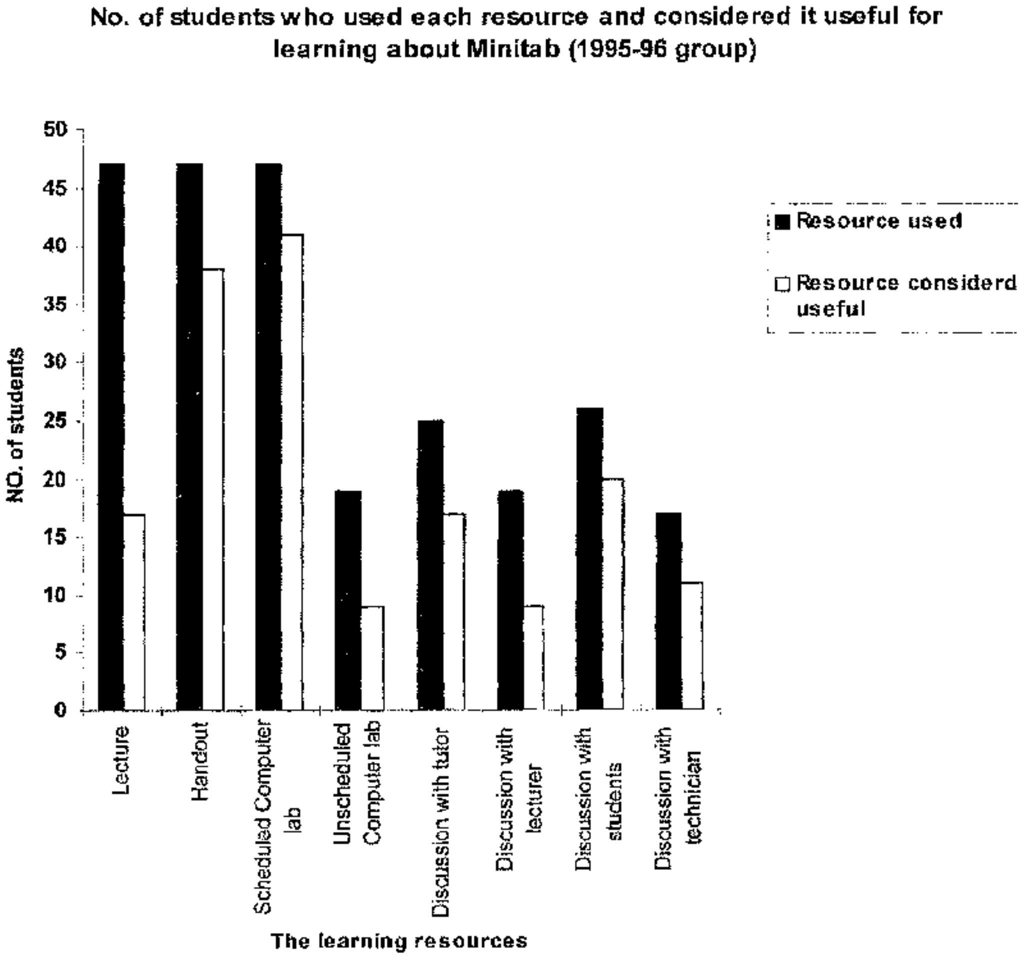
Resources used and considered useful for learning about the five applications covered in the IT course taken in the Geography Department (Glasgow University)


No. of students who used each resource and considered it useful for learning about GIS (1994-95 group)
NO. of students
50
45
40
35
30
25
20
15
10
5
0
Lecture
Handout
Scheduled Computer lab
Unscheduled Computer lab
Discussion with tutor
Discussion with lecturer
Discussion with students
Discussion with technician
The learning resources
□ Resource used
□ Resource considerd useful

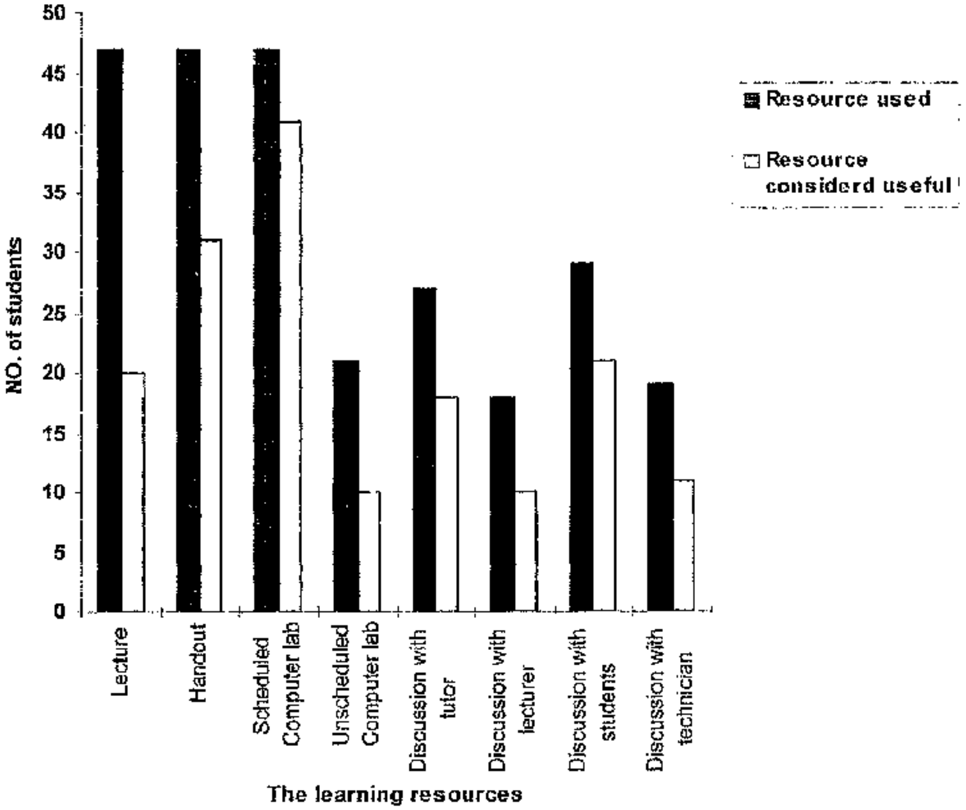

No. of students who used each resource and considered it useful for learning about GIS (1995-96 group)

No. of students who used each resource and considered it useful for learning about Minitab (1994-95 group)

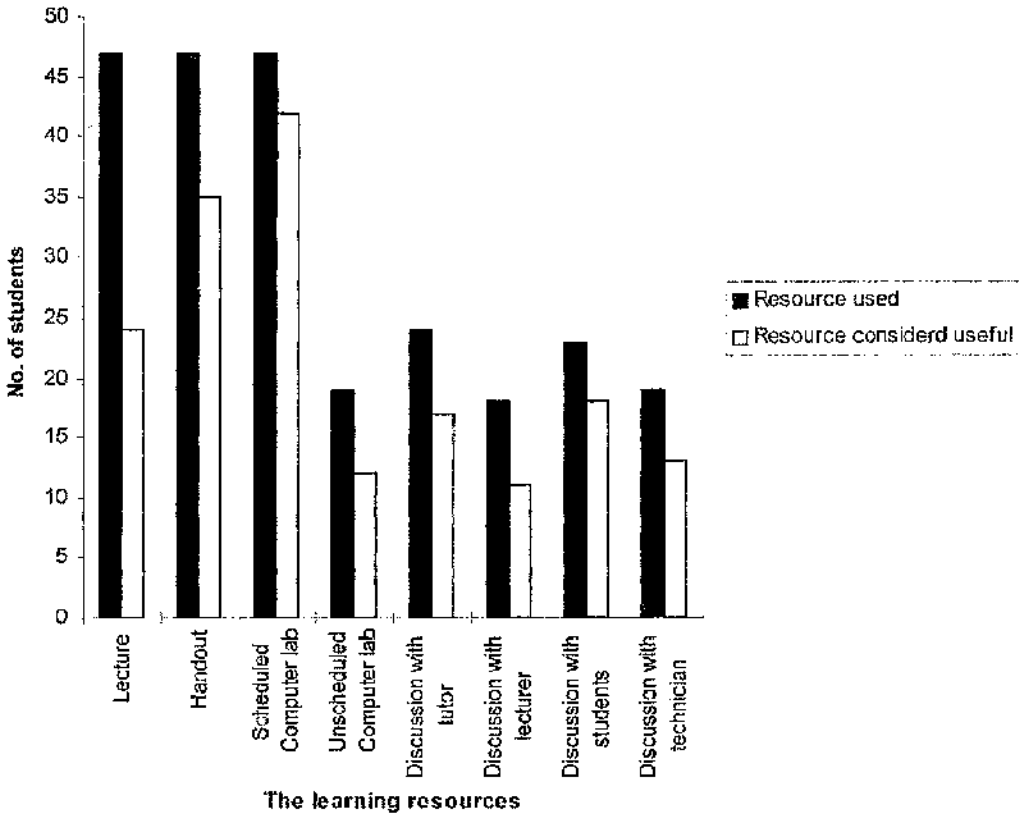




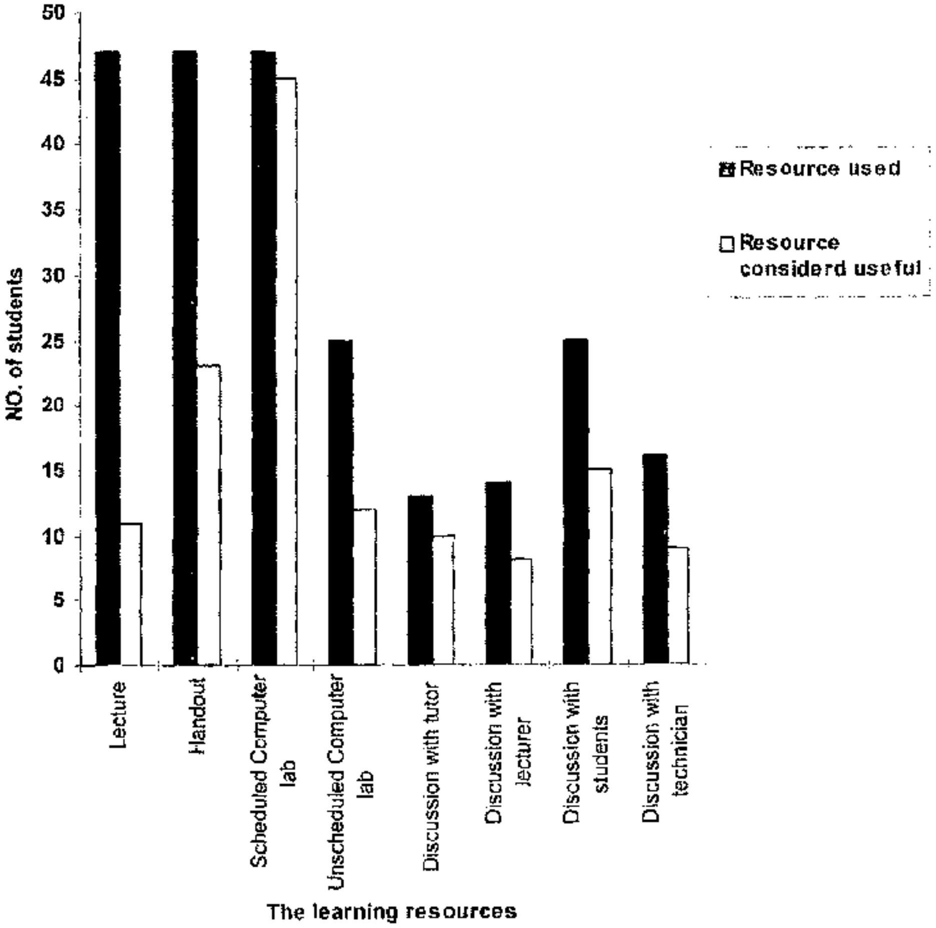
No. of students who used each resource and considered it useful for learning about Minitab (1995-96 group)

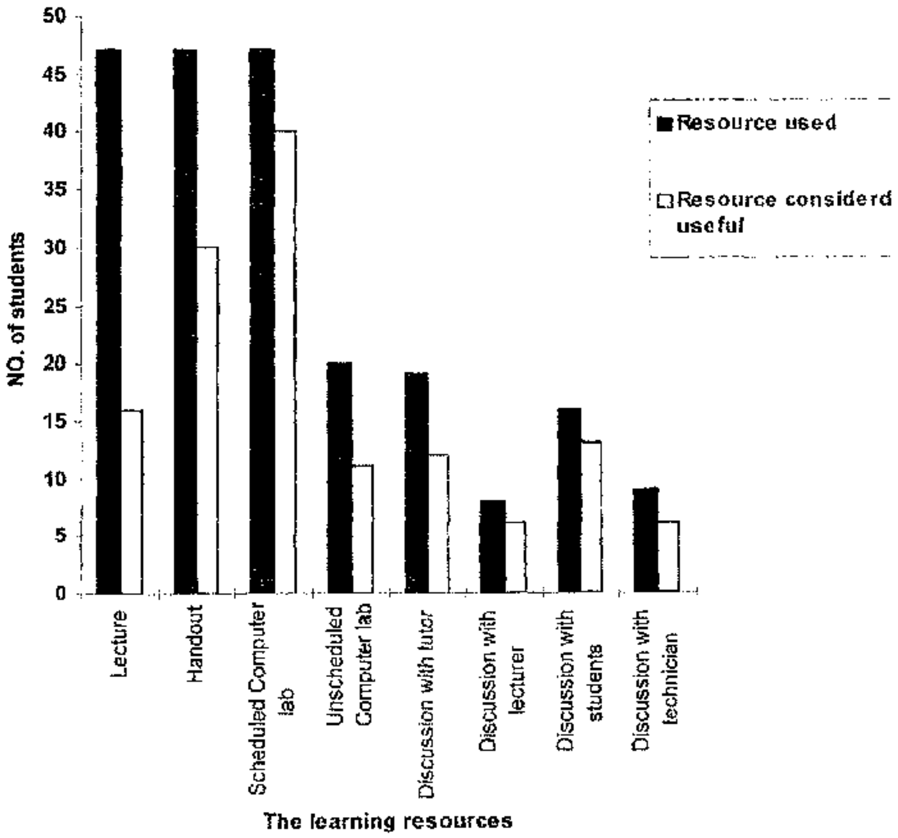


No. of students who used each resource and considered it useful for learning about Excel (1994-95 group)


No of students who used each resource and considered it useful for learning about Excel (1995-96 group)

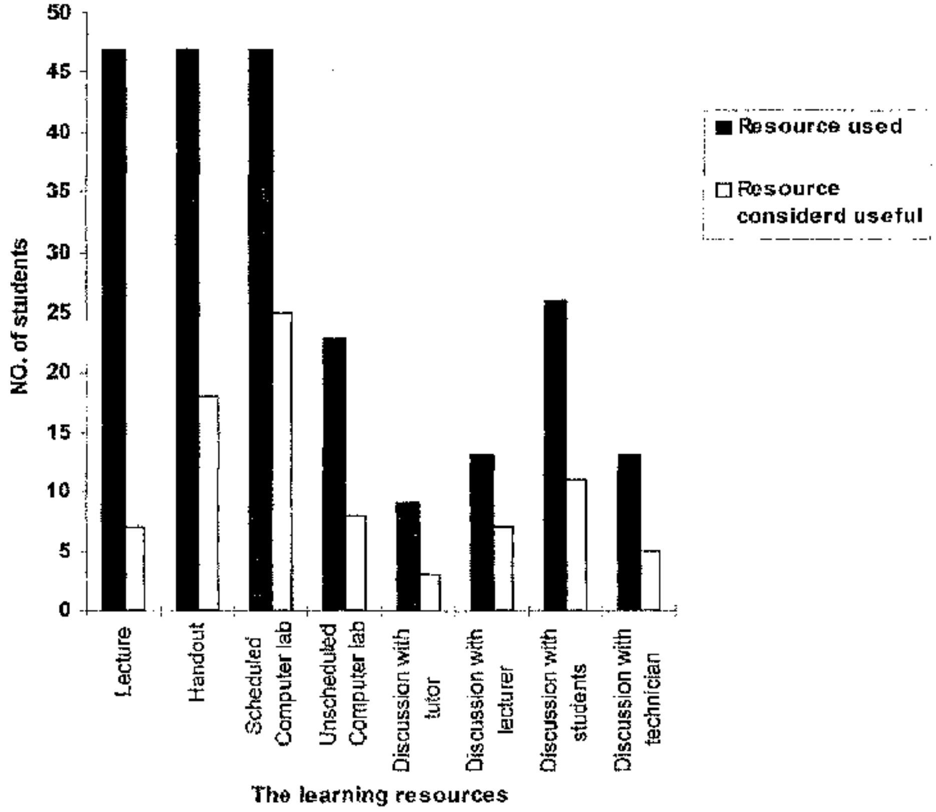
No. of students who used each resource and considered it useful for learning about Write (1994-95 group)



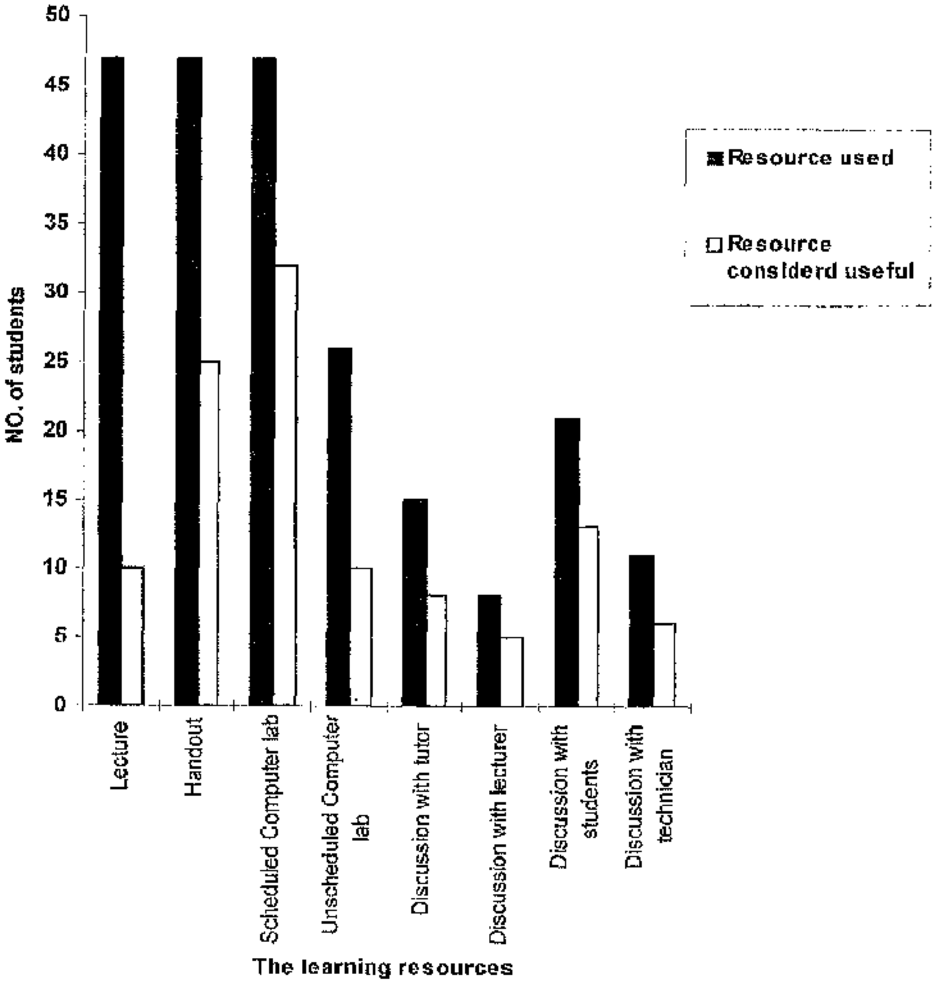


No. of students who used each resource and considered it useful for learning about Write (1995-96 group)

No. of students who used each resource and considered it useful for learning about Netscape (1994-95 group)

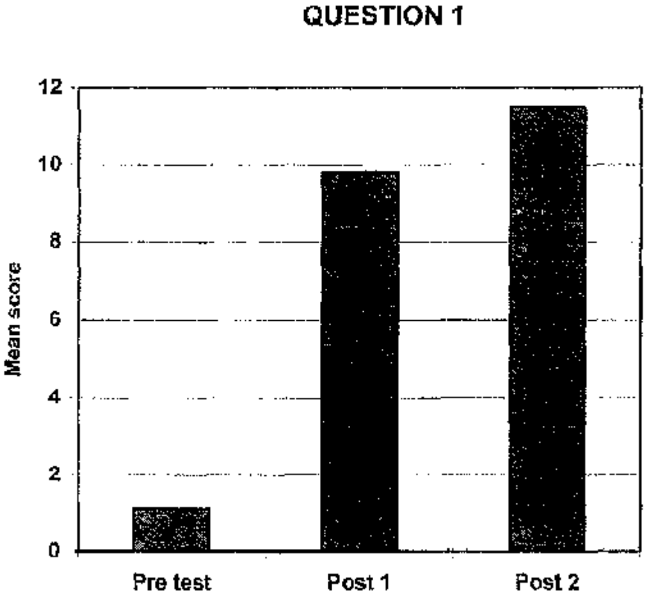


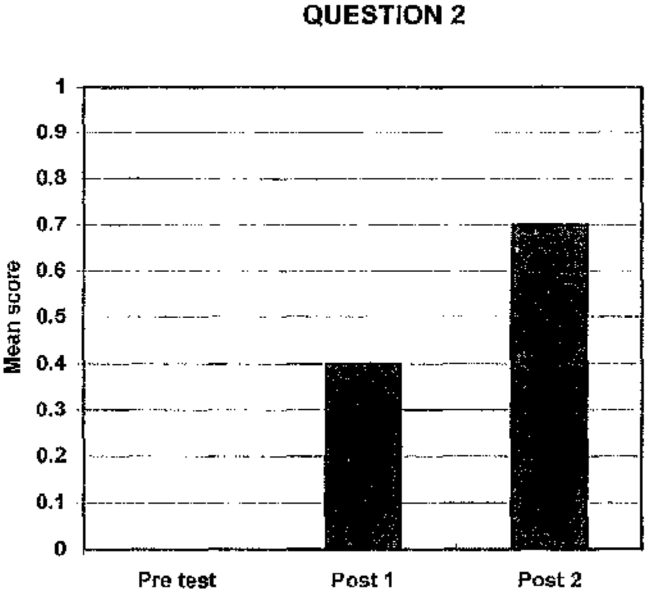
No. of students who used each resource and considered it useful for learning about Netscape (1995-96 group)



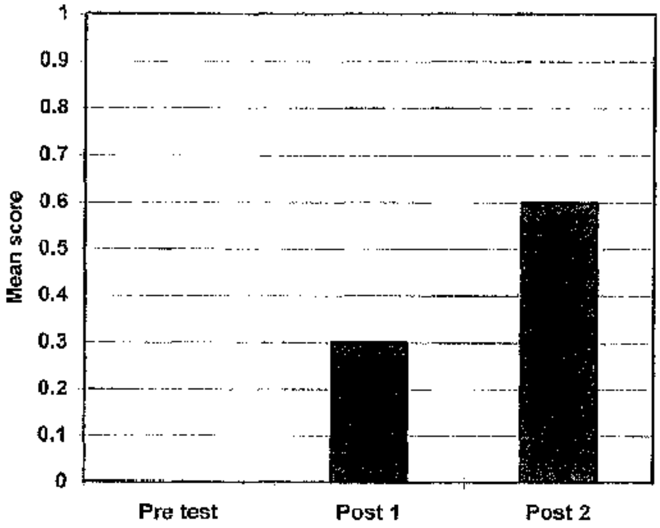
APPENDIX B

The mean score for each question in each of the three tests given to pupils in Study 1

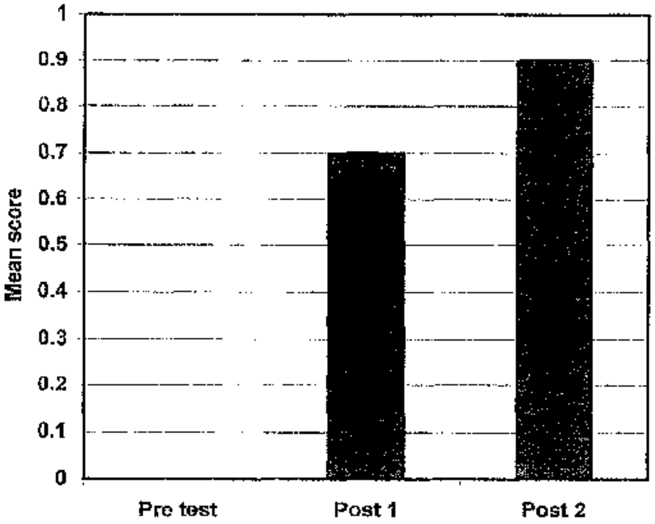

QUESTION 1
Mean score
12
10
8
6
4
2
0
Pre test
Post 1
Post 2

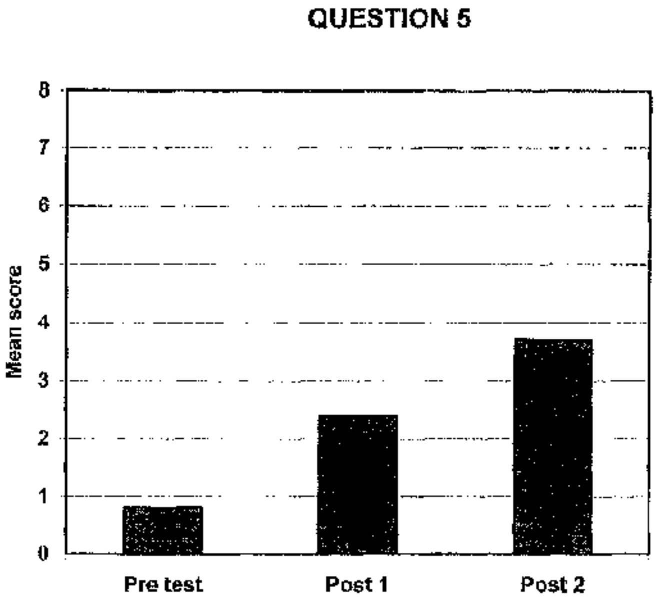

QUESTION 2
Mean score
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pre test
Post 1
Post 2

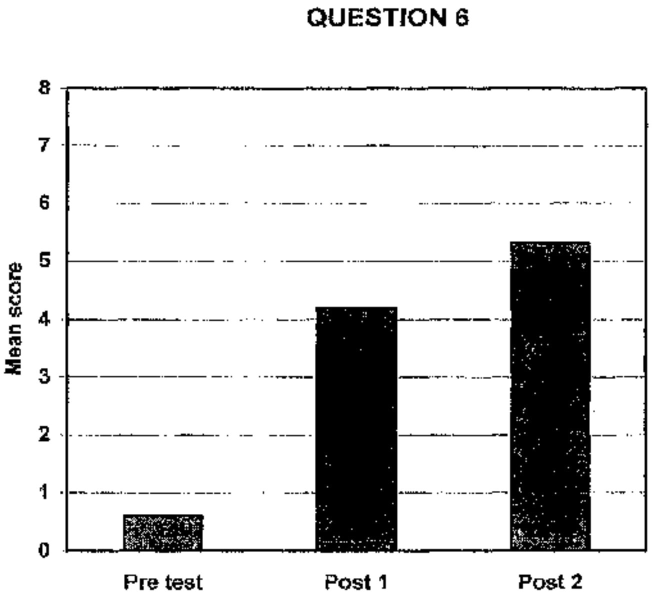
QUESTION 3

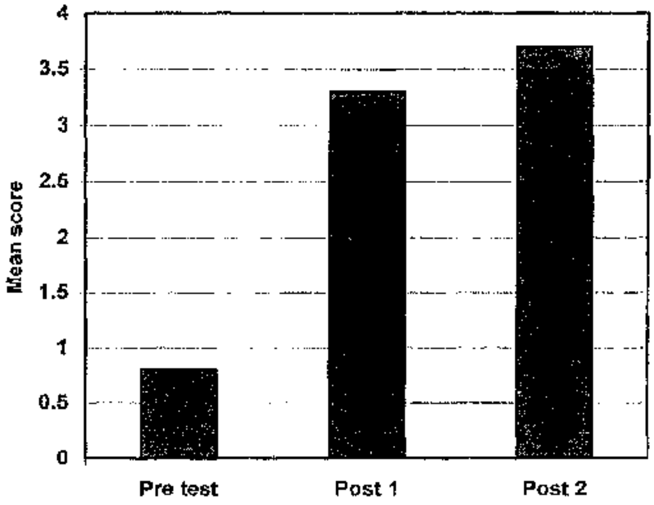


QUESTION 4

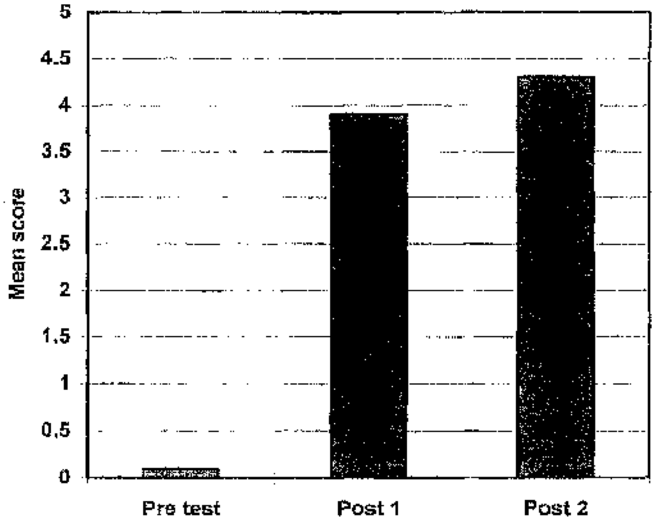



QUESTION 5
Mean score
0
1
2
3
4
5
6
7
8
Pre test
Post 1
Post 2


QUESTION 6
Mean score
0
1
2
3
4
5
6
7
8
Pre test
Post 1
Post 2



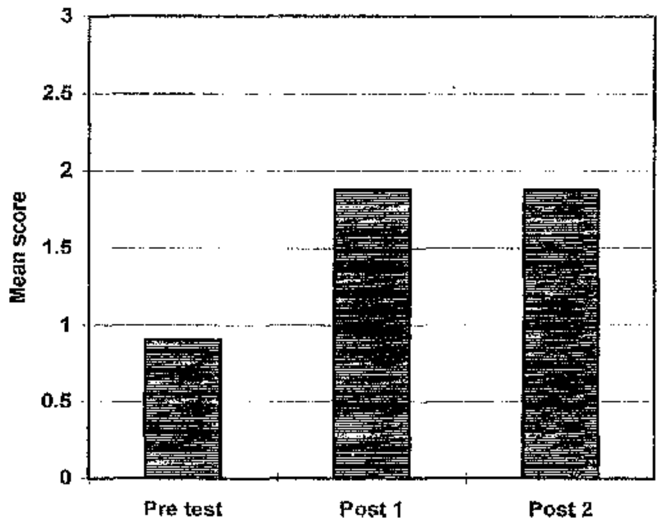
QUESTION 7



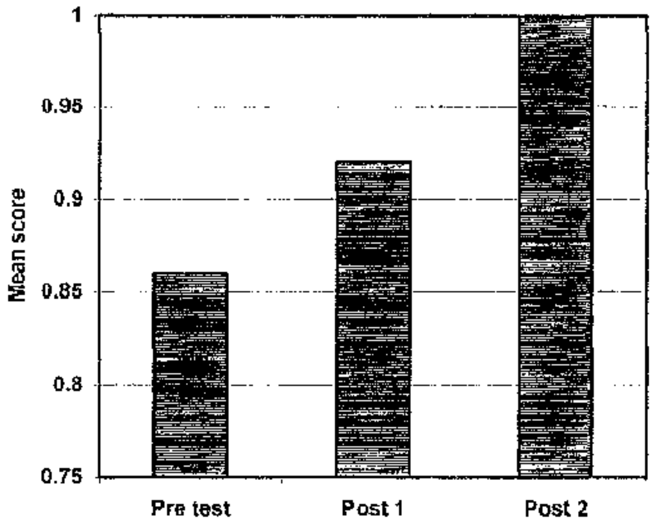
QUESTION 8

APPENDIX C

The mean score for each question in each of the three tests given to pupils in Study 2

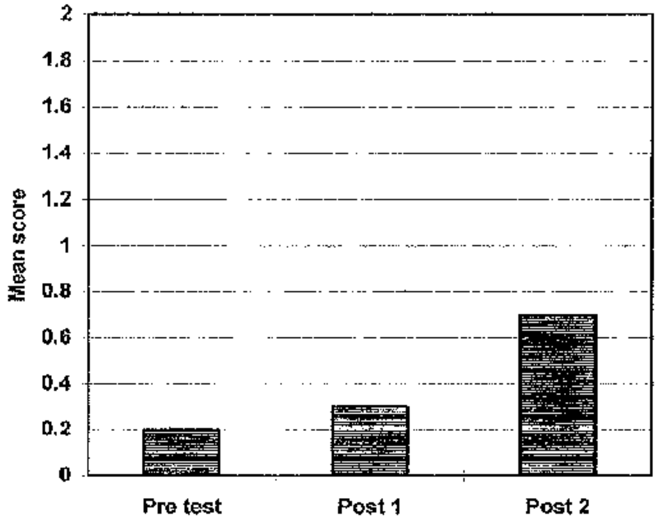


QUESTION 1

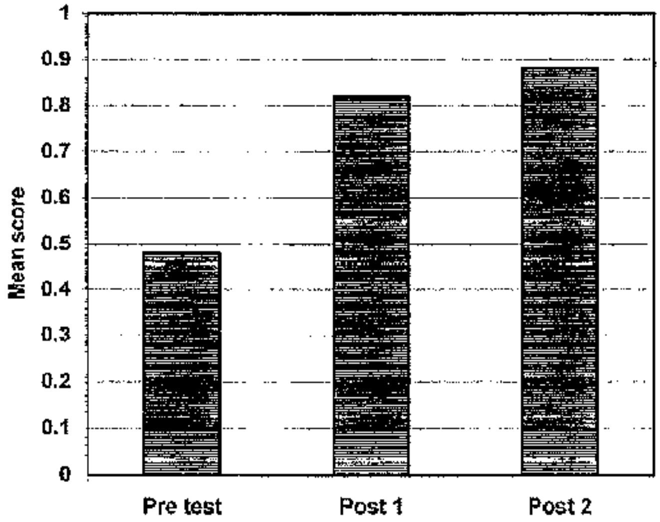


QUESTION 2

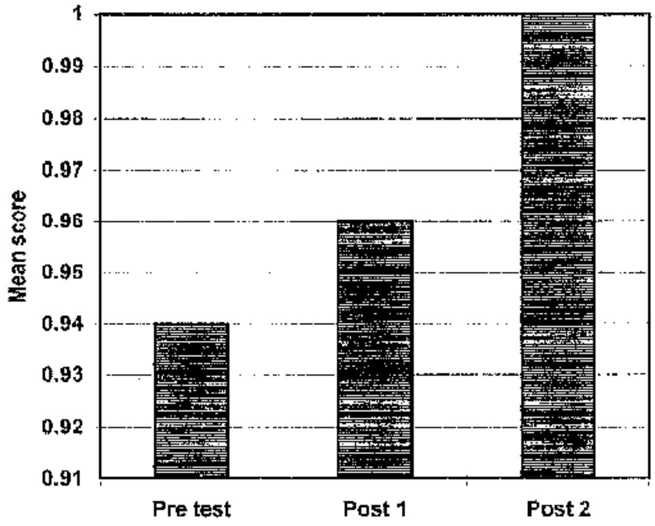
QUESTION 3



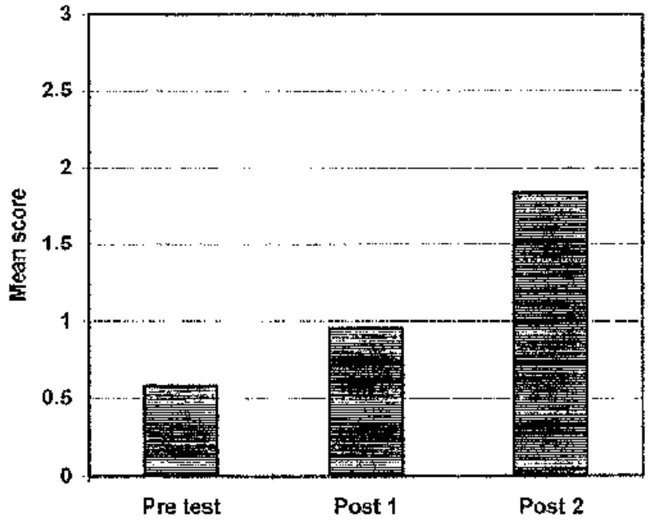
QUESTION 4



QUESTION 5



QUESTION 6



APPENDIX D

Learning Resources Questionnaire
and Confidence Log
(Study 3)

Learning Resources Questionnaire

Matriculation No: -------------------------

The following questionnaire is only concerned with the learning resources that are actually available to you during your course on IT.

What are learning resources?

Learning resources are anything you use to help you to learn/understand a topic. There are a variety of learning resources from lectures and textbooks to your discussion about the subject with other students on the course. The resources are listed in the tables overleaf.

This questionnaire covers the following applications:

- GIS (Geographical Information Systems)
- Minitab
- Excel
- Write
- Netscape

Thank you for your participation in this study. All information I gather is confidential - no individual student is ever identified in studies of this type. Please take your time and consider each question carefully.

Usefulness of Resources for GIS

In the following table, tick each resource you have used on GIS. Tick howUseful you consider each was to you in learning and understanding GIS. Please give reasons for your answers.

Resource	***Tick if used***	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**	**Reasons**
Lectures							
Handouts							
Scheduled computer lab							
Unscheduled computer lab							
Discussion with tutor							
Discussion with lecturer							
Discussion with students							
Discussion with technician							

Usefulness of Resources for Minitab

In the following table, tick each resource you have used on Minitab. Tick how useful you consider each was to you in learning and understanding Minitab. Please give reasons for your answers.

Resource	*Tick if used*	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**	**Reasons**
Lectures							
Handouts							
Scheduled computer lab							
Unscheduled computer lab							
Discussion with tutor							
Discussion with lecturer							
Discussion with students							
Discussion with technician							

Usefulness of Resources for Excel

In the following table, tick each resource you have used on Excel. Tick how Useful you consider each was to you in learning and understanding Excel. Please give reasons for your answers.

Resource	***Tick if used***	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**	**Reasons**
Lectures							
Handouts							
Scheduled computer lab							
Unscheduled computer lab							
Discussion with tutor							
Discussion with lecturer							
Discussion with students							
Discussion with technician							

Usefulness of Resources for Write

In the following table, tick each resource you have used on Write. Tick how useful how useful you consider each was to you in learning and understanding Write. Please give reasons for your answers.

Resource	**Tick if used**	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**	**Reasons**
Lectures							
Handouts							
Scheduled computer lab							
Unscheduled computer lab							
Discussion with tutor							
Discussion with lecturer							
Discussion with students							
Discussion with technician							

Usefulness of Resources for Netscape

In the following table, tick each resource you have used on Netscape. Tick how useful you consider each was to you in learning and understanding Netscape. Please give reasons for your answers.

Resource	**Tick if used**	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**	**Reasons**
Lectures							
Handouts							
Scheduled computer lab							
Unscheduled computer lab							
Discussion with tutor							
Discussion with lecturer							
Discussion with students							
Discussion with technician							

Referring to the list of resources that were available to you, please answer the following questions.

1. If you considered a resource "not at all useful" or "not very useful", what did you do to compensate?

2. Did any of the resources that you have used increase or decrease your interest in learning/understanding the subject?

* Increased YES NO

list them and explain why.

____

____

____

* Decreased YES NO

list them and explain why.

3. Which resources (if any) did you experience difficulty gaining access to during the course?

CONFIDENCE QUESTIONNAIRE

Please complete the following confidence questionnaire. Please indicate, by ticking the relevant box, how confident you feel that you are able to:

Topic	No confidence at all	Little of confidence	Some confidence	Confident	Very confident
transfer data between statistical and word processing packages					
generate graphs using Minitab					
access on-line resource material from the WWW					
describe the main features of (GIS)					
using GIS plus to explore spatial data sets					
produce draft quality summary reports using a basic word-processing					
develop a simple numerical simulation using Excel					
perform a multivariate regression analysis using Minitab					
run pre-programmed numerical simulation programs under Basic					
run computer packages operating on a PC using Windows based software					
input, summarize and graph data using the Excel package					

APPENDIX E

Tests given to pupils in Studies 1 and 2

GEOGRAPHY DEPARTMENT

Weather Unit

Answer the following questions on your answer sheet.

Q1 Complete the table to show all seven Weather Elements and the instruments used to measure them. The first has been done for you.

WEATHER ELEMENT	INSTRUMENT
Temperature	Thermometer

Q2 Name an Air Stream that affects the UK.

Q3 What do you call the line when two Air Streams meet?

Q4 How is air pressure shown on a weather map?

Q5 What kind of weather do you get when,

(a) a warm front passes.

(b) a cold front passes.

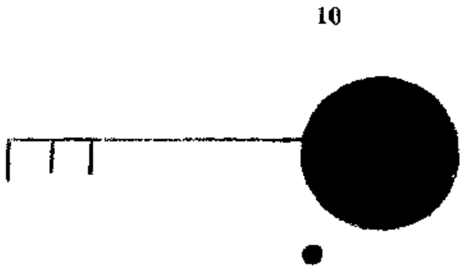
Q6 Describe the weather linked to high pressure in,

(a) summer

(b) winter

Q7 Name 4 ways of collecting weather information to make a forecast.

Q8 What does this weather symbol tell you about the weather at weather station?



JAPAN

These questions are part of a research project on the effectiveness of using computers in Geography lessons. The questions are all about Japan. Please write your name in the space provided.

Name: ------------------------------

1. Name the three largest cities in Japan.

____

____

____

2. Which product is not made in Japan?

(a) televisions

(b) wool

(c) cheese

(d) radios

3. Which is the hottest and rainiest month of the year in Tokyo?

4. Farms in Japan are smaller than farms in the united State of America. Why?

5. Which country has the highest population -- Japan or the United Kingdom?

6. Name 3 countries nearest to Japan.

APPENDIX F

The Test and Post-task Questionnaire
(Study 4)

ANALYSIS OF GLACIAL SEDIMENTS PACKAGE

(EVALUATION QUESTIONS)

This is not a test, but is a series of questions (some of which may focus on material not fully covered in the course) designed for a research project into the effectiveness of IT based teaching in Geography. Your performance will be monitored through the term, but your marks will not be revealed to any member of Geography Department staff at any time. For the research records, please write your matriculation number in the space provided.

Complete ALL of the following. Total time allowed = 10 minutes.
MATRICULATION NUMBER ....

1. Where is the accumulation area of a valley glacier? Circle one answer.
   (a) at its terminus
   (b) in its upper part
   (c) below its surface
   (d) below the firn line

2. What is the classical shape of glaciated valleys? Circle one answer.
   (a) asymmetrical
   (b) V - shape
   (c) U - shape
   (d) concave

3. Do cold-based glaciers move primarily by sliding over their beds?....

4. Which of the following words describes the ways in which warm based glaciers erode their beds? Circle one or more answers.
   - (a) abrasion
   - (b) corrasion
   - (c) attrition

5. What strength of fabric would you expect to find in a melt-out till?
   - (a) week
   - (b) steeply dipping
   - (c) strong
   - (d) poorly developed

6. Circle those part(s) of the glacial land system where glaciatectonic deformation occurs.
   - (a) supraglacial
   - (b) subglacial
   - (c) englacial
   - (d) proglacial
   - (e) fluviglacial

7. Circle those of the following which help to define the term *flow till.*

   (a) angular sediment

   (b) re-sedimented till

   (c) river transported till

   (d) melt-out till

   (e) gravity sedimentation

   (f) sub-glacial deposit

   ----

8. You are given a sample of well rounded particles of a wide range of sizes, mostly aligned in one direction. Why does the sample look like this?

9. A 10m deep hole is to be dug outside the university library. Explain what materials you would expect to find in this hole?

POST TASK QUESTIONNAIRE

Through your study of glacial sediments, three learning methods have been used i.e. the lectures, the physical lab and the CAL package. We would like to determine the importance to the student of each of the methods, and also how each contributed to the students' overall understanding of the subject. Please answer each question accurately. All information gathered is confidential. For the research record, please write your matriculation number in the space provided.

MATRICULATION NUMBER ----------------------------

1. As a learning experience, how do you rate the following:

	Worthless	**Of little value**	**Worthwhile**	**Very valuable**	**Outstanding**
LECTURE					
LAB					
CAL					

2. If you considered the lecture, the physical lab or the CAL package to be "outstanding" or "very valuable", please give reasons.

Lecture --
Physical lab --
CAL package --

3. If you considered the lecture, the physical lab or the CAL package to be "worthless" or "of little value", please give reasons.

Lecture --
Physical lab --
CAL package --

4. What did you find each one most useful for?

APPENDIX G

Post-task Questionnaires
(Studies 1 and 2)
and
Learning Resources Questionnaire
(Study 1)

POST TASK QUESTIONNAIRE (Study 1)

This questionnaire is designed to obtain information on how you felt about the use of computers in learning Geography. Your answers to this questionnaire will be appreciated. Please write your name in the space provided.

Name: ------------------------

1- How would you rate the learning experience using computers in terms of enjoyment?

Enjoyable not enjoyable

2- Do you think the CAL package helped you to learn about the ***Weather***?

Yes No

If yes, please explain. --

If no, please explain. - --

3- How would you rate the computer as a tool to learn about the ***Weather***?

Good poor

4- Would you recommend using the CAL package to other pupils in your school?

Yes No

If no, please explain. ---

POST TASK QUESTIONNAIRE (Study 2)

This questionnaire is designed to obtain information on how you felt about the use of computers in learning Geography. Your answers to this questionnaire will be appreciated. Please write your name in the space provided.

Name: ------------------------

1- How would you rate the learning experience using computers in terms of enjoyment?

Enjoyable not enjoyable

2- Do you think the CAL package helped you to learn about ***Japan***?

Yes No

If yes, please explain. ---

If no, please explain. ---

3- How would you rate the computer as a tool to learn about ***Japan***?

Good poor

4- Would you recommend using the CAL package to other pupils in your school?

Yes No

If no, please explain. --

LEARNING G RESOURCES QUESTIONNAIRE

Name -----------------------------

In the following table, a number of learning resources are listed. Tick how useful you consider each was to you in learning/understanding the Weather.

Resource	**Not at all useful**	**Not very useful**	**Useful**	**Very useful**	**Extremely useful**
Computers					
Radio/Audio					
Textbook					
OHP					
Slides					
Oral teaching					
Discussion with pupils					

Referring to the list of resources that were available to you, please answer
the following questions:

1. If you considered a resource "not very useful" or "not at all useful" what did you do to compensate?

2. Which resources in your opinion increased your interest in learning/ understanding the Weather? Please list them.

----

3. Which resources in your opinion decreased your interest in learning/ understanding the Weather? Please list them.

----

5. Which resource (if any) did you experience difficulty gaining access to?