Investigating computer-supported collaborative learning from an affective perspective

Thesis

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Investigating computer-supported collaborative learning from an affective perspective.

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Abstract

Recent research on computer-supported collaborative learning has an emphasis on cognitive factors and experimental studies. However there are contradictory findings and disagreements about the mechanisms underpinning collaborative learning. In this thesis, computer-supported collaborative learning situations are assessed with an emphasis on the affective factors, students' perceptions and aspects of the learning situation that learners themselves find important.

Three empirical studies were conducted to highlight some of these factors. The first study investigated 11 individuals and 22 pairs of students in a secondary school using a computer to fill in a worksheet about chemistry. The second study examined 61 psychology undergraduates working collaboratively at a summer school. The third study followed a group of three primary school children working collaboratively on a dynamic document in science.

The first study found differences between individuals and pairs in terms of on-task performance but no differences between them in terms of pre- to post-test gain. It also showed the importance of affective factors to students. The analysis of videotapes showed changes over sessions and developments over time in students' collaborative interactions. The affective findings from the first study were supported by the results of the second study which showed that the majority of students thought that it was more important to get along with their peers than to succeed in the task. In the third study, temporal features of the interaction were analysed in a longer-term collaboration.

A number of different methodologies were used in the studies and issues concerning pre- and post-testing and the use of naturalistic and experimental studies are discussed. Time-based analyses are carried out on approximately 26 hours of videotapes of collaborative interactions and these show developments in patterns of interactions.

The thesis supports Ames' (1984) view that a moral dimension is important in collaborative learning, with findings showing that the majority of students think that it is more important to get along with their peers than to get the correct answer, with this being particularly pertinent for women. Together these studies show that both the task structure and the way in which collaboration is resourced has an impact on the products, processes and outcomes of collaborative interactions.

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Chapter 1

Introduction

1.1 Aim of thesis

The aim of this thesis is to investigate students working in computer-supported collaborative learning in a variety of contexts, with a view to illustrating how affective aspects influence learning.

There has been relatively little emphasis in research on affective aspects of working with computers and assessing the efficacy of computer-based learning situations, cognitive criteria have been at the fore. This thesis is concerned with how students feel when they work with computers, especially when they are working with a partner. Additionally, the influence of the role of the computer on the students' perceptions and the outcomes of the learning situation is examined. This thesis presents three empirical studies which investigate computer-supported collaborative learning, from a broader perspective, incorporating affective aspects, and temporal analyses of collaborative interactions.

1.2 Motivation for the thesis

My original intention was to investigate how to incorporate social and motivational information into a computer-assisted learning (CAL) environment for chemistry.

On reviewing the area, it soon became apparent that there was relatively little previous research, except for studies about the motivational effects of software design factors, into the social and motivational factors that affect students when working with computers. However, in order to try to incorporate social and motivational information into computer systems it is necessary to understand what occurs around the computer, from an affective perspective.

The research therefore shifted in emphasis and the aims were widened to investigate the affective (as well as the cognitive) aspects that surround the collaborative use of computers.

1.3 Computer-supported collaborative learning

The increasing focus on computer-supported collaborative learning over recent years has led to a large body of research on the mechanisms and outcomes of computer-supported collaborative learning. Much of this research uses an experimental approach. This thesis extends the typical concern with cognitive outcomes by investigating the affective experience of the students. It also extends the methods so that both experimental and naturalistic studies are used to provide valuable insights into the impact and nature of collaborative activities.

Some writers draw a distinction between these. For example, Damon and Phelps (1989) claim that there are three major approaches to peer-based instruction: peer tutoring, cooperative learning and peer collaboration. These approaches differ both in terms of the way that arrangements organise and encourage students' interactions, in the compositions of their learning groups and in the curriculum material upon which they focus, as well as in the quality of peer engagements that they tend to foster. However, I believe that all group learning situations at computers comprise elements of tutoring, collaboration and cooperative learning and it is neither possible nor useful to separate these features of the interaction. Therefore, in this thesis, collaboration and cooperation (and their derivatives) will be used interchangeably to refer to any situation in which students are working together on a task.

Collaborative CAL essentially refers to two distinct types of collaborative activities: co-present and distance. A rapidly expanding domain is distance collaborations, where students work together at a distance, with their own computers, linked via a telephone line. The alternative is when more than one student shares a single computer, working alongside one another. This thesis investigates side-by-side collaborations in which the students share computers.

Research has been conducted on the affective aspects of collaborative learning in educational settings without computers much of which consists of long-term naturalistic studies e.g. Ames' (1984). However, most of the relevant research has been experimental. Carrying out naturalistic research on computers in education has been difficult, because there was relatively little computer-supported collaborative learning occurring naturally in British educational institutions, although it is now increasing at a rapid rate. Additionally, it is difficult to define the affective criteria that are pertinent.

Given this change in emphasis, the following broad research questions were developed.

1.4 Research questions

1. What is the nature of students' collaborations with/around the computer? Does the computer aid collaboration? What role does the

computer play? How does this impact on the nature of the students' collaborations?

It is important to document and understand the nature of students' collaborations when using computers. However, the computer can be used in a variety of ways and therefore take on different roles in the collaboration. The students may be using the computer for a variety of purposes. For example, the computer may act as a teacher, or an information provider, or as a tool. The role of the computer will have an effect on the nature of the students' interactions. This is discussed in more detail in Chapter 2.

2. How can we study and assess effective computer-supported collaborative learning?

It is important to investigate effective computer-supported collaborative learning (see Chapter 2). However, it is not clear which are the relevant factors that need to be considered when investigating *effective* collaborations. There is a variety of perspectives from which computer-supported collaborative learning can be researched and it is necessary to determine which is the most useful of these to adopt. These issues are considered in Chapter 4.

3. How do students feel about using computers in a learning context? What effect do computers have on students' feelings and perceptions when used in a learning situation? Which aspects of the interactions are most important to students when using computers for learning?

This set of research questions essentially refers to the affective aspects of learning interactions which are introduced in section 1.6.

1.5 Overview of the thesis

This section describes the structure of the thesis. It is necessary to review literature on computer-assisted collaborative learning and literature pertaining to the affective aspects.

Chapter 2 presents the current research situation. The reasons for studying collaborative computer-assisted learning are discussed, along with current research perspectives, paradigms and tools. Four perspectives on computer-supported collaborative learning are discussed.

Chapter 3 reviews recent studies of collaborative learning. The studies are discussed in terms of the nature of the learning situations that are researched and the nature of the analysis. A discussion of the interaction between the research methodologies and the results follows, and a set of research guidelines are then proposed.

Chapters 4, 5 and 6 report on three empirical studies of computer-assisted collaborative learning. They can be considered exploratory, in the sense that the aim was to explore the affective aspects of computer-based collaborative learning, in conjunction with the cognitive aspects. The settings of these studies range from primary school through secondary school to mature undergraduate students. Although the studies span a range of ages, the thesis does not investigate age-related differences.

Secondary School Study

Chapters 4 and 5 report the results of the main study. This aimed to investigate both cognitive and affective outcomes when students use science software in individual and collaborative settings. This study was undertaken in an experimental setting with secondary school students using simple software to learn about the Periodic Table. The study compared individuals to pairs, with two paired conditions. In the first condition, pairs of students shared a worksheet, thereby providing a cooperative task structure. In the other condition, the students had a copy of the worksheet each, creating individual responsibility for each student, but with no cooperative task structure. The students were assessed from an affective as well as cognitive perspective, using questionnaires and their sessions were videotaped. The study incorporated both immediate and delayed cognitive post testing. The results from a cognitive perspective were analysed in terms of the effect of the different conditions and delayed post testing on the cognitive outcomes.

In terms of investigating the affective outcomes, the changes in students' interest, motivation, perceptions of themselves and their peers were analysed. A model of effective learning situations that incorporates both cognitive and affective factors was applied to the data. An analysis of the factors that students found important during the interaction was carried out and aspects of Ames' cognitive-motivational theory of different learning situations were explored.

A selection of the videotapes from the study were analysed using an advanced video analysis tool which allows the researcher to categorise aspects of the interactions and produces summaries and time-based representations of the data. This showed differences both between and within the pairs in terms of the symmetry of their behaviours and the nature and timing of different types of talk.

Two points that emerged from this study were investigated in the second two studies. Firstly, that affective differences do exist and are pertinent to the nature of collaborative computer-assisted learning interactions. This formed the basis of the Summer School study described in the second part of chapter 4. Secondly, that collaborations develop over time, and it is necessary to investigate long term collaborations and the nature of these developments. This formed part of the motivation for the Primary School study presented in Chapter 4.

Summer School study

The second study investigated the affective aspects of groups of distance education undergraduates using computers to complete cognitive psychology projects. It involved investigating, from an affective perspective, students completing four different projects, with varying amounts of computer usage.

Primary School study

The third study investigated longer term computer-supported collaborative learning, with a case study of primary school pupils using a computer to make a multimedia document of the water cycle. The children's behaviour and talk were carefully documented, using observations, video and audio recording.

Chapter 7 discusses the findings of the three studies in terms of assessing learning situations, research methodology, gender differences and the four perspectives introduced in Chapter 3 are revisited.

Chapter 8 reviews the research questions addressed and the extent to which they have been answered. It concludes with a discussion of the contributions and limitations of the research and outlines the directions in which the work reported in this thesis could most usefully be continued.

As the thesis focuses on the affective aspects of learning interactions, these are discussed in the next section.

1.6 Affective aspects

It is necessary to clarify what is meant by affective in this thesis. In this context, it refers to anything pertaining to the emotions. This, in effect, means anything that is not cognitive (in essence, affective is the opposite to intellectual). Examples of affective factors include motivation, attitudes and perceptions.

Obviously this definition incorporates an array of factors, and the different studies presented in this thesis have concentrated on particular affective aspects, pertinent to the situations and the orientation of the study.

The assessment of affective factors in this thesis involved the students' own perceptions. Essentially this involves investigating the students' own evaluations of various aspects of the learning situation. (This includes evaluations of their own and their peers' ability, success and motivation. It also includes their evaluations of how their work affects their relationships.) For example, students were asked to rate their motivation on a five-point scale. The research investigates the students' subjective feelings and perceptions rather than using comprehensive batteries of tests, which are commonly used in collecting data on perceptions, attitudes and opinions. Whilst such a measure does not give an objective measure, of for example, motivation, such measures are not appropriate for the aims of this research in which the overriding concern is with the students' own perceptions. Therefore, throughout the thesis, these results will be discussed in terms of the students' perception of motivation, for example. Weiner (1984), a highly influential theorist in the area states that

> *"A theory of motivation is responsible for examining the experiential state of the organism and the meaning of an action: hence the theory must embrace phenomenology and accept that one acts on the perceived, rather than the real, world.*
>
> *Associated with this position is my belief that many (but not all) of the significant thoughts and feelings are conscious and known by the actor. This is similar to the attitude of Gordon Allport, who stated that the best way to gain information about an individual is to directly ask that person. We may not be aware of psychological processes, such as how we learn, perceive and remember, but we often are quite aware of psychological content (whom we like, why we have succeeded, and when we plan to act)."*
>
> *Weiner, 1984, p. 16-17.*

Chapter 2

Computer-supported collaborative learning

2.1 Introduction

In this chapter research concerning computer-supported collaborative learning is reviewed and the different reasons for studying collaborative learning are discussed. Four purposes for researching computer-supported collaborative learning are identified. The first purpose is to investigate the benefits of collaborations and the situations in which these occur. It is argued that affective outcomes need to be considered in conjunction with cognitive outcomes. Ways in which we can investigate affective factors are discussed and research on computers and motivation is reviewed. Ames' theory of cognitive-motivational factors in different learning situations is presented as an example of an affective theory of collaborative learning. The second purpose of research on computer-supported collaborative learning is to develop theories of collaborative learning and five such theories are discussed. The third reason for computer-supported collaborative learning research is to provide software design guidelines and recent research is discussed. The fourth purpose, providing guidelines for educators, is outlined. After this the two dominant research paradigms are presented and finally, different research tools and the way in which they influence results are discussed.

The next section provides an introduction to computer-supported collaborative learning.

2.2 Computer-supported collaborative learning

Researchers have been studying cooperative learning prior to the advent of computers in classrooms. In particular, cooperative learning has been contrasted with individual and competitive learning situations. Cooperative situations are defined as those in which *"there is a positive interdependence amongst students' goal attainments"* (Johnson and Johnson, 1986, p 13), i.e. students can only reach their required goals if they work with other students, while in individualistic situations, students' goal achievements are independent and students work for themselves. In competitive situations, students' goal achievements are negatively correlated and students compete with one another. When one student achieves his/her goal, the others fail.

Slavin (1983, 1990) reviews much of the research on collaborative learning and distinguishes between cooperative task structures in which heterogeneous groups work in the classroom and cooperative incentive structures, in which students are rewarded and/or assessed in terms of the whole group's performance. There are many different cooperative learning methods, but they all use the basic principles of either or both cooperative incentive and task structures. He claims that the term 'cooperation' refers to four different things:

1. cooperative behaviour, for example, working with others. Here he says that:

> *"cooperative behaviour refers to actual participation and co-ordination of efforts between two or more individuals. The essential ingredient of cooperative behaviour is the attempt of each cooperator to facilitate the task performance or goal attainment of his or her fellow cooperators. This almost always requires co-ordination of efforts between individuals where communication between cooperators is critical."*
>
> *(Slavin, 1983, p. 4.)*

2. cooperative incentive structure, in which rewards are based on the performance of the entire group.

3. cooperative task structure, in which more than one member of the group must participate in the task.

4. cooperative motives:

> *"the predisposition to act cooperatively ... in a situation that allows individuals a choice between cooperative, competitive or individualistic behaviour."*
>
> *(Slavin, 1983, p. 3.)*

However, the presence of cooperative incentive structures, task structures and motives does not guarantee that cooperative behaviour will occur.

Slavin (1983) discusses the many studies that have been carried out comparing cooperative to competitive learning structures since the 1920s. He first considers the effects of cooperation on performance and finds that:

> *"Despite the many studies conducted to find the effects of cooperation on performance, these effects are still rather poorly understood. Four recent reviews completely disagreed on the direction of the effect."*
>
> *(Slavin, 1983, p. 7.)*

Slavin (1983) discusses this in depth, as well as the effects of cooperation on inter-group relations and mainstreaming-related (i.e.

those concerned with integrating previously excluded children) outcomes. Here, the effects of cooperation are more clear-cut.

> *"In general, for any desired outcome of schooling, administer a cooperative learning treatment, and about one-half to two-thirds of the time there will be a significant difference between the experimental and control groups in favour of the experimental groups"*
> *(Slavin, 1983, p ,119.)*

Thus research has shown that cooperation is generally beneficial in terms of inter-group relations and mainstreaming-related outcomes, but the effects of collaboration on performance are not always positive.

Over the past twenty years, there has been an increased focus on computer-supported collaborative learning. There are many reasons to support cooperative computer-based learning as Johnson and Johnson (1986) point out:

> *"The use of computer-supported cooperative learning overcomes many of the instructional limitations of computer-supported individualistic learning. The isolation, the lack of oral explanation and elaboration of the information being learned, the lack of social models, the impersonality of the reinforcement and feedback, the lack of creative and divergent thinking, and the lack of peer accountability existing in computer-supported individualistic learning activities all are reversed in computer-supported cooperative learning activities. The technology of computers and the interpersonal interaction promoted by cooperative learning provide complementary strengths. It is a partnership that maximises the advantages of instructional strategy."*
> *(Johnson and Johnson, 1986, p. 18.)*

However, the results of this research in relation to achievement, are not always clear-cut. Findings are mixed in relation to computer-based instruction (Del Marie Rysavy and Sales, 1990) and O'Malley and Scanlon (1990) discuss this in relation to problem solving in physics:

"However, the overall experimental evidence concerning the effects of cooperative activity on individual learning and development is somewhat equivocal. Benefits appear to be dependent on a number of task-specific factors; research findings are not always replicated; and researchers are divided about the underlying mechanisms responsible for cognitive change."

(O'Malley and Scanlon, 1990, p. 128)

There are many factors which affect the nature and outcomes of collaborations. The nature of the task will obviously have an influence on the collaboration and this will be affected by the role that the computer plays.

O'Malley (1992) describes three main roles for the computer in cooperative learning:

1. learning around the computer - the computer is a catalyst or object for reflection on some joint activity.
2. learning through the computer - the computer supports communication e.g. conferencing
3. learning mediated via the computer - the computer is seen as a 'tool which *augments* collaborative learning, supporting not only communication but also *joint activities* in some particular way.' The most extreme example of this is the computer as a collaborator in the interaction i.e. when the computer is explicitly a member of the pair or the group which is collaborating (see Dillenbourg and Self, 1992).

This distinction concerning the different roles that computers can play deserves attention and is an aspect explored in this thesis, as discussed in Chapter 1, section 1.4. O'Malley's taxonomy can be extended because the computer can have different functions within the roles that she describes. For example, when students are learning around the computer, the computer can act as a resource, providing information. It can act as a tool, as for example in word processing or as an environment within which students can experience a microworld. The role that the computer plays will have differential effects on the nature and outcomes of the collaborations.

As we have seen (e.g. Slavin, op. cit. and Del Marie Rysavy, op. cit.) findings on the effects of cooperative learning on performance and achievement have been equivocal. In research on collaborative CAL some studies have found that collaborative learning has enhanced achievement, there have been studies in which learning is not enhanced, and recently, a study in which peer interaction inhibited learning. Successful collaboration was found by Blaye et al. (1991) who found on a planning task that children working as pairs were more likely to succeed than children working alone. In contrast, Messer et al. (1992) found that peer interaction did not facilitate learning on a balancing task, and in fact, inhibited learning. Salomon and Globerson (1989) discuss reasons for cooperative learning failures in particular, when participants as a consequence of group working, reduce their individual mental effort.

This section has given a broad overview of the results of research on computer-supported collaborative learning and discussed the reasons for carrying out these types of studies. In general, there is evidence for enhanced learning from computer-supported collaborations, but this is not always the situation. In the following section, the reasons for studying computer-supported collaborative learning are discussed.

2.3 Why study computer-supported collaborative learning?

The focus on studying computer-supported learning when there is more than one student at the computer has arisen for several reasons, both pragmatic and pedagogical. From a pragmatic perspective, the majority of schools cannot afford to have one computer per student owing to the high cost of hardware and software and lack of funding. Therefore there is limited access to computers for children in schools which has led to a focus on groupwork at computers. In addition, Slavin's reviews (1983, 1990) showed that in traditional classroom studies, researchers have found that cooperative learning can have positive outcomes both in terms of achievement and non-cognitive measures, although the mechanisms and effects in relation to performance are still poorly understood. Some studies of computer-based cooperative learning have found that, in certain structured situations, learning may be enhanced when there is more than one student working at the computer (for an overview, see Light and Littleton, 1994). Teachers seem to value computer work as socially beneficial (Jackson et al., 1986). An additional appeal of computer-supported cooperative learning is that it reintroduces a social component to learning, which many people fear may be diminished by the use of computers for education (especially if computers are seen as a form of individualised tuition).

In the next four sections, four principle reasons for researching computer-supported collaborative learning are discussed. These are: investigating the benefits of computer-supported collaborative learning, determining the mechanisms of collaborative learning, software design and educational guidelines.

2.4 Investigating the benefits of computer-supported collaborative learning

Probably the main purpose of studying collaborative learning is to determine the benefits to students of collaborative learning. This has largely, especially in terms of computer-supported collaborative learning, been interpreted in terms of cognitive outcomes. Therefore, research has investigated whether students working individually learn more than those in pairs or in groups, or how the nature of groupings and task structure affect cognitive outcomes. However, there is a significant body of research which has shown that there are other outcomes from collaborative learning. When discussing outcomes other than achievement in the relevant task, Slavin (1983, 1990) points to the positive effects created by cooperative learning on inter-group relations, the mainstreaming of handicapped students, self-esteem, time on-task and classroom behaviour, liking of class and liking classmates and feeling liked by classmates. There are two different types of benefits that can be expected from collaborative learning: cognitive and affective. The important affective outcomes in terms of computer-supported collaborative learning need to be considered.

2.4.1 Investigating affective factors

There are a multitude of positive affective outcomes one could suggest as a requirement for an effective learning situation. The required outcomes are often intertwined and may apply only to particular situations. However, for our purposes, it is prudent to focus on specific aspects.

For the individual, it is an appropriate social goal to ensure that they retain an adequate perception of themselves in terms of their ability, that they retain their motivation and interest, that they perceive any success which may have occurred and that the factors that are important to them are satisfied. It is important that they retain a sense of their own ability in order to ensure that they have confidence for future learning. It is obviously important for them to retain their interest and motivation for their future learning. They also need to feel that they have been successful for their confidence levels.

In considering affective factors associated with computer-supported learning, there can be no doubt that when people use computers, they often exhibit behaviour that is interpreted as motivated. However, the affect of using computers on people's motivation is unclear. Children spend hours playing computer games and programmers often lose track of time when trying to solve implementation problems. These occurences are often cited as evidence for the motivating effects of working with computers. Computers offer a number of features such as interactivity, feedback, graphics capability and sound which enable them to be used for activities that are particularly motivating. Conversely, many people are scared of computers which are often perceived as stressful and anxiety producing. There is not yet a clear idea of the factors which influence learners' motivation towards (or away from) learning activities which involve the computer in some way.

In relation to education, the aim should be to capture the enhanced motivating effects and harness this to improve the educational efficacy of computers in classrooms. However, relatively little research has been carried out into what it is about working with the computer that motivates the students and how this affects the learning process and learning outcomes (see Lens, 1992). Much of the research on computers in education has involved pre-testing and post-testing students' ability where investigators have focused on the change in a student's ability or knowledge using these tests, often making vague and anecdotal claims about affective outcomes. There has been very little research on how psychological factors, like motivation, are affected when students learn from the computer.

2.4.2 Computers and motivation

As Malone and Lepper (1987) point out:

> *"Over the past 2 decades, great strides have been made in analysing the cognitive processes involved in learning and instruction. During the same period, however, attention to motivational issues has been minimal."*
> *(Malone and Lepper, 1987, p. 223.)*

If the use of computers in learning contexts is motivating students in some special way, then we can use this to help us to define tasks for computer use and in designing programs so as to create situations in which motivation is at a maximum and the amount of learning increases. This research could also aid teachers in setting up optimal situations in which students should learn from the computer. A study of motivation may also help us understand the learning processes and outcomes which occur when students learn from the computer.

Some research on computers and motivation has been carried out from the instructional design perspective, and focuses on how to make teaching programs more motivating to students. Variables which affect motivation can be systematically manipulated and studied.

> *"The computer provides a common context in which the concepts and principles developed within several historically distinct research traditions can be systematically and simultaneously studied."*
> *(Lepper and Malone, 1987, p. 258.)*

Keller (1983) proposes a systematic, theory-based approach to designing motivating instruction. He identifies four major dimensions of motivation:

1. interest - how curious the learner is and whether or not this curiosity is sustained.
2. relevance - the learner's perception of personal need satisfaction.
3. expectancy - the perceived likelihood of success.
4. satisfaction - the combination of extrinsic rewards and intrinsic motivation.

He describes strategies which can be used to enhance these dimensions of motivation and conditions under which these strategies should be used. This is used as the basis for the ARCS Motivation Model, Keller (1984) which describes four general requirements (attention, relevance, confidence and satisfaction) which need to be met in order for people to be motivated to learn. There are practical strategies for achieving these requirements. Keller (1987a and 1987b) describes the research that supports his theory and explains what steps to follow in producing motivational design and how these steps interface with instructional design.

Bohlin (1987) compares Keller's ARCS model with Markova et al's (1986) model for the design of motivating instruction. The Keller model has already been described. The model proposed by Markova et al. specifies a sequence of three stages of instruction for effective development and promotion of motivation. The motivational phase is designed to show the student the importance of the area being studied. The operational-cognitive phase is the period in which the student assimilates the required knowledge. In the introspective-evaluative phase, the student reflects on his/her learning. There are specific strategies that enhance motivation during the three phases. There are four categories of strategies: material, activities, group work and evaluation. Activities are used during all the stages, while motivational materials are concentrated in the first stage, group work in the second stage and evaluation in the third stage. Bohlin found that the two models are very similar, with three common areas: interest, relevance and satisfaction and similarities in motivational strategies. However, Keller's theory is more general and therefore allows for more flexibility. Bohlin points out the Soviet view that group work is motivating due to its intrinsically rewarding nature. They believe that group work enhances individual motivation by promoting the effects of peer pressure, role modelling, specialisation of skills to improve personal chances for successful accomplishment and the potentially rewarding nature of group work. Bohlin suggests that the use of role-modelling, relevancy of instruction to the students' own perceived future needs, and involvement of the learner in self-evaluation are the aspects of Markova's model which should be included in the Keller model.

Lepper and Malone (1987) discuss seven processes by which motivational appeal might enhance instructional value or, alternatively produce detrimental effects on learning. They propose a set of general design principles concerning attention, feedback, depth-of-involvement, control, arousal, affect and multiple channels. However, these principles are difficult to implement and they propose some specific principles concerning challenge, curiosity, control and fantasy.

A different approach has been taken by Del Soldato (1991, 1992) who considers design-related aspects of motivating tutoring systems. She discusses implementing theories of instructional motivation in ITSs. She points out that

> *"Even though a broad analysis shows that most ITSs have some implicit motivational theory embedded in the way they interact with learners, more systematic research is need in order to investigate the instructional potentialities of implementing explicit motivational techniques."*
>
> *(Del Soldato, 1991)*

She discusses the motivational concepts of challenge, curiosity, confidence, control and feedback and describes some techniques by which these can be implemented in the student model of an ITS. Her aim is to investigate whether these techniques actually improve instruction. She also addresses the need to detect the student's motivational state and react in order to motivate the student or sustain already motivated students. Her techniques appear to be domain independent and rely on many features of the tutoring system.

However, as previously discussed, these types of approaches do not focus on the student, and do not focus on the effects of working collaboratively. In the next section, ways in which motivation in the context of computer-supported collaborative learning can be investigated, are discussed.

2.4.3 Investigating motivation

As we saw, much of the research on the motivational aspects of using computers in education has focused on the instructional design aspects. This is undoubtedly important, but neglects the learners, their behaviours and feelings. By focusing on the computer and how it can be programmed to enhance motivation, the learner is virtually ignored. There has been relatively little research into how the learner behaves when learning from a computer. As Keller (1983) points out,

> *"Motivation, by definition, refers to the magnitude and direction of behaviour."*
>
> *(Keller, 1983.)*

Yet, if we are interested in what motivates the learner, we should be looking at the behaviours of students. By disregarding the behaviour of the learner, researchers are ignoring a vital aspect of the interaction from which much can be gained. There has also been little research into what the learner feels when learning from the computer and learners' attitudes towards the computer in terms of motivation. As Stipek (1988) points out, many theorists conceptualise motivation in terms of conscious beliefs and values. They stress the effects of recent experiences in achievement situations and the effects of the immediate environment on individuals' achievement related beliefs. Therefore, one of our primary aims is to investigate students' behaviour and feelings when learning from the computer.

There are many different theories and methods of assessing students behaviour and feelings with regard to motivation in classrooms <u>without</u> computers. These can be used to investigate learning situations with a computer, and used to measure and assess students when they are working with computers. This will help to clarify the reasons for any changes in motivation which occurs when students learn from the computer. In addition, this may provide us with instructional principles for designing and implementing teaching systems and aid us in explaining the learning process and learning outcomes.

However, it is not a trivial task to determine which factors are pertinent and how best to investigate them. Maehr (1982), in a review of literature on motivation relating to the classroom, stresses the difficulties associated with defining and studying motivation and the need to look at motivation-related behaviour:

> *"While folklore would have it that motivation has something to do with inner states of the person - needs, drives, psychic energies, unconscious wishes etc.- that folklore has also confused the issues. As a result, discussion about motivation can be, often unwittingly, discussions about widely disparate problems. For this reason, it is important at the outset to consider more precisely the <u>behavioural patterns</u> which make teachers, researchers, principals and parents <u>think</u> that motivation is involved in a given instance."*
>
> *(Maehr, 1982, p. 5.)*

Maehr (1982) claims that although people refer to a wide variety of behaviours when discussing motivation, much of this relates to five behavioural patterns. He argues that in order to study motivation, we must begin by observing these behaviours and their variations and then try to understand, predict and control them. This can be viewed as a <u>quantitative</u> method of investigating motivation. The behavioural patterns he refers to are:

1. Direction - this refers to the choice a student has between a set of action possibilities. If a student attends to one activity and not another, we infer that he/she is motivated towards that activity.
2. Persistence - observers infer that a student is motivated when the individual concentrates attention on a task for a period of time.
3. Continuing motivation - when a student returns to an activity without external constraint to do so, one infers that the student is motivated towards this activity. This, Maehr claims, is a crucial educational outcome for many educators. Continuing motivation differs from persistence, in that it involves a 'spontaneous' return to a previously encountered activity.
(Maehr points out that continuing motivation, persistence and apparent choice may be viewed as instances in which the same direction in behaviour is retained.)
4. Activity level - some students appear to be more active than others and seem to have more energy and this is viewed as a behavioural index of motivation. However, this may be complicated by physiological factors, such as health or fatigue.
5. Performance - when variations in performance cannot be explained by variations in competence, skills, or physiological factors, they are attributed to differences in motivation. However, performance level reflects choice, persistence, continuing motivation and activity level, along with a variety of other factors.
Maehr stresses that these behavioural patterns are clearly overlapping and need further elaboration but that

> *"they suffice to suggest what it is that we are talking about when we say that a person is or is not motivated."*
>
> *(Maehr, 1982, p. 13.)*

Maehr's views on the behaviour that researchers perceive as motivation-related provides a basis for the study of motivation when students learn from computers. His taxonomy can be used to define the behaviours that lead researchers, teachers and parents to describe a student as motivated. By measuring students' behaviours when they are learning from the computer and how the computer affects their behaviour while learning we can use the results to explain aspects of the learning process and its outcomes.

However, Maehr's research is not concerned with students learning from computers and he does not appear to have actually measured these behavioural patterns in a stringent manner. For example, it is difficult to measure activity level in the sense of energy levels as Maehr describes it and continuing motivation may have to be assessed by a questionnaire probing the intentions of students as limited time and resources mean that students cannot just return to work at a computer even if they are motivated towards doing so. Therefore, Maehr's taxonomy needs to be modified to suit learning situations at a computer.

In contrast to Maehr's quantitative motivational indices, motivational studies can be approached from a qualitative perspective. This involves investigating students' perceptions, thoughts and feelings about themselves, others and their social situation. Although students may have the same 'social environment', they may perceive different 'psychological environments'. Ladd and Crick (1989) review research on this, with an emphasis on peer relations. In order to investigate the 'psychological environment' they discuss investigating students' goals, strategies, outcome expectations, attributions, feelings and self-perceptions of peer interaction. They also propose a model linking these factors. This work has largely been carried out in relation to lonely children but the theories and methodology may help us in uncovering the 'psychological environment' which occurs around the computer. These factors also provide a basis for carrying out qualitative measurements of social and motivational factors which affect students when working at the computer. For example, by investigating the goals that students have when working in a learning context with computers, software which is congruent with these goals can be designed. Alternatively the desired goals may need to be explicitly stated in order to ensure that students work effectively.

2.4.4 An affective theory of collaborative learning

Looked at from the perspective of collaborative learning, we are particularly concerned with the students' perceptions (by which is meant their subjective evaluations) of their partners' ability and the effect that working together has on their perceptions of the strength of their relationship as friends. When learners are friends, which they often are, it is appropriate to ensure that they remain friends, and that their perceptions of one another do not decrease as a result of their cooperative interactions. This will have implications for the students' future collaborations and for their general relations both within the learning institution and in other situations. Additionally, we want the students to continue to be motivated and interested, and to ensure that they feel that they have been successful and that their confidence in themselves has not diminished. It is also desirable to make sure that their perceptions of their partners have not decreased.

There have been very few theories which consider affective factors in different learning situations. One such theory is Ames' (1984) cognitive-motivational theory which is discussed in detail in this section.

Ames (1984) has studied different learning situations from a motivational perspective, but she has not researched learning situations with a computer. In referring to cooperative learning, she says, *"one point remains clear and that is that substantially more attention has been directed towards predicting outcomes than to understanding the motivational processes that mediate these outcomes."*

(Ames, 1984, p, 177,)

By studying the learning process in depth from a motivational perspective, we may gain insights into aspects of the learning process and outcomes in different learning situations.

Ames (1984) claims that children's evaluation of performance is a function of perceived success or failure. Success enhances feelings of competence and failure diminishes feelings of worth. There are also other sources of information that influence children's self-evaluations and resulting motivation. Therefore we must investigate how the goal-reward structure of an achievement setting affects the salience of various information sources that children use in making self-evaluations.
She characterises the different learning situations as follows:

Competitive: There is a negative interdependence among students i.e. students' gains or rewards are negatively related. This leads to peer comparison.

Individualised: Rewards are based on self-improvement. Therefore students will compare their present levels of performance with previous levels. Thus the students' achievements are independent of each other and past performances are salient. She cites a study (Ames and Ames, 1981) in which they found that past performance information was important only to children's self-evaluations in individualised settings.

Cooperative: There is a positive interdependence among a group of students i.e. group members share in the rewards or punishments as a function of their combined group performance. Ames (1981) showed that the outcome of a cooperative group was an important factor influencing children's self-evaluations. Thus the group outcome moderated the positive or negative influence of the child's own high or low performance.

Ames stresses that for all three learning situations, the individual's own level of achievement is constant and important to esteem-related evaluations. However, in the individualised setting, the consistency of one's performance over time is important whereas in the competitive situation, social comparison information is important and in the cooperative situation, group performance is salient. This implies that students should be motivated towards different goals in the different settings, for example, motivating children for self-improvement may be incompatible with cooperative settings.

Ames points out that success and failure are differentially valued as a function of the social context. Success is more valued when in a competitive situation and children place more value on winning than on performing a task well. Failure in competitive settings has more negative consequences for one's self-esteem than failure in non-competitive settings. In contrast, in cooperative structures, the consequences of failure are dependent on the group outcome. Ames (1981) compared competitive to cooperative structures and found that children in competitive and unsuccessful cooperative situations expressed the most dissatisfaction.

Ames has also found that the reward-goal structure of a learning situation is also important for self-perception. Competitive situations lead to large incongruities in interpersonal perceptions. Thus perceptions of inequality are present in competitive settings, while cooperative settings promote perceptions of equality. Competitive settings maximise differences in student motivation, while cooperative settings focus students less on their own performance because this is intrinsically connected with the groups performance.

Ames views goal structures as motivational systems. Although cooperation and competition can be viewed as behaviours directed to a task situation, Ames views them as situational factors that impinge upon a child's motivation and achievement-related cognitions. Ames hypothesises that the motivational consequences of the three goal structures differ qualitatively, whether or not they differ quantitatively. She has shown that goal structure was a critical factor that differentially influences the salience of performance information cues, the affective value of success and failure and the perception of individual differences. She proposes that motivational processes within the different goal structures can be meaningfully related to distinct motivational orientations - self-worth or ego-involvement, moral responsibility, and achievement motivation.

Ames posits three motivational systems as relating to competitive, cooperative and individualistic goal structures. She claims that

> *"the motivational processes within each structure can be analysed in relation to the dispositional factors that provide the basis for self-evaluation and attribution."*
>
> *(Ames, 1984, p. 189.)*

These derive from different sources of performance information and result in different affective consequences. Competitive structures promote egoistic or social comparative orientations, cooperative structures elicit moral orientations and individualistic structures evoke achievement-mastery orientations. She summarises this in the diagram reproduced in Figure 2.1:

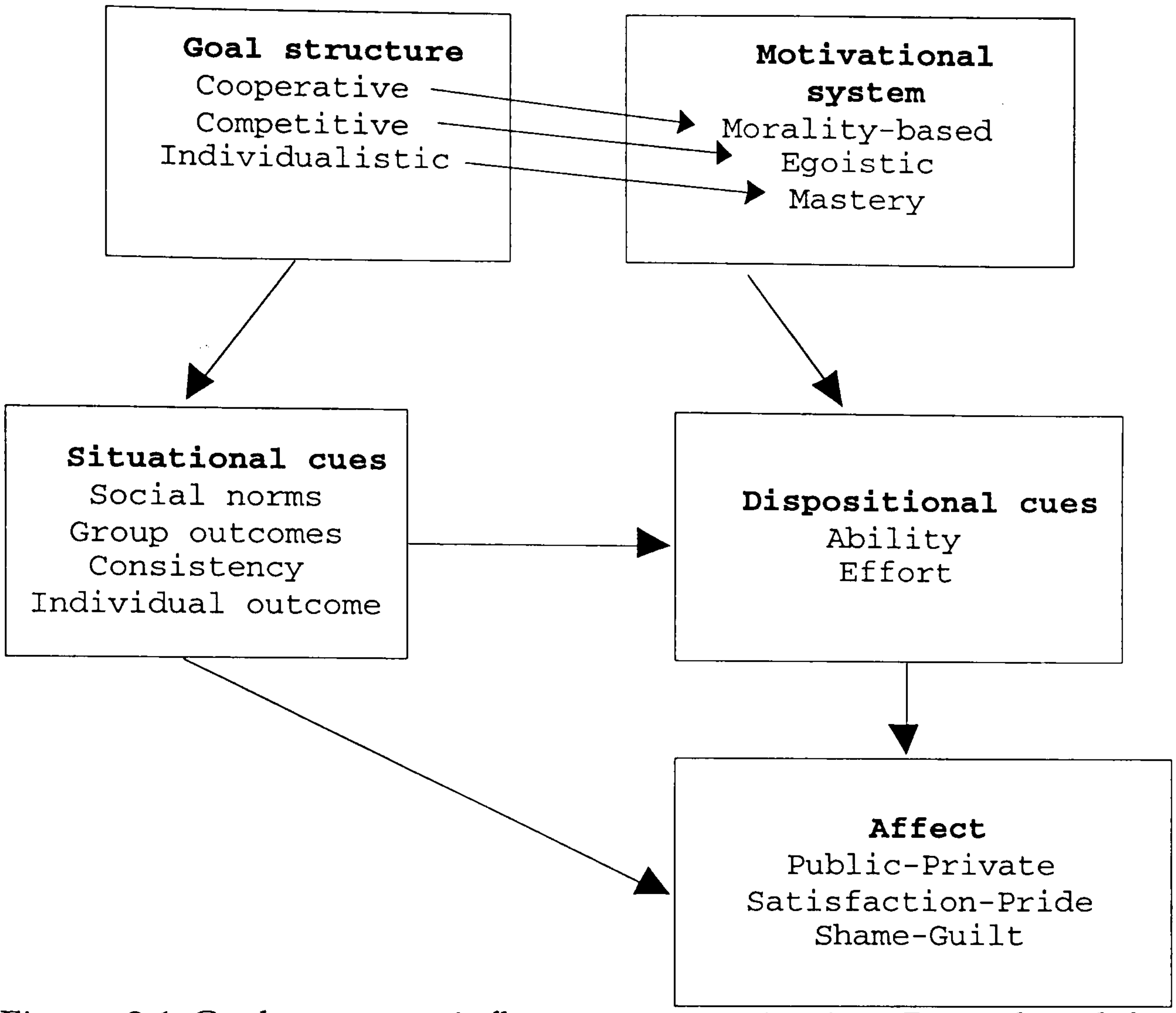


Figure 2.1 Goal structure influences on motivation. Reproduced from Ames (1984).

Cooperative motivational systems.

In cooperative settings, there are common goals and rewards and this is often viewed as helping, sharing or taking turns. Ames claims that these situations are moral since they elicit norms of helping and social interdependence among group members which is characteristic of moral situations. Her claim is that if cooperative situations are within the moral domain, we would expect to find a valuing of effort within the achievement context of cooperation. She is not referring to Protestant effort (trying hard for one's own gain) but to a conception of effort that serves group goals and demonstrates social responsibility i.e. group directed rather than individually directed effort. Thus the focus is directed on group performance over and above any individual characteristics. Competitive situations foster perceptions of individual differences, whereas cooperative situations contribute to perceptions of similarity. Ames also claims that interpersonal evaluations within cooperative groups operate in the same way as in moral situations and that cooperation reflects primarily a moral system in which intent-based cues should be salient.

> *"When cooperation is described as increasing students' motivation to learn ... it implies a moral responsibility of being motivated to fulfil one's obligation to the group by putting forth effort. It is a task orientation only in the sense that cooperation implies an obligation to the group*

task. The effects of cooperative structures on learning are mediated by motivational factors that involve the concept of "ought" - that one ought to pull one's weight, to contribute, to satisfy peer norms and sanctions."

(Ames, 1984, p. 198.)

Individualistic motivation system.

Individualism implies an independence of goals such that one individual's rewards are not dependent upon anothers. Individualistic structures produce self-competition in that performance evaluations are based on external criteria. Thus evaluations in competitive situations are based on social norms whereas in individualistic situations, evaluations occur in relation to some absolute standard. Individualistic settings have a stronger task focus than competitive settings. Self-awareness (relative to other children), which is very prevalent in competitive settings, is minimised in individualistic settings. Individualised learning involves trying with goal-focused behaviour.

Competitive motivational system.

In a competitive setting, winning is everything. Ames builds on the work of Nicholls (1982) who states that competition is an ego-involved situation and students' attention is directed to their own ability to perform or win, rather than on "how" to do the task at hand. There is a focus on ability and self-evaluations of ability are dependent on one's performance in relation to others' or to social norms. Thus competitive structures accentuate the salience of ability and levels of satisfaction seem to be related to self-perceptions of ability. Ames has found in several studies that self-attributions of ability mediate affective reactions to success and failure within a competitive context. This is consistent with a view of motivation as`self-worth .

However, these types of learning situations may never occur in isolation. For example, even when children in a school are working in groups, they know that ultimately, they will be assessed on individual performance in an examination. It is nevertheless appropriate to examine the factors which have an influence on the different learning situations.

Ames (1984) examined a variety of cognitive-motivational thought patterns as a function of differing goal structures. She reasoned that if individualistic structures focus children on how to do a task and how to improve their performance, they should employ self-instructional strategies i.e. if an individualistic structure promotes a process or mastery orientation, children should actively search for ways to improve their performance through self-instruction. She found that children selected more ability-related attributional statements in the competitive than in the individualised structure. Children selected more effort-related and self-instructional statements in the individual settings than in competitive settings. This supports the view that there is an ability focus in competitive structures since students believe that their ability is the factor that differentiates success and failure. In individualistic structures there is a strong achievement orientation. Students attribute performance to effort and think about how to do the task.

This type of theory needs to be considered in relation to computer-supported collaborative learning. Two of the studies presented in this thesis (chapters 4 and 6) directly address factors which Ames discusses in her theory. In particular, the importance that students place on different aspects of the learning situation, the students' perceptions of their own and their groups' success and their helping behaviour.

2.4.5 Discussion

In this section on the benefits of collaboration, it has been argued that research on computer-supported collaborative learning has focused primarily on cognitive outcomes and that there is a need to investigate the affective aspects of computer-supported collaborative learning. Approaches to the investigation of affective aspects were discussed and current research on motivation and computers was presented. Ames' theory of the motivational factors affecting collaborative learning was presented and it was argued that factors that this theory discusses need to be considered in relation to computer-supported collaborative learning. In particular, the salience of groups outcomes and the moral dimension of collaboration, in terms of students getting along with their peers will be investigated in the thesis.

In the next section, a second purpose for studying computer-supported collaborative learning is discussed: researching the mechanisms of collaborative learning.

2.5 Mechanisms of collaborative learning

Psychological and educational theories concerned with collaborative learning aim to describe and explain the collaborative learning process. There is a plethora of possible theories and a multitude of associated studies. In this section, these theories will be presented briefly.

Slavin (1983) distinguishes between two different types of theories.

1. Motivational theories which focus primarily on the reward or goal structures under which students operate i.e. cooperative, competitive and individualistic. Cooperative structures create norms which emphasise academic accomplishment amongst students which has a positive effect on academic achievement.

2. Cognitive theories which emphasise the effect of working together. Within this category, there are two major categories:

i. Developmental theories which encompass the view that interaction amongst students around appropriate tasks increases their learning of the important concepts. This incorporates theories based on the work of both Vygotsky and Piaget (for example, Vygotsky (1978), Piaget (1978)).

ii. Cognitive elaboration theories which focus on the view that in order to learn, the student must restructure or elaborate the knowledge already held. One method of elaboration is to explain the information to someone else.

For our purposes, we will discuss five different theoretical ideas about why collaborative learning is effective: increasing the cognitive resources, verbalisation, conflict, co-construction, social facilitation and observation.

2.5.1 Increasing the cognitive resources

This theoretical stance suggests that working collaboratively is beneficial simply because the student has access to the resources of other students (Kelley and Thibaut, 1969). An individual student will be able to draw on other students' knowledge and abilities and it is this which leads to more effective collaborative learning situations.

2.5.2 Verbalisation

Some theorists have suggested that simply verbalising one's thoughts for someone else can have a significant impact on one's cognitive progress (Hoyles et al., 1990). They discuss distancing as the way in which articulating one's thought processes raises one's level of awareness. However, the evidence for this is mixed. Fletcher (1985) found that groups and verbalising individuals performed better on a problem solving task than silent individuals and he argues that verbalising may account for some of the benefits of collaboration. However, Jackson et al. (1992) found that silent groups did not perform significantly worse than verbalising groups on problem solving tasks. They explain their results in terms of social facilitation effects i.e. the mere presence of other students facilitates performance.

2.5.3 Conflict

Conflict-based approaches have sprung from the work of Doise and Mugny (1984) who based their work on Piagetian tasks and claim that sociocognitive conflict is a key factor in collaborative learning. When students with different ideas work together, there is inevitably some difference in the way that the students view the task. Working together leads to an awareness of these different perspectives and this engenders conflict. The conflict leads to the joint construction of a different concept which is then internalised in the individual. Thus this view emphasises inter-individual differences which must be present in order to create the sociocognitive conflict. However, it is not clear which aspects of the conflict promote cognitive development (Joiner, 1989). Joiner discusses two factors that affect sociocognitive conflict: level of knowledge and conflict resolution. This approach leads to an emphasis on group composition, with the view that if groups are composed of heterogeneous members, the interaction will be more profitable since the likelihood of conflict is greater. However, the results of studies investigating group composition have been mixed. Whitelock et al. (1992) tested similar and different groups and found that although pairs were more likely to improve their post-test scores than individuals, conflict was not the effective variable i.e. in their study, similar pairs improved more than the different pairs. The important factor seemed to be dominance. If a pair shared the mouse, and there was little dominance, performance improved. In contrast, Howe et al. (1990) found in two experiments across two tasks concerning floating and sinking, that understanding is facilitated by interactions between students with different viewpoints. They view this as support for the Piagetian position.

There is also evidence that there may be little or no conflict in cooperative learning situations. Amigues (1990) looked at physics problem-solving and hypothesised that despite the cognitive difficulty in changing mental models of a situation, changes in the description of a technical situation should be more frequent when students work in dyads than individually. In a peer-interaction context, individual change should depend on it being possible for the subject to modify his or her problem representation and regulate his or her own actions. He found that dyads focused on the functional aspects of the task and that proficient performance resulted from the destabilisation of sequential reasoning methods. He claims that destabilisation brings about cognitive change and found a lack of cognitive or social conflict when destabilisation occurred.

Blaye (1990) found that the emergence of disagreements between partners was not a critical dimension affecting cognitive development. Disagreements about 'intermediate or final answers' were found but were not frequent. She did find conflicts about the means used to solve the problem which were active and destabilising. She proposes that destabilization of the problem-solving procedure is one of the causal mechanisms of cognitive progress because this forces the subjects to find another means of monitoring their solving activity and may therefore be responsible for the elaboration of a new representation of the problem.

There are also difficulties with the idea of conflict, as O'Malley and Scanlon (1990) point out:

> *"The notion of conflict as a mechanism for conceptual change is unsatisfactory for several reasons: there is no explanation for how conflict is perceived and resolved, nor why there is an impetus to resolve it. Furthermore, it is possible that learning can take place in peer interaction without there being any conflict. Even where there are differences in schemas or models of the task, these may not necessarily compete or be inconsistent with each other, they may actually be alternative perspectives or viewpoints which contribute equally to the problem solving task."*
>
> *(O'Malley and Scanlon, 1990, p .128.)*

Even though there are difficulties with the notion of conflict, there is still considerable interest in the concept. Two examples of this are Joiner's (1993) work on the nature of conflicts and Howe et al's (1992) extension to Piagetian theory to incorporate delayed effects.

Joiner (1993) proposes a dialogue model of the resolution of inter-individual conflicts. This model has three components: the task representation, the task focus and the dialogue focus. He differentiates between three different causes of conflict: task representation differences, intersection differences and task focus differences. These are resolved by a set of discourse transactions and a set of internal resolution procedures.

2.5.4 Co-construction

Ideas of co-construction have sprung from the work of Vygotsky (1978) and involve the notion of students working together to increase their joint knowledge. Vygotsky's emphasis was on the social aspects of cognition and he discussed cognitive development, problem solving and learning in the context of language development. Vygotsky introduced the Zone of Proximal Development (ZPD) which can be viewed as the area into which a student is capable of developing. Vygotsky (1978) defines the zone of proximal development as

> *"the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more able peers."*
>
> *Vygotsky, 1974, p. 86.*

When a student is working with a more able person, growth occurs within the ZPD. In a situation in which there is an adult and a child, the adult scaffolds the child's learning. The notion behind this type of theory is that students may also be able to scaffold each others' learning. Researchers concerned with this type of theory have investigated the dialogues that occur when students work collaboratively and related these to the learning gains. Barbieri and Light's (1992) research found that interactions that were interpreted as co-constructive predicted successful performance in post tests. The Spoken Language and New Technology (SLANT) project (Mercer, 1994a) studied the talk of primary school children which argues that exploratory talk is indicative of success. Concepts developed from a Vygotskian perspective can be used to inform our understanding of collaborative activities, for example, notions of joint construction of understanding and scaffolding (Light et al., 1994).

2.5.5 Social facilitation

This type of theory suggests that the mere presence of other students facilitates learning (for a review, see Bond and Titus, 1983). However, this effect is not always positive and some studies have found that for complex tasks, the presence of others impairs achievement. There are a range of theories which claim to explain these effects, involving notions of drive or arousal, evaluation and competition and information processing and attention. However, these types of theories are rarely used to explain computer-supported collaborative learning.

2.5.6 Observation

This theory suggests that students benefit from the opportunity to watch other students carrying out a task. Observational learning involves students remembering what their peers did or said and using this in their own work.

2.5.7 Discussion

Some of the theories presented in the previous sections have received very little attention from researchers in the area. Research has focused on the notions of conflict and co-construction, which are generally seen as competing, but, as Blaye (1990) points out:

> *"... there is not just one mechanism underlying the facilitating effect of peer interaction in problem-solving, and hence that the Vygotskian and Piagetian approaches should be considered jointly for better comprehension of the processes at play."*
>
> *(Blaye, 1990, p. 55.)*

The different descriptions of the ways in which collaborations occur, described in this section, could all happen at different times during a single collaborative session. In experimental studies, these mechanisms are sometimes manipulated. However, the research in this thesis is not concerned with manipulating these factors. The studies presented only discuss the ways in which some of these mechanisms are apparent in computer-supported collaborative learning situations.

In the next section, collaborative learning research is discussed in the context of providing guidelines for software design.

2.6 Software design

The nature of the software will have various effects, both cognitive and affective on the way that students interact and the efficacy of the learning situation. One of the aims of research on collaborative computer-supported learning has been to investigate the aspects of software design that affect collaborative learning and to design software that maximises the efficacy of collaborative interactions. As Light and Mevarech (1992) point out:

> *"Undoubtedly, differing software creates different types of computer learning environments that may result in different types of peer interaction and different outcomes."*
>
> *(Light and Mevarech, 1992, p. 157.)*

Nevertheless, as O'Malley (1992) indicates, there has been little emphasis on software design:

> *"Despite the increasingly large literature on peer interaction and on computer supported collaborative learning, there still remains very little which considers explicitly how to design effective collaborative learning environment."*
>
> *(O'Malley, 1995, p. 283.)*

However, this situation is changing. Joiner (1993) provides a number of design guidelines for supporting effective computer-supported collaborations and Wegerif (1994) provides design guidelines which support exploratory talk (which is, he argues, an essential factor in effective collaborations). Examples of these are "If designers want to encourage discussion then make the task as motivating as possible so that it engages the children" (Joiner, 1993).

While research on software design is increasing, providing guidelines for educators remains a fundamental purpose of research on collaborative computer-supported learning. This is probably one of the most neglected aspects and is discussed in the next section.

2.7 Guidelines for educators

Although many studies mention educator guidelines, these are rarely in a format that is useful for teachers. For example, Mevarech and Kramarski (1992) state in their abstract that the theoretical and practical implications of the study are discussed. However, the practical implications are that their research provides a tool that can help teachers and researchers implement learning environments which can enhance cognitive and social outcomes. They do not provide any specific guidelines for educators. Howe (1995) writing predominantly for teachers, in an overview of her research, gives two guidelines for teachers: that pupils should have different preconceptions about the subject matter and that task structure makes a difference to the efficacy of collaborations. However, these do not give clear guidelines. As Crook (1991) points out

> *"To be valuable, an evaluation must be sufficiently open ended to unravel what is being learned and where the learning is located. Arguably, what is particularly needed is a tradition of evaluation research that is more formative in its orientation: more concerned with actively refining classroom practice. Indeed, there is something especially irritating about evaluations that do no more than declare whether a computer experience predicts this or that particular student achievement."*
>
> *(Crook, 1991, p. 82.)*

There are many aspects of computer-supported cooperative learning situations that need attention in this respect. These include the nature of tasks, training and groupings and outcomes. Although there is extensive literature on how best to create and manage group work without computers, for example, Cowie and Rudduck (1990), there is a scarcity of information for educators who are keen to use computers in collaborative settings.

2.8 Research paradigms

A distinction can be made betwen two research paradigms which have emerged in recent work on computer-supported collaboration: experimental and naturalistic. The majority of studies occur within an experimental setting, but it is also possible to study these types of collaborations in naturalistic settings. Although this mirrors a long standing debate in psychology, it is pertinent to discuss the paradigms here, especially in the relation to the goals of research on computer-supported collaborative learning research.

2.8.1 Experimental Research

Within this paradigm, the classic approach has been to set up specific conditions, in which a range of different learning situations are examined. Typically, researchers design an appropriate task and set up an experimental situation. This may involve, for example, comparing individuals and pairs completing the same task, or different types of pairings completing a task. Thus studies involve students working in a learning situation that is not part of their normal educational context. The students are normally pre- and post-tested and these results are analysed in conjunction with the factors affecting the experimental setting. This type of research has generally led to descriptions of collaborative interactions and specific results concerning the efficacy of different groupings and tasks. The work of Paul Light and his colleagues epitomises this type of research (see for example, Littleton et al. 1992). This approach emphasises cause and effect, i.e. relating factors that occur during the collaborative interaction, or are part of the design of the different conditions to the learning outcomes. The main advantage of this type of approach is that it allows the researcher to systematically manipulate conditions, while keeping other factors constant.

Although experimental research has produced interesting and important results, it appears to provide little for educational practice, as Mercer and Scrimshaw (1993) point out:

> *"From the perspective of practice, however, the findings of experimental studies may have little apparent validity for teachers, if the experiments appear to screen out too many factors which operate in real classrooms, making its findings only partly applicable there."*
>
> *(Mercer and Scrimshaw, 1993. p. 167.)*

The fact that it is difficult to derive educational guidelines from experimental research is not the only disadvantage of this type of research. Experimental research often occurs in artificial situations and therefore many of the factors relevant to learning in more natural settings are not apparent. This applies particularly to affective factors. Conversely, experimental conditions may unwittingly create situations with affective pressures, for example, anxiety, that would otherwise not be present. However, this type of research does allow researchers to systematically manipulate factors and investigate their effects and this type of research is particularly suited to theory development and software design. It also enables systematic comparisons which prescribe when collaboration is beneficial. A contrasting approach is naturalistic research which is discussed in the next section.

2.8.2 Naturalistic Research

In this approach, rather than setting up experimental situations, where different groups are assigned to different treatments, naturally occurring situations are studied, for example, collaborative CAL in classrooms, especially in primary schools. However, relatively little research has focused on these collaborations. This is partly due to the fact that this type of research is difficult and time consuming, but the situation may also have arisen because researchers are generally concerned with one or more specific aspects of the learning situation and these cannot be manipulated in naturalistic settings.

If one is concerned with providing guidelines for educators, it is vital that these collaborations are investigated. An example of this type of research is the Spoken Language And New Technology (SLANT) project (Mercer, 1994a). This project examined talk between children using different types of software. The project found considerable variation in the nature and quality of talk when children used the different types of software and suggested ways in which the quality of talk and collaboration can be improved. Mercer argues that researchers and teachers need to take a broader view of computer-supported collaborative learning. Another example is a study on children's collaborations in the domain of mathematics (Hoyles et al., 1992). In this study, two groups of children were studied and the influence of task design and the role of the computer were discussed relative to the outcomes of the collaborations.

This type of investigation allows researchers to study real collaborations and provide guidelines that fit in with normal teaching practice. It can also provide information about the benefits of collaborative learning, aid in the development of theory and provide software design guidelines.

The major disadvantage of this type of research is that a large amount of data is collected that is very varied in its form, making it difficult to analyse systematically. Additionally, because of the length of time required to carry out these studies, they are normally small scale and therefore difficult to use to make generalisations.

Both experimental and naturalistic research provide rich data concerning computer-supported collaborations, and there is a need for complementary information, gleaned from different sources to be brought together to enhance our understanding of computer-supported collaborative learning. Within these paradigms, a range of tools have been used to investigate the learning situations. These are discussed in the next section.

2.9 Research Tools

Research occurs at three different times during collaborative learning interactions: before the collaborative interaction with the computer, during the interaction and after the interaction. Additionally, general information may be sought at any time. Both students and teachers are often investigated and in the following discussion of research tools, emphasis is laid on ways in which the choice of tools may influence the results obtained.

2.9.1 Questionnaires

Questionnaires are often used for testing both before and after the interaction and for gaining general information about students' and educators' opinions. They can encompass both cognitive and affective dimensions. They are relatively easy to administer, and can provide a wide range of data. However, they can be criticised for simplifying data because of the defined nature of the questions and being narrow in that they may simply reflect the researcher's preconceptions.

The data derived from questionnaires can be used in several ways: it may be used to provide descriptions of the population being studied, to assess the learning that may have occurred and to assess students' feelings and perceptions. Thus they can aid in evaluating the learning situation.

2.9.2 Interaction transcripts

Interaction transcripts are transcribed audio-recordings of collaborative interactions. They provide a comprehensive record of the talk during the collaboration, but cannot provide any indication of gesture or body language and may prove difficult to analyse. Researchers classify the different interactions that occur within the collaboration, for example, the number of hypotheses generated, the number of turns taken, the number of explanations. This usually involves a simplification of the data.

However, the data obtained can be considered in relation to the learning gains and effective learning situations can be identified in terms of the nature of the verbal interactions that occur in these situations. The effects of different groupings, software and task structures can also be measured in terms of the nature of the verbal interactions that occur.

2.9.3 Computer-based recordings

The computer itself can be used to record research data. Computers can be used to record pre- and-post test scores and on-task performance. This can provide evaluations of the effectiveness of a learning situation and information about the nature of the collaboration in relation to the task.

2.9.4 Videotape recordings

Videotape recordings provide a very rich source of data about the nature of the collaboration and a record of the interactions. They can be used to investigate students' behaviours and teacher interventions during collaborations.

However, these recordings are very difficult to analyse. They can be analysed by coding different aspects of the interactions. This inevitably leads to a simplification of the data but provides evidence of the amounts of different behaviours that occur during the interaction. Additionally, patterns of interactions can be seen from videotape recordings. Another use of videotape recordings is to provide snapshots of important episodes or critical instances during the interaction which can illustrate important points.

2.9.5 Interviews

Both students and teachers can be interviewed before, during and after collaborative interactions. This can provide in-depth information about what a student knows and feels. Additionally, interview data provides information about students' feelings about their interactions and their perspective on why they took certain actions during the collaborations. In terms of the teacher, interviews help to ascertain the ethos of the educational institutions, the teacher's ideas about collaboration in general and specific information about the collaborations being studied.

While this type of tool may produce comprehensive data, the data obtained can be influenced by the researcher's preconceptions and by students' and teachers' subjectivity.

2.9.6 Observations

Researchers frequently watch learning interactions and take their own notes. These may be useful to capture information not otherwise recorded and can also provide an overview of the interaction which may be difficult to obtain by other means. However, this data is also subject to the researcher's preconceptions.

2.10 Summary

This chapter has provided a general introduction to research on computer-supported collaborative learning. The chapter began by discussing computer-supported collaborative learning. In terms of research investigating whether collaboration is beneficial, it was argued that affective factors need to be considered and ways of investigating these were discussed. Ames' cognitive-motivational theory of different learning situations was introduced and it was argued that this theory provides the impetus for research on computer-supported collaborative learning. In particular, the salience of group outcomes and the moral nature of collaboration need to be probed. A number of proposed mechanisms for collaborative learning were discussed. It was argued that these may all occur at different times during an interaction. These are not explicitly manipulated in the studies presented in this thesis. Two research paradigms commonly used in approaching computer-supported collaboration were presented and finally, a range of research tools was described. This provides a framework for looking at some recent case studies in detail in the next chapter

Chapter 3

Case studies of research on collaboration.

3.1 Introduction

Why do different studies give conflicting results? Do some approaches yield more satisfactory outcomes than others? This chapter reports on a review of thirteen studies and analyses the relationship between the method adopted and the outcome and quality of the data obtained with a view to determining guidelines for the research undertaken in this thesis. In this chapter, I will discuss the methodology used in both designing and analysing cooperative computer based learning. The discussion will begin with a review of current methods, using seven papers in a special issue of Social Development, edited by Howe (1993) and six papers from a special issue of Learning and Instruction, edited by Mevarech and Light (1992) as case studies. Eight of these studies involve the use of computers. Firstly, the thirteen studies will be briefly described, followed by descriptions of the siting and nature of the learning situations in the papers. This is followed by a discussion of the "ideal" research methodology and the pragmatic reasons why these ideals are difficult to realise. The nature of the analyses carried out is described and there is then a discussion of the merits of the different analysis methods. The chapter ends with a set of research guidelines for effectively studying computer-based collaborative learning.

3.2 Thirteen Case Studies

Kruger's (1993) study investigated the mechanism of cognitive change when 8 year olds discuss two socio-moral dilemmas either with a peer or their mother. The study provided a description of the group differences in the discussion of accepted and rejected solutions. She also analysed discussion of solutions relative to post-test performance. She defines two types of discussion style: persuasive and egalitarian. She found that the discussion of rejected solutions and the consequent focus on more acceptable solutions is related to the cognitive outcome. She claims that the collaborations were both conflictual and cooperative and characterises discussions that lead to cognitive change. Her dialogue analysis and outcome results are applied to current theory in that she argues that cognitive benefit arises out of conflict and the consequent co-construction.
She proposes a model of collaboration focusing on socio-cognitive conflict and cooperation.

Tolmie et al. (1993) varied the task constraints while investigating primary school students physics problem solving. They found that conceptual change is related to the amount of discussion that took place and these results are related to Piagetian accounts of conceptual conflict. They also discuss the effects of different task constraints on dialogue which are also interpreted within a Piagetian perspective. They argue that task structure can significantly effect the nature of dialogues and the consequent cognitive outcomes, but do not specifically prescribe task structures or teaching guidelines for effective collaboration.

Azmitia and Montgomery (1993) investigated the effect of friendship on scientific reasoning. They found differences in dialogues between friendship and acquaintance pairs and cognitive benefits of working with a friend in difficult problems. They discuss their results relative to Piagetian theory, in particular, Howe et al's (1992b) refinement that only certain types of conflict promote cognitive development. They also discuss their results in relation to Hartup's (1986) theory about working with a friend. Thus their focus on dialogues and problem solving ability lead to prescriptions about under which circumstances collaboration is beneficial (friendship versus non-friendship).

Pozzi et al. (1993) investigated the background and process factors influencing primary school mathematics learning when groups cooperatively use computers. They found that gender and ability do not have a direct effect on group progress, but pupils' perceptions do. They discuss the demotivating effects of viewing other groups achieving (Johnson and Johnson, 1975), the effects of different task perspectives from a socio-cognitive conflict perspective and co-construction between peers. They suggest an optimal scenario for learning and they discuss the role of the software and the structure of the task. They also discuss gender, attitudinal differences and interpersonal differences. Thus this study, which investigated behaviours and cognitive processes, discussed theory development, and software and task structure.

Tudge and Winterhoff (1993) investigated 5/6 year olds problem solving, in the context of repeated collaborative sessions, which involved working with a more able partner and feedback. They found that working with a more able partner was more productive only if feedback was present. However, when feedback was present, individuals improved more than pairs. Improvement levelled off and repeated collaborative sessions produced no benefit. Although they did compare individuals to pairs, they do not explicitly discuss the cognitive differences between working on your own or with a partner. They discuss their results in relation to Vygotskian theory, in particular, cultural influences.

Thomson (1993) reports on two studies concerned with the communicative and social aspects of interactions of 5 to 8 year olds with mild learning disabilities and their peers. She found differences in the social content of language, in particular that the peers played a more central role and children with learning difficulties had lower status and less influential position. This is discussed in relation to theory concerning communicative competence in peer interaction.

Messer et al. (1993) investigated 6/7 year olds working with a more able partner in a computer-based task. They found that students working with a more able partner performed significantly worse than other children and they attribute this to the incomplete knowledge of the more able partner and peer dominance. They discuss this in relation to Karmiloff-Smith's model of cognitive development. They also discuss dominance in terms of social modelling.

Howe et al. (1992a) studied undergraduates solving a computer-based kinematics task and found that gains in strategic knowledge were promoted by both peer conflict and hypothesis testing. They discuss two types of approaches to the task: co-ordinated and exploratory. They also discuss their results from a methodological perspective, claiming that the nature of interactions can be related to conceptual change.

Jackson et al. (1992) report on two experiments of groups of primary school children using a computer for a problem solving task and found that groups achieved more than individuals while on-task but that task verbalisation had no significant effect on performance. They claim that group superiority is due to the greater availability of resources, theories about members watching other group members and theories concerned with social facilitation. They also discuss the effects of verbalisation on task performance. Thus this study was interpreted in relation to theory development.

Barbieri and Light (1992) studied primary school pairs using a computer for a problem solving task and found significant correlations between verbal interactions and success and different patterns of interaction for different gender pairs. Their results are interpreted as supporting a view of collaboration as cooperation rather than conflict. They also discuss gender differences in relation to various previous studies, but do not specifically discuss task design or educator guidelines.

Natasi and Clements (1992) examined the social-cognitive behaviours of groups of primary school students using the computer language Logo or writing environments and found that Logo students used more cognitively -based resolution of cognitive conflict, which they argue, fostered cognitive growth. They discuss their findings in relation to previous research, in particular, the resolution of social and cognitive conflict.

Hoyles et al. (1992) studied groups of pupils working with computers on mathematical tasks, in order to characterise effective group work. They claim that it is important to develop a synergy between pupil interdependence and pupil autonomy for effective group work. They characterise working patterns which produce good group outcomes but this is not related to any of the current theories.

Mevarech and Kramarski (1992) investigated the effect of collaborative learning of different types of Logo on creativity and interpersonal relationships. They found that problem solving-based Logo had a significant effect on creativity and positively affected students' interpersonal relationships. They discuss this relative to previous studies and claim that they have provided 'a framework to integrate studies focusing on positive changes in children's cognitive performance and interpersonal relations'.

A table summarising the characteristics of each study is given below (Table 3.1)

Study	Age	Subject	Investigating	Computer Based
Kruger	7-10	socio-moral reasoning	mechanism of cognitive change	no
Tolmie et al.	8-12	physics	task constraints	no
Azmitia and Montgomery	11	problem solving	friendship	no
Pozzi et al.	9-12	mathematics	background and process factors	yes
Tudge and Winterhoff	5-6	balance beams	repeated collaboration, ability mix, feedback	no
Thomson	5-8	drawing	communicative and social aspects	no
Messer et al.	6-7	balance beams	ability mix	yes
Howe et al.	Under-graduates	kinematics	knowledge distribution	yes
Jackson et al.	10-11	problem solving	silent/verbalising individuals/groups	yes
Barbieri and Light	11-12	problem solving	verbal interaction and gender	yes
Natasi and Clements	8	Logo and word processing	social-cognitive behaviours	yes
Hoyles et al.	9-12	Logo and database	effective group work	yes
Mevarech and Kramarski	12	Logo	creativity and interpersonal relations	yes

Table 3.1 General information about the thirteen studies

3.3 The nature of the learning situations.

In this section, collaborative learning studies will be discussed from five perspectives: time period, the nature of the post-test, the siting of the learning situation, the task and tool structure, and the nature of the groupings. These will be discussed within the context of computer-assisted cooperative learning studies as this is the main concern of this thesis. Specific reference will be made to the thirteen studies presented in section 3.2.

3.3.1 Time period

The time spent on the actual intervention in the studies previously discussed is shown in table 3.2 below.

Study	Time spent on task
Kruger	one session
Tolmie et al.	one session (60-90 minutes)
Azmitia and Montgomery	one session (18-35 minutes)
Pozzi et al.	one session
Tudge and Winterhoff	eight sessions
Thomson	one session
Messer et al.	one session
Howe et al.	one session
Jackson et al.	one session
Barbieri and Light	one session (25 minutes)
Natasi and Clements	two to three sessions (45-50 minutes each)
Hoyles et al.	one session (150 minutes)
Mevarech and Kramarski	one session (90 minutes) a week for an academic year

Table 3.2 Time periods of the thirteen studies

Seven of the thirteen papers do not report the actual time spent on task. Four of the studies involve the students spending more than an hour on a task and in three of the studies the students spend more than one session on the task.

The majority of computer-assisted cooperative learning studies occur over relatively short periods of time. Typically, students carry out between one and three one hour sessions at the computer. This may be insufficient to study the full effects of cooperative learning, as Slavin (1990) points out:

> *"it is critical that cooperative methods be assessed in actual classrooms over realistic time periods to determine if they have an impact on measures of school achievement."*
>
> *Slavin, 1990 page 17*

Slavin (1990) only reviewed studies which lasted at least four weeks (20 hours) and excluded many shorter studies which he claims may be useful for theory building but cannot be used as evidence for achievement effects.

There are at least two reasons why cooperative computer-assisted learning research should use longer studies. Firstly, the computer is still a novel item in classrooms and students should be given the chance to familiarise themselves with the computer, the software and working collaboratively at the computer. This would ensure that any effects recorded are not merely due to this novelty for novices. This may not be the case for computer-literate students. Secondly, students working together need time to allow for the development of effective cooperative work. A final factor is that the intervention needs to be significant enough to achieve an effect. As in other domains, it is not reasonable to expect significant outcomes from modest exposure (Pea and Kerland, 1985). Students may not be familiar with working cooperatively with other students and the way in which they work together will need to be worked out. For example, Salomon and Globerson (1989) discuss the development of interdependencies within a group over time. Thus, to investigate the cognitive and affective aspects of cooperative computer-assisted learning, studies need to be carried out over reasonably long periods of time.

However, there are major practical difficulties, least of which is that longer studies would take up too much time when the participants are school children. Much of the research involves taking students out of lessons in order to carry out the research and teachers may not be amenable to this. This difficulty can be partially overcome by using groups of students who normally work together because they will be familiar with each other and interdependencies will already have developed. It then becomes important to be aware of existing dependencies.

3.3.2 The nature of the post-testing

The timing and the nature of the post-tests used in the studies discussed are shown in the Table 3.3,

Study	Timing	Nature
Kruger	immediate	individual
Tolmie et al.	immediate	individual
Azmitia and Montgomery	immediate (1 week)	individual
Pozzi et al.	immediate and delayed	individual
Tudge and Winterhoff	immediate and delayed	individual
Thomson	no post-testing	n/a
Messer et al.	immediate	individual
Howe et al.	delayed	individual
Jackson et al.	immediate	individual
Barbieri and Light	immediate (1 week)	individual
Natasi and Clements	not stated	individual
Hoyles et al.	immediate and delayed	individual
Mevarech and Kramarski	immediate	individual

Table 3.3 Post-testing in the thirteen studies

The Pozzi et al. study used immediate group interviews for post-testing, which formed part of the qualitative analysis. However, the quantitative analysis centred around individual post-tests. It is difficult to determine after what period of time a post-test can be classified as delayed. The post-tests used by Azmitia and Montgomery are classified as immediate even though they occurred 1 week after the intervention because these were the only post-tests that were carried out. Howe et al.'s post-test is specifically referred to as a delayed post-test by the authors as it was the only post-testing that was carried out and occurred three weeks after the intervention. Only four out of the thirteen studies that post-tested the students included a delayed post-test and none of the studies had collaborative post-testing.

There are two reasons to criticise the post-testing which occurs in research on computer-assisted cooperative learning;

1. The majority of studies involve individual pre- and post-testing and it is not clear that this adequately assesses the outcomes of cooperative learning. This is indicative of the focus on individual achievement, which is reflected in our education system. Forman (1989) conducted an in-depth study of one dyad and found that the students did not perform to their full potential during the individual post-test session. She views this as a direct result of the successful collaboration as neither of the students were motivated to perform at

their highest levels when on their own. Webb (1989) found differences when students have individual achievement tests in comparison to those in which a group product is required. Therefore, students ideally should be post-tested both cooperatively and individually.

2. Post-testing normally occurs shortly after the session(s) at the computer. It is not clear that this adequately assesses the full effects of computer-assisted cooperative learning. Delayed post-tests should also be carried out, since it is possible that the effects of cooperative learning do not appear immediately and cooperative learning may differ from individualistic learning in this respect. It may be impossible to specify an optimum time at which to assess the cognitive outcomes of a learning situation.

However, there are difficulties with carrying out individual and cooperative and delayed post-tests. Firstly, carrying out post-tests takes up a lot of time, which can be limited in research situations. Secondly, the process of the first post-test may influence the results of later post-tests, especially if the same questions are asked. Thirdly, the students may become bored with answering similar questions in repeated post-testing. It is also often difficult to keep track of students in an educational institution in order to carry out delayed post-tests.

3.3.3 The siting of the learning situation

The thirteen studies under discussion are classified according to whether or not they provide students with training in cooperation and whether any cooperative incentive structure is set up (table 3.4).

Study	Training	Incentive structure
Kruger	none	none
Tolmie et al.	none	none
Azmitia and Montgomery	none	none
Pozzi et al.	none	none
Tudge and Winterhoff	none	none
Thomson	none	none
Messer et al.	none	none
Howe et al.	none	none
Jackson et al.	none	none
Barbieri and Light	'invited to talk to each other and help each other'	none
Natasi and Clements	'encouraged to solve problems cooperatively'	none
Hoyles et al.	none	tasks had group outcomes
Mevarech and Kramarski	none	none

Table 3.4 Siting of the learning situations in the thirteen studies

Therefore in the studies reviewed, only two of the studies report some form of training in cooperative learning (although they often incorporate an element of training in how to use the computer) and only the Hoyles et al. study set up a cooperative incentive structure.

Cooperative learning situations need to be set up carefully in order to promote effective interactions. Hooper (1992) states that:

> *"Cooperative learning requires careful awareness of, and attention to, student interaction. Effective interaction is influenced by several factors, including task structure, rewards, group dynamics and interpersonal skills."*
>
> *(Hooper, 1992, p. 22.)*

Cooperative incentive structures and motives are provided by the learning situation. Studies in computer-assisted cooperative learning rarely create cooperative incentive structures. If there is a cooperative incentive structure, it may not be clear to the students. Students may not be told that rewards are based on the group's performance and very often there are no rewards. Additionally, cooperative motives are not generally encouraged in schools or in society (although students often work in groups, they are assessed individually and they have grown up in a society which encourages individuality). To overcome these difficulties, we need to structure the learning situation carefully. As Del Marie Rysavy and Sales (1990) point out:

> *"Working together in pairs or small groups at the computer, as in any instructional situation, does not automatically promote what has been termed 'cooperative learning' ".*
>
> *(Del Marie Rysavy and Sales, 1990, p, 77.)*

Researchers need to ensure that the participants in cooperative learning studies understand what they have to do and how they are going to be assessed. The cooperative nature of the work should be stressed. In particular, students should be made individually responsible for some aspect of the work, for example, each student could have their own worksheet. This can also be achieved by telling students explicitly that they will be assessed individually. There are no significant pragmatic difficulties with this for researchers, but ideally, students should be taught about cooperative work and this may not be possible.

3.3.4 The task and tool structure

The thirteen studies under discussion are classified according to whether or not they provide students with cooperative task structures (table 3.5). Although Slavin only discusses cooperative task structure, the tool structure here refers to the computer, which is part of the task.

Study	Cooperative task	Cooperative tool
Kruger	none	n/a
Tolmie et al.	some - only one student given a workbook	none
Azmitia and Montgomery	none	none
Pozzi et al.	none	none
Tudge and Winterhoff	some - 'took turns'	none
Thomson	students given roles	n/a
Messer et al.	none	none
Howe et al.	none	none
Jackson et al.	some - 'took turns' 'reached group decisions'	none
Barbieri and Light	none	none
Natasi and Clements	none	none
Hoyles et al.	one copy of task between six students	none
Mevarech and Kramarski	none	none

Table 3.5 Task and tool structure of the learning situations in the thirteen studies

Six of the thirteen studies gave students some sort of cooperative task structure, one of which involved giving students roles, two by making students take turns, and two by giving only one copy of the task between the students. None of the studies that used tools (computers or other materials) provided any cooperative tool structure.

Neither the task nor the tool generally used in computer-assisted cooperative learning research is designed for cooperative work. Thus, in Slavin's terms, there is no cooperative task structure and most software is designed for individual use. In the majority of studies, researchers have made little attempt to explicitly create a cooperative task structure. This could be provided in two ways: the software could be designed to incorporate a cooperative structure or the worksheets and questions that are used during the study could force a cooperative structure onto the task.

The tool (the hardware) is designed specifically for individual use, with one mouse and one keyboard and most studies involve more than one individual trying to share the medium. This leads to role differentiation and can encourage the 'free-rider' effect (in which one or more students in a group do not participate and leave the other members of the group to carry out the task). This can be detrimental to the cooperative interaction.

Ideally, studies of cooperative learning would involve a cooperative task structure and a cooperative tool. In pragmatic terms, it is possible to use cooperative task structures. Providing a cooperative tool is more difficult given the current state of the technology and resources available. However, the software and the worksheets could be used to try to prevent the 'free-rider' effect by forcing participants to equally share control of the hardware.

3.3.5 The nature of groupings

The thirteen studies under discussion were classified according to the nature of the groupings that occurred in the studies (table 3.6).

Study	Grouping
Kruger	friendship and mother
Tolmie et al.	random
Azmitia and Montgomery	friendship
Pozzi et al.	students gender and ability
Tudge and Winterhoff	students conceptions
Thomson	some contact
Messer et al.	students conceptions / computer ability
Howe et al.	gender and similar/different judgements/strategies/principles
Jackson et al.	similar ability
Barbieri and Light	random
Natasi and Clements	friendship
Hoyles et al.	achievement level and gender
Mevarech and Kramarski	not stated

Table 3.6 The nature of the groupings in the thirteen studies

From this table it can be seen that the thirteen studies under discussion show a wide variation in the way in which students are assigned to groups, including friendship, gender, ability, random and student's conceptions.

There are significant difficulties associated with determining the cognitive criteria by which students should be grouped. Grouping can occur in terms of ability on a particular task, or 'general' ability or complimentary knowledge or conflicting knowledge. In a classroom situation, teachers would have to spend a considerable amount of time determining these factors and defining the groups.

Any interaction between more than one individual will necessarily be affected by the personal characteristics of the individuals involved. Much of the current research on computer-assisted cooperative learning has involved groupings which are dependent on cognitive factors, i.e. grouping according to ability or initial conceptions. While these studies will inform theory, they are of relatively little use from a pragmatic perspective. This type of grouping is impractical and time consuming. An alternative is to pair students by friendship. This assumes that much of the motivation for effective cooperation is moral i.e. students are guided by their respect for their peers and their wishes to help (Ames, 1984). Grouping by friendship is preferable for teachers, who will have knowledge of the friendship groups within the class, whereas grouping by cognitive criteria as noted above can be very difficult and time consuming.

3.3.6 Foci of analysis

Researchers interested in computer-supported collaborative learning have generally used an experimental methodology, with pre and post-testing either side of a computer intervention. Many different variables have been investigated with a focus on the *outcomes* of the interactions. Some research has focused on the nature of the interaction which can be studied in three different ways:

1. By analysing the *dialogues* which occur during cooperative interactions. This leads to analyses which try to determine which dialogues lead to productive interactions and what other factors, for example the nature of the software and the siting of the learning situation, affect the nature of the dialogue.

2. By analysing the *behaviours* that occur when students work together. This involves intensive analysis of videotapes of the interactions. A variety of factors can be investigated, for example, interactions with each other, interactions with the hardware and external events. This allows an in-depth description of the nature of the interaction.

3. By analysing the students' *performance* on the task during the session. This involves analysing student performance during the course of the interaction or post-experimentally from videotapes. This may facilitate describing why students gained from the interaction.

The thirteen studies under discussion have been classified in terms of how the data collected was analysed in relation to the outcomes and in terms of the nature of the interaction (table 3.7).

Study	Outcomes	Interactions
Kruger	moral reasoning	dialogue
Tolmie et al.	conceptual change	dialogue
Azmitia and Montgomery	problem solving ability	dialogue
Pozzi et al.	cognitive progress	behaviour
Tudge and Winterhoff	problem solving ability	none
Thomson	none	dialogue
Messer et al.	problem solving	none/session performance
Howe et al.	conceptual change	none
Jackson et al.	moves to solution	session performance
Barbieri and Light	problem solving	session performance, behaviour and dialogue
Natasi and Clements	higher order thinking	behaviours
Hoyles et al.	Logo ability, mathematical ability and classification and sorting, group products, affective measures	session performance and behaviour
Mevarech and Kramarski	aptitude, creativity, interpersonal relations	none

Table 3.7 The nature of the analysis in the thirteen studies

From this, it is clear that studies vary in the way in which they analyse the data. There is one study which did not focus on the outcomes of cooperative learning but this was solely concerned with the dialogues that occur in different groupings. There were also two studies that did not investigate the interactions that occurred. Five of the studies investigated dialogues, four studies looked at behaviours and four investigated session performance. Only one focused on dialogues, session performance and behaviours.

As discussions in sections 3 and 4 of this chapter have shown a range of aspects of collaborative interactions have been studied. Researchers have looked at the nature of interactions, both in terms of dialogues and behaviours, at outcomes of interactions and at on-task performance. In the final section of this chapter, guidelines derived from the previous discussions are described.

3.4 Guidelines for cooperative computer-supported learning research

As put forward earlier in this chapter, in order to encourage cooperative behaviour and therefore effectively study computer-supported cooperative learning, more attention needs to be paid to the structure of the research situation. It is recommended that when setting up computer-supported cooperative learning studies, researchers should attempt to implement the following guidelines. (For more detailed information on these guidelines, see Issroff, 1993). However, it must be borne in mind that to do so may be impossible when carrying out naturalistic studies.

1. *Studies should take place over a significant period of time.* This is necessary in order to ensure that effects are not solely due to novelty and that any interdependencies within a group working at a computer have time to develop.

2. *Students should be post-tested individually and cooperatively.* This will ensure that students perform to the best of their ability and thus reflect the true effects of the cooperative learning process.

3. *There should also be delayed post-testing.* This may uncover beneficial effects of cooperative learning relative to other learning situations.

4. *Students should be told that they are expected to work together.* This will help the students to perceive the learning situation as cooperative, therefore helping to set up a cooperative incentive structure.

5. *Students should be given some form of individual responsibility.* This will help to prevent the detrimental 'free-rider' effect and can be achieved either by telling the students that they will be assessed individually and/or by giving students individual worksheets.

6 *Students should be taught about cooperative work and what this involves.* This will help to set up cooperative motives.

7. *A cooperative task structure should be created.* This can be achieved either by designing software which enforces a cooperative task structure, or by providing worksheets which serve this purpose.

8. *A cooperative tool should be created.* This can also be achieved using the software or the worksheets.

9. *Studies should use friendship groupings.* This is easier to achieve than cognitive matching and may be a contributing factor to the success of the cooperative learning process.

The research guidelines presented in this section were used to define the nature of the empirical studies presented in this thesis. In the next chapter, the main empirical study is presented.

Chapter 4

Investigating affective factors: two studies

4.1 Introduction

Chapters 2 and 3 have reviewed collaborative learning research including research on computer-supported collaborative learning. Chapter 3 drawing on 13 studies, reviewed the methods for carrying out such research. This chapter presents two studies investigating computer-supported collaborative learning, with an emphasis on affective aspects.

The first study involved secondary school children using a computer to fill in a worksheet about the Periodic Table. The background to the this study is described and the results from a cognitive perspective are given, followed by the affective results pertinent to the description of effective learning situations. The data is then applied to this description and the results discussed. There is then a discussion of the affective factors relevant to the framework of Ames' cognitive-motivational theory of different learning situations described in Chapter 2. The second study involved Open University students working in groups with computers at summer school. Again, the background to the study is described and the results pertinent to the description of effective learning situations are presented and the data applied to the description. The data relevant to the Ames' cognitive-motivational theory of different learning situations is then presented and the chapter ends with a discussion of the findings from both studies.

In the next section the rationale behind the investigations of affective factors is described.

4.2 Rationale

The overall aim of the studies was to investigate affective aspects of computer-supported learning. Although cognitive outcomes should undoubtedly be a priority in education, there is also a need to consider affective outcomes of learning situations, as was argued in chapters 1 and 2. The main importance of this is in terms of the students' future learning and interactions with the world. Additionally, within a learning situation, students perceptions' will have an impact on their behaviour and learning.

The interplay between the cognitive and the affective is a two way process. The initial knowledge and competence of the student has an effect on their motivation, their interest, their perceptions of themselves (their self evaluations) and others and this in turn has an effect on their performance during the learning interaction. The students' perceptions of success or failure of a learning interaction in conjunction with the aforementioned factors, will have an effect on their future learning interactions.

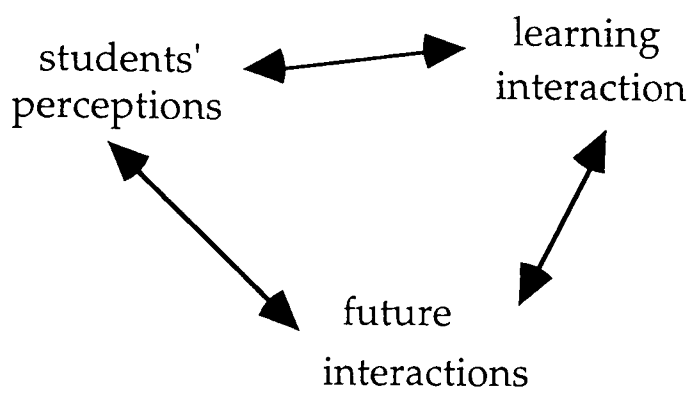


Figure 4.1 Diagram of the effects of students' perceptions

A simple description of an effective learning situation in which the following should apply, is proposed:

1. There should be a cognitive gain. This can be measured by pre- and post- (and/or delayed post) testing.

2. The students should perceive themselves as having been successful in that particular learning situation. This can be measured by getting students to rate their success on a questionnaire after the learning has occurred.

3. The students should be as interested and motivated towards the subject or more interested and motivated towards the subjects after the learning as before. This can be measured by getting students to rate their motivation and interest on questionnaires before and after the learning has occurred.

4. The students should retain or increase their perception of themselves in general. This can be measured by getting students to rate how good they think they are at this kind of work using questionnaires before and after the learning has occurred.

The above criteria can be said to apply to any learning situation. However, if a student is working cooperatively, there are some additional criteria.

5. The students should retain or increase their perception of their peers' ability. This can be measured by getting students to rate how good they think their peers are, by filling in questionnaires before and after the learning has occurred.

6. The students should still get along with their peers. This can be measured by getting students to rate how well they get on with their peers by filling in questionnaires before and after the learning has occurred.

The students were asked about all these criteria and the results from the study were applied to the description of effective learning situations in order to compare the efficacy of the different conditions.

The other affective factors presented here arise from Ames's (1984) cognitive-motivational theory of learning situations discussed in Chapter 2. The studies assessed the factors that students found important in order to test Ames's view that the emphasis in cooperative learning situations is on the group's success. In this respect, students were asked about what factors they found important and their perceptions of the importance of their own and their groups' success were also obtained.

4.3 An experimental study of Secondary School pupils' interactions with a computer

4.3.1 Design of the study

Fifty five students in year 9, aged between 13 and 14, took part in the study. Twenty eight pupils were girls, 27 boys. Three classes were involved in the empirical work. The school was an inner London secondary school, drawing on a working and middle class population. The pupils represent a variety of ethnic backgrounds, for example, Eastern Europe, North Africa and India. Classes have between 25 and 30 pupils, and the science classes were the same as the tutor groups, therefore the children have generally known each other for two years and were familiar with one another, having most of their lessons together.

Software

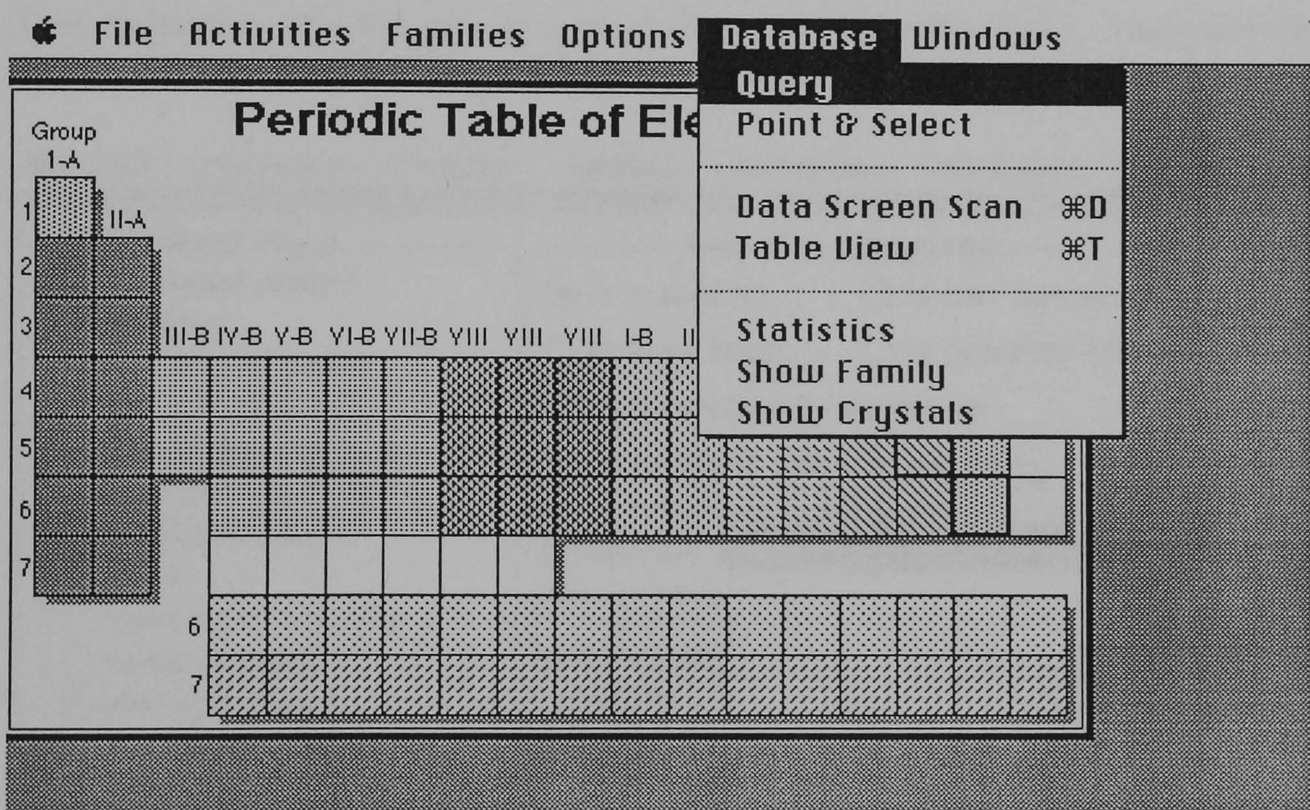
The software used was a commercially available package called ChemAid. This was described as 'a learning system that presents information on the elements in the Periodic Table. It was designed to help students become familiar with each of the elements and their characteristics.' The primary goals for the use of ChemAid were described as:

1. To extend an individual's knowledge about the elements by providing a computer-based reference system which represents the organisation of the Periodic Table and basic information on each element for use in science, library or laboratory setting.

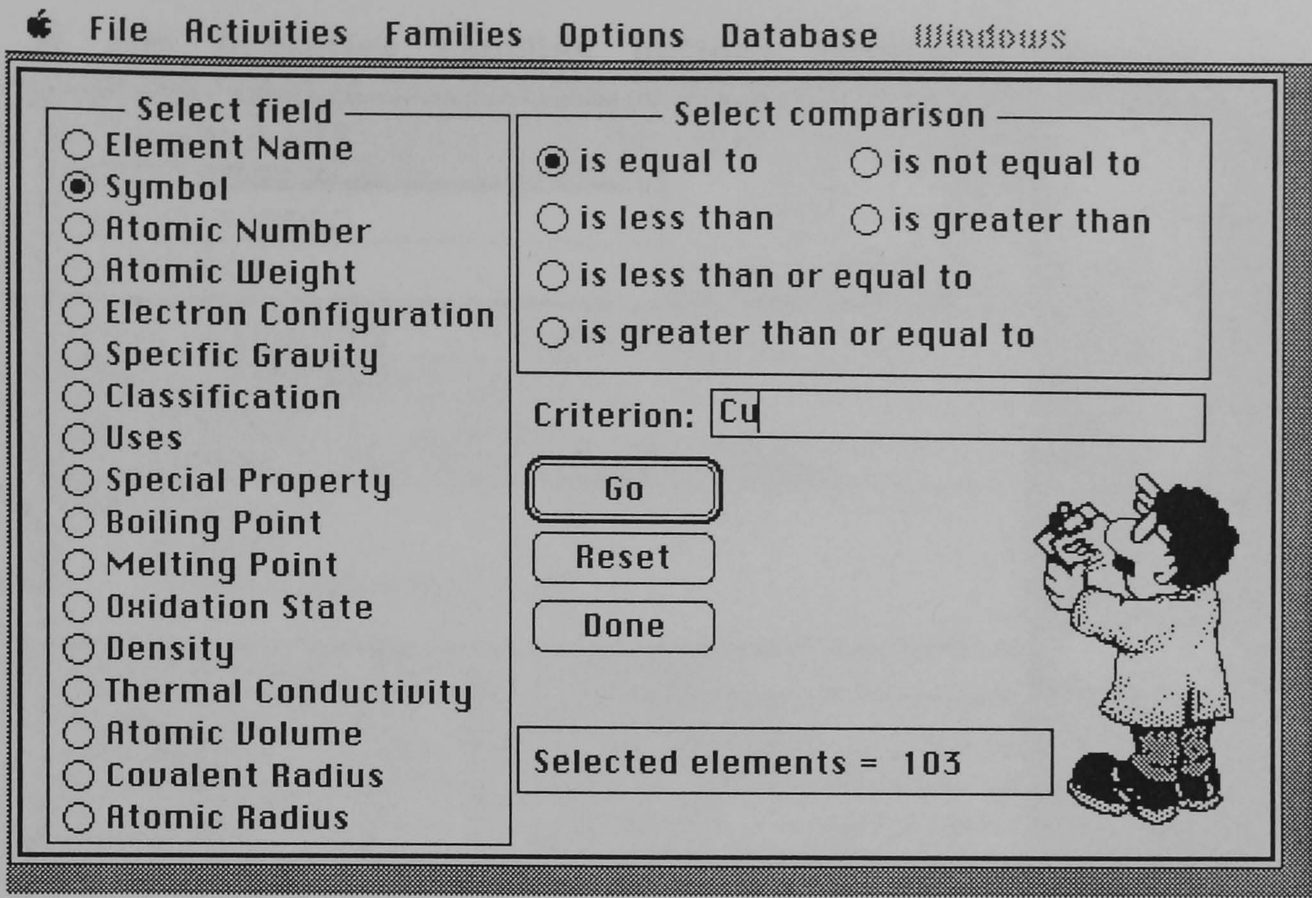
2. To provide an interactive learning environment where the student can develop his ability to recognise each element by its position in the Periodic Table and by its symbol.

3. To present concise, detailed information about each element, including the atomic number, atomic weight, electron configuration, specific gravity, uses, special properties and other basic information in a database format which can be queried in a variety of ways.
Although there were several activities incorporated in the system, the students in this study only used one aspect of the program which allowed them to interrogate the database. They used a 'Query' option in which they specified which element name, symbol, classification, melting point, boiling point, thermal conductivity etc. was to be selected. They then chose a type of comparison (e.g. is equal to, is greater than) and then specified the criterion (e.g. the element name, a boiling point). They then clicked on a 'Go' button which instructs the computer to query the database. When this was completed they selected the 'Done' button and then went to a 'Data Screen Scan' menu item which allowed them to view the element/s that had been selected using the Query. This brought up a window with information about the selected element or elements.

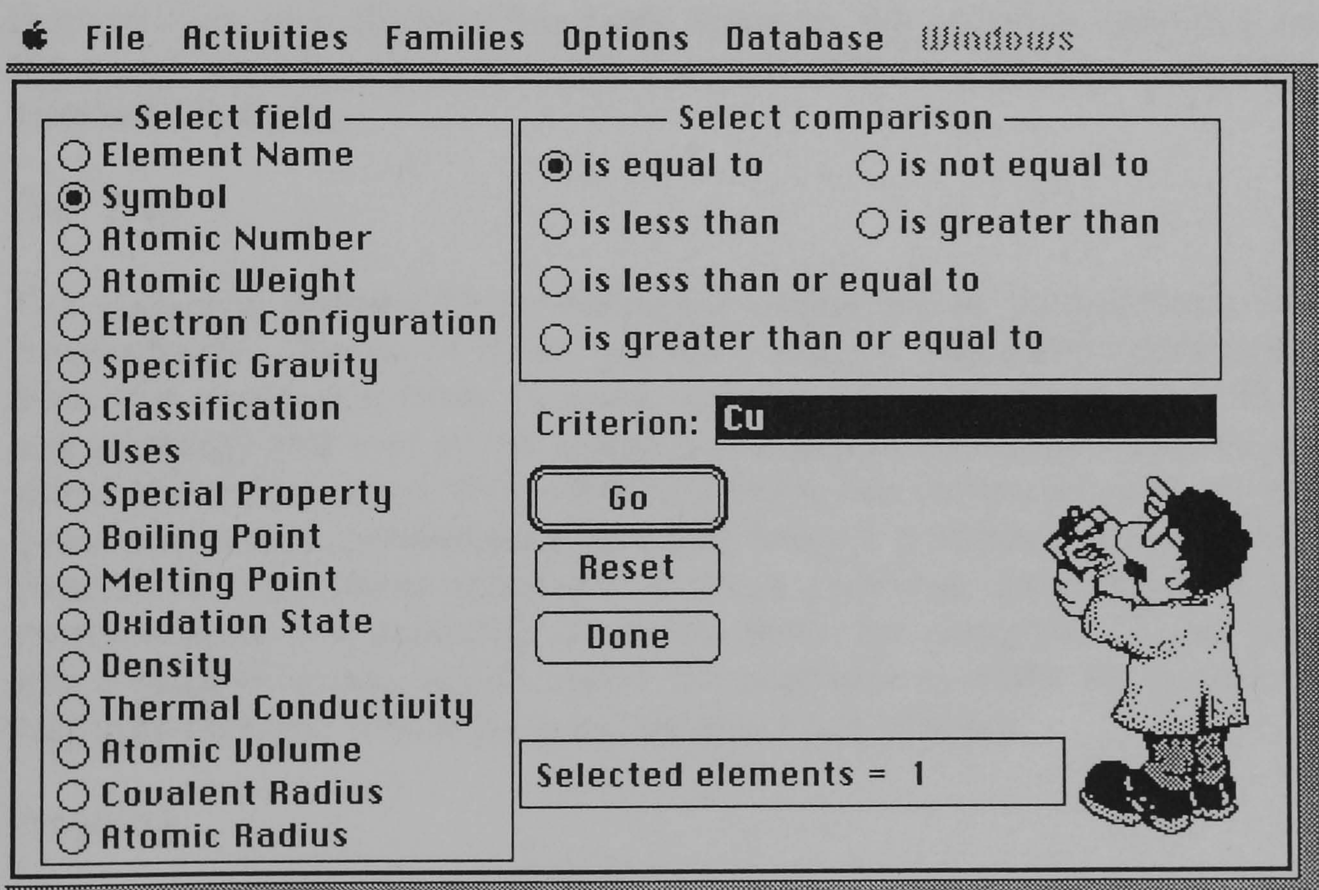
Screen dumps of an interaction with the software are shown below.



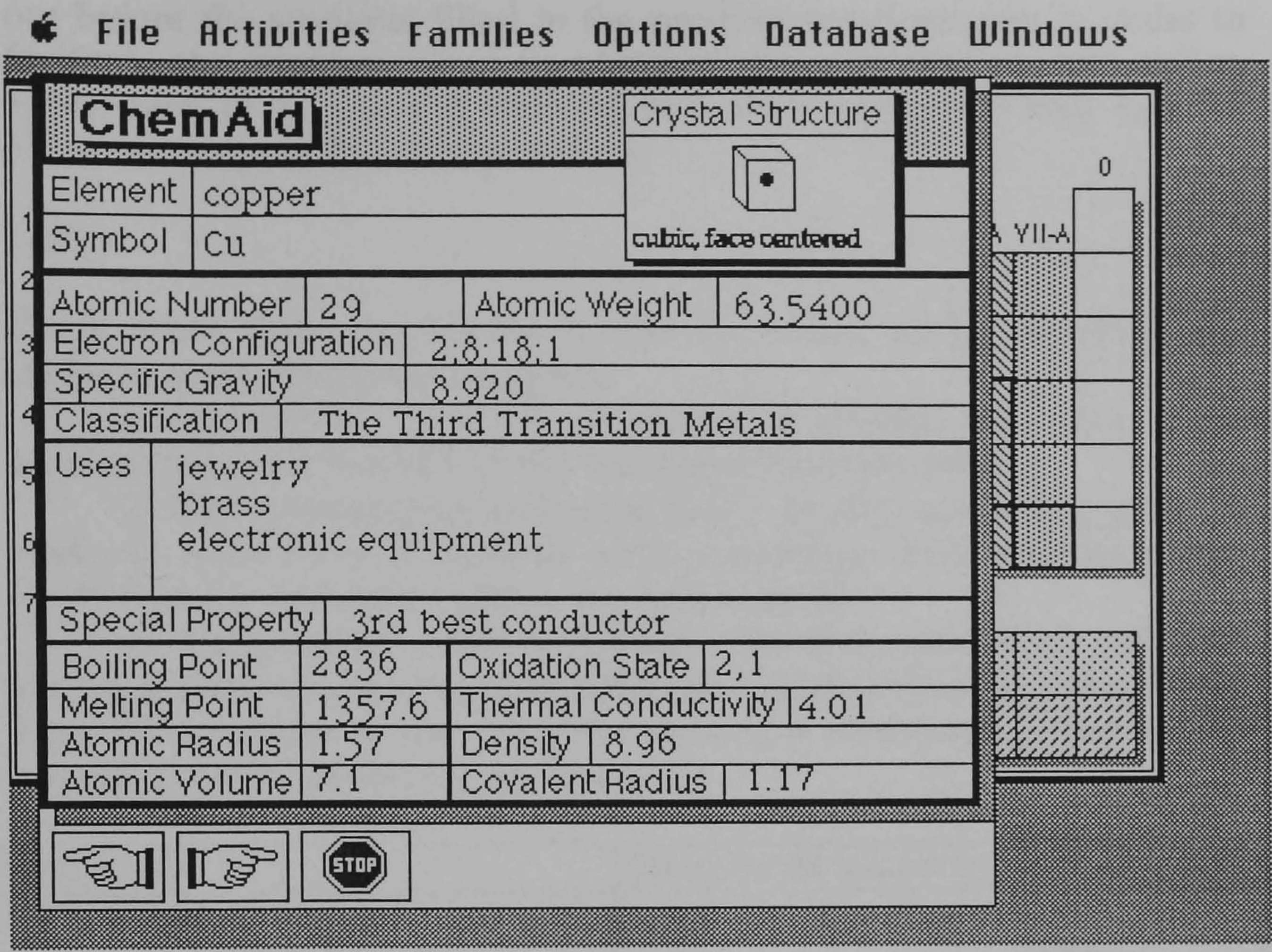
The students initially select "Query" from the Database menu.



The students then have to select the appropriate field, comparison and criterion for the information they wish to obtain.



Once the students have selected go, the computer selects one or more elements that satisfy the criteria. The students then click on the done button and a window about the selected element appears.



If more than one element has been selected, the students can click on the hand icon to move through the information windows about the selected elements.

The Task

The task was defined by a worksheet consisting of 17 questions (see Appendix A). Eleven of these questions simply asked for information from the computer (four of these ask for answers about more than one element) and two of the questions required the students to reason about the information they obtained from the computer. One of the questions was a prediction following from a previous question and three of the questions followed on from previous questions and the answers were not explicitly available from the computer. There was also a final question which asked the students to make up questions that they thought would be good for this kind of work.

Training

Students were taught how to use the software with a training sheet (see Appendix A). This generally took between 10 and 20 minutes. The training sheet had four questions, the first two had explicit instructions detailing exactly what needed to be done, while the last two had no instructions and were designed to show students different aspects of the software. The researcher helped the students through the training, although this was kept to a minimum and checked that they felt confident after the training. The training session was carried out before the students filled in the pre-test questionnaires in order to facilitate the assessment of their expectations in the pre-test and to allow them to get used to working with their partners if they were in either of the cooperative conditions.

Design

There were three conditions in the empirical study to which the students were randomly assigned:

1. Individual - In this condition, a student was trained on his/her own and worked at the computer individually.
2. Non-cooperative task structure - In this condition, pairs of students were trained together with a training sheet each and then worked at the computer with a worksheet each.
3. Cooperative task structure - In this condition, pairs of students were trained together with one training sheet between them. They then worked at the computer sharing a worksheet. The pre- and post-tests were carried out individually.

Condition	Number of students	Worksheet
Individual	One	Own
Non-cooperative task structure	Two	Own
Cooperative task structure	Two	Shared

Table 4.1 Summary of the conditions

The pairings were friendship pairs generally chosen by the teachers. Occasionally (especially when the teacher was a supply teacher), a student would choose someone that they felt happy to work with. The students were then randomly assigned to the different conditions.

Eleven individuals (six males and five females) and 22 pairs (10 female:female pairs, nine male:male pairs and three mixed gender pairs) completed the study. The design is not balanced because there were very few mixed gender friendship pairs. This is summarised in the table 4.2.

Condition	Male/ Male:Male	Female/ Female:Female	Male:Female
Individual	Six	Five	
Non-cooperative task structure	Four	Five	Two
Cooperative task structure	Five	Five	One

Table 4.2 The number and gender of students in the conditions

Experimental Situation

The learning interaction occurred at the back of the classroom. Although this meant that the work was open to interruptions, it was felt that this would avoid anxiety and help to make the students feel at ease. Generally, when the students entered the classroom/laboratory, the computer would be ready, with the keyboard nearby and the mouse placed in the middle.

The students were told that the research was concerned with the difference between students working at computers in pairs as opposed to individually. They were then told exactly what they would be required to do. It was explained that they would be taught how to use the computer and then asked some chemistry questions followed by some general questions about science, chemistry, working at the computer and working with their partners. They would then fill in a worksheet using the computer, without the researcher's help and answer similar questions at the end. The pairs were explicitly told that these would be individual tests and where possible, one student moved to a different table for the pre- and post-tests.

After the students had been briefed, they were trained using the training sheet and then given the pre-tests. The pairs were reminded to work together and they were then left to complete the worksheet. The researcher remained nearby throughout the interaction and although they were told to complete the worksheet without the researcher, they sometimes asked for guidance, which was generally given in a non-directive manner, in order to ensure that the interaction continued.

Some of the sessions lasted more than one lesson, in which case the students would repeat the pre-test and the researcher would check that they still felt confident about using the software before they continued the worksheet.

Questionnaires

The study involved pre- and post-testing with questionnaires for both cognitive (chemistry) knowledge and background information and affective factors which were piloted prior to the main study (Issroff, 1994a). There are different affective questionnaires for the individuals and the pairs. All the questionnaires can be found in Appendix A.

Pre-chemistry questionnaire

This questionnaire aimed to assess the students' prior knowledge of aspects of chemistry involved in the computer interaction. It consisted of ten questions. Six of the questions were conceptual questions, four referring to conceptual questions in the worksheet, the other two asking for explanations of concepts which were described in the worksheet. Four questions asked for facts.

Post-chemistry questionnaire

This questionnaire aimed to assess the students' knowledge of aspects of chemistry involved in the computer interaction after the session. It consists of ten questions. Six of the questions were conceptual questions, four referred to conceptual questions in the worksheet (one of these questions was analogous to a question in the pre-test), the other two asked for explanations of concepts which were described in the worksheet. Four questions asked for facts, the answers to three of these should have been used to answer questions in the worksheet. One question involved a fact which the students should have seen displayed on the screen during the interaction.

Pre-affective questionnaire

This questionnaire consisted of predominantly five-point rating scales and open-ended questions. There were different questionnaires for the individual and the cooperative conditions which were tailored to reflect the nature of their working conditions. It asked for students' use of computers and their favourite parts of science and the lessons that they enjoyed. Their motivation towards and interest in chemistry and learning from computers was assessed. They were also asked how good they thought they would be at this type of work and what they wanted to get out of the session.

The pairs were also asked how well they got on with their partner, how good they thought their partner would be at this type of work, how much they respected their partner, how much they wanted to help their partners and how much they thought their partners will help them.

Post-affective questionnaire

This questionnaire consisted of predominantly 5-point rating scales and open-ended questions. There were different questionnaires for the individual and the cooperative conditions which were tailored to reflect the nature of their working conditions. The students' motivation towards and interest in chemistry and learning from computers was assessed. All the students were asked how successful they thought they were in the session and why. Their goals were assessed by both an open-ended question and a multiple-choice question. They were asked whether they found the session frightening, how pleased they felt with what they had done and how good they thought they were at this kind of work. Their continuing motivation was assessed and they were asked how important it was to get the answers correct, whether they would rather have worked in the other condition (i.e. either on their own or with someone else) and what they think they have achieved.

The pairs were also asked how well they got on with their partner, how good they thought their partner was at this type of work, how much they respected their partner, how much they helped their partners and how much they thought their partners helped them. They were also asked how successful they thought their group was and why, and how important their group's and their own success was. They were also asked how satisfied they were with their own and their group's performance and why. How important they felt it was to get along with their partner was also assessed.

Additional Data

Friendship rating data was also collected for each pair. Three randomly chosen students from each class rated the friendship of the pairs used in the empirical work on a five point scale.

Summary

Training
↓
Individual cognitive and affective pre-test questionnaires
↓
Computer Interaction
↓
Individual cognitive and affective post-test questionnaires
.
.
.
↓
Individual delayed post-test questionnaire

Figure 4.2 Summary of the empirical study

In terms of the research guidelines derived in chapter 3, this study did not take place over a considerable period of time, but the children were familiar with one another and did have a training period to familiarise themselves with the computer. The original plan was to post-test the students collaboratively, but in practice, this was impossible, because of the timing and because the children became frustrated with filling in the questionnaires. There was delayed post-testing (between six weeks and three months after the students had used the computer) and the students were told that they were expected to work together. The majority of the pairs were friendship pairs and in the relevant conditions, students were given a cooperative task structure and individual responsibility.

4.3.3 Results

In this section, the results are presented, first detailing general information about the students, followed by the cognitive results, including the pre-, post- and delayed post-tests and the on-task performance results. These are discussed within the context of the different conditions and from a gender perspective. This is followed by an analysis of the affective questionnaires, firstly in terms of the model of effective learning situations presented in section 4.1 and then in terms of the factors pertinent to Ames' cognitive-motivational model of learning situations introduced in Chapter 2.

4.3.2a Cognitive

The means of the test scores on the pre-, post- and delayed post-tests are shown in Figure 4.3.

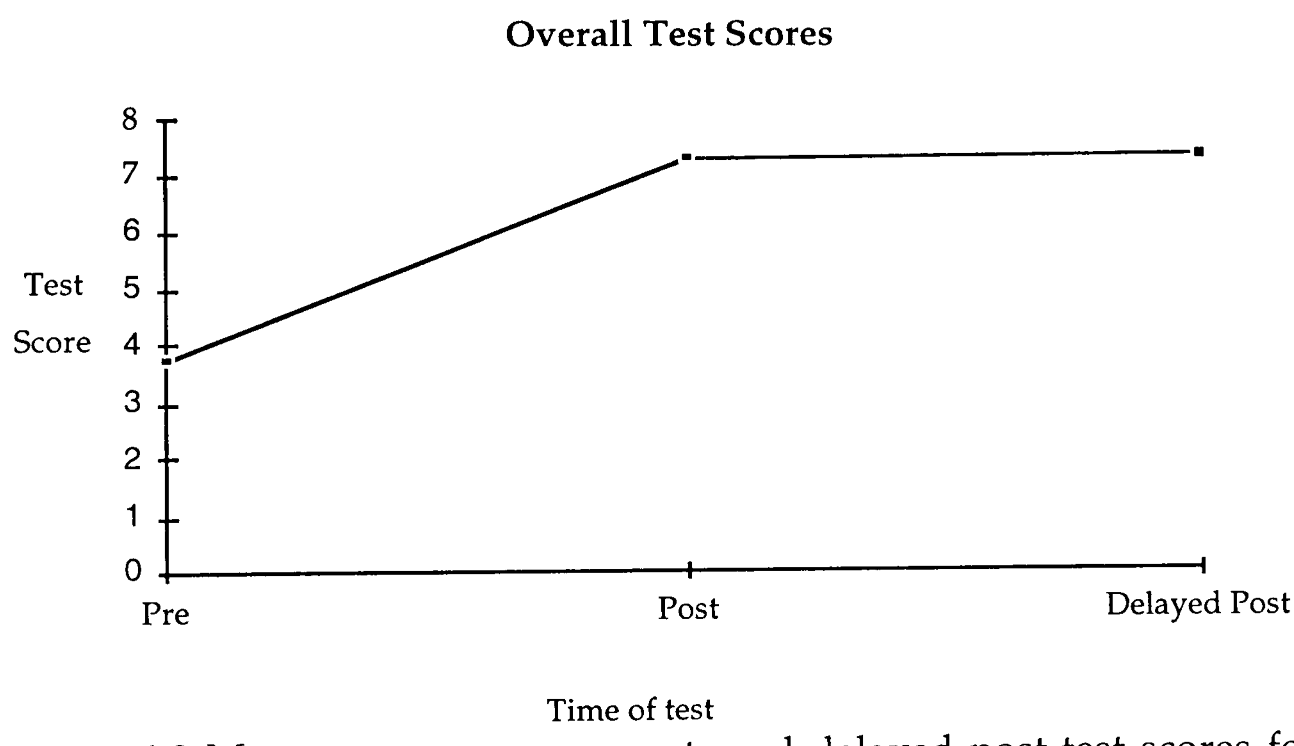


Figure 4.3 Mean scores on pre-, post- and delayed post-test scores for all the students.

There was a significant difference between the pre-test scores and post-test scores, $t=9.48$, $df=54$, $p<0.0001$ and between the pre-test and delayed post-test scores, $t=8.29$, $df=45$, $p<0.0001$. The results of nine students were not available for the delayed post-test scores. Therefore the student's interaction with the computer had a significant effect on their test scores. It is possible that the students underwent some teaching between the post- and delayed post-tests which will have had some bearing on the delayed post-test scores, but we can assume that all the students had a similar amount of teaching.

However, the students' on-task performance is also important and this is reflected in the scores that students obtained on their worksheets while using the computer, which are shown in Figure 4.4. The students working in pairs achieved significantly higher total scores than the individuals ($F_{2,52}=3.734$, $p<0.031$).

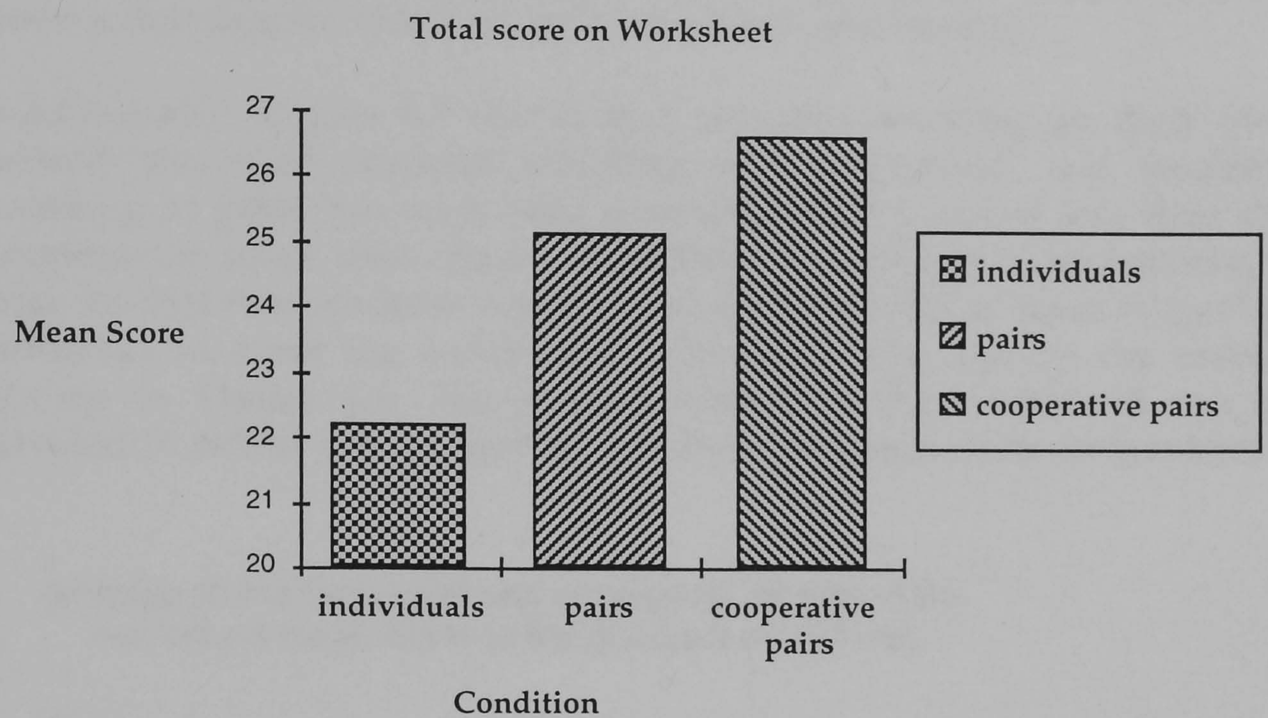


Figure 4.4 Mean total scores on the worksheet for pupils in the three conditions.

This result is interesting because there were no significant differences between the pre-, post- and delayed post-test scores for the three different conditions. These results are shown in Figure 4.5.

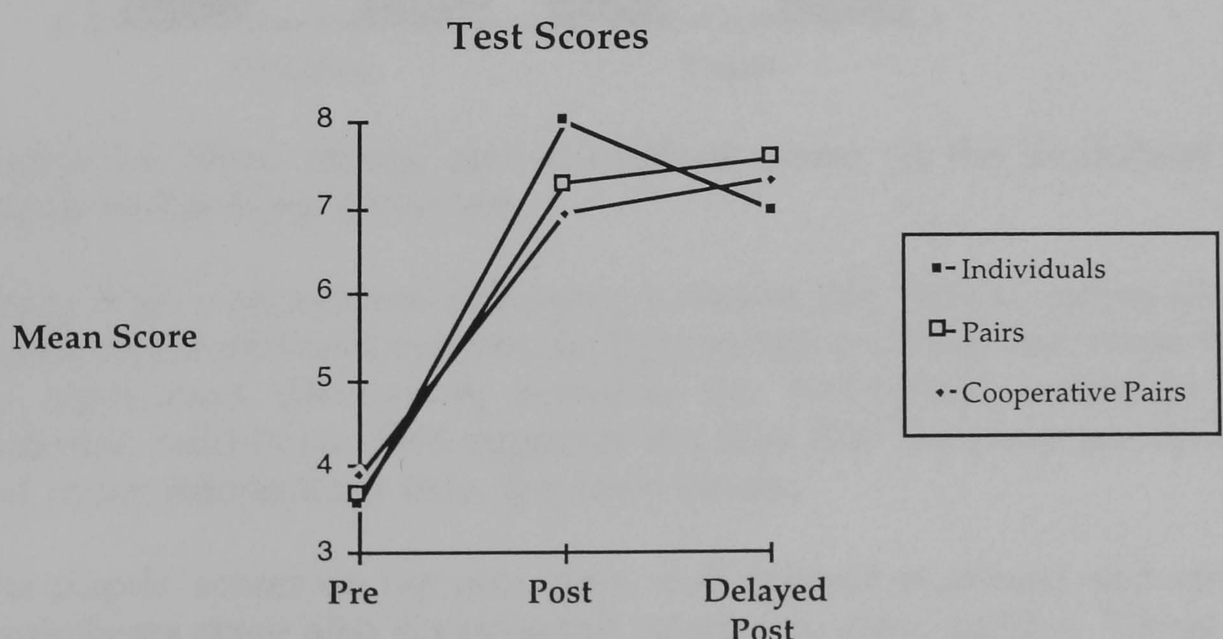


Figure 4.5 Mean scores on pre-, post- and delayed post-test scores for students in the three conditions.

Although there were no significant differences between the conditions, some differences are apparent. The students who worked as individuals scored higher on the post-tests than the students working as pairs in the immediate post-test. However, in the delayed post-tests, the students who worked in pairs achieve better scores than those who work as individuals. A possible interpretation of this is the fact that all students are post-tested individually, even when they have been working collaboratively. Working together may therefore have a detrimental effect on individualised post-testing.

Additionally, Figure 4.4 shows that students working on their own scored less than students working with a partner, and students working in pairs but with their own worksheets scored less than the cooperative pairs who shared worksheets on on-task performance. It may be that two students together can work out more ways of getting information from the computer. This was borne out by the results shown in Figure 4.6. The pupils' scores on the worksheet can be divided to reflect the conceptual and factual aspects of the worksheet.

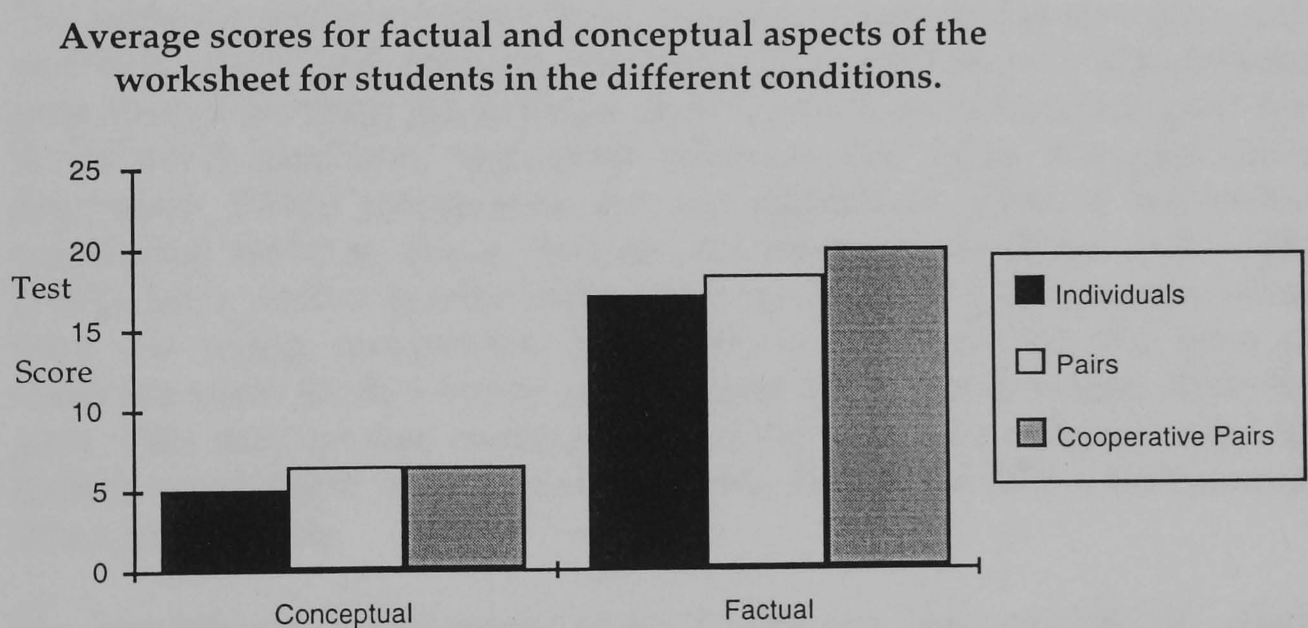


Figure 4.6 Mean factual and conceptual scores on the worksheet for pupils in the three conditions.

There was a significant difference between the factual scores of the pupils in the different conditions ($F_{2,52}=6.444$, $p<0.003$) and there were no significant differences between the conceptual scores in the different conditions. This supports the idea that the pairs are finding out more information than the individuals.

The pupils' scores on the pre-, post- and delayed post-tests and on the worksheets were also investigated relative to their gender. Figure 4.7 shows the mean total scores for boys and girls in the different tests.

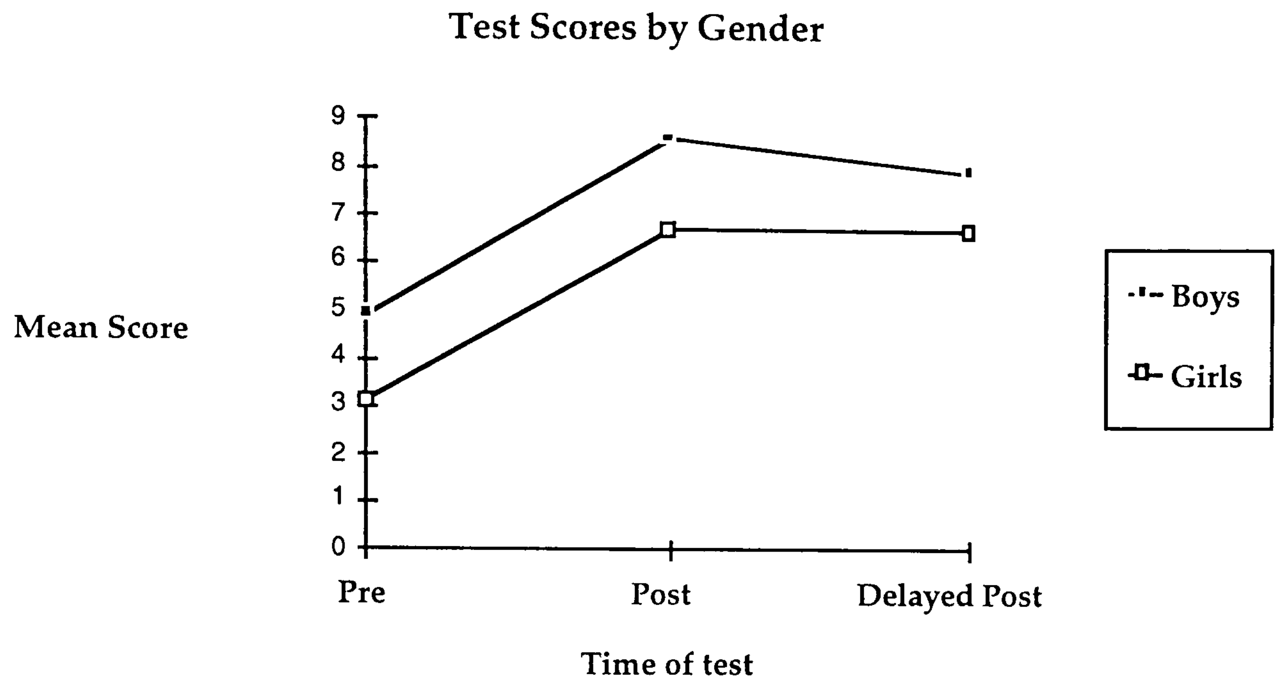


Figure 4.7 Mean scores on pre-, post- and delayed post-tests for girls and boys.

The boys started at a higher level of performance on the test than girls and this continued through the immediate post-test to the delayed post-tests. However, the average girls scores from immediate post-test to delayed post-test improved whereas the boys average score decreased. These differences are not significant. This is somewhat surprising because some studies, for example, Barbieri and Light (1992), have found gender differences in students' performance when they are using computers. However, it appears that the type of software used in this study is not more beneficial for boys than for girls. This may be due to the nature of the task. The software used by Barbieri and Light was a game and this may have had a detrimental effect on the girls.

No significant differences were found on the worksheet when comparing the scores of girls and boys.

The students were divided into two groups according to how much they gained from the pre- to post-tests. Figure 4.8 shows the mean test scores on the pre-, post- and delayed post-tests for high and low gain students.

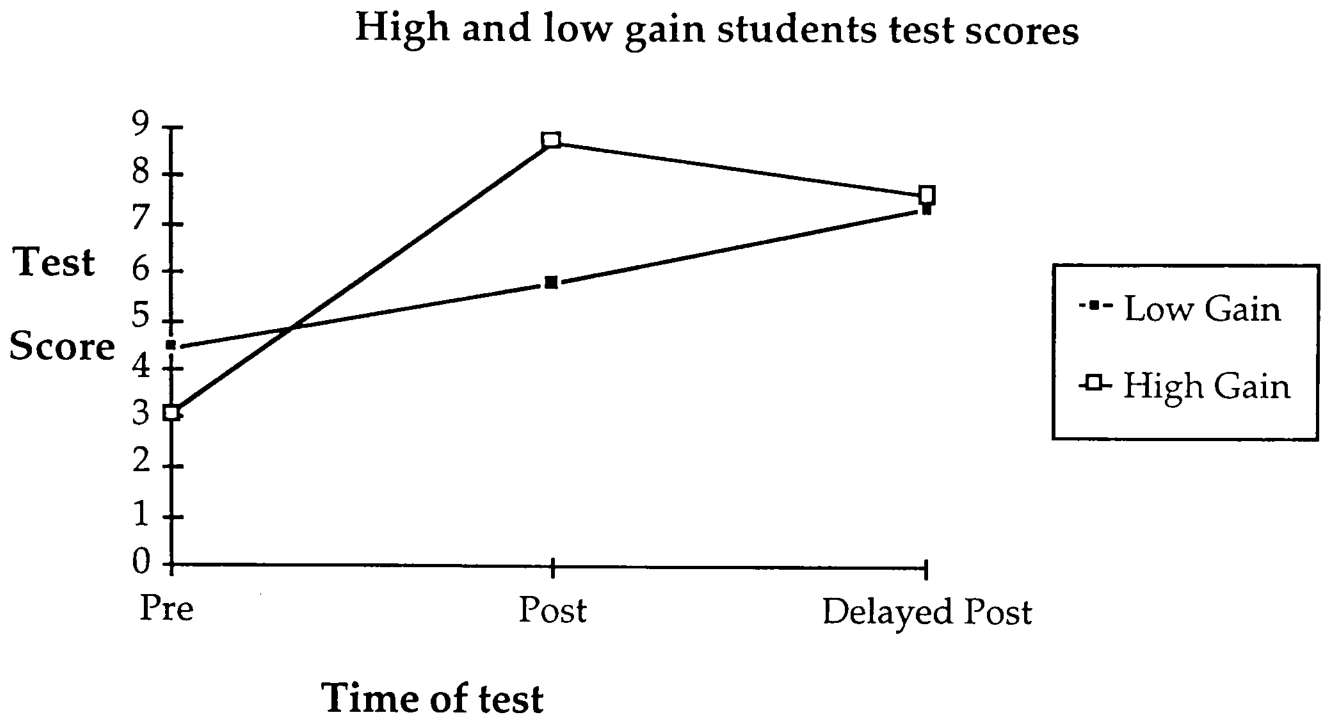


Figure 4.8 Mean pre-, post- and delayed post-test scores for high and low gain students.

There were no significant differences between the high and low gain students at the pre-test , but there was a significant difference at the post-test ($t=2.85$, $df=45$, $p<0.006$). However, there was no significant difference at the delayed post-test. Many studies use pre- to immediate post-test scores as a way of assessing the success and failure of collaboration. Researchers then investigate the interactions of those showing high pre- to post-test gains in order to determine the factors that lead to successful collaborations. However, this result shows that in the long term, the students that appear to be 'good' on an immediate post-test are not necessarily the only ones who benefit in the long run and students who appear to be 'bad' in an immediate post-test have not necessarily had an unproductive interaction.

Summary

It is clear that these students showed a pre- to post-test gain in cognitive terms from using simple software for a relatively short period of time. However, the pre- to post- and delayed post-test scores do not show a clear benefit from working in pairs, although there is a significant benefit from working in pairs in terms of on-task performance. When reviewing the cognitive results of the study, it should be noted that one of the teachers said that she had noticed that the students had a good understanding of the Periodic Table relative to the other subjects when she was doing revision with the class.

A possible explanation for the difference between the pre- to post-test gains and the scores on the worksheets is that individualised post-tests do not reflect the success or failure of an interaction. It may be that a successful collaboration has a detrimental effect on an individualised post-test.

The results clearly show that simply investigating an immediate post-test score does not adequately reflect the benefits of the interaction. Results in a delayed post-test may paint a different picture. In this study, the individuals scored higher on the immediate post-test, while the pairs scored higher on the delayed post-test. It may be that for students working in pairs there is an incubation period, during which the knowledge is consolidated within the individual and this is then reflected in the delayed post-test.

The benefit to the students working in pairs on the worksheet is seen in their better performance on the factual questions. This can be explained if one considers that two students may have the ability to gain access to more information from the database than one student.

Although there are differences between boys and girls, these are not significant. However, the girls do improve at the delayed post-test, whereas the boys' average score decreases.

The results of this study also show that investigating the interactions of students that have shown high pre- to immediate post-test score gains is not necessarily indicative of productive interactions. It was found that there is no significant difference between high and low gain students in the delayed post-test. Therefore, investigating students who did well on the pre- to immediate post-test is not necessarily investigating the most productive interactions.

In the next section, the results of the affective questionnaires are presented. This is followed by a model of effective learning situations which combines both the cognitive and the affective factors.

4.3.2b Affective factors

The study investigated affective as well as cognitive factors. The results of the affective questionnaires are presented in this section in terms of the description of effective learning situations presented in section 4.2 and then in terms of the factors pertinent to Ames' cognitive-motivational theory.

Description of effective learning situations.

The description of effective learning situations in section 4.2 incorporates students' perceptions of their success, their change in interest and motivation, their perceptions of themselves and their peers and how well they get along with one another. These results are presented next.

The students were asked how successful they thought they were at the activity (they were not asked in advance of completing the worksheet how successful they thought they would be). The results of this are shown in Figure 4.9 below:

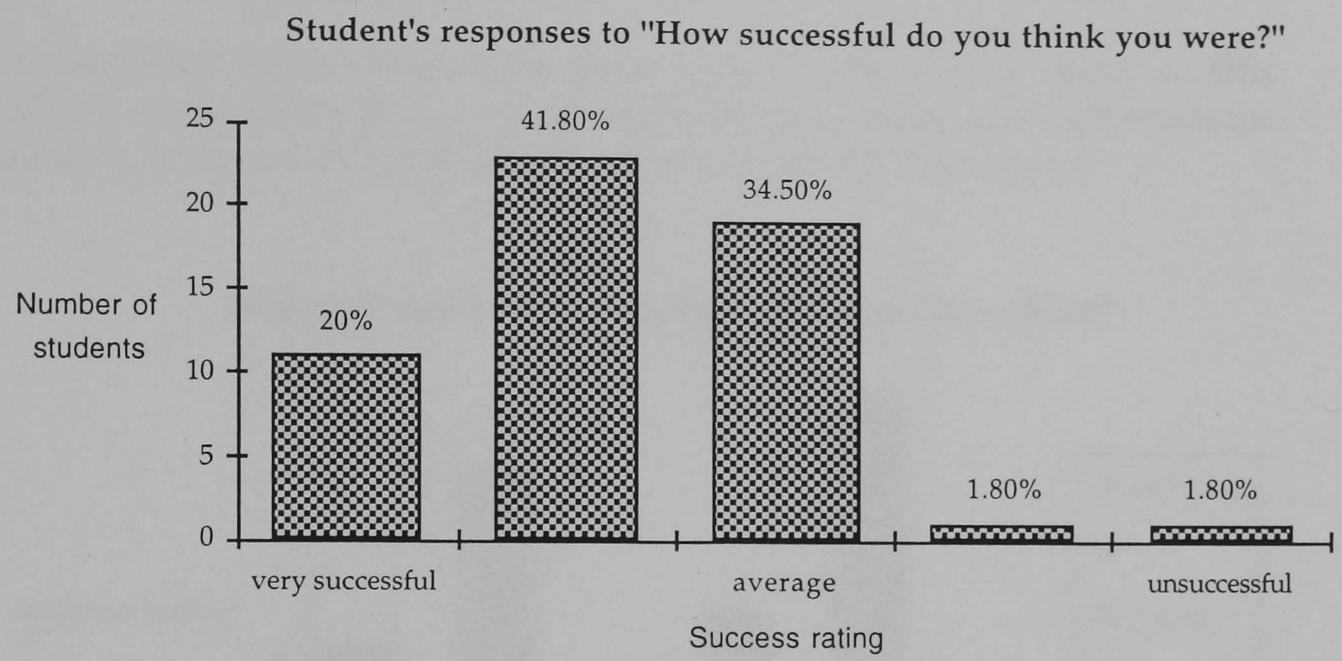


Figure 4.9 Graph of students' responses to the question "How successful do you think you were?"

Sixty percent of the students thought that they were more successful than average and very few students rated themselves below average. There were no significant differences between the three conditions and no significant differences between the girls' and boys' ratings.

The students were also asked to rate on a five point scale both before and after the computer intervention how interested and motivated they were towards chemistry and computers. There were no significant changes in the students' motivation and interest towards chemistry and the only gender differences found were in the students' post-test ratings of their motivation towards chemistry (Wilcoxon $W=2.1417$, $N=55$, $p<0.0322$). There was more change in the boys' ratings than the girls' and this was generally to a higher post-test rating. Therefore using the computer increased the boys' perceived motivation towards chemistry, but had no effect on the girls.

There is a significant difference between the students' pre- and post-test ratings of their interest in computers (Wilcoxon $W=2.1539$, $N=55$, $p<0.0312$). Twelve out of the 17 students whose interest changed increased their interest in computers. This difference in the pre- and post- interest in computers was due to the girls whose interest in computers increased significantly (Wilcoxon $W=2.317$, $N=28$ $p<0.0208$), although there was no corresponding increase for the boys. Seven of the nine girls whose ratings changed increased their ratings.

There was also a significant difference between students' pre- and post- motivation ratings towards computers (Wilcoxon W=2.0853, N=55, p<0.0370). Twenty five students changed their ratings, and 17 of these changes were increases. Again this increase is predominantly due to the girls although there is no significant difference between the girls' pre- and post-test ratings (Wilcoxon W=1.9595, N=28, p<0.0501).

The students were asked how good they thought they were at this kind of work both before they used the computer and afterwards. Figure 4.10 shows the distribution of the students responses.

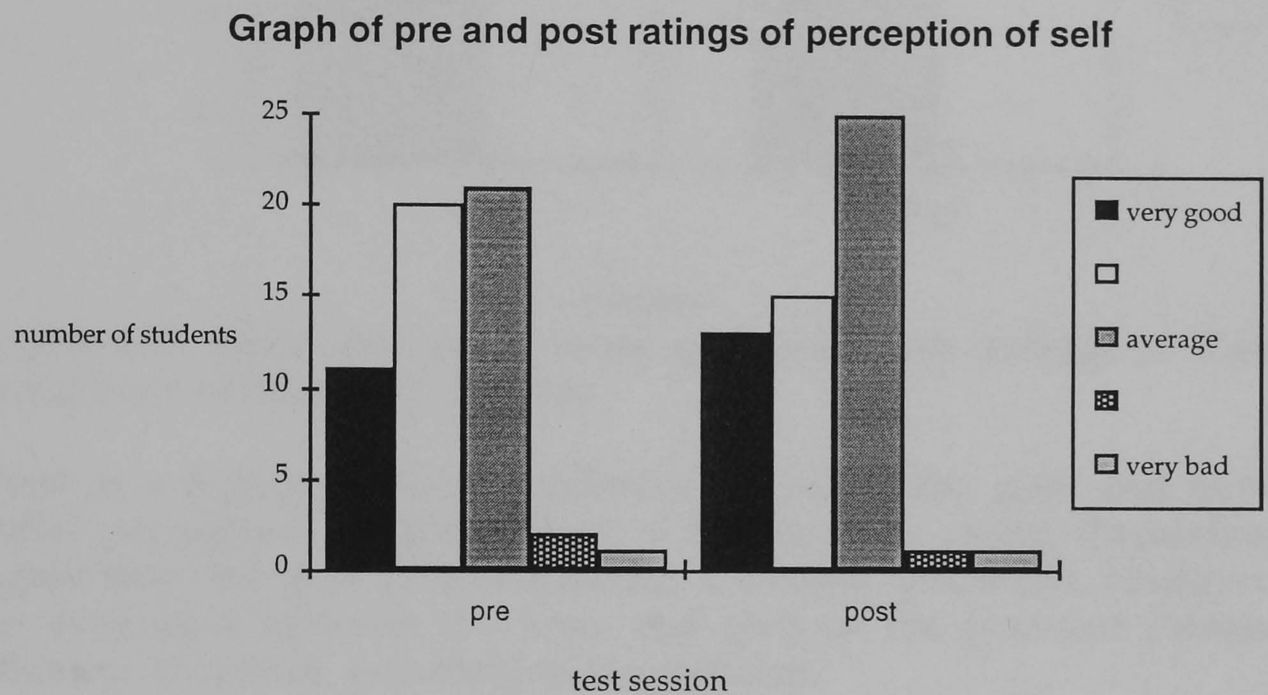


Figure 4.10 Students' pre-test and post-test ratings of their perceptions of how good they are at this kind of work.

Overall, there is no significant change from pre-test to post-test. There are no significant differences within the conditions, but gender differences are significant. Figure 4.11 shows the pre-test and post-test averages for girls and boys.

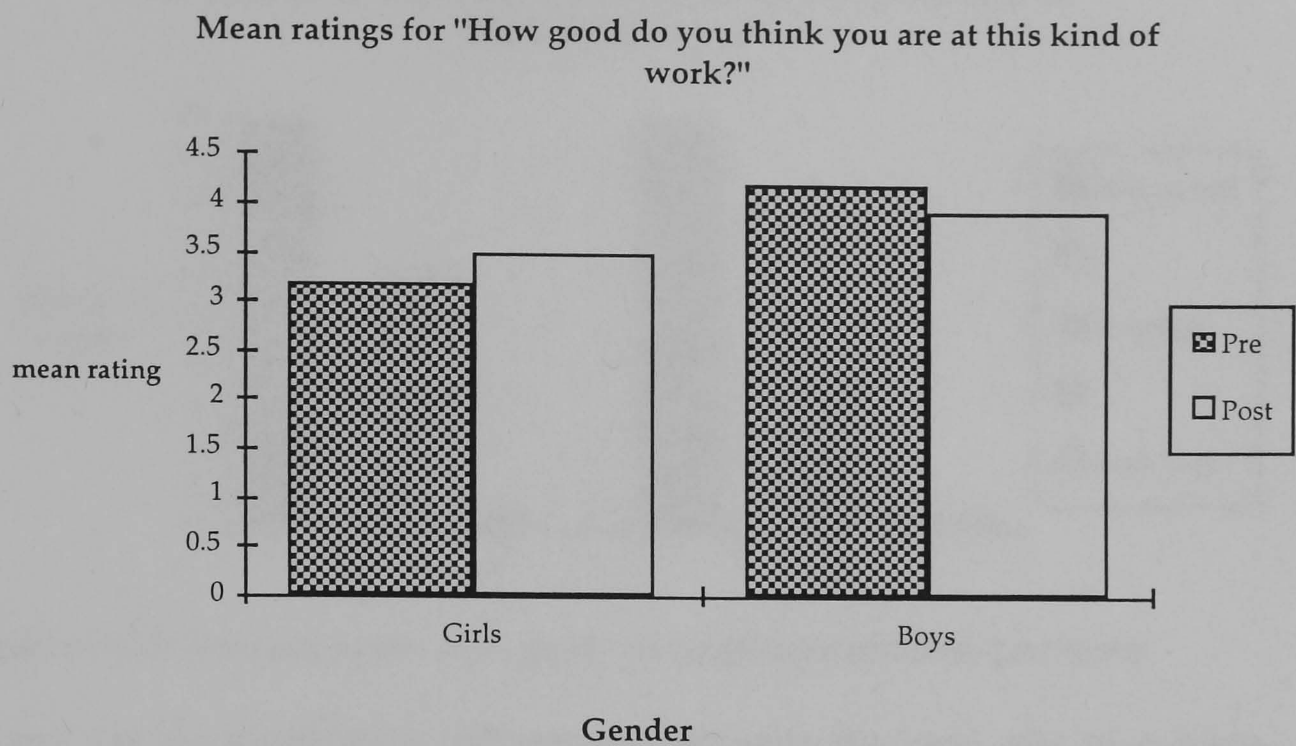


Figure 4.11 Girls' and boys' mean pre- and post- ratings of their perceptions of how good they are.

There is a highly significant difference between the girls' and boys' initial perceptions of themselves, with the boys rating themselves higher than the girls (Mann-Whitney: $U=4.0185$, $p<0.0001$). However, the difference between the boys and girls at the post-test (Mann-Whitney: $U=1.8218$, $p<0.0685$) is insignificant.

Although the majority of ratings stayed the same, there is a significant difference between the girls' and boys' rating change (Mann-Whitney: $U=4.7399$, $p<0.0295$). Ten girls' perceptions of themselves increased, and 3 decreased, while for the boys, 3 increased and 6 decreased. The majority of the increase in the girls were those who considered themselves average and the majority of the decrease for the boys was from those who rated themselves as very good.

Thus the use of the computer increased the self perceptions of the girls who rated themselves as average and decreased the self perceptions of the boys who rated themselves as very good.

The students were asked how good they thought their partners were both before and after they used the computer. The results are shown in Figure 4.12.

Responses to "How good do you think your partner is at this kind of work?"

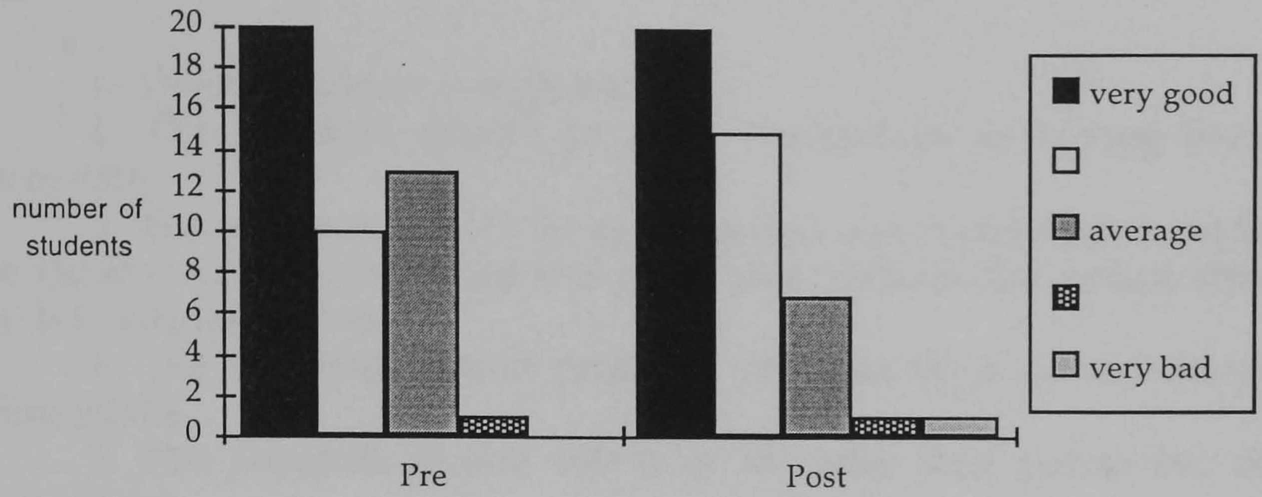


Figure 4.12 Students pre- and post- perceptions of their partners.

There are no significant differences between the two sets of ratings. The pre-test ratings were very high and overall there was not much change.

The students who worked in pairs were asked how well they got on with one another both before and after the computer intervention. The results are shown in Figure 4.13.

Responses to "How well did you get on with your partner?"

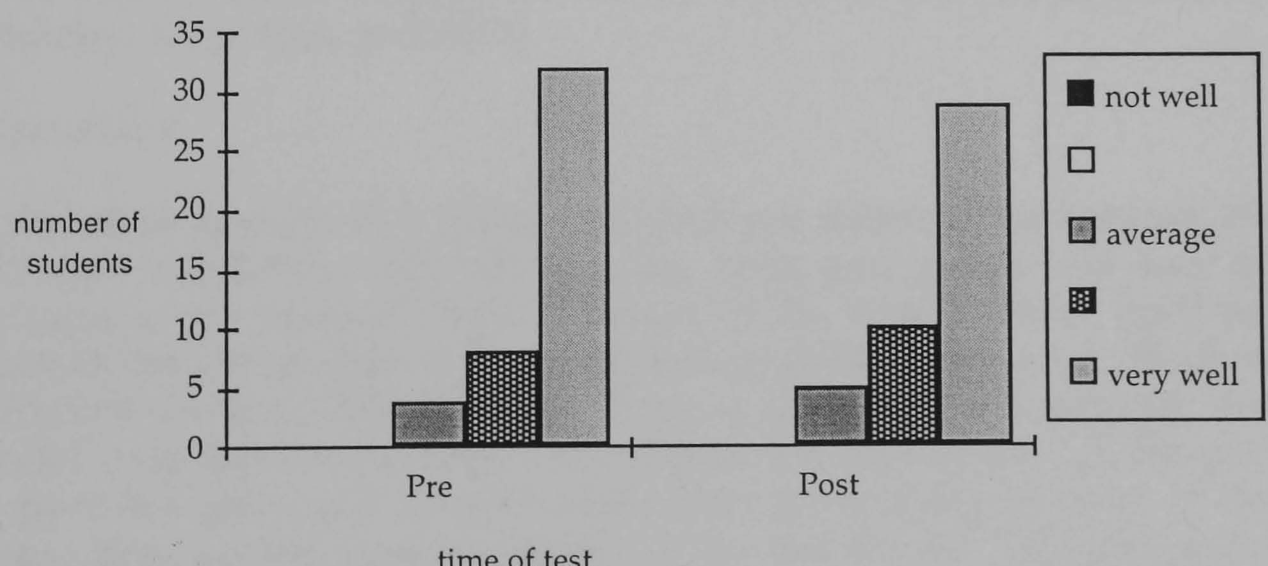


Figure 4.13 Students pre- and post-test ratings of how well they got on with their partners.

Overall, the ratings are very high, which is to be expected since the pairings were largely based on friendship and there are no significant differences between the pre- and post- ratings.

Assessing the effectiveness of the learning situations

The description was applied to the data both with and without the collaborative criteria reproduced here and first presented in section 4.2.

1. There should be a cognitive gain.
2. The students should perceive themselves as having been successful.
3. The students should be as interested and motivated towards the subject or more interested and motivated towards the subject after the learning as before.
4. The students should retain or increase their perception of themselves.
5. The students should retain or increase their perception of their peers.
6. The students should still get along with their peers.

The raw scores for each student were added together and the different conditions and genders compared.

Description without collaborative criteria:
No significant differences were found between students in the three conditions (Kruskal-Wallis: H=3.7440, df=2, p=0.1538), nor were there any significant differences between the boys and the girls (Mann-Whitney: U=3.175, p=0.9129).

Description with collaborative criteria:
No significant differences were found between students in the two paired conditions (Mann-Whitney: U=-0.9037, p=0.3661), nor were there any significant differences between the boys and the girls (Mann-Whitney: U=-0.4465, p=0.6553).

Discussion

It therefore appears that this model does not differentiate between the different conditions nor between the boys and girls. This may be because of the simple additive nature of the model which does not capture the complexity of the situations and the differential effects of different factors. Additionally, from a cognitive perspective, the model only incorporates the outcomes of the interaction i.e. the pre- to post-test gain, and does not take into account the product of the interaction, i.e. the students' scores on the worksheet. This distinction will be revisited in chapters 7 and 8.

A weighted model would provide a better approach, but there are difficulties in determining the weightings. In a real educational setting, these weightings could be determined by the purpose of the task but it is beyond the scope of this thesis to define appropriate weightings for the different factors in a particular learning situation.

Ames' cognitive-motivational theory

As discussed in section 4.2, the factors pertinent to Ames' cognitive-motivational theory in different learning situations were also investigated. In relation to this, results on which factors the students working in pairs found important are presented. This is followed by a discussion of the students' perceptions of their own and their groups success and a discussion of their perceived helping behaviour.

The pupils who worked in pairs were asked to rate on a five point scale, from very important to not important, how important it was that they got the correct answers, that they got along with their partner, that their group was successful and that they individually were successful. The results are presented in Figure 4.14 below:

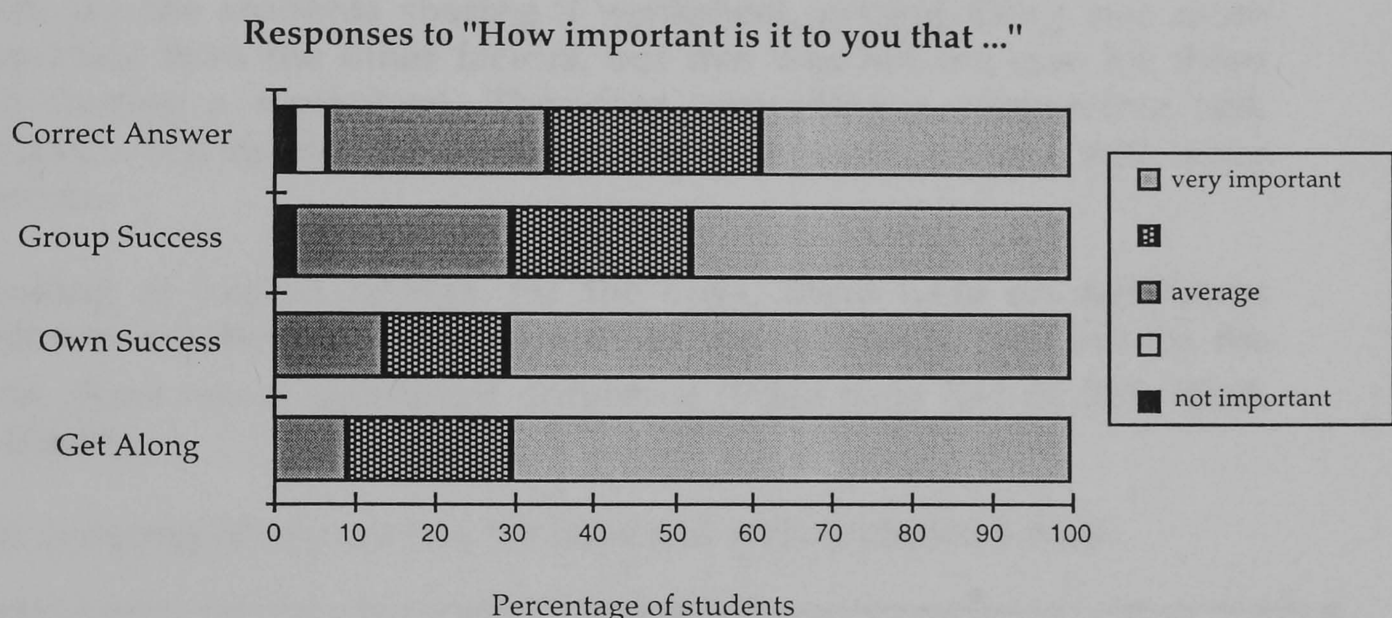


Figure 4.14 Graph of students who worked in pairs responses to the question "How important is it to you that you get the correct answer/group success/own success/get along?"

There were significant differences between these ratings (Friedmans $Xr^2=11.58$, $df=3$, $p<0.009$). Overall the students rated getting along with each other as most important, followed by their own success, followed by group success. Getting the correct answer was seen as the least important.

Thus the overall results of this study only partially support Ames' theory. Although the students value getting along with one another more than the other factors, they do not value their groups' success more than their own success. Of course, in a small experimental intervention like this, the culture of group success may not have been established.

Although there were no significant differences in direct comparisons of the paired conditions, there were differences between the two paired conditions. There was a significant difference in their importance ratings of the four factors for the pairs who shared a worksheet (Friedmans $Xr^2=7.8682$, df= 3, $p<0.038$). However, there were no comparable differences for the pairs who did not share a worksheet.

The order of importance for these two groups is shown in table 4.4:

Pairs	Cooperative Pairs
own success	get along
get along	own success
group success	correct answer
correct answer	group success

Table 4.3 Order of importance for pairs and cooperative pairs

Thus for the students sharing a worksheet, getting along was more important than the other factors, but this was not the case for those not sharing a worksheet. Therefore, providing a cooperative task structure led to an increased emphasis on getting along with your partner.

Looking at overall ratings, for the boys, there were no significant differences between the importance of the various factors, but for the girls, there was a significant difference (Friedmans $Xr^2=10.735$, df=3, $p=0.0488$).

The ordering of importance for boys and girls is shown below:

Girls	Boys
get along	own success
own success	get along
group success	correct answer
correct answer	group success

Table 4.4 Order of importance for girls and boys

Thus for girls, getting along with each other is most important whereas for boys, this is not the case. This difference between boys and girls is important, both in terms of mixed gender groupings and in terms of the value of cooperative learning to the students.

However, it is also important to examine the students' perceptions of their own and their group's success and the ways in which they assess these. Therefore the students working in pairs were asked to rate their group's success as well as their own success. These group and individual success results are shown in Figure 4.15.

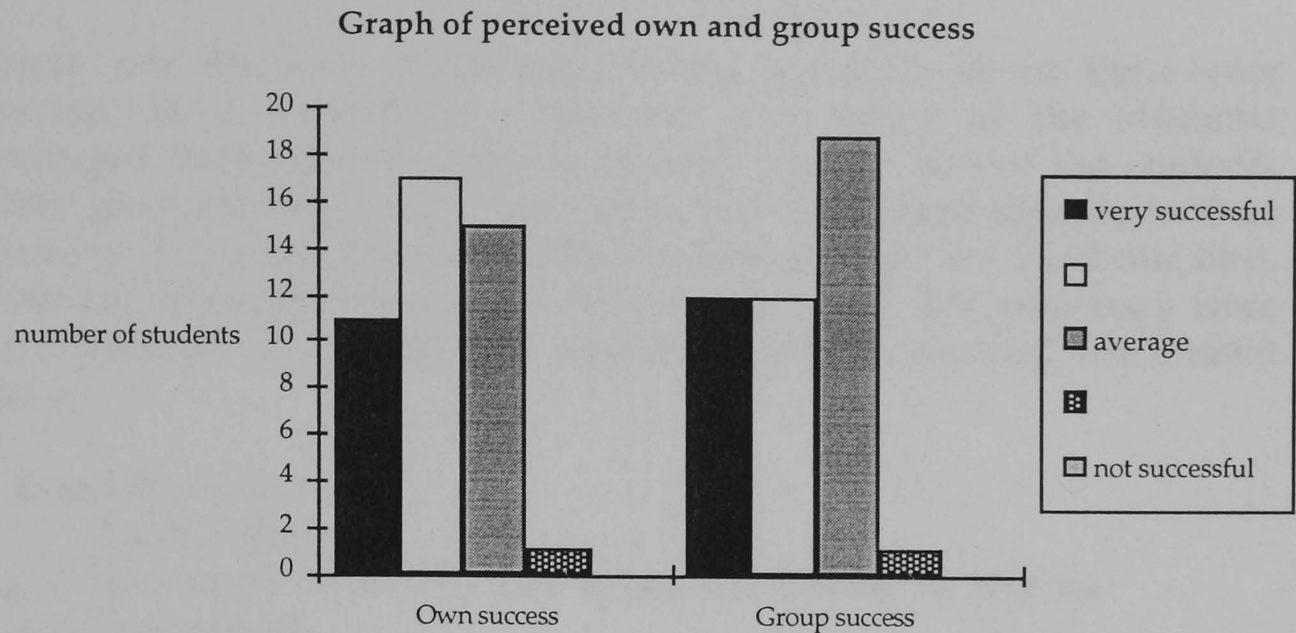


Figure 4.15 Graph of students' perceptions of their own and their group's success

In general, the students perceived themselves as successful. There was however no significant difference between their ratings of group success and own success. This casts doubt on the students' abilities to differentiate between their own and their groups' success. The students were asked open-ended questions about how they judged their group and own success.

Thirty seven of the students responded to the open-ended question about how they judged their group success. Of these, seven students used 'I' in their responses but only 3 of these directly referred to the individual's action. This suggests that the students do think in terms of a pair and can evaluate how their group performed. Twenty seven of the responses have been classified into 3 categories which are
1. using the computer, 2. getting on, helping, communicating, 3. answering the question. Some of the responses incorporated two categories and these are referred to as shared. Ten responses could not be classified.

1. using the computer
 4 and 1 shared
e.g.: *"because the computer was easy to use"*
2. getting on, helping, communicating
 11 and 1 shared
e.g.; *"because we got on well and helped each other out"*
3. answering questions
 10 and 2 shared
e.g.: *"I think this because we answered most questions right so I think we did ok."*

From this, it appears that students evaluate their groups success according to the number of questions they answer correctly and to how well they get on with each other. The ease of use of the computer also has an impact on their evaluation of group success.

Thirty one students responded to the question about their own success. It is immediately apparent that many of the students evaluated themselves in relation to their partner. Ten of the students either gave answers which referred to 'we' or referred directly to their partners. For example, one student wrote: because we tried our best. Answers were classified into four categories and five responses were not classified. The categories and the number classified are shown below:

1. asked for help,
   2 and 2 shared
   e.g.: *"How many times I/we had to ask the teacher to help us."*
2. used computers
   1 and 3 shared
   e.g.: *"by how I used the computer"*
3. answered the questions/completed the worksheet
   15 and 5 shared
   e.g.: *"I judged this by thinking how much we answered without problems"*
4. evaluation of oneself
   3 and 2 shared
   e.g.: *"by my attitude towards the questions"*

Therefore it seems that the students predominantly evaluate their own success in terms of the questions that they answer but also in terms of their use of the computer, their help seeking behaviour and evaluations of themselves. However, as previously discussed, they also often refer to their partners, and it may be that they have difficulties with separating their own success from the success of the group.

The percentages of students giving each response are shown in the table 4.5:

Category	Own Success	Group Success
Answer questions	64.8	40.7
Evaluate performance	14.8	0
Asked for help	11.1	0
Use of computer	9.3	16.7
Got on/helped	0	42.6

Table 4.5 Summary of students' responses about their success

It is clear that the students evaluated their group success more in terms of how well they got on with or helped one another than their individual success.

The percentages of the boys and girls giving each response are shown in the two Tables 4.6 and 4.7:

Girls

Category	Own Success	Group Success
Answer questions	60.7	46.4
Evaluate performance	7.1	0
Asked for help	21.4	0
Use of computer	10.8	26.9
Got on/helped	0	38.5

Table 4.6 Summary of girls' responses about their success

Boys

Category	Own Success	Group Success
Answer questions	69.2	46.4
Evaluate performance	23.1	0
Asked for help	0	0
Use of computer	7.7	14.3
Got on/helped	0	39.3

Table 4.7 Summary of boys' responses about their success

There are gender differences in terms of the ways in which the girls and boys evaluate their own success, but not their group success. Girls consider their help seeking behaviour, whereas boys put more emphasis on evaluating their own performances.

Discussion

These results provide partial support for Ames' theory. Students did value getting along with one another more than their success or getting the correct answer. However, they did not value their groups' success more than their own success. The gender differences have important implications for the use of mixed gender groups and for the appropriateness of collaborative learning in different situations. The students who shared a worksheet valued getting along with one another significantly more than those who did not share a worksheet and providing a cooperative task structure placed added emphasis on getting along with your partner.

The students did not rate their own success as significantly different from their group success. However, their answers to the open-ended questions about how they judge these factors were ambivalent and some gender differences were also apparent.

It is important to note that the students were working in an experimental situation, without any of the expectations and values of a normal classroom environment. This may have had a considerable influence on their perceptions, particularly with respect to the importance ratings. In Chapter 6, similar factors are investigated in a naturalistic setting, during an obligatory residential summer school and these results may provide a truer reflection of these factors.

Summary of affective results

In this section, an overview of the affective results will be presented from three perspectives: overall, the different conditions and gender differences.

Overall

Students' perceptions of success were generally high but there were no significant differences between their perceptions of their own success and their group success. However, their responses to open-ended questions suggest that they may have difficulties in evaluating their own success, independently of their partners.

There was no significant change in the students' perceptions of how good they were at this type of work and no significant change in their interest or motivation towards chemistry, following their computer work. However, there was a significant increase in their motivation and interest towards the computer.

Their perceptions of how well they got on with their partners were generally high, which is not surprising because they were friendship pairs and there were no significant changes in how well they got on with their partners. There were no significant differences in the students pre- and post-test ratings of how good their peers were at this type of work nor were there significant differences between their pre- and post-test ratings of their respect for their peers.

Although they generally said that it was very important to get correct answers, getting along was rated as most important followed by their own success, group success and getting the answer correct.

Conditions

Surprisingly, there were no significant differences between the individuals and the students who worked in pairs. This may be a reflection of the small number of individuals used in the study. The students were reticent about working on their own and it was sometimes difficult to get students to work in the individual condition.

However, there were significant differences between the two different paired conditions. Getting along with one another was significantly more important for the pairs sharing a worksheet than for those who did not share a worksheet.

Gender

There were interesting gender differences in their open-ended responses to a question about how they evaluate their own success. Girls referred to their help seeking behaviour, whereas boys referred more to self evaluations.

Getting along with their peers was significantly more important than the other factors for the girls while for boys there were no significant differences between the importance of the various factors.

There were no significant differences between boys and girls in their interest towards chemistry, but boys had higher perceived motivation towards chemistry in their post-test than girls. This had not been apparent in the pre-test. The girls showed an increase in their perceived interest towards computers and the overall increase in motivation towards computers is largely due to the girls.

The girls' perceptions of how good they are at this kind of work increased. The boys had significantly higher perceptions of themselves than girls at the pre-test, but there was no significant difference between the boys and girls at the post-test.

The girls' perceptions of how well they get along with their partners increased as a result of the interaction, but the boys' did not. There was a significant decrease in girls' perceptions of how much they helped their partner, but no corresponding decrease for the boys' perceptions.

The first section of this chapter presented the analysis of questionnaires and worksheets of individuals and pairs of Secondary School students using a computer to learn about the Periodic Table. The attention to affective factors showed differences between the two collaborative conditions and between girls and boys. However, the model which incorporated both cognitive and affective factors did not differentiate between the conditions, nor between the boys and girls. Ames' cognitive-motivational model of different learning situations was partially supported by the data collected, and important gender differences were discussed. However, these results were obtained in an experimental situation and this may have had a distorting effect. In the second part of this chapter, a study is presented of Open University students collaborating at summer school which investigates similar factors in a naturalistic setting.

4.4 An empirical study of naturalistic Summer School collaborations

Whilst there are clear findings in the secondary school study presented in the first part of this chapter, there remains a question about the extent to which these findings hold in a more naturalistic situation. 'Naturalistic' collaborations are common in our educational institutions in the form of group work (indeed, this is one of the reasons why research into collaborative computer-supported learning is needed) and are also widespread in the Open University in the form of group work.

In this section, a study of the affective aspects of Open University students collaborating while using computers at summer school will be discussed. The study investigated naturalistic collaborations involving varying amounts of computer use. The students were mature, distance education undergraduates studying D309, a cognitive psychology course, part of which requires students to attend a one week residential summer school. This provides a realistic environment in which to study naturalistic collaborations. The Open University's summer schools place an emphasis on group work and for the students, summer school is one of the rare opportunities that they get to collaborate with their peers. In particular, the factors pertinent to the description of effective learning situations are presented and Ames' claims about the pertinence of affective factors and emphasis on group success in collaborative settings are investigated.

There are relatively few studies concerning the efficacy of summer schools, although there have been studies of particular aspects of summer schools. For example, Ross (1990) studied students' use of an interactive videodisc about water, in which she discusses issues concerning the size of groups using the videodisc. It is clear that groupwork is valued at summer school, as the following quote from a student interviewed by Lunneborg (1994) illustrates:

> *Everybody says that there's something incredible about the OU system of summer schools and they're absolutely right. You get these 120 people at a particular week at a particular place. Split them up alphabetically into groups of 10 or 12, stick them in a room with a tutor, and by the end of the week you still have a bunch of 12 total strangers but who are a cohesive group of people who have worked together like a dream.*
>
> *(Lunneborg, 1994, p. 30.)*

The course is described, followed by a description of the summer school and the four projects the students completed. This is followed by the design of the study and an analysis of the results. The results are then discussed.

4.4.1 Background to the Summer School

This is a third level Open University Social Science course which is an essential course for students who want British Psychological Society recognition for their degree. It covers the most important theories and methods of cognitive psychology, the main focus being higher mental processes and the ways in which knowledge is acquired, stored and used, with an emphasis on mental activities in everyday life. Experiments, computer models and introspection methods are introduced and the students are introduced to writing simple computer programs, experimental design and statistical analysis.

The course is divided into four main areas: Memory, Language Understanding, Problem Solving and Perception and Representation. All students are required to attend a residential summer school for one week approximately midway through the course. The summer school aims to provide students with experience and training in experimental methods and there is an option concerned with writing simple computer programs. There are four possible projects which aim to answer fairly specific questions in cognitive psychology. These are in the areas of language, problem solving, memory and artificial intelligence. The first three involve designing and carrying out experiments while the latter involves writing a computer program which simulates aspects of psychological theory. The experimental projects involve using the computer to analyse and/or present data while the artificial intelligence project involves using the computer almost continuously.

Students are required to complete two of these projects, and one of these is written up for a Tutor Marked Assignment (TMA). At the summer school there are also other activities including talks by tutors, revision sessions and methodology workshops.

The students attend four project trailers: one for each project and then fill in a preference form. The summer school staff try to assign all students to their first or second preference, but this is not always possible and students may be forced to complete their third or fourth choice. The students generally choose their own project groupings, however, sometimes tutors are forced to group the students. They then spend five sessions (approximately 16 hours) working on their projects at the end of which there is a mini-plenary session where students spend about 10 minutes presenting their project to the rest of the group. The process (without the trailers) is then repeated for the second project. At the end of the summer school, there is a plenary session, in which one group from each topic area presents their project to all the students.

It is important to note that there are different tutors for each project. Their abilities obviously will have an effect on the success of each project. The data presented in this chapter are from one week at a summer school in which the tutors remained constant, but it is acknowledged that the influences of the different tutors have not been considered.

4.4.2 Design of the study

The study involved students filling in two questionnaires, one before their project and one after. Only questionnaires from one project for each student was analysed. They were told about the study at their first meeting with the Course Director and the questionnaires were handed out during one of their first teaching sessions. The questionnaires were filled in on a voluntary basis and were anonymous. A box was left in a public place for completed questionnaires. A copy of the pre- and post-questionnaires can be found in Appendix C.

The pre-project questionnaire asked about the students' gender, which project they would be completing, their previous computer experience and groupwork experience, their perceived interest and motivation, their perceptions of themselves and of their peers.

The post-project questionnaire asked about the students' gender, which project they had just completed, their perceived interest and motivation, their perceptions of themselves and their peers, how successful they thought their group and they as individuals had been, how important their group and their own success is, how satisfied they were with their group and themselves, their goals, whether or not they had split the task, their individual and group computer use, the importance of getting the correct answers and of getting along with one another, how pleased they felt with what they had done, whether they would have rather worked on their own and whether or not they were going to write up the project for their TMA.

In the following section, background information about the students' previous experience is first presented, followed by the results concerning the students intentions about which project they would be writing up for their TMAs. The students' use of the computer and whether or not they split the task is then discussed relative to the four different projects. The affective results are then presented in terms of the description of effective learning situations presented in section 4.2. This is followed by a discussion of what factors students found important in relation to Ames' theory are then discussed.

4.4.3 Background information

Sixty one pre and 61 post questionnaires were analysed. This represents approximately 60% of the students who attended the Summer School. Thirty-one of these were filled in by men and thirty by women. Thirty one (51%) students said that they used computers less than once a month, and 25 students (41%) said that they used computers more than once a week. Forty five (74%) of the students said that they had experience of group work, and examples of their responses are shown below:

> *'yes, training session when I work for the Citizens Advice Bureau'*
> *'yes, as a member of the forces'*
> *'yes, preparing exhibitions for a museum'*
> *'yes, run company employing women who work in small groups'*

As this is a third level course, the majority of the students will have attended at least one summer school before and therefore have experience of working in groups in the context of the Open University.

The distribution of the responses across the four projects are shown in Figure 4.16.

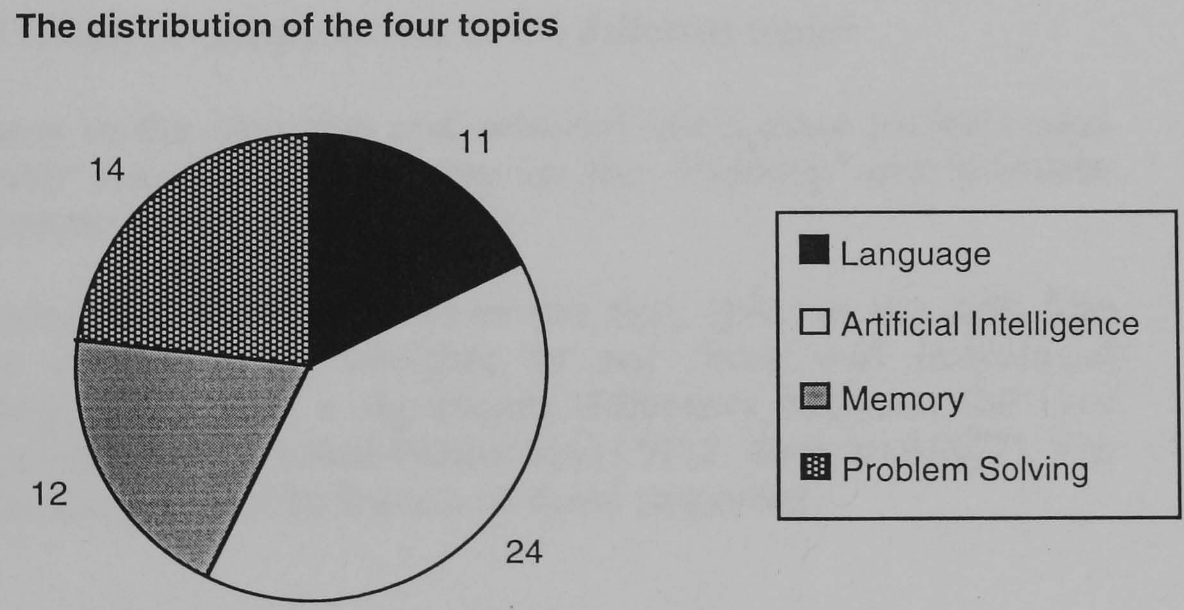


Figure 4.16 Distribution of the four topics

There are 25 student slots for each project so that the maximum possible returns on any questionnaire for each project would be 50. No more detailed records of student numbers were kept. Artificial intelligence is generally the most popular project and is often over subscribed and problem solving is sometimes undersubscribed.

The computer use of the students in the four project areas was assessed by getting the students to rate their own and their group's computer use. Figure 4.17 shows the group computer use reported according to the different topics. There was a significant difference between the four project areas (Kruskal-Wallis: H=11.3598, df=3, p=0.0099).

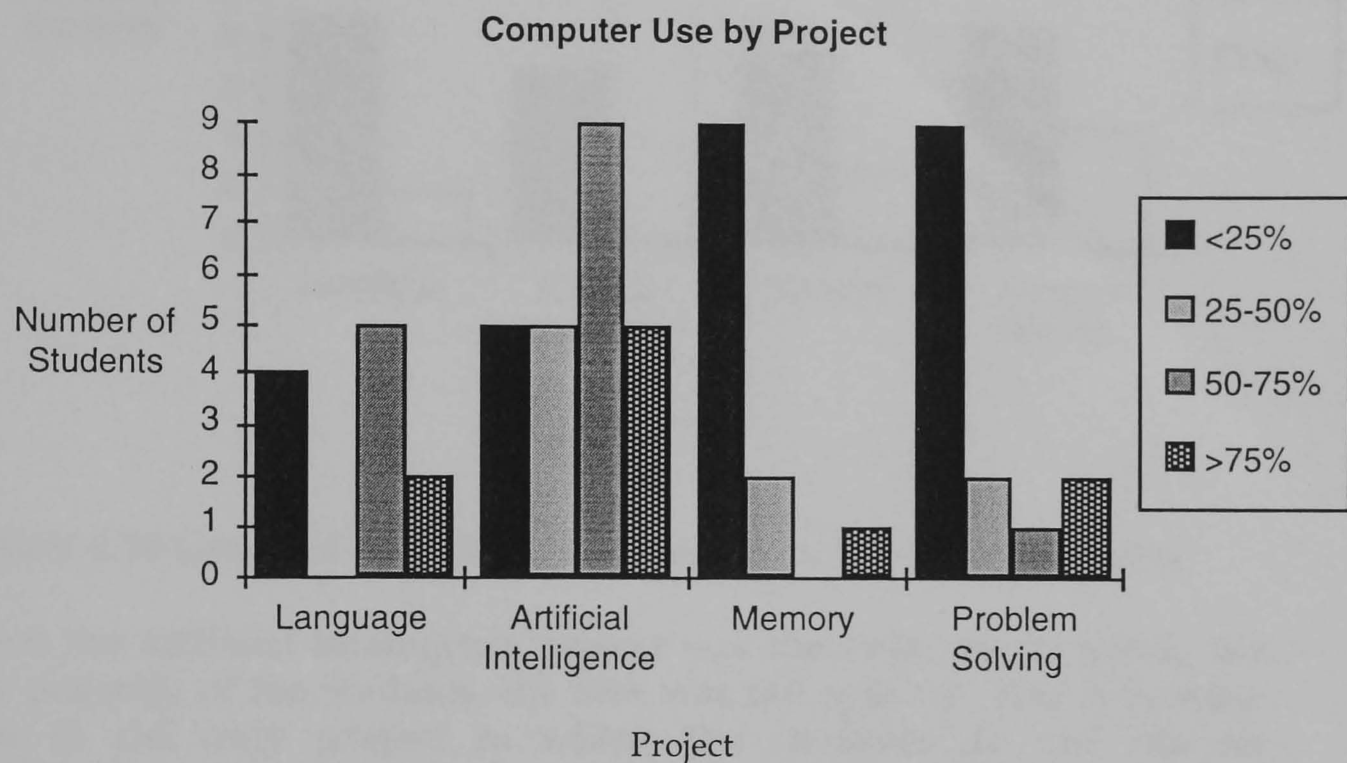


Figure 4.17 Graph of computer use in the different topics

Thus students in the language and artificial intelligence projects used the computer more than students in the memory and problem solving projects.

Students were also asked whether or not they split up the task. The importance of this is in whether or not there was individual responsibility. There was a significant difference between the four different project areas (Kruskal-Wallis: H=11.9217, df=3, p=0.0077). The graph below shows the distribution of these responses.

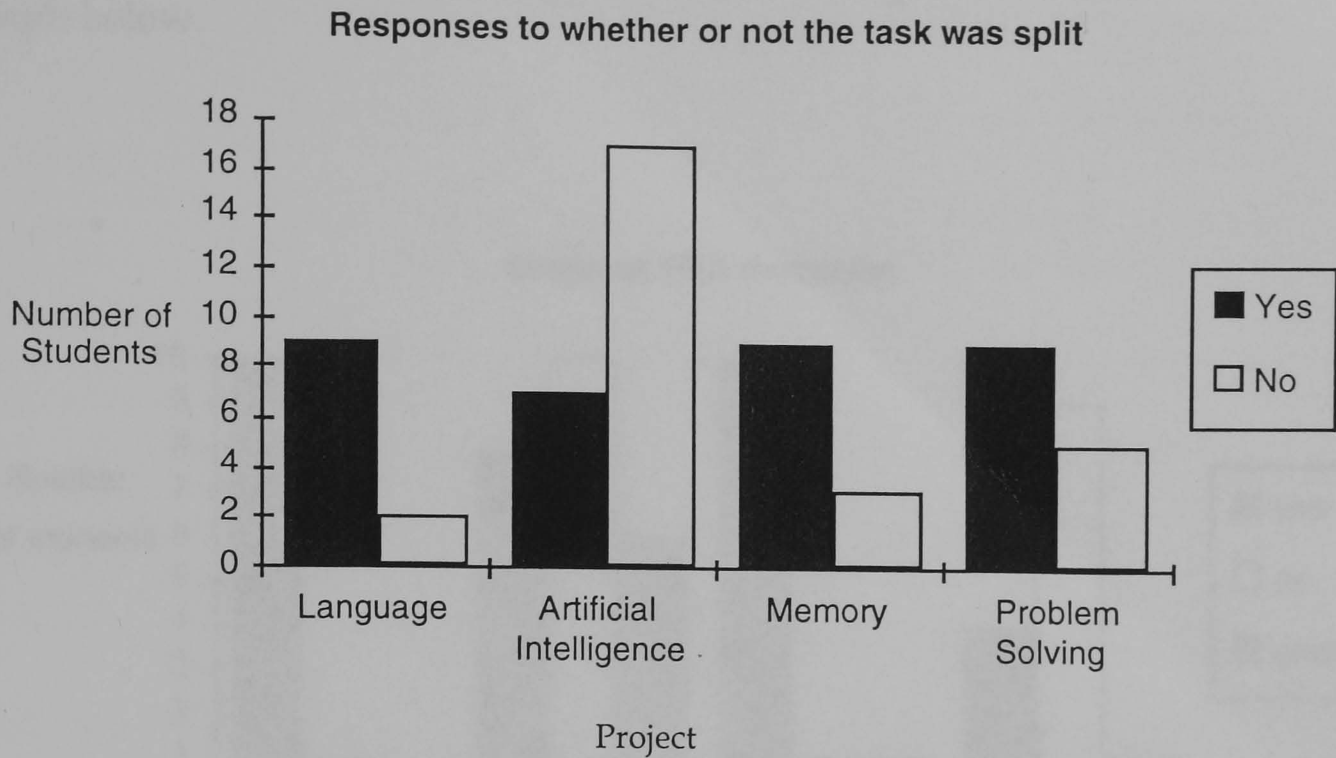


Figure 4.18 Graph of the division of the task in the different topics

Thus the artificial intelligence project was the only one in which, for the majority of the students, the task was not split up. This is because this is the only project in which the students do not run an experiment and therefore do not assign different tasks or roles to members of the group. So for the majority of the students doing the artificial intelligence project there was no individual responsibility, which, according to Slavin, encourages effective cooperation.

The nature of the four projects, from the perspectives of computer use and individual responsibility are summarised in the table 4.8.

	Memory	Language	Artificial Intelligence	Problem Solving
Computer use	x	√	√	x
Individual responsibility	√	√	x	√

Table 4.8 Summary of the four projects

As previously discussed, the students write up one of their projects as a TMA. Given that the students have a choice about which project to write up as a TMA, their decisions about which project to write up can be seen as a measure of the projects' success. Students intended to write up thirty three of the projects and nineteen of the projects were not going to written up. Nine of the students said that they were undecided. Thus the majority of questionnaires were about projects that would be written up as TMAs.

The distribution of the decisions over the four topics is shown in the graph below.

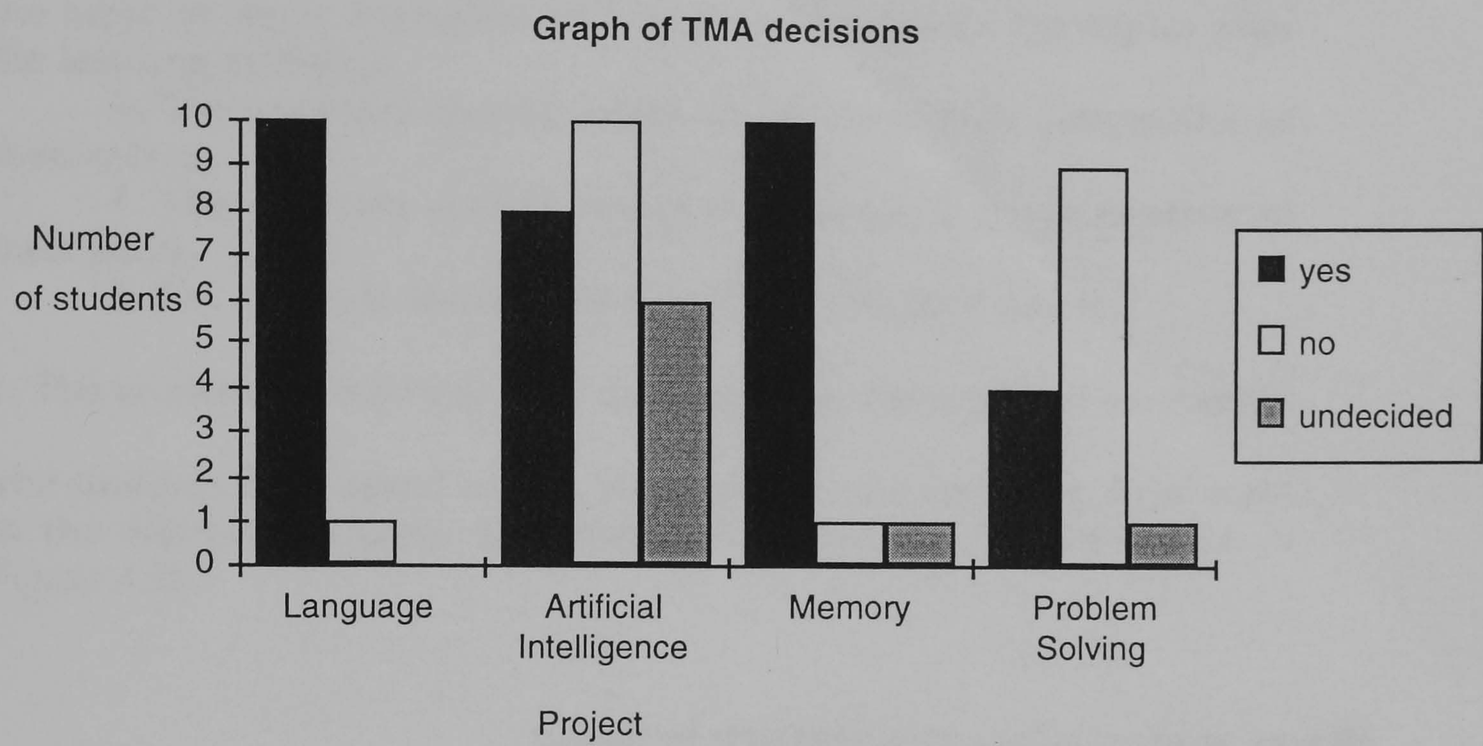


Figure 4.19 Graph of students' decisions about TMAs in the different topics.

If one examines only the results where students had made a decision about whether or not they would write up the TMA, there is a significant difference between the four project areas (Kruskal-Wallis: H=17.3413, df=3, p=0.0006). The majority of students on the language and memory projects intended to write up these projects for their TMAs whereas many students did not have the intention to write up the artificial intelligence and problem solving projects.

4.4.4 Affective factors

The results in this section will be presented in a similar way to those of the Secondary School study. First the description of effective learning situations will be represented and the results discussed in these terms. This will be followed by a discussion of the factors pertinent to Ames' cognitive-motivational theory presented in Chapter 2.

Description of effective learning situations

The description of effective learning discussed in section 4.3.4 has been used to analyse the questionnaires. However, the cognitive aspects are not incorporated because they were not available. A modified description combining only the affective aspects of the collaborative learning situation is presented below. The results pertinent to the description are then presented.

1. The students should perceive themselves as having been successful.

2. The students should be as interested and motivated towards the topic or more interested and motivated towards the topics after the learning as before.

3. The students should retain or increase their perception of themselves.

4. The students should retain or increase their perception of their peers.

5. The students should still get along with their peers.

1. The students should perceive themselves as having been successful.

The students were asked to rate their own success on a five point scale in the different projects. The students' success ratings are shown in Figure 4.20.

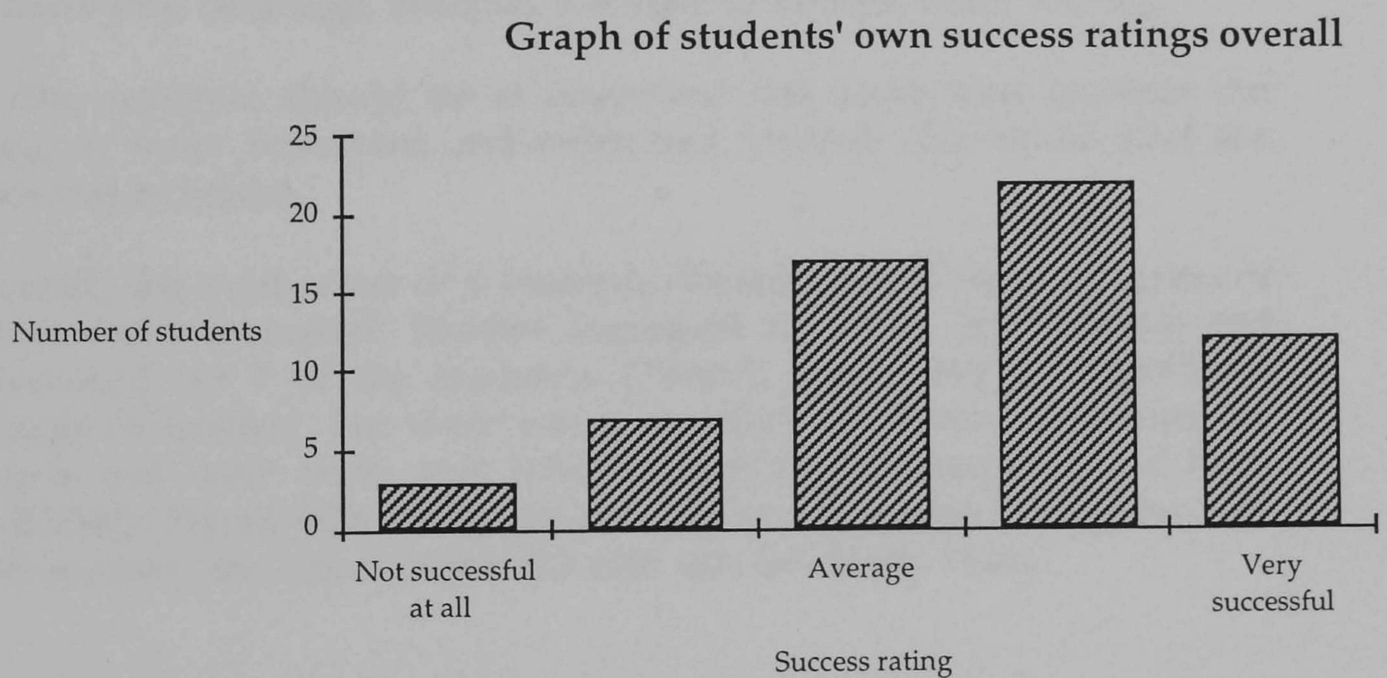


Figure 4.20 Graph of students' own success ratings overall.

More than half the students rated their success as above average. Figure 4.21 shows the success ratings for the four projects.

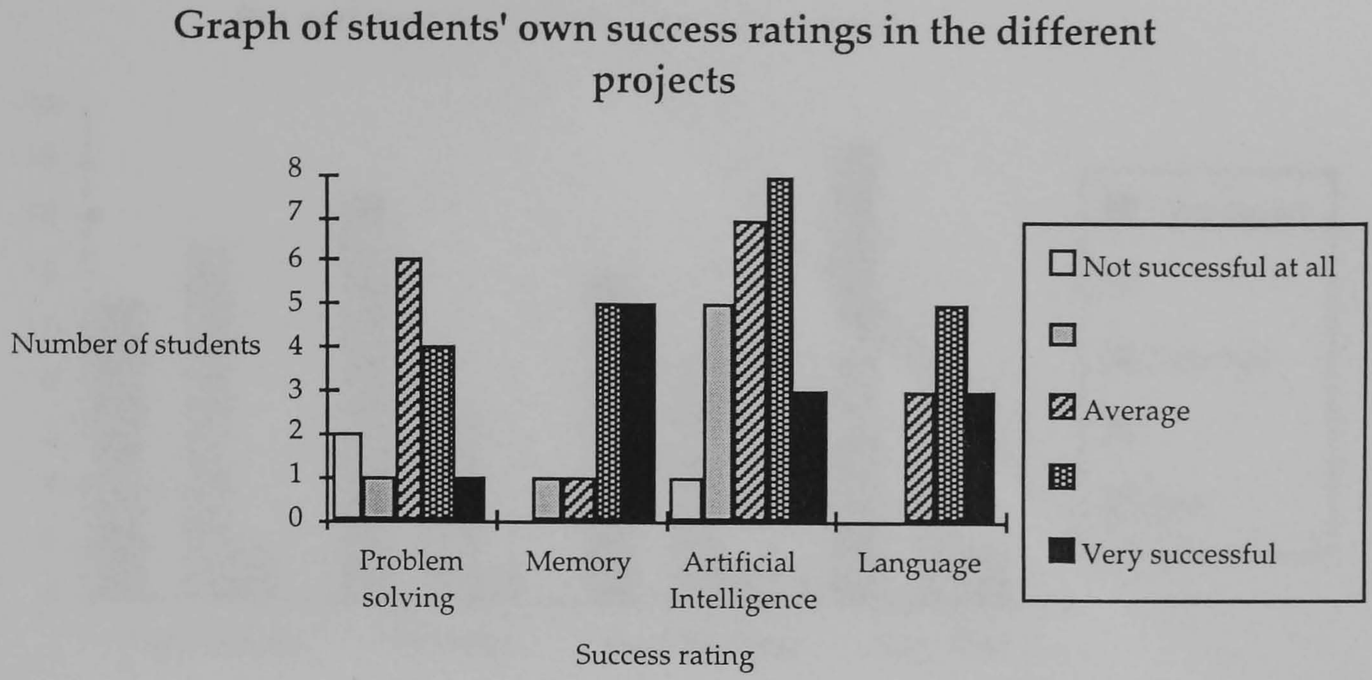


Figure 4.21 Graph of success ratings in the different projects.

There were significant differences in these ratings (Kruskal-Wallis H=10.0176, df=3, p=0.0184), with memory being rated the highest, followed by language, artificial intelligence and problem solving.

2. The students should be as interested and motivated towards the topic or more interested and motivated towards the topics after the learning as before.

Overall, the motivation of 6 students decreased and the motivation of 14 students increased. Interest increased for 14 of the students and decreased for 7 of the students. Overall, there was no significant change in interest, but there was a significant difference between the men's pre- and post- test interest ratings (Wilcoxon: W=-2.1181, p=0.0342). Figure 4.22 shows the pre- and post- interest ratings for men and women, and the increase for men can be clearly seen.

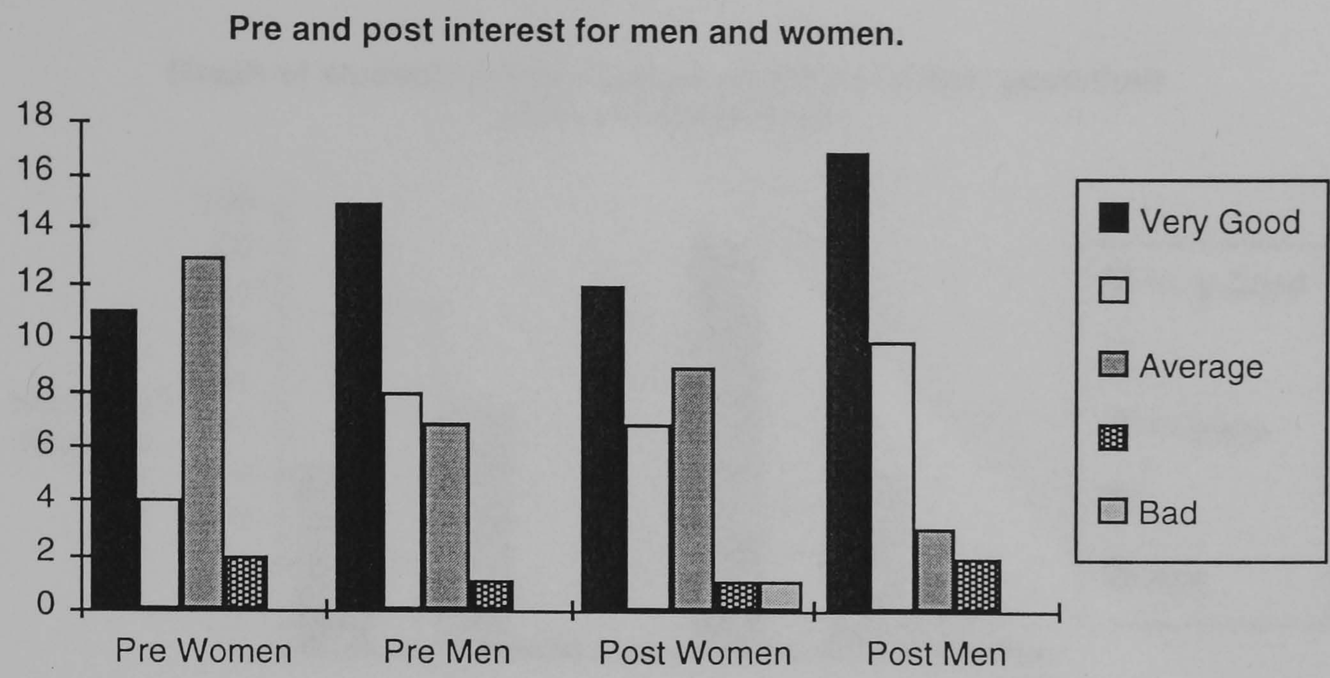


Figure 4.22 Graph of men and women's pre- and post-project interest ratings.

When one examines the students' ratings according to the different topics, there is a significant difference between the pre- and post-test ratings of motivation and interest for the language project (Wilcoxon: W=-2.0266, p=0.0431 and Wilcoxon: W=-2.0266, p=0.0431 respectively).

Although completing the projects had no significant overall difference on the students' perceived motivation and interest, the men's interest was significantly increased and there was a significant increase in motivation and interest for the students who completed the language project.

3. The students should retain or increase their perception of themselves.

The students were asked how good they thought they were at this type of work, both before and after each project. For 15 of the students, their self perceptions increased, and 16 of the students' self perceptions decreased. Overall, there is no significant difference between the students pre- and post-project self perception ratings. Six students' perceptions decreased by two points and two students decreased by three points. Although this is not significant, it is worrying that the self perceptions of eight students' decreased.

4. The students should retain or increase their perception of their peers.

The students were asked to rate on a five point scale how good they thought their peers were at the work both before and after the session. The results are shown in the graph below:

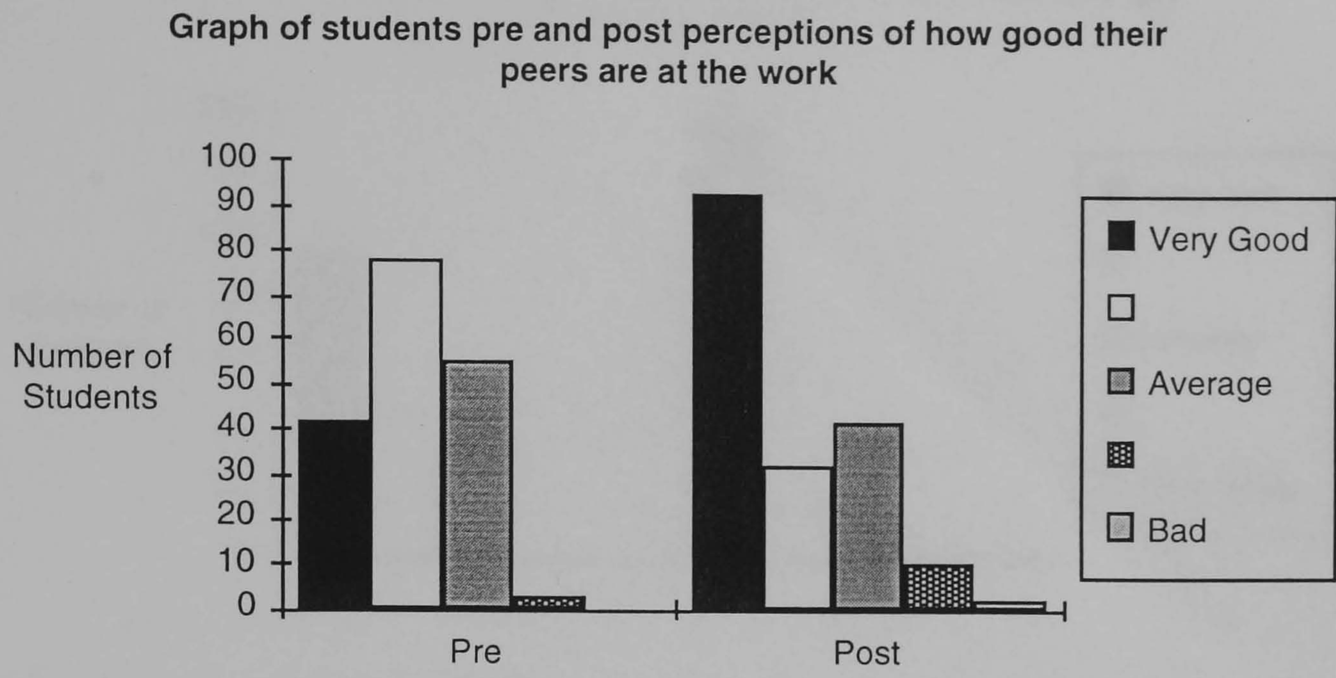


Figure 4.23 Graph of students' pre- and post-project perceptions of their peers

There is a significant difference between the pre- and post- ratings (Wilcoxon: W=-3.1779, p=0.0015). The post- ratings are higher, showing that the project interactions generally increased the students' positive perceptions of one another.

These changes are not significantly different for men and women, but there are significant differences in terms of the project area. There is a significant difference between the four project areas in terms of the change in peer perceptions (Kruskal-Wallis: H=15.3972, df=3, p=0.0015). The change was greatest for memory, followed by language, followed by problem solving and artificial intelligence.

5. The students should still get along with their peers.

The students were asked to rate on a five point scale how well they got on with their peers both before and after the project. The results are shown in the Figure 4.24.

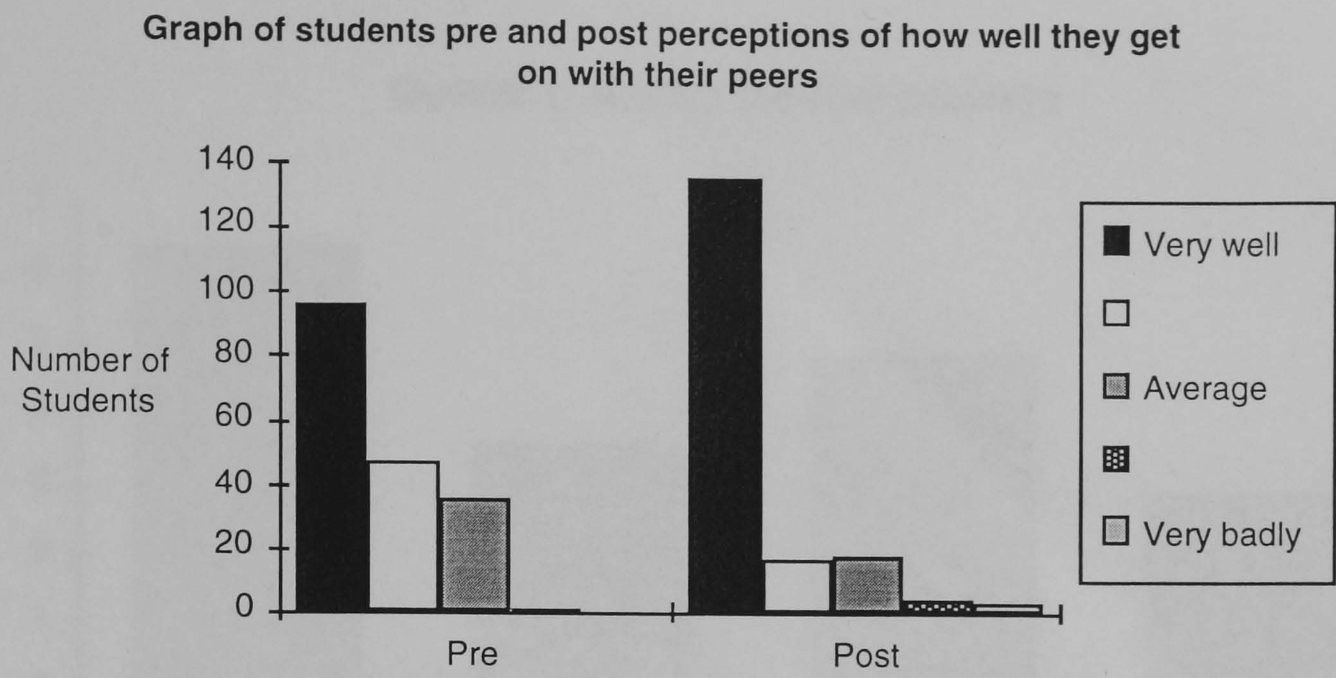


Figure 4.24 Graph of students' pre- and post-project perceptions of how well they get on with their peers

There is a significant difference between the pre- and post- ratings of how well the students got along (Wilcoxon: W=-2.9885 p=0.0028). The post- ratings are higher, showing that the project interactions had generally led to students getting on better with one another.

These changes are not significantly different for men and women, but there are significant differences in terms of the project area. There is a significant difference between the four project areas in terms of the change in getting along (Kruskal-Wallis: H=17.1157, df=3, p=0.0007). The positive change was greatest for language, followed by memory, followed by problem solving and artificial intelligence.

Summary

Overall, the students perceived themselves as successful. Completing the projects made no significant difference to the students' motivation and interest ratings nor to their perceptions of themselves. The project interactions generally increased the students' perceptions of each other and how well they got on with one another. In the next section, the description is applied to the results.

Applying the description to the data

This description was applied to the data obtained from the questionnaires. The overall score was calculated by adding together the students' perceptions of success, their change in interest and motivation, their change in self perception, the average change in their perception of their peers and the average change in their perception of how well they got on with their peers. The mean scores for each topic area is shown in Figure 4.25.

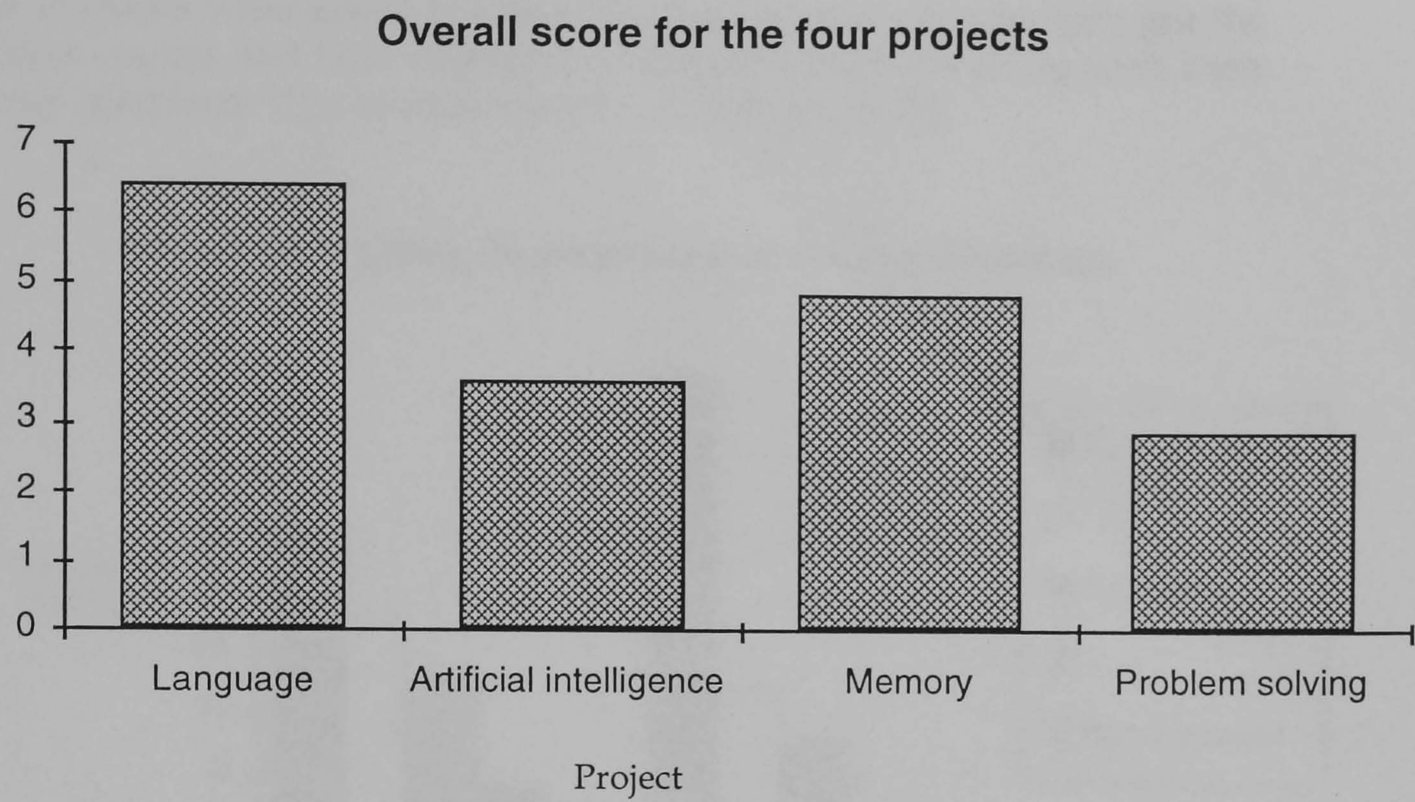


Figure 4.25 Graph of the overall scores for the four topic areas.

There is a significant difference between the four topics (Kruskal-Wallis: H=7.8858, df=3, p=0.0484). However, if the differences between the projects are examined on an individual basis, there is only a significant difference between language and artificial intelligence (Mann-Whitney: U=-2.2266, p=0.0260) and language and problem solving (Mann-Whitney: U=-2.4664, p=0.0136).

There were no significant differences in this overall score between men and women (Mann-Whitney: U=-0.4694, p=0.6386) neither were there significant differences between those with high and low computer usage (Mann-Whitney: U=-0.7268, p=0.4674). There were significant differences between those who wrote up a TMA and those who did not (Mann-Whitney: U=-4.05, p=0.0001). This supports the description, in that the projects that students chose to write up as TMAs were those which resulted from successful collaborations.

Ames' cognitive-motivational theory

As in the Secondary School study, the factors pertinent to Ames' cognitive-motivational theory in different learning situations were investigated. In this respect, results on what factors the students found important are presented and a comparison of the students ratings of the importance of their groups' and their own success.

Importance

The students were asked to rate how important it was that they got the project correct and how important it was that they got along with their group members. The results are shown in Figure 4.26.

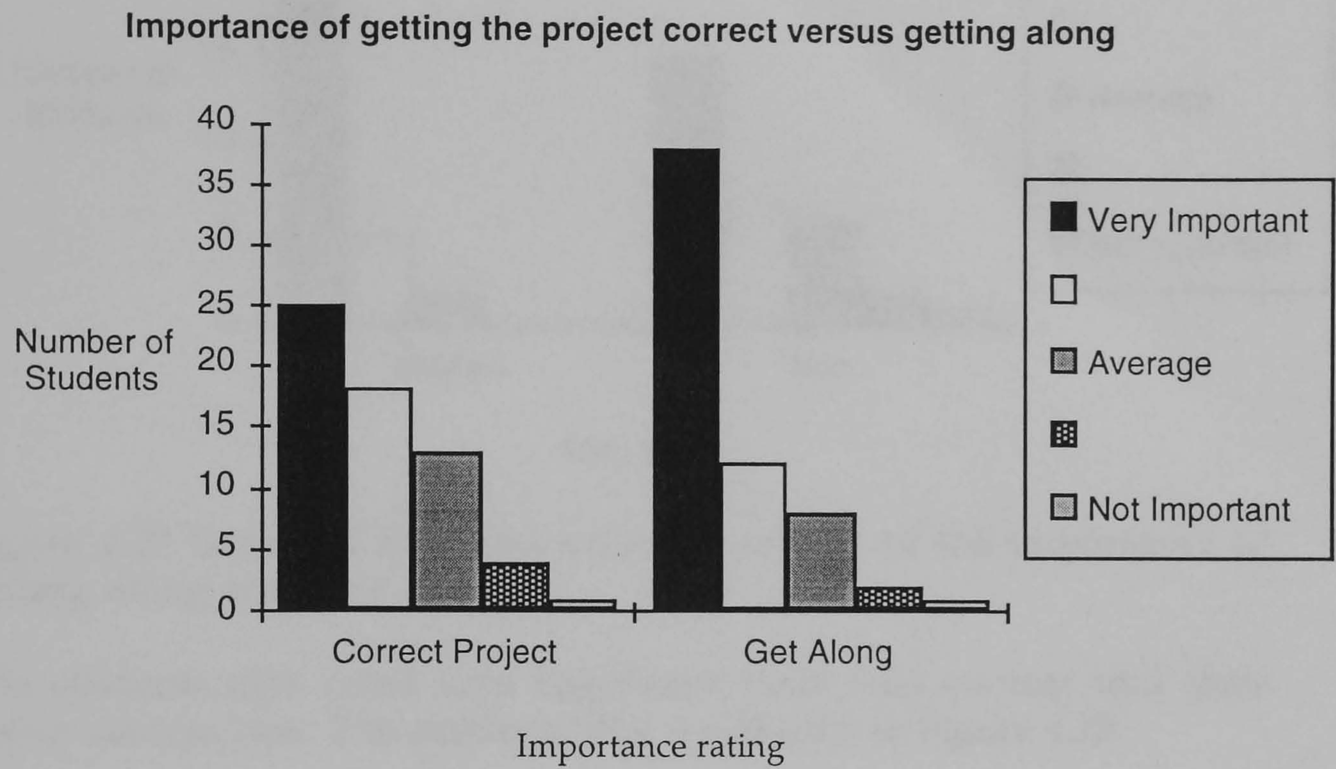


Figure 4.26 Graph of students' ratings of importance of getting the project correct and getting along with one another.

It was significantly more important to students that they got along with each other than getting the project correct (Wilcoxon: W=-2.6414, p=0.0083).

Women found getting along with the other group members significantly more important than the men (Mann-Whitney: U=-2.5011, p=0.0124). This data is shown in Figure 4.27

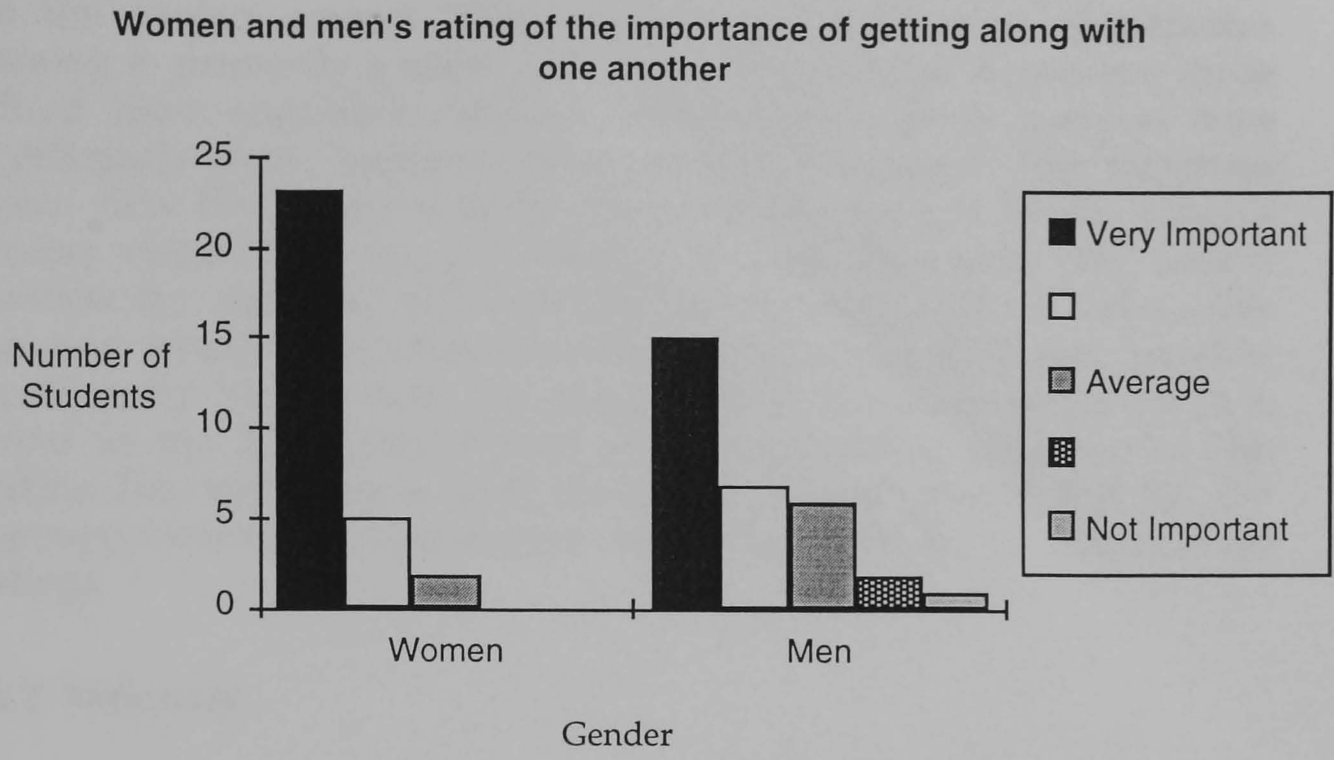


Figure 4.27 Graph of men and women's ratings of the importance of getting along with one another

The students also rated how important their own success and their group success was. The results of this are shown in Figure 4.28.

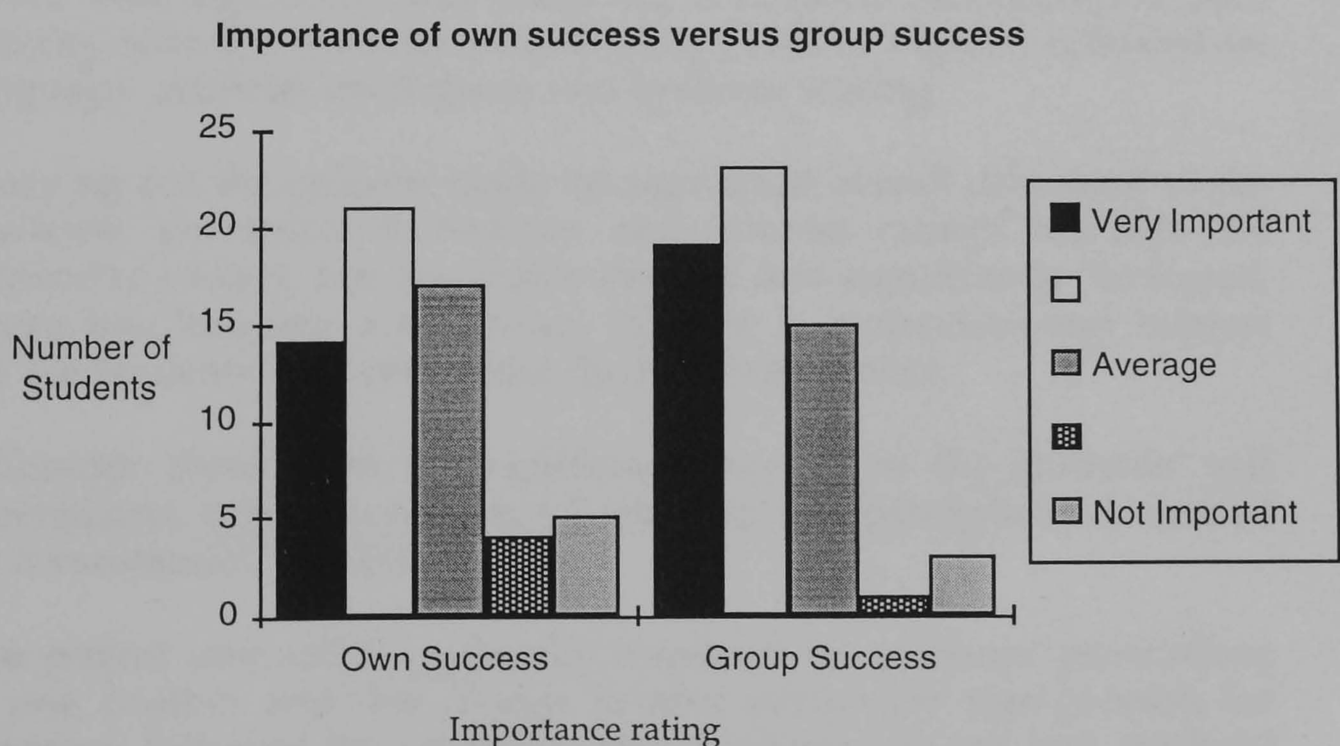


Figure 4.28 Graph of students' ratings of importance of their own and their group's success.

For students their group success was significantly more important than their own success (Wilcoxon: W=-2.6571, p=0.0079).

It was significantly more important to get on with each other than to get the project correct. This supports the view that cooperative learning is primarily a social activity in which social factors are more salient than cognitive factors. Additionally, group success was significantly more important than their own success. This supports Ames' view that when students cooperate, the focus is on the group's success rather than the individual's success. However, this causes conflicts for students, who have to individually write a TMA after summer school. The women rated getting along with one another significantly higher than the men. This is a similar result to that found in the Secondary School study reported in Chapter 4. The finding has implications both for mixed gender groups and for the appropriateness of cooperative work for women in educational settings.

4.4.5 Summary

This section has described the results of a study of Open University students at summer school, completing one of four projects on memory, language, artificial intelligence or problem solving. The study involved 61 pre- and post-project questionnaires. The artificial intelligence and language projects were the ones which involved significant computer use.

There were significant differences in the students' perceptions of their success, with the memory project being rated as highest, followed by language, artificial intelligence and problem solving.

Carrying out the projects made no significant overall difference to the students' perceived motivation and interest ratings towards the particular project, but the men's interest was significantly increased. There was however a significant increase in motivation and interest for the students who completed the language project.

Although there were no significant changes in the students' self perceptions, it is worrying that 8 students' self perceptions decreased by a substantial amount.

The project interactions generally increased the students' perceptions of one another and this change in peer perception was greatest for memory, followed by language, then problem solving and artificial intelligence. Additionally, the students' post-project ratings of how well they get on with their peers are higher than their pre-project rating, showing that the project interactions generally increased how well the students got on with one another. This change was greatest for language, followed by memory, followed by problem solving and artificial intelligence.

The description of effective learning situations was modified to only include affective aspects and applied to the data. There was a significant difference between the four topics. However, when the differences between the projects are examined on an individual basis, there was only a significant difference between language and artificial intelligence and language and problem solving.

There were no significant differences in this overall score between men and women neither were there significant differences between those with high and low computer usage. There were significant differences between those who wrote up a TMA and those who did not.

It was significantly more important to the students to get on with each other than to complete the project correctly. This supports the view that cooperative learning is primarily a social activity in which social factors are more salient than cognitive factors. The course does not provide any training in group work and there are always group dynamics problems, which may be particularly difficult for women, as they found getting along with the other group members significantly more important than the men.

This is illustrated by another quote from a student interviewed by Lunneborg (1994).

> *And the majority of people would go along to summer school feeling they were fed up, they wanted to pack it in, and by the end of it, people would say, 'Well, I'm going to finish this. This is great.' They'd made new contacts to help them carry on or they had just gained confidence.*
>
> *Lunneborg, 1994, p 57*

The students' group success was significantly more important than their own success. This supports Ames' view that when students cooperate, the focus is on the group's success rather than the individual's success. However, this causes conflicts for students, who have to individually write a TMA after summer school.

This section has described a study which investigated the affective factors found to be pertinent in the Secondary School study described earlier in the chapter. The next section provides an overview of the results from the two studies.

4.5 Conclusion

The two studies presented in this chapter have shown that affective factors are influenced by collaborations with computers. The factors pertinent to the description of effective learning situations show significant differences between conditions, genders and projects. In both studies, students rated getting along with one another as more important than getting the correct answer. This provides support for Ames' cognitive-motivational theory of different learning situations. However, Ames' theory proposes that group success is more important than individual success. This was not borne out by the results of the secondary school study, but was true of the summer school study. This was attributed to the experimental nature of the study.

This chapter has focused on analysing the pre-, post- and delayed post-questionnaires and the on-task performance of the students. As with most studies of educational technology innovations, there is no single overall 'answer' or conclusion, and nor could we expect there to be one. The situation is complex and multi-faceted, and needs to be approached as such. The quantitative analysis discussed in this chapter cannot provide the complete story. It has told us which students were successful from various perspectives, but it does not fully address the question of why one condition might afford more effective learning or collaboration than another. It does not show us, for example, the nature of the interactions, such as whether one member of a pair dominates, or the nature of the talk that occurs during the interaction. In order to get some understanding of these factors, an analysis of the interactions that occur is needed. In Chapter 5, the analysis of the videotapes of the interactions from the secondary school study is presented.

Chapter 5

Videotape analysis of the results of the Secondary School study

5.1 Introduction

In chapter 4, the results of a study of Secondary School children using a computer to learn about the Periodic Table were presented. In this chapter, the analysis of the videotape recordings is presented. A selection of the videotapes were analysed using an advanced computer based tool. The method is discussed, followed by the results of an in-depth analysis of five pairs. An analysis of five further pairs was undertaken to see whether the first five pairs were typical of the pairs in the study. Five individuals videotapes were also analysed and these are presented and discussed relative to the analysis of the pairs.

Before moving on to discuss the analysis of the videotapes, it is important to consider the role of the computer in the collaborative interactions in this study. Essentially, the computer was acting as an information provider. For the majority of the students, the computer did provide an environment in which the students could collaborate. The students worked together at the computer, and of the 22 pairs, there was only one pair (Nick and Mike) in which collaboration did not occur. The computer provided a shared environment around which the students could work and a focus for the students' interactions. In the next section, the importance of time-based analysis of collaborative interactions is discussed.

5.2 The value of time-based analysis

Analysing the nature of collaborative interactions is one way of investigating computer-supported collaborative learning. Researchers often videotape interactions and these videotapes are normally analysed using categories of behaviours or talk that are considered important. The number of occurrences of these categories are summed and differences between pairs and within pairs reported. These results are sometimes correlated with the cognitive results derived from the study, and for example, conclusions drawn about the behaviours of successful pairs.

However, this type of approach ignores the temporal aspects of the collaborations. Several researchers have discussed developments which occur during the period of a collaboration. Salomon & Globerson (1989) discuss the development of interdependencies within a group over time, while Crook (1994) discusses the development of shared understanding over time. Mercer (1994b) discussed the historical and cumulative nature of talk and the way in which patterns of talk recur over time. However, none of these researchers have, so far, presented time-based representations of interactions and shown with empirical data, the ways in which these theoretical concepts develop over time.

This chapter presents the results of the video analysis which incorporates time-based views of collaborative interactions. Initially, the interactions of five pairs were analysed and five further pairs were then analysed to verify these results. Time-based analyses of the interactions is achieved using software called Timelines[1] which facilitates the investigation of inter-pair, intra-pair and inter-individual differences as well as providing time-based views of interactions.

5.3 Timelines

Timelines is a system for annotating or coding videotape data (for more information on Timelines, see Harrison and Chignell (1994)). It supports three different types of qualitative data: events, intervals and comments. Events are moments in time which are tagged with a category, which the user defines. Intervals represent time intervals on the videotape with a definite start and stop time. Like events, intervals are tagged with categories, defined by the user. Comments also represent a moment of time on the videotape, but these can be tagged with any text, defined by the user. The analysis in this study involved only the use of intervals. A set of finite categories was used which applied to the type of talk, the actions of either of the individuals and other external events. The videotapes were analysed using the software which then produces two types of outputs:

1. a summary with the total number of entries, the number of categories and for each category, the total number, their total duration and their average duration.
2. a timeline display which shows the categories on the y-axis and time on the x-axis.

It is possible to edit the timelines so that they only incorporate selected entries. Appendix B shows a sample of the Timelines interface used for this analysis, a sample summary and a sample timeline[2]. The coding of the videotapes was validated by getting a second person to recode a section of videotape using the categories provided and

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[1]Developed by Russell Owen, Ronald Baecker and Beverly Harrison at the University of Toronto for the Ontario Telepresence Project and the Institute for Robotics and Intelligent Systems.

[2]When referring to the Timelines coding system, Timelines with a capital T is used. When referring to the output from the system, as here, lower case is used.

comparing the coding. Seventy eight percent of the categories were the same.

5.4 Analysis of five pairs

Five pairs were selected for in-depth analysis of their interactions. These pairs were chosen to cover a range of criteria. One mixed gender pair, two girl:girl pairs and two boy:boy pairs were chosen. Within this, two successful and two unsuccessful pairs in terms of pre-to post-test gains were chosen. This baseline information is summarised in Table 5.1. Two of these pairs, David and Andy and Debbie and Kara, spent two sessions completing the worksheet. David and Andy's second session was a week after the first and there was a two week gap between Debbie and Kara's two sessions. It is important to note that these students may have talked to one another and other children in between the sessions. Additional detailed information abou the pairs is given in Appendix D.

Name	Ability rating	Motivation rating	Pre- to post-test gain	Friendship rating
Steve	high	high	gain	4
Donna	high	high	decrease	
Nick	high	high	gain	1.7
Mike	low	low	none	
Sue	low	low	decrease	2
Jane	low	low	gain	
David	average	average	gain	4.7
Andy	low	low	gain	
Debbie	low	low	gain	4.6
Kara	low	low	gain	

Name	Pre-test	Post-test	Delayed post-test
Steve	8	13.5	10
Donna	7	5.5	10
Nick	15.5	16.5	17
Mike	0	0	2
Sue	2	0	2
Jane	3	6.5	6
David	2.5	8.5	5.5
Andy	0	8.5	not available
Debbie	0	6	9
Kara	0	5	7

Table 5.1 Summary of the first five pairs

From this Table, it can be seen that those with high friendship ratings (Steve and Donna, David and Andy and Debbie and Kara) were more successful in terms of their pre-to post-test gain than those with low friendship ratings.

The analysis of the interactions aimed to investigate inter-individual, inter-pair and intra-pair differences. One aim of the coding was carried to look at the nature of the talk and any patterns within this. Additionally, the students' use of the mouse and typing behaviour were coded in order to investigate dominance of the hardware. The students' reading and writing behaviour was also coded. The students' off-task behaviour and instances of the students asking the researcher for help were also noted.

In the next section, the results of the analysis are presented. The pairs are discussed in terms of time spent on task, time spent talking, the nature of the talk, their mouse and typing use, their reading and writing behaviour, off-task action and instances of the researcher helping the students. This is followed by selected timelines and a discussion of the changes over two sessions seen in two of the pairs.

5.4.2 Results

The results are presented in terms of the time spent using the computer, the talk which occurred, students' mouse use and typing, reading and writing, off-task action and the researcher helping. Selected timelines are presented followed by a discussion of developments over time.

Total time

The Table below shows the total time spent using the computer to complete the worksheet for each pair. The average time spent on the worksheet was 40.46 minutes. David and Andy and Debbie and Kara spent longer completing the worksheet than the other pairs.

Pair	Total Time
Steve and Donna	31.01
Nick and Mike	30.52
Sue and Jane	35.42
David and Andy	60.53
Debbie and Kara	46.40

Table 5.2 The total time spent on the task by the first five pairs

Figure 5.1 shows the total time and the total talk time for each pair.

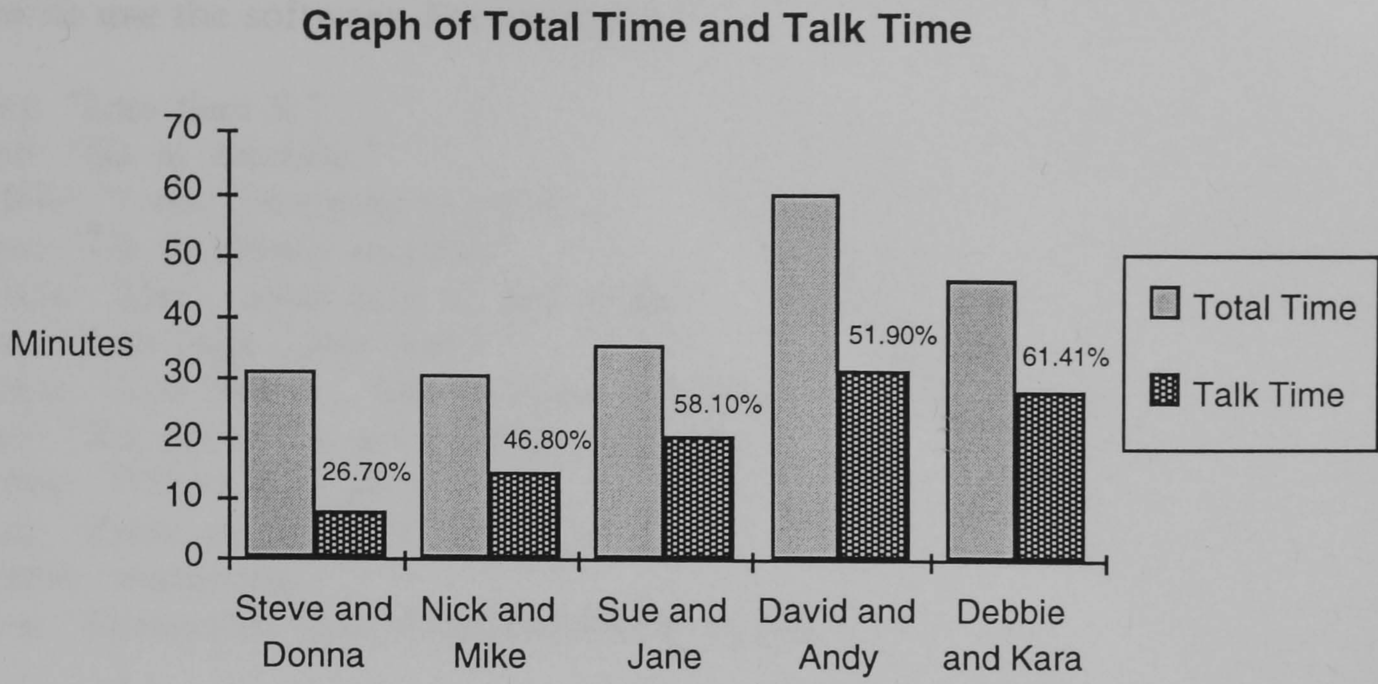

Figure 5.1 Graph of total time and talk time for the five pairs.

There are large variations in the amount of time spent talking. For example, Debbie and Kara spent 61.41% of their time talking whereas Steve and Donna only spent 26.7% of their time talking.

Talk

Using the Timelines software, the pair's talk was divided into 4 categories: topic, next, control and other. This analysis of talk is relatively high level, but still enables patterns of talk to be elucidated and it brings out distinct differences between the pairs. Topic talk refers to any talk about the chemistry that the students were studying. For example:

Sue and Jane have just found out that their prediction for the electronic configuration is incorrect and have found the correct configuration.
Sue: "Two, eight, four"
Jane: "Oh I know what that is. You know what it is? On the shells."
Sue: "Oh yes."
Jane: giggles "It's confusing."
Sue: "Oi, we nearly got it right. Two, eight"
Jane: reading "Is this the same as your prediction? If not why not? "
laughter and mumbling
Jane: "We got confused - well I did anyway."
Jane: reading "What does the atomic number of an element represent?"
Jane: "It's the ...um...."
Sue:"...nucleus ..."
Both: "..neutrons...around the shells"

Next talk refers to any discussion about what to do next in terms of how to use the software. For example:

Kara: "Less than 5."
Kara: "Go to database."
Debbie: "I am. I'm trying to get it..."
Kara: "Go to atomic number."
Debbie: "Um .. what have we got to do?"
Kara: "Less than ...less than"
Debbie: "Less than 5 .. Should I just type 5 in?"
Kara: "No, cause it's not what you put in."
Debbie: "Where do I go now?"
Kara: "Press go, delete, I mean done."
Debbie: muttering
Kara: "Datascreen scan, DATASCREEN SCAN."

Control talk refers to discussion of the control of the hardware, for example:

Steve: "You can do this one."
Donna: "OK, thanks."

Other talk refers to any talk that is not explicitly related to the task. For example:

Sue: "I have to get another pair of (inaudible) I think my brothers taken it."
Jane: "What? Do you think she might be (inaudible)' .. she should be ..(inaudible)"
Sue: "I haven't seen her have I?"
Jane: "No, I'm not going to see her either."

Figure 5.2 shows the percentages of the different types of talk that the pairs used during their interaction.

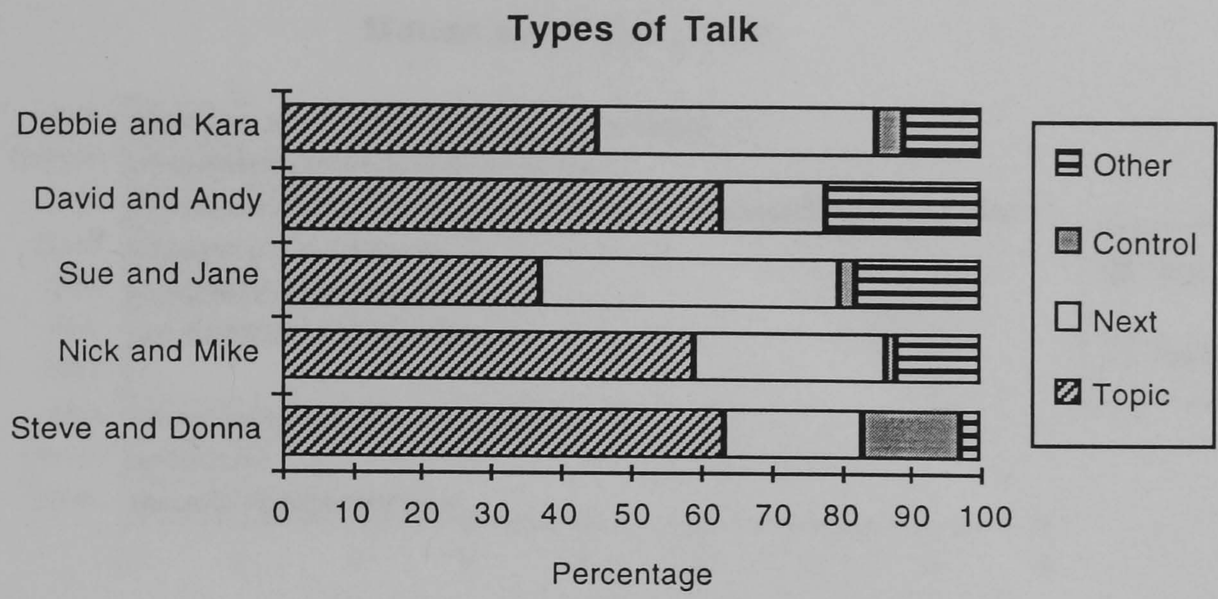

Figure 5.2 Graph of the percentage of the different types of talk for the five pairs.

As with the amount of talk overall, there was a large amount of variation between the pairs in the different types of talk which occurred. For three pairs, over half the talk was concerned with the topic. The girl:girl pairs spent more time than the other pairs discussing the interface and what to do next which may reflect their difficulties in understanding how the software worked. Nick and Mike spent over a quarter of their talk time discussing the interface and what to do next. However, this predominantly consisted of Mike asking Nick what he was doing and Nick telling (rather than explaining) to Mike what was happening. David and Andy spent nearly a quarter of their time talking about non-task related aspects and this is reflected in the length of time they spent completing their worksheets. The main finding from analysing the different types of talk is that the pairs that spent time talking about things that were off-task had greater pre- to post-test gain.

Mouse use and typing

Figure 5.3 shows the mouse and typing use of the individuals. The figure at the end of each bar shows the total number of occurrences of mouse and typing use.

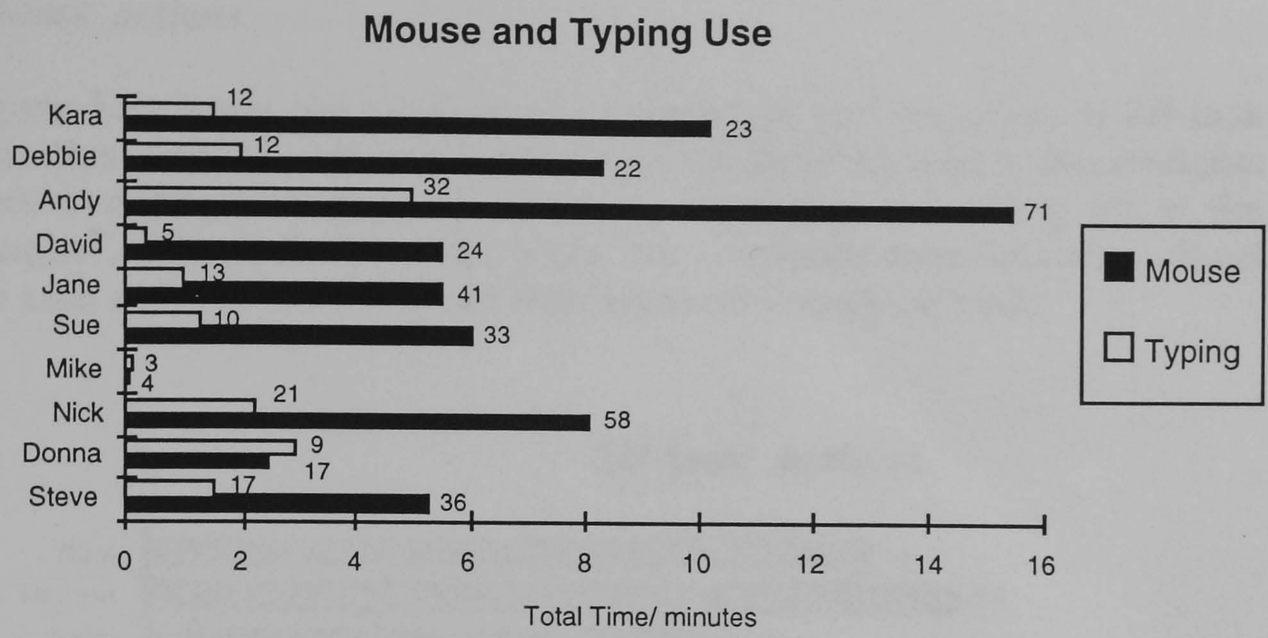

Figure 5.3 Graph of the mouse and typing use of the five pairs.

The girl:girl pairs are the only pairs in which there was no hardware dominance.

Reading and writing

Figure 5.4 shows the reading and writing occurrences for the individuals. The figure at the end of each bar shows the total number of occurrences of reading and writing.

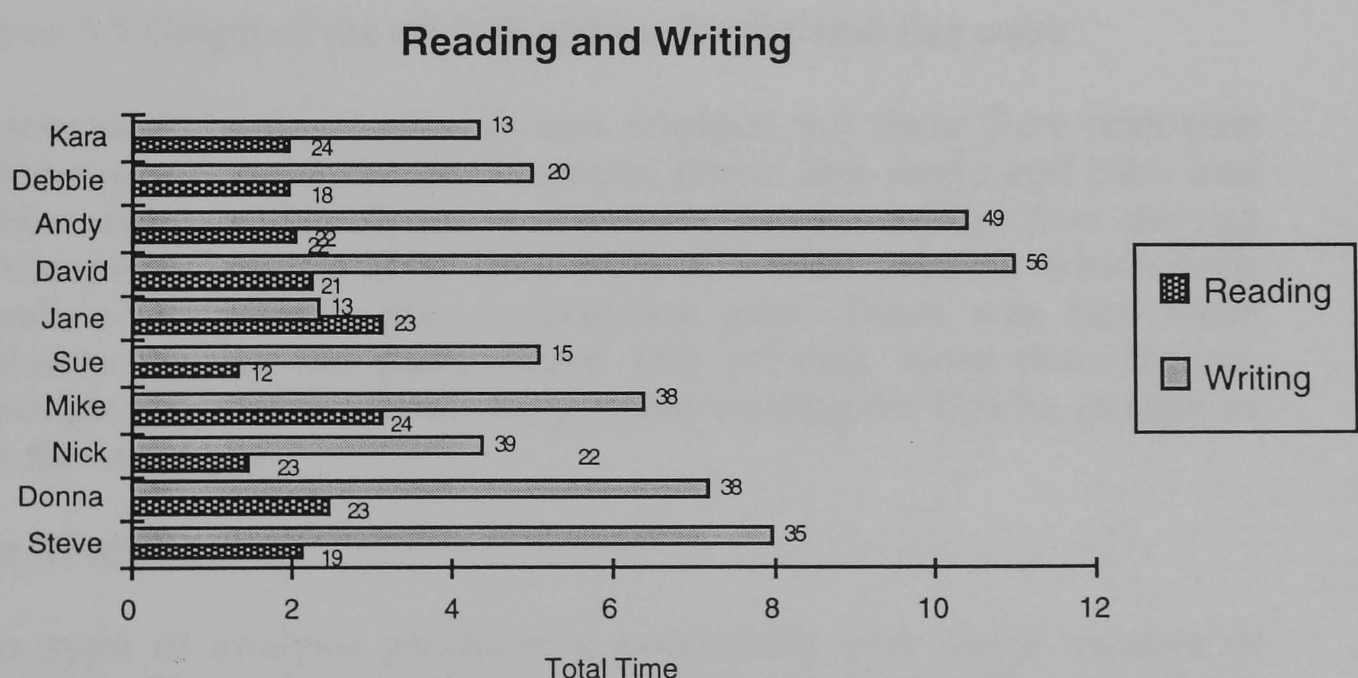

Figure 5.4 Graph of the reading and writing of the first five pairs.

There are less occurrences of reading and writing in the two pairs who shared a worksheet (Kara and Debbie, Sue and Jane). There are intra-pair differences which may reflect ability.

Off-task actions

Figure 5.5 shows the number of occurrences and duration of off-task activities. Off-task actions were coded as those in which the students were overtly not engaged in the task, for example, looking out of the window. This included time when the students were thinking about the task as well as time when they were obviously off-task.

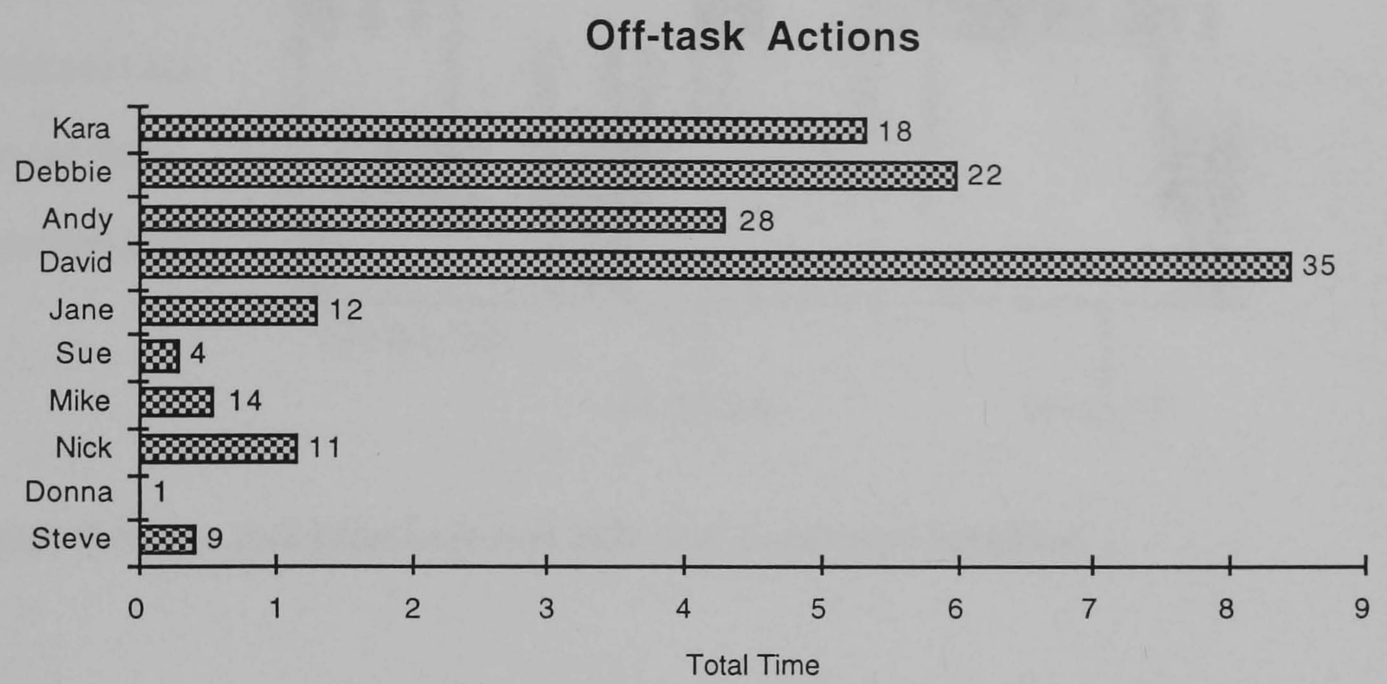

Figure 5.5 Graph of the off-task actions for the first five pairs.

In general, time spent off-task was minimal but there were inter-pair differences are apparent, for example, David and Andy and Kara and Debbie did considerably more non-task related activities than the rest of the pairs and, notably, they were the only pairs in which both members achieved a pre- to post-test gain. There was also some variation within the pairs. Steve was off-task more than Donna, although this was predominantly while waiting for Donna to type or use the mouse.

Timelines

This type of analysis produces a potentially very large number of timelines. The software allows the user to create timelines involving all the categories defined, or timelines with a selection of categories. The timelines presented below are a selection of those produced by the analysis, and were chosen to address specific points.

The three timelines below show the hardware use and control talk of three of the pairs. From Sue and Jane's timeline, Figure 5.6, one can see a slightly uneven distribution of the hardware use and that the control talk virtually always leads to Sue using the hardware. Steve and Donna's timeline, Figure 5.7, shows very clearly the uneven distribution of hardware control and the control talk always leads to Donna using the hardware. Nick and Mike's timeline, Figure 5.8, also clearly shows the uneven distribution of control, with control talk always leading to Mike using the hardware.

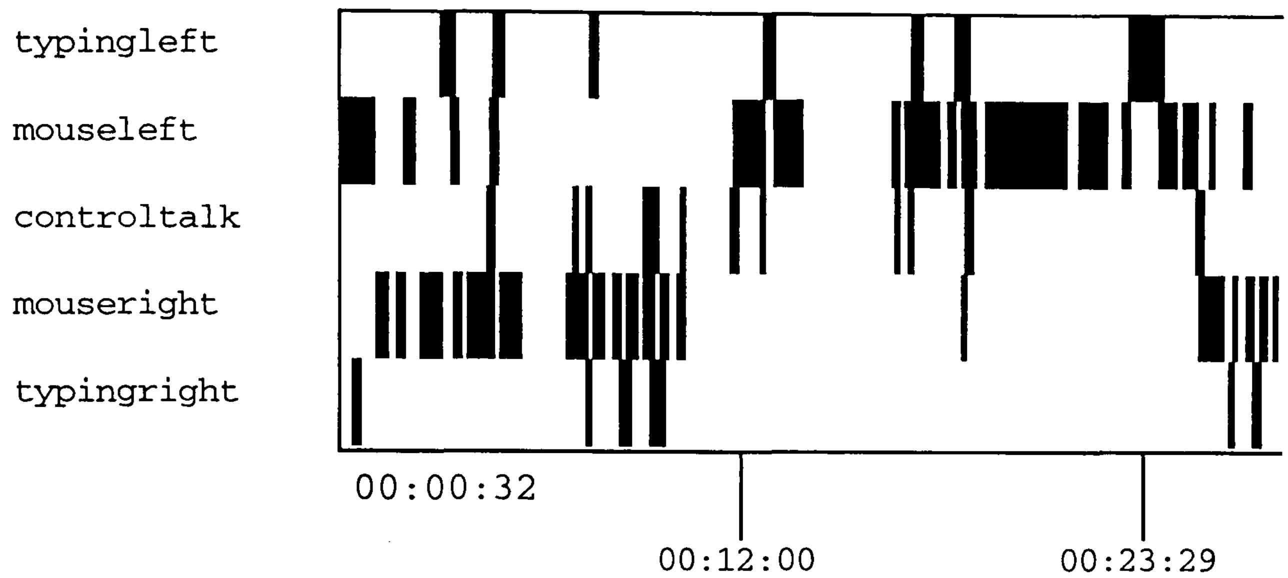

Figure 5.6 Sue and Jane's control talk and hardware timeline.

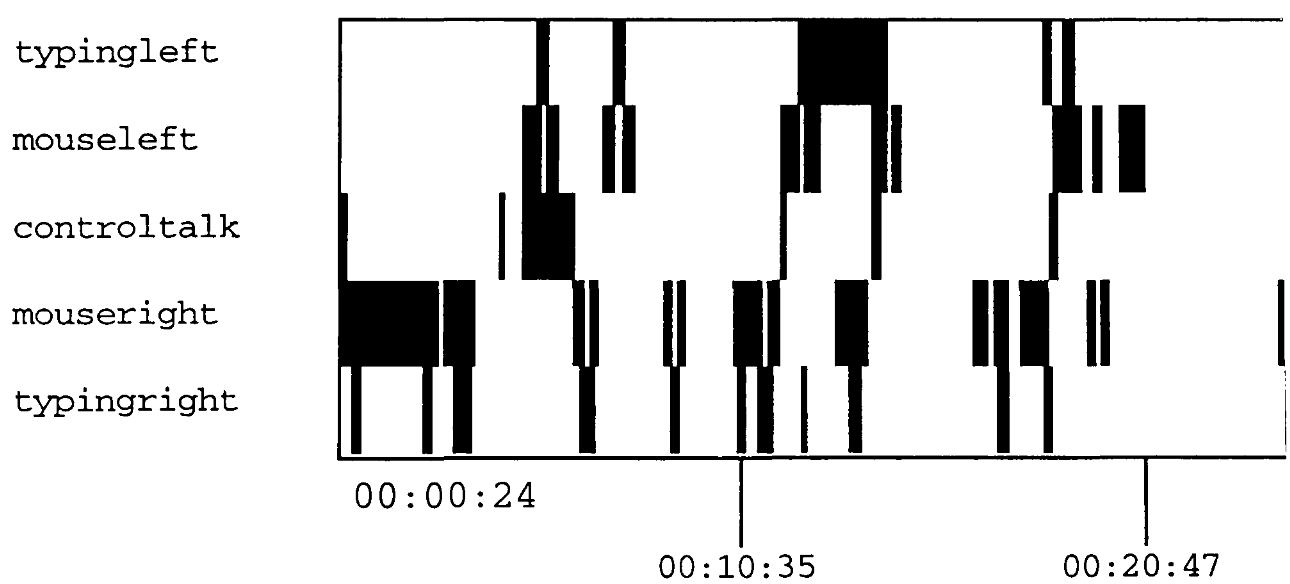

Figure 5.7 Steve and Donna's control talk and hardware timeline.

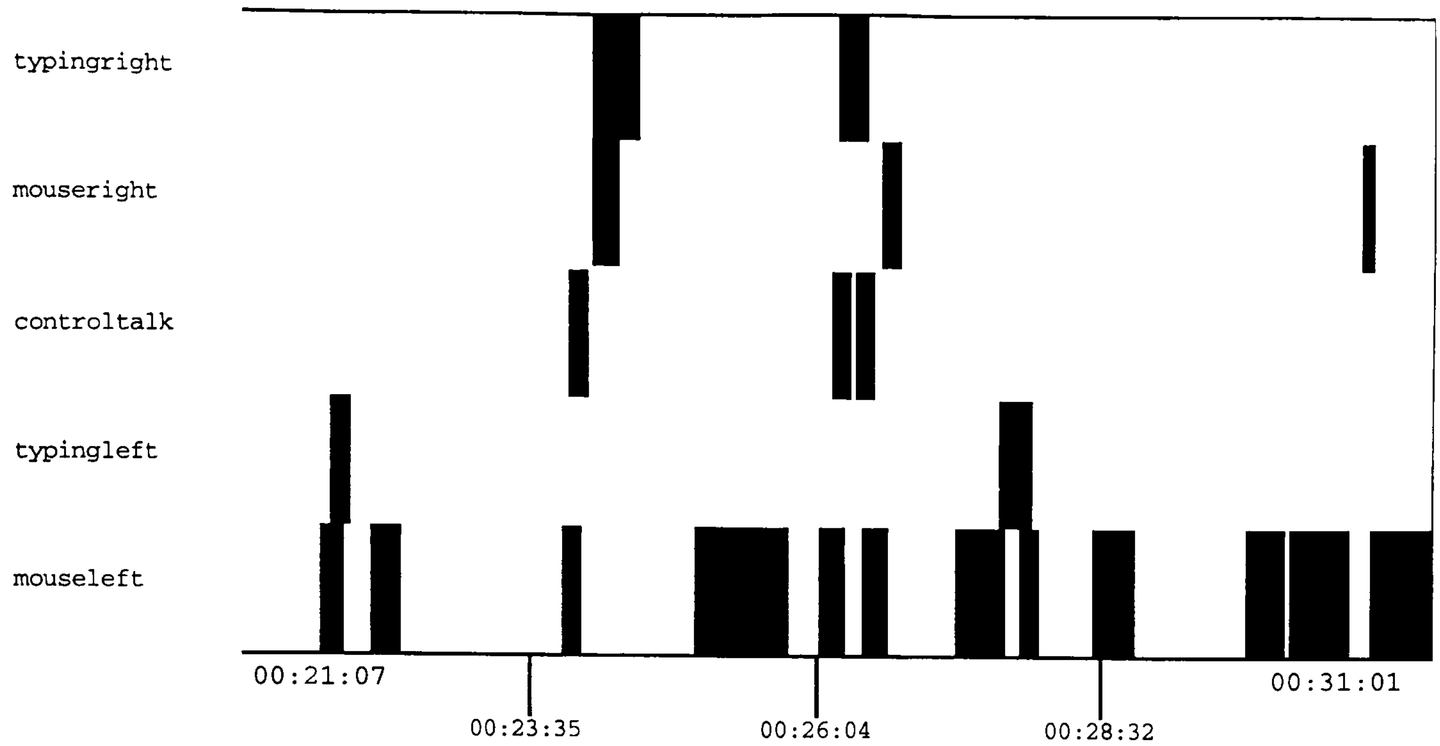

Figure 5.8 Nick and Mike's control talk and hardware timeline.

5.4.3 Changes in patterns of interactions over sessions

There is evidence of changes in the way that the students interacted with each other over time. This is shown both in the distribution of the use of the hardware and writing and in the nature of the talk.

The two pairs who spent more than one session using the computer (see section 5.4) showed changes in their patterns of interaction between their first and second session. For David and Andy, in their first session, the hardware use was evenly distributed between them, but during the second session, a week later, Andy dominated the hardware. This is shown in Table 5.3.

Session	First		Second	
	Mouse	Typing	Mouse	Typing
David	20	5	4	0
Andy	25	14	46	18

Table 5.3 Mouse and typing use in David and Andy's two sessions.

Changes over Debbie and Kara's two sessions can be seen in their use of the mouse and the amount of writing (Table 5.4). They physically fought over the use of the mouse and the typing. There were 16 instances of this during the two sessions, but they were generally short lived, with Kara dominating the first session. Debbie used the mouse for the majority of the second session, which was two weeks later, and she insisted that Kara fill in the worksheet.

Session	First		Second	
	Mouse	Writing	Mouse	Writing
Debbie	9	20	13	0
Kara	21	2	2	11

Table 5.4 Mouse and writing use in Debbie and Kara's two sessions.

The timelines show the distribution of the different types of talk and these also show some changes over time. Steve and Donna's talk timeline (Figure 5.9) show a decrease in talk about the interface (next talk) and an increase in the amount of topic talk over the session.

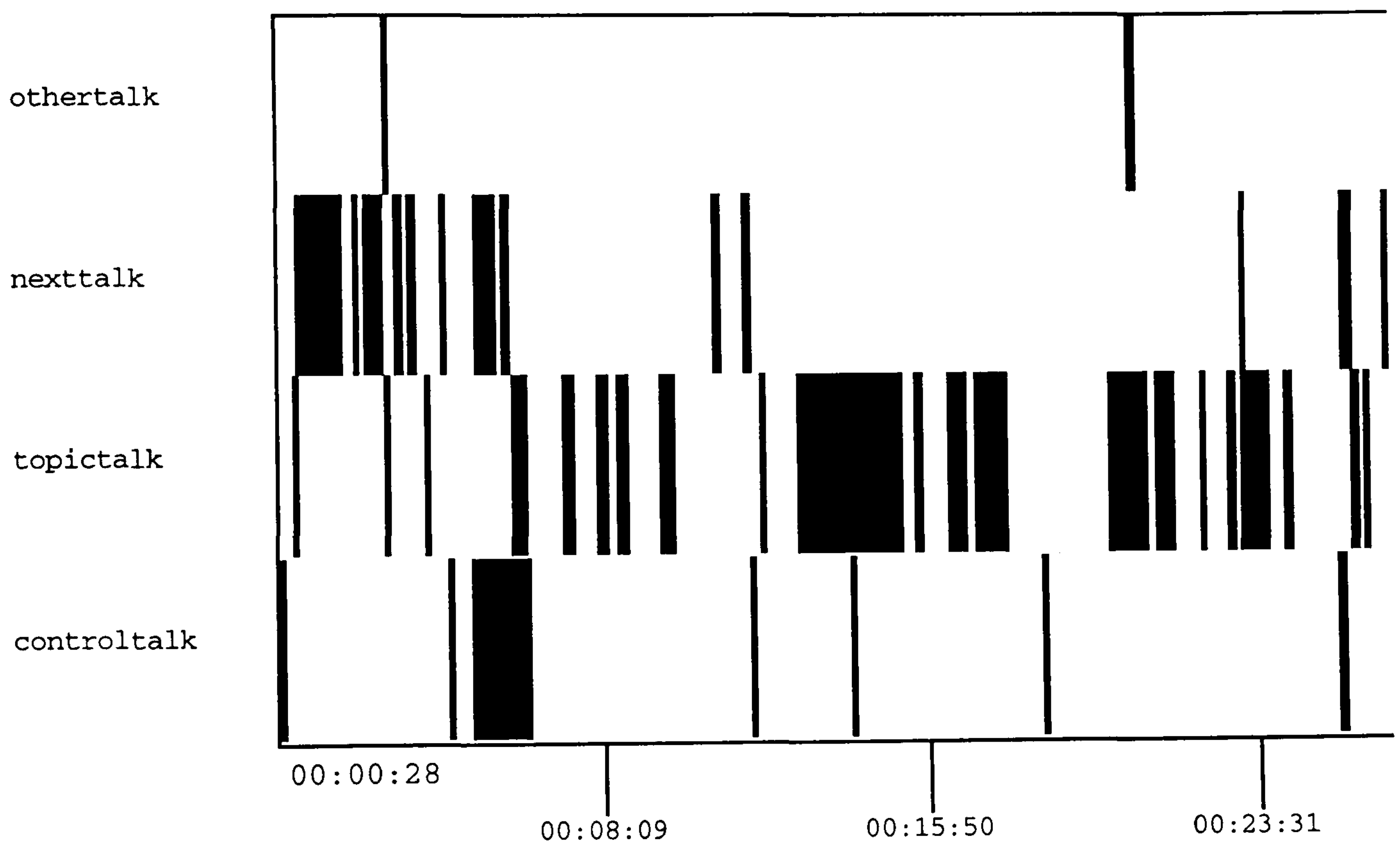

Figure 5.9 Steve and Donna's talk timeline

In contrast, Sue and Jane's talk timeline (Figure 5.10) shows no decrease in next talk, with a slight increase in topic talk. This reflects the fact that they never fully mastered the use of the software. The timeline also shows the relatively large amount of other talk that occurred during their interaction.

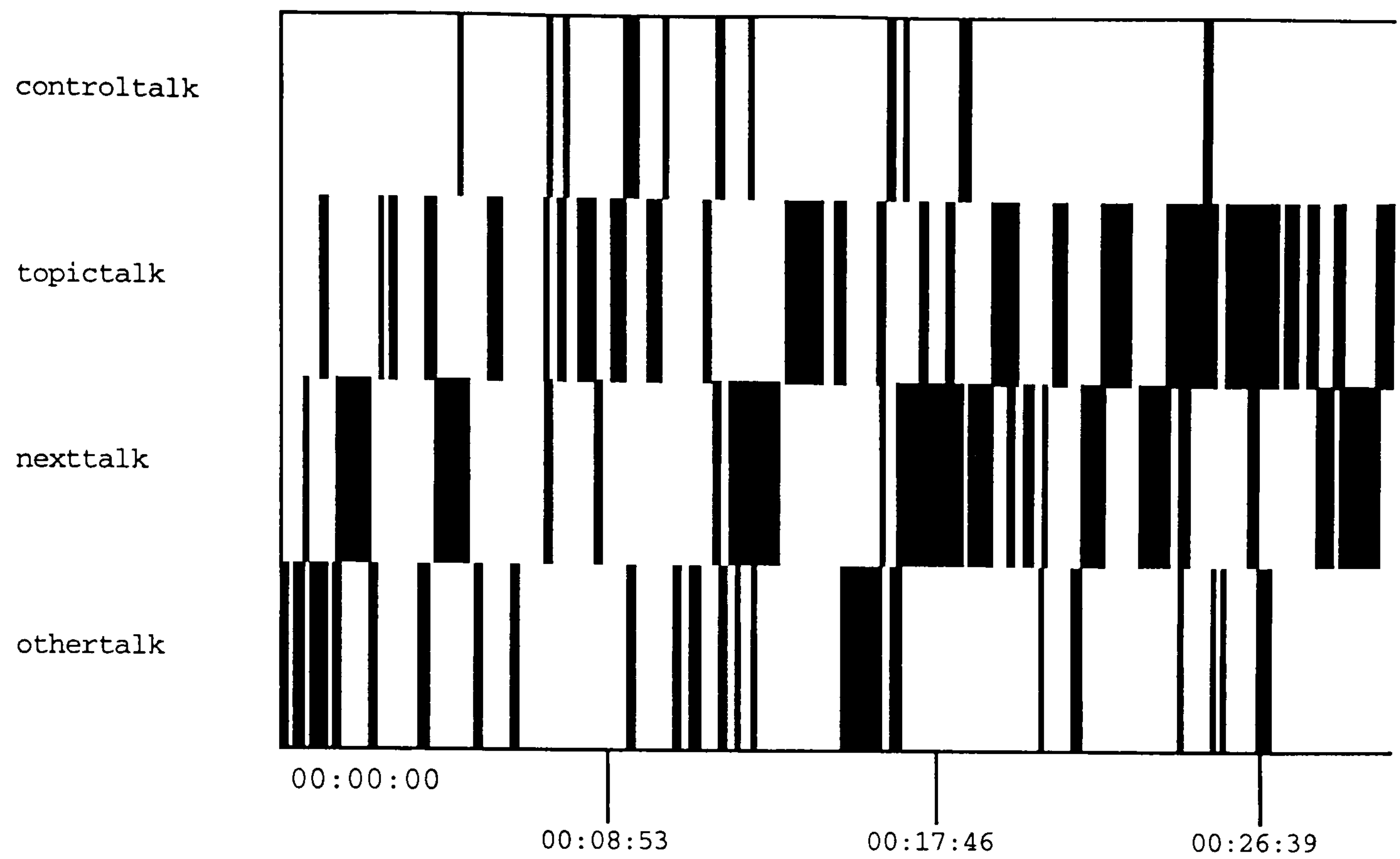

Figure 5.10 Sue and Jane's talk Timeline

5.4.4 Discussion of each pair

Steve and Donna
Steve and Donna spent less than average time completing the worksheet and talked for very little of the time. They spent a lot of time discussing the topic, and a significant amount of time discussing control. The control of the hardware was dominated by Steve and the discussion of control always consisted of Steve asking Donna if she wanted to use the mouse or type. Donna's mouse control and typing was inferior to Steve's. The amount of talk about the interface (next talk) decreased over the session, while the amount of topic talk increased. They spent equal amounts of time reading and writing, but Donna barely went off task at all, while Steve spent some time off-task, although this was largely while Donna was using the hardware. This pair only asked for help from the researcher once. Steve benefited from the use of the computer while Donna did not on the immediate post-test. This may be due to the fact that Donna had very little control or say in what happened during the session. However, as the results of their delayed post-test shows, from a long term perspective, Donna ultimately was at the same level as Steve. Donna improved from the immediate post-test to the delayed post-test, while Steve's score decreased.

Nick and Mike
Nick and Mike's interaction was dominated both physically and cognitively by Nick. They spent a relatively short period of time using

the computer and talked for about 45% of the session. The majority of the talk was Nick explaining to Mike either what he was doing, or some of the topic material. Mike would often joke about the subject matter which sometimes spurred Nick on. This can be seen in the following transcription of their dialogue:
Nick: "The atomic number ..."
Mike: "You're joking. huh."
Nick: "The atomic number is the amount of ..."
Mike: "The things in the ... that make it up .... into"
Nick: "Yeah it would be wouldn't it. It would be the amount ... "
Mike: "The amount of different sorts .. of things that are bunged together to make one ... one certain thing ... "
Nick: "Yeah it would be the mass, it would be the mass I think. I think."
Mike: "She said we didn't have to do all the questions."
Nick: "Oh I know, it's the amount of protons."
Mike: "The amount of different protons?"
Nick: "The amount of protons."

Thus Mike did have some influence on the interaction, although this was not necessarily topic related. This piece of their dialogue also shows that, in a sense, Nick and Mike were speaking in a different language. Mike uses words like "things" and "bunged" while Nick language involves scientific terms, like "mass" and "protons". Nick dominated the control of the hardware. Nick's reading and writing ability is superior to Mike's and Mike spent considerably more time than Nick working on the worksheet. Nick spent more time off-task than Mike, although this was predominantly while Mike was completing his worksheet. They asked for relatively little help from the researcher. Nick's post-test score was greater than his pre-test score and it was obvious that he knew most of what the worksheet was designed to teach before using the computer. However, Mike did not improve his performance at all, possibly because he did not participate in the task from a cognitive perspective. Nick and Mike's lack of friendship may have contributed to this, but additionally, they were talking and operating on a completely different level. Thus it appears that the large differences in their abilities also contributed to the ineffectiveness of the interaction.

Sue and Jane
Sue and Jane's interaction was not focused on the topic. They took an average amount of time to complete the worksheet and never totally mastered the use of the software. Thus much of their talk was concerned with aspects of the interface and what to do next, and there was a large proportion of non-task related talk. The focus on next talk can be attributed to the fact that Sue and Jane had difficulties with the software. Their use of the hardware was evenly distributed between the pair but Sue read for a shorter period of time than Jane and wrote for more time than Jane. There is also an asymmetry in their off-task

actions. Jane went off-task more often and for longer than Sue. They asked for little help from the researcher. Although Jane did appear to benefit from using the computer, Sue did not. It is interesting that Jane spent more time off-task than Sue, but gained more than Sue in the post-test scores.

David and Andy
David and Andy spent two sessions filling in the worksheet and a relatively large proportion of this time was spent talking. Their talk was dominated by discussion of the topic and non-task related talk. The use of the hardware was overall extremely asymmetrical with Andy dominating. However, this was a change in the pattern of their interaction over the two sessions, where use of the hardware became dominated by Andy in the second session. Their reading and writing was symmetrical but there was a large asymmetry in their off-task actions: David went off-task for significantly more often and for longer than Andy. However, this does not seem to be indicative of not "learning" from the interaction, as David was one of the students who improved most after using the computer. They asked for little help from the researcher. Both David and Andy showed high pre-to post-test gains. This may seem at odds with their behaviour given that neither appeared to be engaged in the task for significant proportions of their interaction. Andy's gain was greater than David's even though Andy is considered by their teacher to be low ability and his pre-test score was lower than David's. This may also be due to the fact that Andy dominated the interaction.

Debbie and Kara
Debbie and Kara's interaction was the only interaction in which the students physically fought over control of the hardware. They spent two sessions filling in the worksheet and were very talkative. They never fully mastered the use of the software and there was a lot of next talk as well as a topic talk. Their use of the hardware was relatively symmetrical overall. However, Debbie wrote more than Kara and this was largely to do with the fact that in the longer first session, Debbie filled in the worksheet while Kara wrote and in the second session, Debbie dominated the use of the hardware, and forced Kara to fill in the worksheet. Both Kara and Debbie improved from pre-test to post-test. Like David and Andy, they spent a significant proportion of their interaction off-task and this may have affected their performance. Additionally, they asked for constant reassurance and help from the researcher and the fact that the researcher is female may have had an impact on their performance.

5.4.5 Summary of the analysis

In the previous section, the results of qualitative video analysis of five pairs of students working together at a computer have been presented. The video analysis has enabled categorisation of the pairs, according to the amount of time spent, the amount of talk, the nature of the talk, symmetry of mouse usage and typing, reading and writing. This is summarised in Table 5.5 below in which the second column shows whether or not the pair shared a worksheet.

Pair	Own or shared	Total Time	Total Talk	Dominant Talk	Off-task actions
Steve and Donna	own	low	low	topic and control	low
Nick and Mike	own	low	medium	topic and next	medium
Sue and Jane	shared	medium	high	next and other	medium
David and Andy	own	high	high	topic and other	high
Debbie and Kara	shared	high	high	topic and next	high

Table 5.5 Summary of the results of the first five pairs

Both David and Andy and Debbie and Kara spent longer than average completing the worksheet and these pairs talked more than average and spent more time doing other actions. Sue and Jane were the only pair in which topic talk was not dominant and they were the pair that achieved the least. Debbie and Kara, Sue and Jane and Nick and Mike spent considerable amounts of time talking about how to use the software. As previously discussed, for Nick and Mike this predominantly consisted of Mike telling Nick what he was doing. However, for the other two pairs, this talk shows that they never really understood how to use the software. Steve and Donna are the only pair who discussed control to a significant extent. Therefore, it appears that the control of software is normally 'assumed' between the pairs. However, for Debbie and Kara, control was gained by physical fighting.

Table 5.6 below shows the differences within the pairs between mouse and typing use and reading and writing.

Name	Mouse	Typing	Reading	Writing
Steve	dominant	dominant	equal	equal
Donna	subordinate	subordinate	equal	equal
Nick	dominant	dominant	less	less

Mike	subordinate	subordinate	more	more
Sue	equal	equal	less	more
Jane	equal	equal	more	less
David	subordinate	subordinate	equal	equal
Andy	dominant	dominant	equal	equal
Debbie	equal	equal	equal	more
Kara	equal	equal	equal	less

Table 5.6 Summary of the differences within the first five pairs

Sue and Jane and Debbie and Kara were the only pairs in which the use of the hardware was equal. This may be a genuine gender difference, but this conclusion cannot be reached from such small numbers. It is also important to consider that these were the only two pairs who shared a worksheet. In the other pairs, there was unequal distribution of the use of hardware. However, this did not necessarily lead to the subordinate member not benefiting from the interaction, as shown by David, who obtained one of the highest pre-to post score gains. In terms of reading and writing, the inter-individual differences between Sue and Jane and Debbie and Kara can be attributed to the fact that they shared a worksheet. Mike read and wrote for longer than Nick. This difference is due to the vast differences in reading and writing abilities of Mike and Nick.

5.4.6 Conclusions

From this small sample of pairs, several features seem to be indicative of pre-to post cognitive gains.

- The pairs with high friendship ratings (Debbie and Kara and David and Andy) improved on their pre-to post-tests. The pairs with lower friendship ratings (Sue and Jane and Nick and Mike) were not as successful in these terms.
- The pairs that spent time off-task have greater pre-to post gains. This may be a reflection of consolidation during off-task periods.
- These pairs spent longer on the task, although this may simply be a reflection of their off-task activities.
- The girl:girl pairs were the only pairs in which there was no dominance in the use of the hardware. This may be a gender difference, but it also may be a reflection of the fact that these students shared a worksheet.
- In the pairs where dominance did occur, the dominant member achieved more gain from the pre-test to the immediate post-test.
- Inter-pair differences in reading and writing were only found in the pairs who shared a worksheet, and between Nick and Mike, where the large ability discrepancy can explain this difference.
- The control of the hardware is often tacitly assumed, with only Steve and Donna discussing control and Kara and Debbie fighting over control.

- In the pairs that spent more than one session using the computer, changes in the ways that they interacted over the two sessions can be seen.

This section has presented a detailed analysis of the videotapes of five pairs of students. In order to check whether these pairs were typical of the pairs in the study, five further pairs were analysed in a similar fashion, and this analysis is discussed next.

5.5 Analysis of five further pairs

In this section, the analysis of five further pairs is presented. This is followed by a discussion of the similarities and differences found between the two sets of analyses. The baseline information about the pairs can be found in Table 5.7 and background information is given in Appendix D.

Summary

Name	Ability rating	Motivation rating	Pre-to post-test gain	Friendship rating
Alys	4	3	gain	5
Mark	3	2	gain	
Nicholas	5	1	gain	5
Josef	5	5	gain	
Rina	2	2	gain	5
Gabby	4	4	gain	
Arthur	5	1	gain	4
James	5	3	gain	
Hetal	4	4	gain	5
Ursula	4	3	gain	

Name	Pre-test	Post-test	Delayed post-test
Alys	2	4.5	3
Mark	7	7.5	7
Nicholas	6	8	10
Josef	12	12.5	15.5
Rina	2	5	5
Gabby	4	7	7
Arthur	0	2.5	not available
James	2	9.5	4.5
Hetal	5	10	6
Ursula	3	6.5	8.5

Table 5.7 Summary of the second five pairs

5.5.1 Results

Time

The total time that these pairs spent on the task is shown in Table 5.8.

Pair	Total Time
Alys and Mark	32.09
Nicholas and Josef	24.52
Rina and Gabby	38.50
Arthur and James	40.54
Hetal and Ursula	35.54

Table 5.8 The total time spent on the task by the second five pairs

Nicholas and Josef spent relatively little time completing the task, while Arthur and James and Rina and Gabby spent a relatively long time on the task (working on the computer and completing the worksheet).

Talk

Figure 5.11 shows the total time and time spent talking for each pair, and Table 5.9 and Figure 5.12 show the number of occurrences of different types of talk and the percentage of time spent on different types of talk.

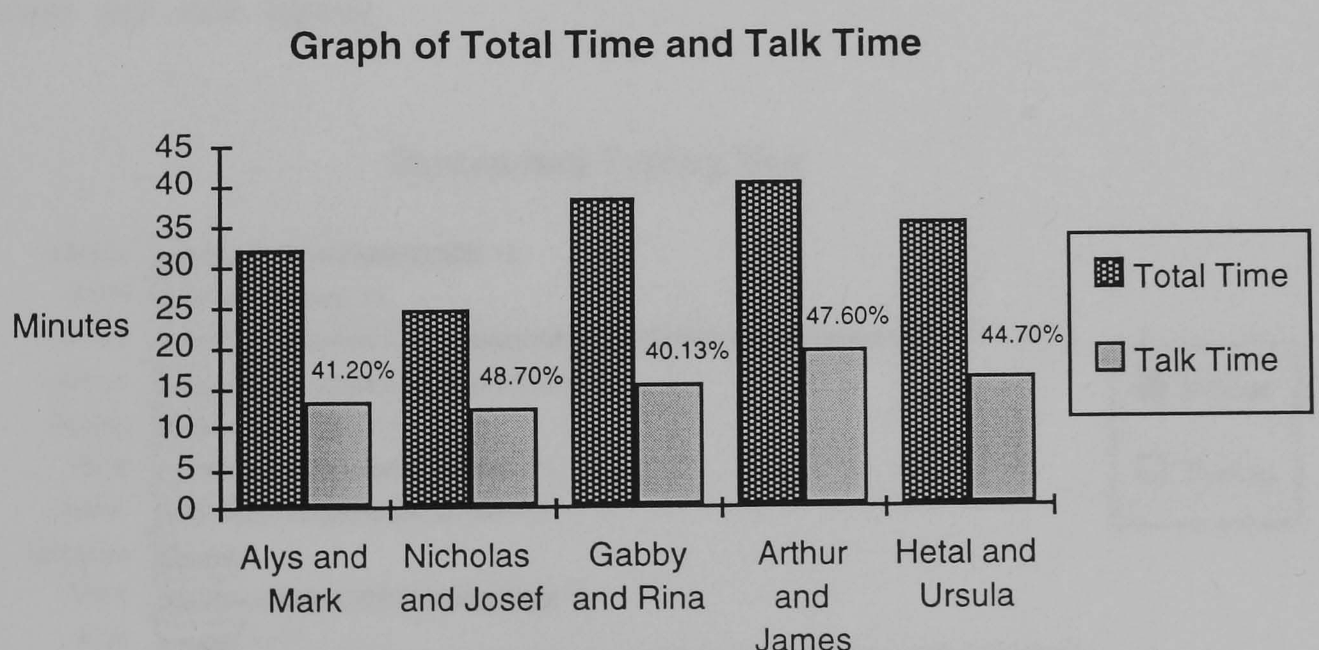

Figure 5.11 Graph of the total time and talk time of the second five pairs

Figure 5.12 shows the different types of talk which occurred for the second five pairs.

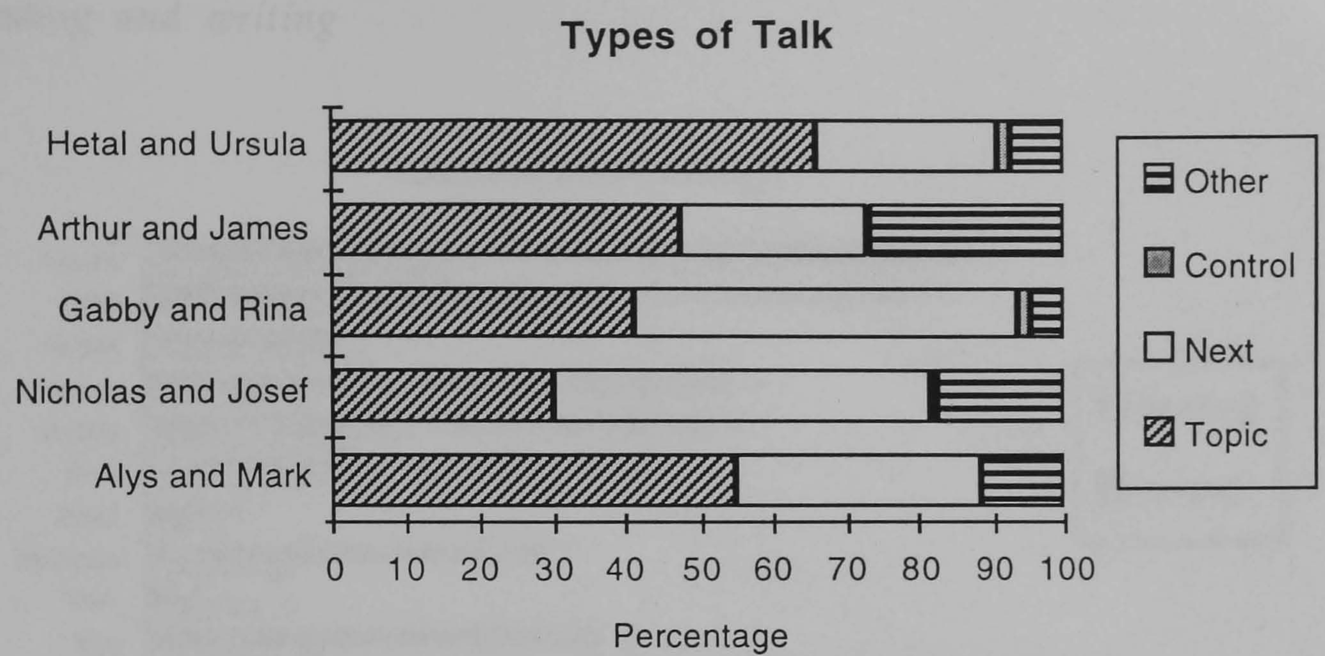

Figure 5.12 The different types of talk by the second five pairs

The notable aspects about the types of talk are how much topic talk dominated Hetal and Ursula's interaction and the large amount of other talk in Arthur and James and Nicholas and Josef's interaction. Additionally, Nicholas and Josef had very little topic talk - they are both very able and knew most of the information before they started. The majority of their talk is about what to do next. Similarly, Rina and Gabby's interaction is dominated by interface talk. There is relatively little control talk.

Mouse use and typing

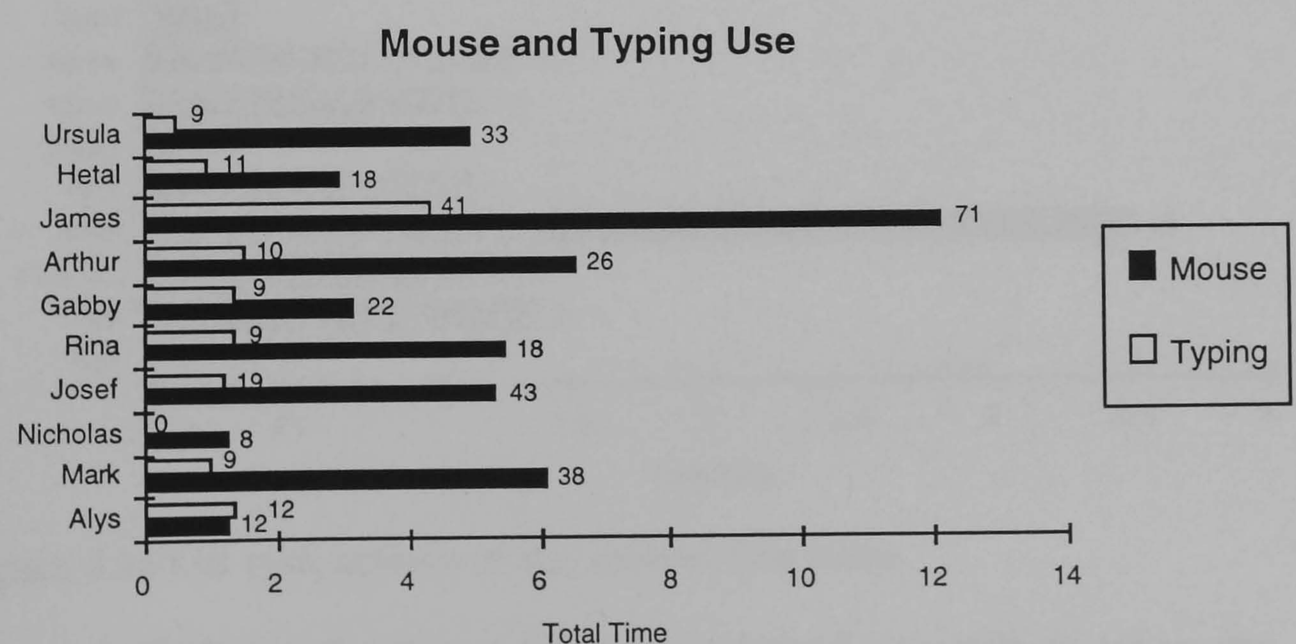

Figure 5.13 Mouse and typing use by the second five pairs

Recordings of control of the mouse and typing clearly show hardware dominance in the male:male pairs, both of whom shared worksheets (Figure 5.13). There is no dominance in the female:female pairs and the boy (Mark) dominated in the mixed gender interaction.

Reading and writing

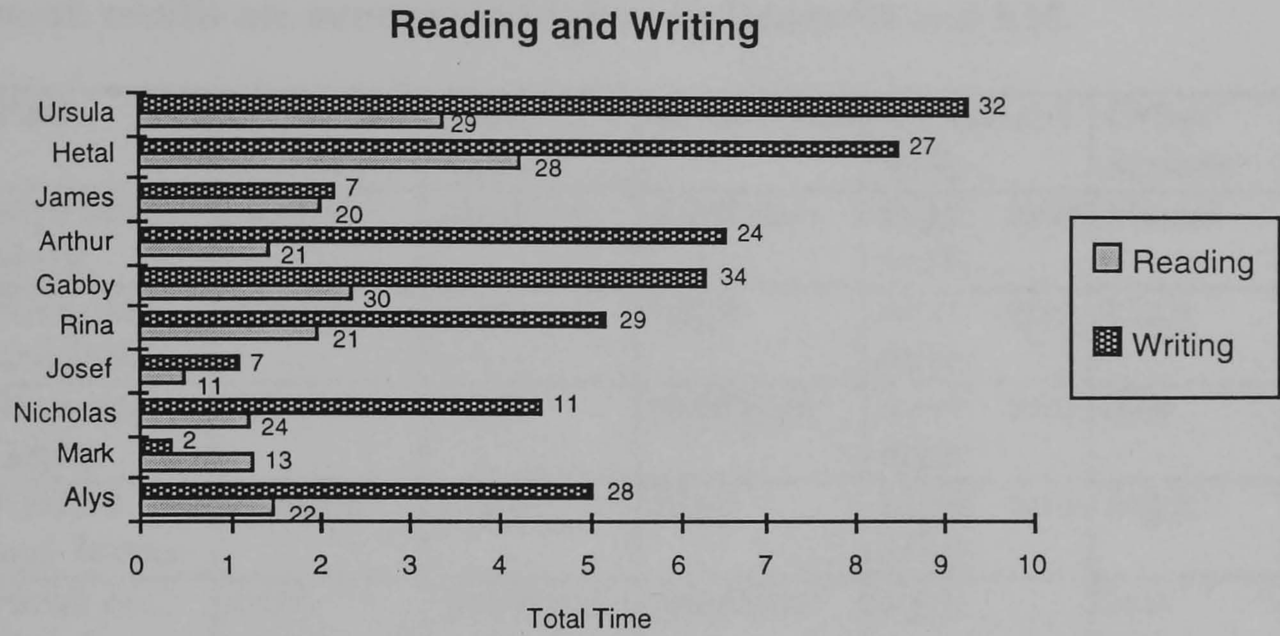

Figure 5.14 The reading and writing of the second five pairs

Writing dominance is shown in the pairs that shared a worksheet - Alys, Nicholas and Arthur did the writing and their partners were dominant with the hardware (Figure 5.14).

Off-task actions

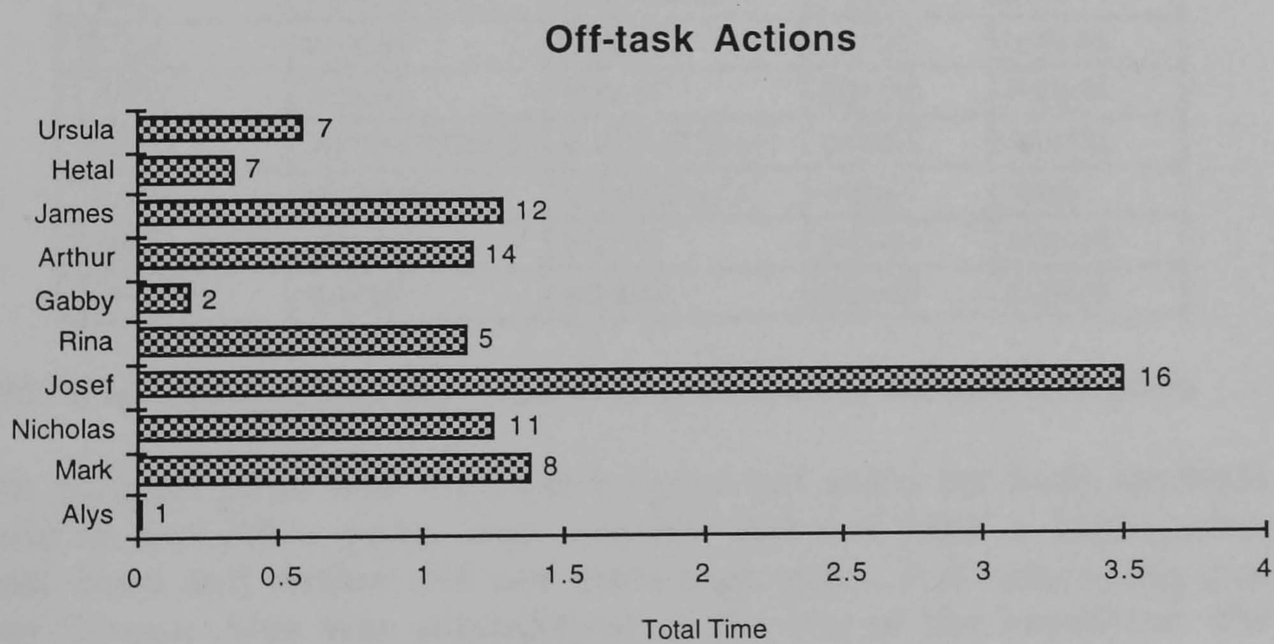

Figure 5.15 Off task actions of the second five pairs

Figure 5.15 shows the time and the number of occurrences when the students' were off-task behaviour. There is asymmetry in Nicholas and Josef's off task behaviour. Josef went off task while Nicholas was writing. The same situation applied to Mark and Alys and the asymmetry between Rina and Gabby reflects their normal classroom behaviour.

Summary

Overall results are summarised below in Tables 5.9 and 5.10.

Pair	Own or shared	Total Time	Total Talk	Dominant Talk	Other actions
Alys and Mark	shared	medium	medium	topic and next	mixed
Nicholas and Josef	shared	low	high	next and other	high
Rina and Gabby	own	high	medium	next and topic	low
Arthur and James	shared	high	high	topic and other	high
Hetal and Ursula	own	medium	medium	topic	low

Table 5.9 Summary of the results of the second five pairs

Name	Mouse	Typing	Reading	Writing
Alys	subordinate	equal	equal	more
Mark	dominant	equal	equal	less
Nicholas	subordinate	subordinate	equal	more
Josef	dominant	dominant	equal	less
Rina	equal	equal	equal	equal
Gabby	equal	equal	equal	equal
Arthur	subordinate	subordinate	equal	more
James	dominant	dominant	equal	less
Hetal	equal	equal	equal	equal
Ursula	equal	equal	equal	equal

Table 5.10 Summary of the differences within the second five pairs

Both girl:girl pairs had high pre-to post-test gains for both students while in the other pairs, one member did not have a high gains. Mark, Josef and Arthur did not show high gains. It is interesting that even though Alys was subordinate in the use of the hardware, she still showed a high pre-to post-test gain.

5.6 Comparing the two sets of analyses

The pairs in the second analysis all had relatively high friendship ratings and it is therefore not possible to verify the finding from the first five pairs that those with high friendship ratings were more successful than those with low friendship ratings in cognitive terms.

There was not as much variation in the total time spent on the task in the second five pairs (24-41 minutes) when compared to the first five pairs (30-61 minutes). Although the second five spent less time on task, they spent about more of their time talking (40-48%) than the first five (26-41%).

In terms of the nature of the talk, the second five discussed control less than the first five and again the control of the hardware was often tacitly assumed. Otherwise the proportions of the different types of talk are similar between the two sets of analyses.

The results in terms of dominance are very similar. There is no dominance in the girl:girl pairs in both data sets, and in both mixed gender pairs, the boy dominates. There are similar variations within and between pairs and between individuals. However, the dominant partner was not always the one with the greatest gain.

The first five pairs spent more time off-task more than the second five, but in both symmetries and asymmetries within pairs can be seen. The female member of the mixed gender pair went off-task considerably less than the male member.

In terms of the researcher helping, the two samples required help from the researcher for approximately equal amounts of time. Help was particularly required by the girl:girl pairs.

Overall, the results of the analysis of the pairs show differences between pairs and within pairs. The analysis of the ten pairs gives a good sense of the nature of the interactions and was felt to be sufficient to allow comparison with the individuals. Five individuals were randomly chosen from the second five pairs. They were chosen from these pairs because these were originally chosen randomly whereas the first set of five were chosen for specific reasons as discussed in section 5.4. The results of the analysis of their interactions are presented in the next section.

5.7 Analysis of five individuals

Detailed background information about the five individuals involved in this analysis can be found in Appendix D. This information is summarised in Table 5.11.

	Age	Ability	Motivation	Gain
Nathan	14	4	2	High
Brenda	14	4	4	High
Bhina	13	2	2	Average
Gemma	14	2	2	Average
Wayne	14	2	2	Low

Table 5.11 Summary of the five individuals

5.7.1 Results

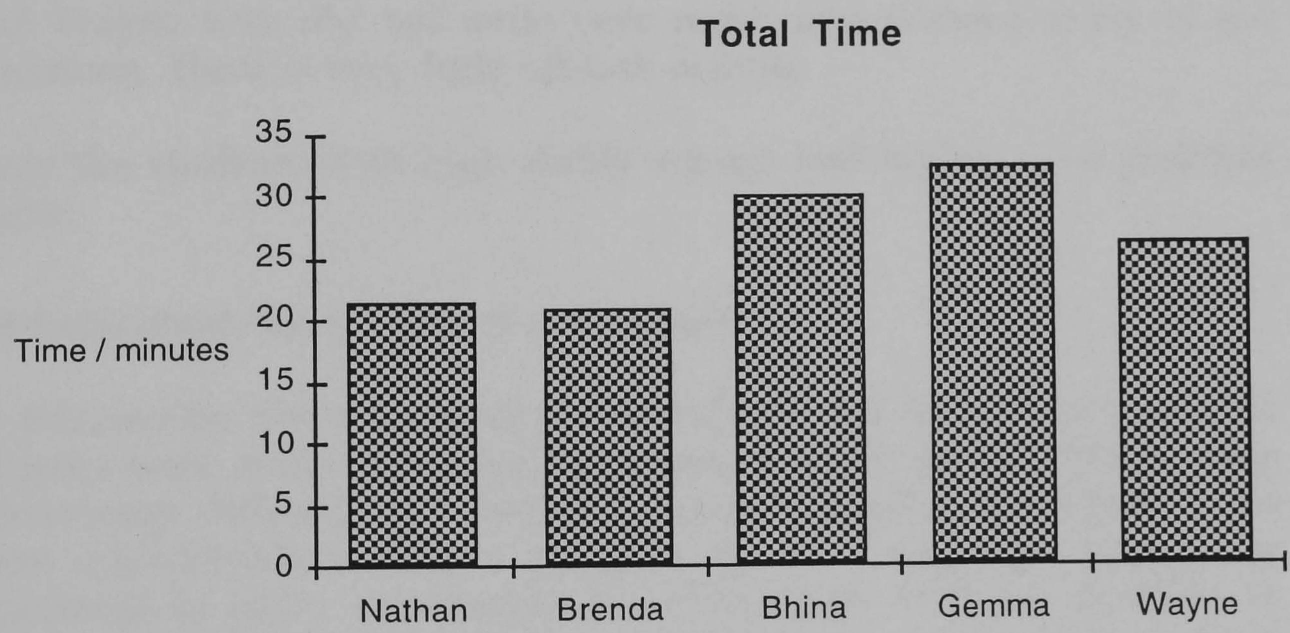

Figure 5.16 Graph of the total time spent on the task by the five individuals

There was some variation in the amount of time spent completing the worksheet between the five individuals.

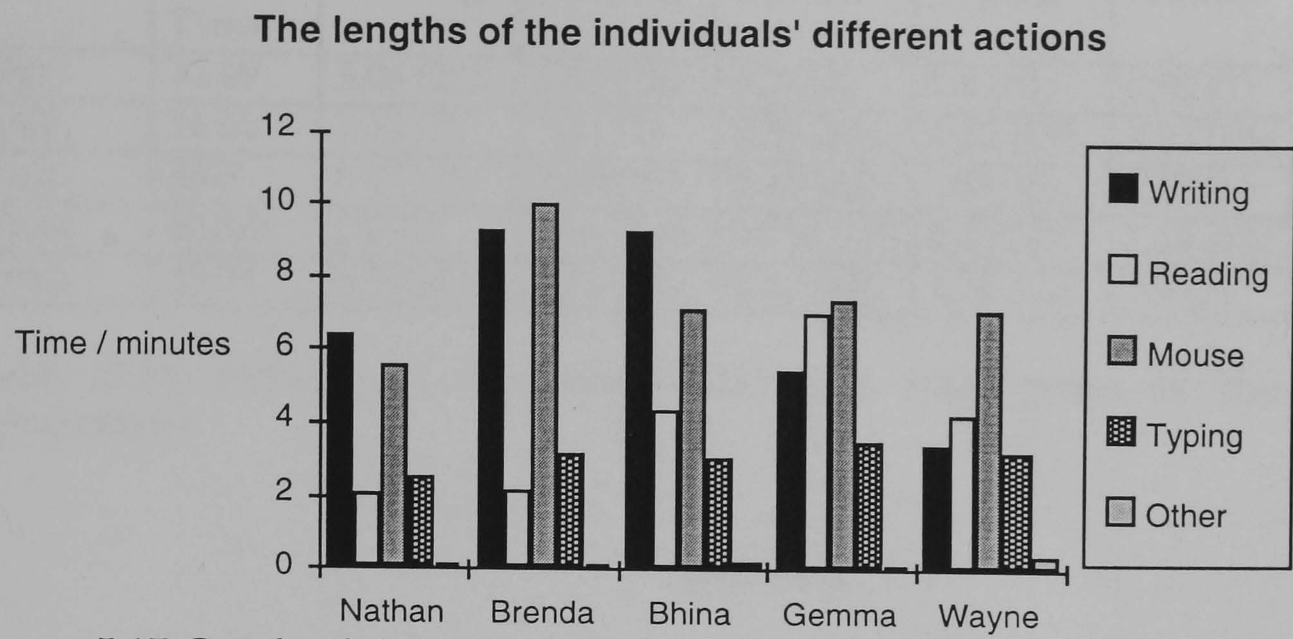

Figure 5.17 Graph of the actions of the five individuals

The profiles of the five students are very similar, except for Gemma and Wayne who did not write very much and skipped many of the questions. There is very little off-task activity.

Only the students with high ability ratings had high pre- to post-test gains.

5.8 Individuals versus paired individuals

In this section the videotapes of individuals and individual members of pairs were compared using Timelines in order to see whether their behaviours differed. For example, do individuals go off-task more than individuals within a pair, or spend more time using the interface? In order to compare the behaviours of those working in pairs with individuals working on their own, a comparison of the 5 individuals analysed was made with 5 students chosen randomly from the pairs.

	Total Time	Writing	Reading	Mouse	Typing	Off-task
Nathan	21.31	6.33 (37)	2.08 (30)	5.55 (53)	2.51 (19)	.08 (4)
Brenda	21.00	9.30 (41)	2.14 (27)	10.03(74)	3.15 (30)	.04 (4)
Bhina	30.11	9.29 (30).	4.37 (42)	7.13 (37)	3.02 (13)	.22 (5)
Gemma	32.30	5.47 (31)	7.01 (41)	7.47 (58)	3.55 (20)	.11 (2)
Wayne	26.33	3.41 (14)	4.27 (44)	7.07 (33)	3.27 (15)	.38 (5)

Table 5.12 Actions of the five individuals in the comparison

Five individuals were chosen randomly from the second set of pairs in order to make comparisons with the individuals whose videotapes had been analysed.

	Total Time	Writing	Reading	Mouse	Typing	Off-task
Alys	32.09	5.06 (28)	1.53 (22)	1.3 (12)	1.4 (14)	0.02 (1)
Josef	24.52	1.13 (7)	.53 (11)	5.36 (43)	1.24 (19)	3.52 (16)
Rina	38.5	5.22 (29)	2.03 (21)	5.48 (22)	1.38 (9)	1.17 (5)
James	40.54	2.2 (7)	2.06 (20)	12.16 (47)	4.35 (41)	1.29 (12)
Hetal	35.54	8.53 (27)	4.29 (28)	3.01 (18)	1.10 (11)	.35 (7)

Table 5.13 Actions of the five individuals from pairs in the comparison

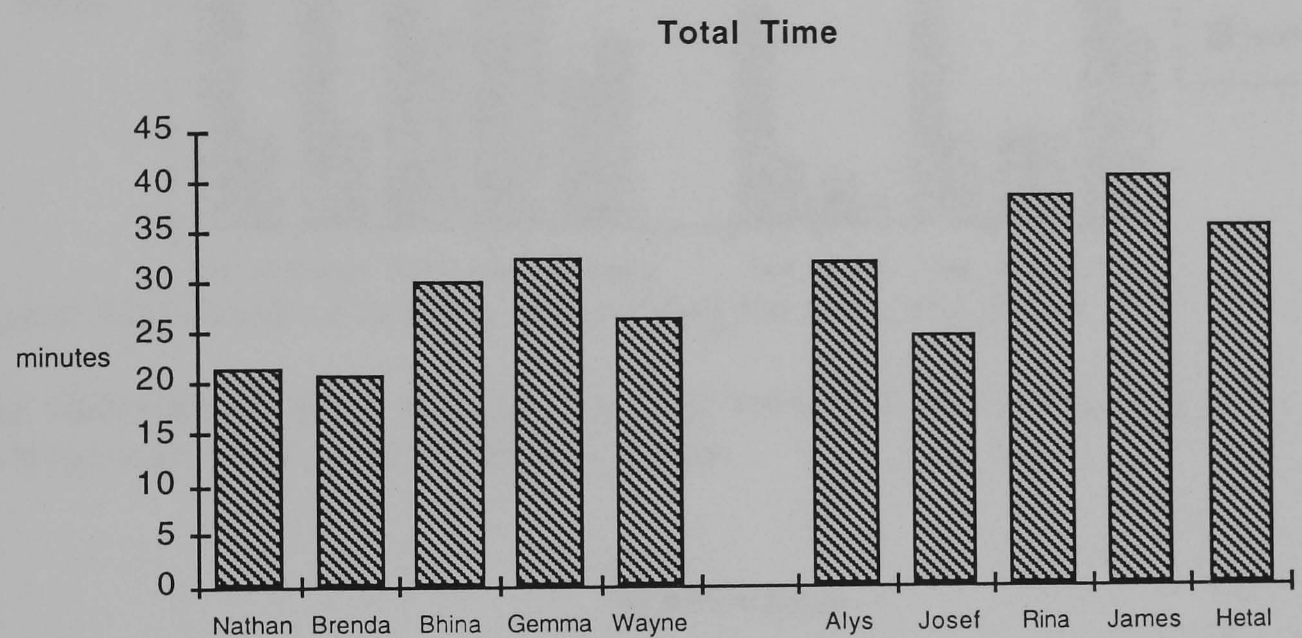

Figure 5.18 Graph of the time on the task for the comparison

The total time is higher for the individuals from pairs than for those who worked on their own.

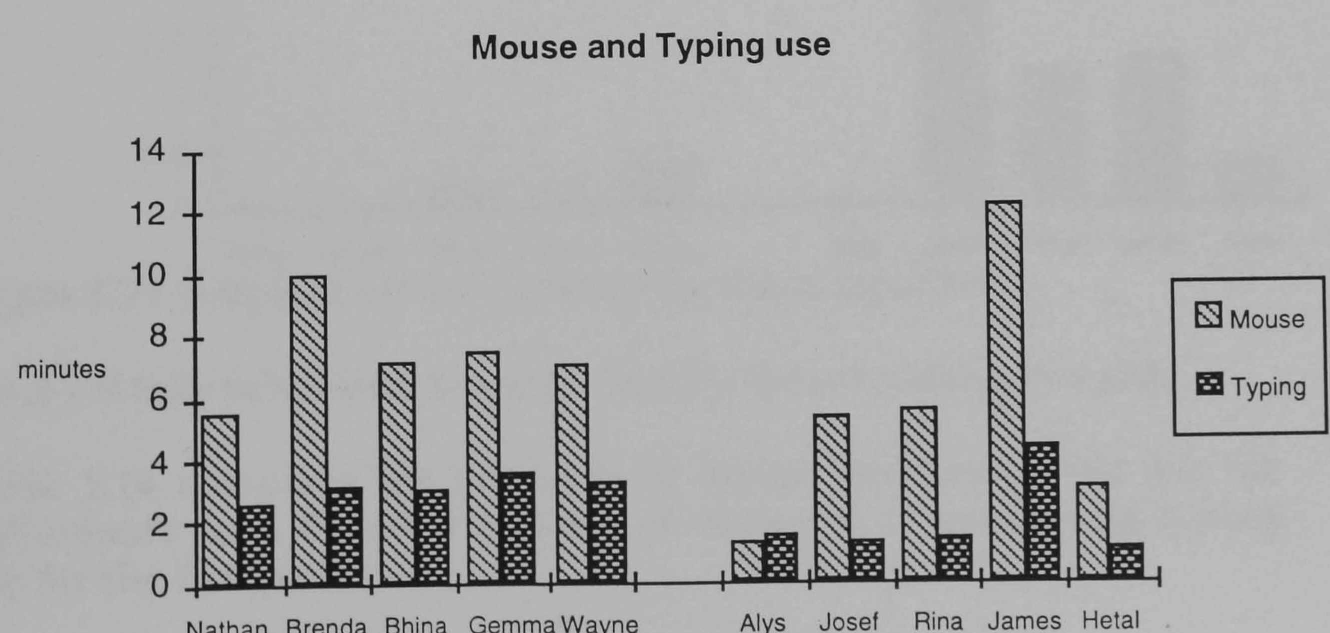

Figure 5.19 Graph of mouse and typing use for the comparison

The pattern here is similar for the two groups, except for Alys who was the subordinate member of a pair in terms of mouse use and typing.

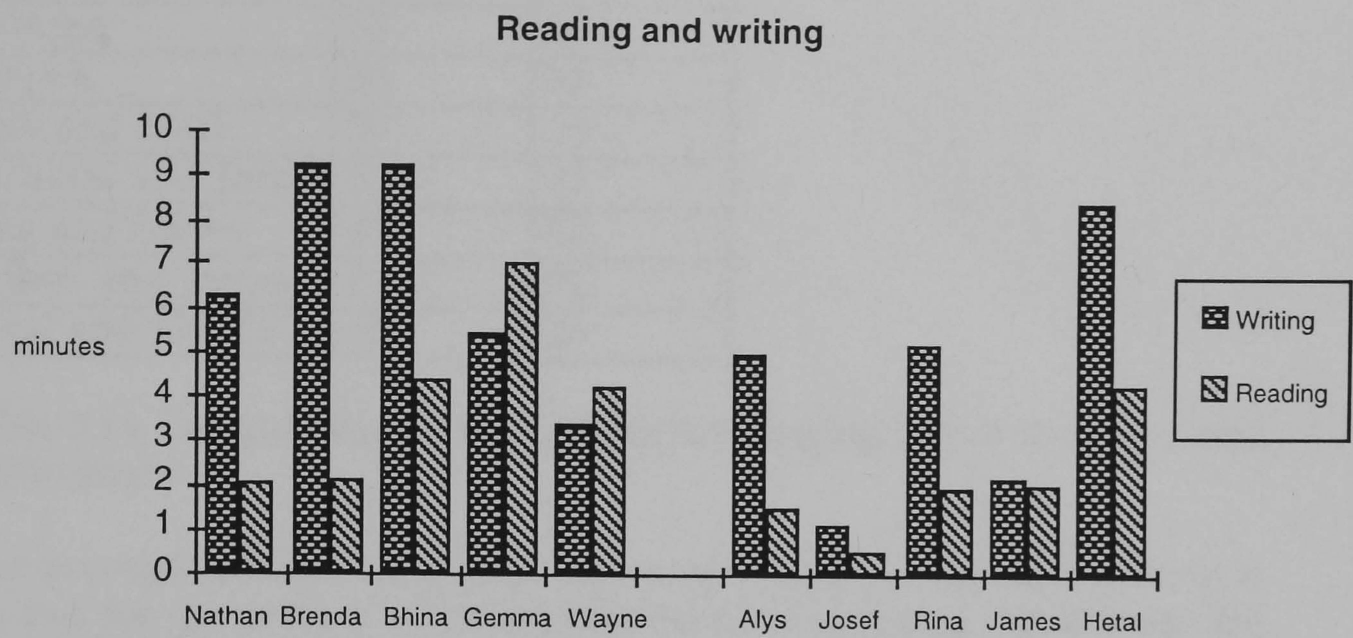

Figure 5.20 Graph of reading and writing for the comparison

The individuals who worked on their own did more reading and writing than those who worked in a pair.

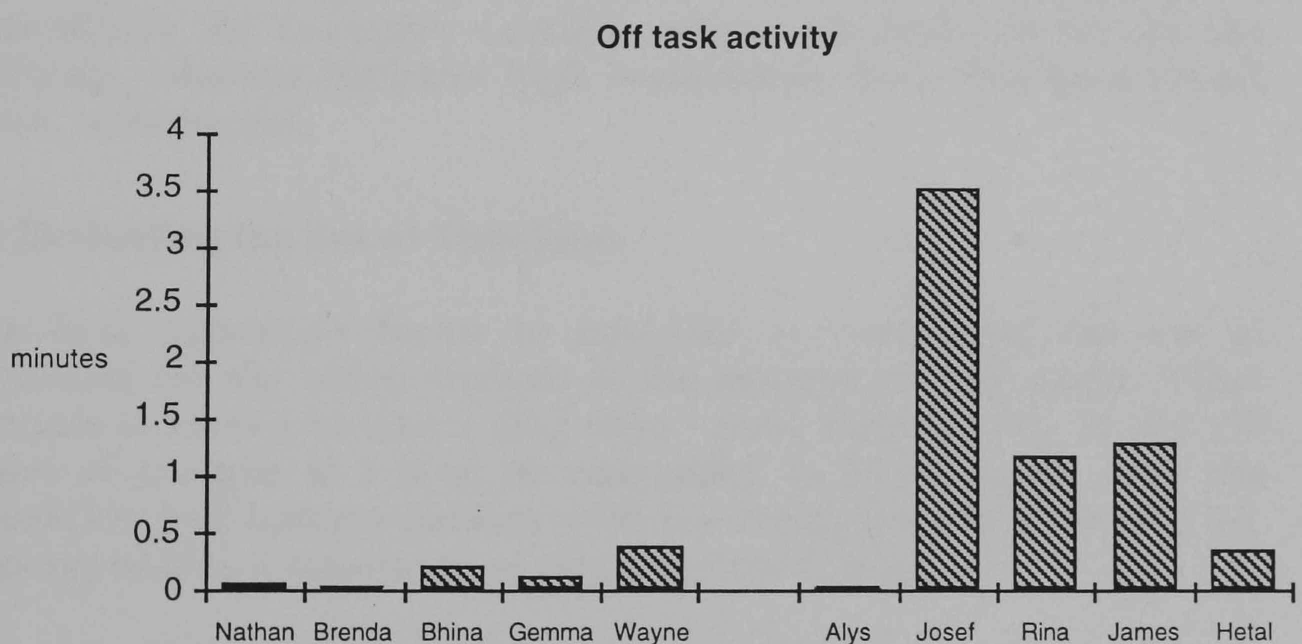

Figure 5.21 Graph of off-task activity for the comparison

More off task behaviour was exhibited by those working in a pair.

Table 5.14 compares the instances of mouse and typing use for the individuals with the total number of instances of mouse and typing use for the five pairs.

	Mouse	Typing
Nathan	53	19
Brenda	74	30
Bhina	37	13
Gemma	58	20
Wayne	33	15
Alys and Mark	50	23
Nicholas and Josef	51	19
Rina and Gabby	40	18
Arthur and James	73	51
Hetal and Ursula	51	20

Table 5.14 Comparison of total mouse and typing use of the pairs and individuals

The average number of mouse use occurrences for the individuals is 51, and for the pairs, 53. The average number of typing occurrences for the individuals is 19.4 and for the pairs, 26.2. These can be seen as a measure of either students' difficulties with interpreting the system or the amount of information that the student accessed. Given that the pairs achieved significantly higher scores on their worksheets, it seems that the pairs generally accessed more information than the individuals. The high number of occurrences for the less successful individuals for example, Gemma, reflects an inability to use the software, whereas Nathan's high occurrences show that he accessed more information.

5.9 Evaluating the use of Timelines

The first important factor to consider in evaluating the use of Timelines for the video analysis is the amount of time spent. Video analysis is known to take a long time - some claim a ratio of 10:1 (10 hours of analysis to 1 hour of videotape). In this analysis, once the researcher had become familiar with the categories, the ratio was 2:1. This represents a significant saving in terms of time.

The summaries that Timelines produces allow the analysis of inter-individual, inter-pair and intra-pair differences and from the timelines, patterns of behaviour and changes in behaviour over sessions can be seen. The fact that timelines of different intervals can be created, facilitates the analysis of the relations between different types of actions/talk. However, the meta-analysis of the data from the Timelines data also provide rich data for analysis.

One of the major difficulties with using this type of tool is selecting the appropriate categories/events/intervals and the level of granularity for the analysis. For example, in this study, the behavioural categories were fine grained, while the talk categories were at a higher level. This is suitable for the present analysis but for more dialogue focused analyses, a finer level of granularity may be needed to adequately explore the nature of the dialogues.

5.10 Discussion of videotape analysis

One contribution of this chapter is the time-based views of interactions that the software facilitates. As discussed at the beginning of the chapter, researchers have recognised time-based developments in interactions. This type of analysis is one way of representing these types of developments.

The analysis of the videotapes has also enabled the elucidation of differences between pairs, within pairs and between individuals. The results from the first five pairs have been related back to the results of the pre and post cognitive tests and although the sample is small, some conclusions were drawn about this. Additionally, the timelines show that there are developments during interactions and patterns of talk can clearly be discerned for some of the pairs. Both the summaries and timelines show hardware dominance within some of the pairs and differences in reading and writing.

Analysis of the second group of five pairs showed similarities between these pairs and the first five analysed. In particular, the girl:girl pairs are the pairs in which no hardware dominance occurs, and in both sets, the girl in the mixed gender pair was the subordinate member.

Analysis of the individuals shows that the individuals tend to have similar activity profiles, and from this small sample, it seems that only the high ability individuals benefit from the interactions. The profiles show that those with a small pre-to post-test gain had less hardware activity and seemed to skip many of the questions.

The comparison of the individuals to the pairs shows that the individuals generally spent a shorter time completing the task, and the pairs went off-task more than the individuals. The individuals did more reading and writing than those who worked in a pair but it appears that as individuals there was equal mouse and typing use. However, the total use of the hardware for individuals to pairs was compared and the pairs make greater use of the hardware. This has been interpreted in terms of the pairs accessing more information from the computer than the individuals.

5.11 Conclusion

This chapter described the analysis of videotapes of individuals and pairs of Secondary School students using a computer to learn about the Periodic Table. The video analysis showed time-based views of the interactions and inter-pair, intra-pair and inter-individual differences. It also showed that the students who worked for more than one session, showed changes in their ways of interacting with each other over time.

The study reported in this chapter and Chapter 4 was an experimental study, in an artificial environment. The students were working with an unfamiliar adult, on a task which was relevant to their curriculum, but not part of their normal work in the classroom. This will have had an effect on their behaviour and responses. The empirical study which will be presented in Chapter 6 involves naturalistic computer-supported collaborations. The Primary School study was aimed at investigating patterns in the ways in which the children interacted with one another while creating a dynamic document about the water cycle in a long-term collaboration.

Chapter 6

A case study of collaborating on a dynamic document

6.1 Introduction

The secondary school study presented in chapter 4 provided evidence that during collaborations, groups of children change their ways of interacting with one another when they work for more than one session. The study was experimental in nature with collaborations over short periods of time, and some of the difficulties of experimental research were elucidated. The study presented in this chapter involves a naturalistic collaboration, which was observed intensively over a significant period of time. Collaborations often occur over a considerable period of time and evolve during this time. Students adopt modes of interactions and take on roles during the collaborations. They have a cumulative history of working in groups.

This chapter describes an in-depth study involving observations of a group of three primary school children making a Kid Pix slide show of the water cycle, over a significant period of time. This part of the chapter is divided into four sections, the first section describes the background to the research, the second section describes the creation of the document. The third documents the collaboration and in the fourth and last section some conclusions are drawn. The chapter also includes a description of a snapshot of another group of children creating a similar document in order to show that the nature of this interaction is typical of those in this particular classroom.

6.2 Background

In this section, the background is described in terms of the school, the class and the teacher. The three pupils that the study focused on are then described, followed by the task, the phases in constructing this type of document and the software used.

6.2.1 The school, class and teacher

The study was carried out in a Milton Keynes primary school. The class had been involved in an intensive study of collaborative primary science by the Collaborative Learning and Primary Science project team and were therefore accustomed to having researchers in the classroom. The teacher had been identified as having a strong commitment to group work.

6.2.2 The pupils

Three pupils (aged 9/10), Kerry, Emma and Robert, took part in the study, and made a slide show collaboratively. The teacher chose these three children because it was a particularly difficult task, suitable only for the more able children. The children's attitudes to group work were assessed using a questionnaire created by Patricia Murphy and administered for the Collaborative Learning and Primary Science project (for an overview of this project, see Scanlon et al., 1994).

Kerry

Kerry was the most experienced computer user. She had made a slide show before on her own and she has an Apple Macintosh at home with the drawing package. She lives with her mother, who uses Macs at work and she says that she teaches her mother how to use applications like spreadsheets. Kerry prefers group and paired work to working on her own or working with the teacher. She does not like whole class work. She said that she normally works on her own, in a group or in a pair. She likes working in friendship groups but does not like teacher chosen groups. She prefers mixed gender groups to working in all girl groups or with only boys. For Kerry, this group represented the type of group work that she enjoys. Kerry likes working with others because *"You get different ideas and it often makes your work better because there is two brains working together."* but *"Some times they say they did all the work and you can get into fights."*

Emma

Emma acknowledges that Kerry is very good at the computer. They had worked collaboratively on many different tasks. Emma had also made a slide show before, and although she does not have a computer at home, she had a good grasp of the concepts required to use the computer, but her mouse control was slow. Emma prefers class, group and paired work to working on her own or with the teacher. She said that she normally works on her own, in a group or in a pair. She prefers working in friendship groups as opposed to teacher chosen groups and working with girls rather than mixed gender or boy groups where she is the only girl. Thus for Emma, this group represented the type of group that she only liked a bit. Emma wrote that she enjoys working with others because *"its different you get everyone else's ideas and not just your own one's."*

Robert

Robert was new to the class. He had only been there for two months and retained a strong Yorkshire accent. He did not have a computer at home and was obviously less certain of himself when using the computer but had good mouse control. Robert prefers class, group and paired work to working on his own or with the teacher. He said that he normally works on his own, in contrast to Emma and Kerry. He prefers working in friendship groups and does not like working in teacher chosen groups. He likes working in boys only groups and does not enjoy mixed gender groups. He doesn't like working with only girls. Thus for Robert, this group represented the type of group that he does not like. Robert wrote that working with others is good because *"You can all get on together."* and working on your own is bad because *"some times it helps to work together because you can put ideas together."*

6.2.3 The task

This task occurred at the end of a long section of work about water. The pupils had been studying water for about six weeks, including experiments on dissolving, evaporation and rainfall. They had investigated their own use of water, where it comes from and the disposal of dirty water, including methods of filtering dirty water. They studied the significance of water in different religions and carried out a study of rainfall and river systems and looked at evaporation and condensation and then the water cycle.

The teacher asked the three pupils to create a Kid Pix slide show of the water cycle in order to teach the rest of the class about the water cycle. He did not give them any structure but checked on their progress throughout the interactions. The students first did their research from approximately 10 books about water, then created a storyboard and implemented this on the computer. Storyboards are used to plan this type of work and typically consist of hand drawn pictures and text, which represent the future document. They decided that they could only add their own voiceovers at break or during lunch and so they left this to the end.

6.2.4 The design of the study

The study involved intensively following the children throughout their interactions when they were creating the document. Seven sessions were observed, using a combination of videotaping, audiotaping and note taking. Unfortunately, the teacher had already introduced the task and much of the children's research had been carried out when the study began. The study started when the children began to plan their slideshow. The children's behaviour and progress was discussed with the teacher throughout the two week period and about a week later, the children were interviewed individually about their work. The interview involved discussing a diagram of the water cycle with the children and open-ended questions designed to probe certain aspects of the interaction.

6.2.5 Phases in constructing a dynamic document

This type of work has been described as topic work which is common in British primary schools. The teacher facilitates the work, which is based on a theme, but the pupils choose, plan and present their work. The outcome is normally a document, with appropriate text and graphics. This is now increasingly produced on a computer. In this project, the document is a multi-media document, which incorporates sound as well as graphics and text.

Moar (1994) describes four phases in the construction of this type of dynamic document. After the teacher has introduced the subject area, the children collect the relevant data in the research phase, and then they determine the nature of the document in the storyboard or planning phase. In the third phase they construct their document and in the fourth phase, the children view the document.

In discussing why the construction of dynamic documents may have a beneficial effect on learning, Moar suggests that "the storyboarding phase invites a chunking down of the material into key events and also requires the production of annotated sketches of the interaction between key elements of the described domain." He claims that deeper processing is involved in constructing graphical representations with text, relative to conventional note taking. He also suggests that the temporal aspects may provide an additional representation.

In an empirical study of primary school children constructing these documents, Moar found a facilitative effect on retention and the use of information. He used pre-stored graphical representations, as it was felt that it would take too long for the students to construct their own pictures.

6.2.6 The software

The pupils used Kid Pix and Slide Show Kid Pix Companion. Kid Pix is a drawing package which allows the creation of slides, incorporating both graphics and text that are then inserted into the Slide Show The creation of documents in Kid Pix is achieved using the mouse only. Different shapes, colours, shadings, backgrounds and letters are selected using the mouse. The keyboard is only used when saving the documents. Once a slide has been created and saved, the pupils close Kid Pix and start up the Slide Show. They then insert the slide into the Slide Show. The different slides are presented in a series of railway carriages and the amount of time that the slide is on screen can be manipulated, as can the nature of the transition. The Slide Show incorporates about 10 different transitions. The students can also add either pre-stored sound or record their own sound onto each slide using the Macintosh microphone.

Figure 6.1 shows the interface of the Slide Show software.

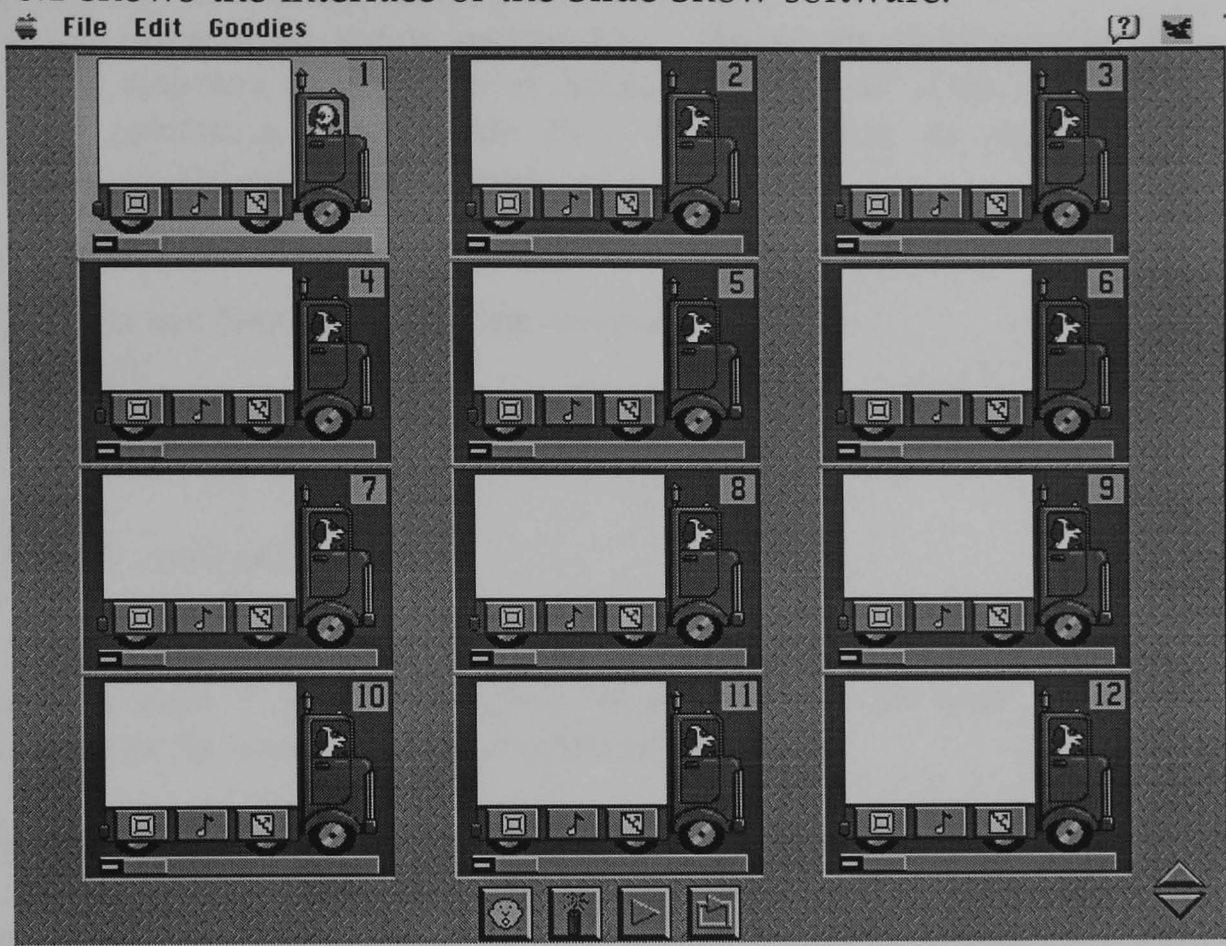

Figure 6.1 The Slide Show interface.

6.3 Creating the document

In this section, the children's draft notes created during their research and their notes and storyboards made during the interaction are described. This is followed by a description of the interaction and a time-based representation of the interaction is then presented.

6.3.1 Their draft notes

The children had done some research before the study began and their notes are described in this section.[1]

Robert

Robert's notes are quite detailed. He wrote:

"Warm air carries the water vapour up into the sky when it cools down
if the air is loaded with water vapour, tiny droplets begin to form. This is called condensation
The water droplets make clouds. The drops join up and grow bigger as they sink to the bottom of the cloud.
Heavy raindrops fall out."

---

1 The children's work is reproduced exactly as it was written, including their own spelling and punctuation.

During the creation of the slide show, he added:
"Clouds are formed by water evaporating. Warm air flowing over the sea absorbs moisture and carries it inland. As the air rises over hills, The water condenses into clouds then falls to earth as rain, rivers carry it back to the sea - and it starts all over."

Kerry
Kerry's notes are less detailed. She wrote:
"<u>Waters cycle</u>
rain to mountains - down moutins - forms rivers - some evaporated

water facts
3 1/4 of earth covered in water

water evaporated from oceans forms clouds, clouds realse (release) *moisture as rain * show rain falls back to ocens or land. flows to rivers. returns to ocens . Then evaporates again."*

Underneath this, the teacher has written:

"evaporates
into air –› water vapour –› clouds
clouds –› moisture –› rain –› rivers

Why does it rain from clouds?"

Emma
Emma wrote:

"Water cycle

The never ending way in which the water moves around the world. People normally think of the water cycle as starting in the oceans. They then follow the path of the water thourgh clouds and rain thourgh rocks and soil, to the rivers that return the water to the sea."

Although these notes cannot be said to be a full representation of the children's knowledge and understanding, they may provide some insight into their conceptual understanding. Robert's notes are scientifically the most advanced and although all three of them described the water cycle, Robert dealt with concepts like condensation and water vapour. Emma and Kerry's notes are at a similar level of detail, although Kerry's include more scientific words than Emma's. Emma's appear to be copied directly from a book and while it was not possible to ascertain this, it does give some indication of what she attended to in order to answer the question posed.

6.3.2 Notes and storyboards made during the creation of the document

Kerry and Emma initially made a list of the questions that should be answered, which was added to as the planning progressed. The final list was:
"How does a cloud form?
Where does rain go?
Where does rain come from?
What is condensation?
Why do we get it?
What is water vapour?
Why does rain fall?"

On the other side of this piece of paper, Kerry drew a draft storyboard. The storyboards they made are generally structured as below:

graphics for slide

picture

script

From these questions, they made a draft storyboard which was written in pencil only and divided into ten sections. This is shown in Figure 6.2.

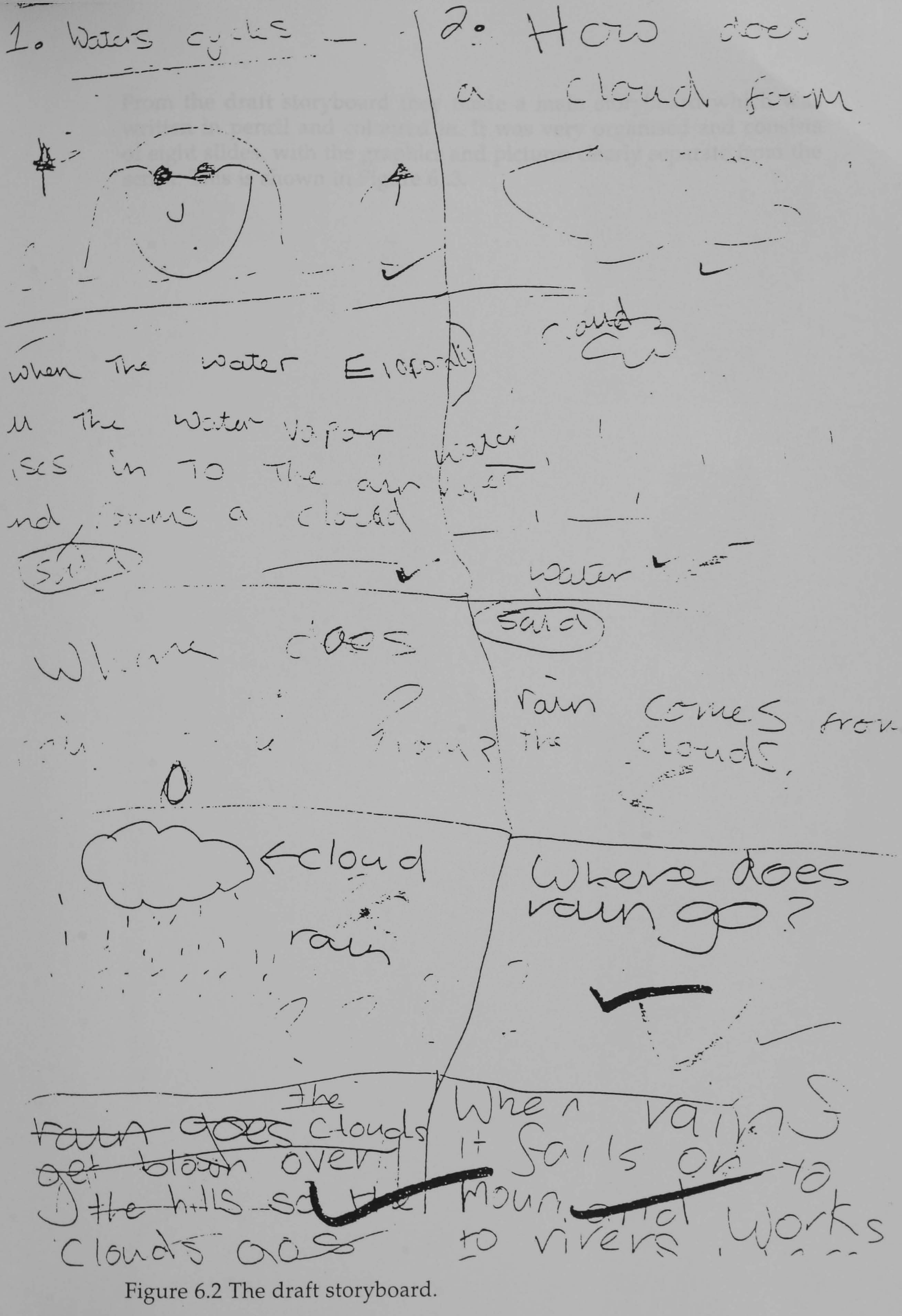

Figure 6.2 The draft storyboard.

From the draft storyboard they made a main storyboard which was written in pencil and coloured in. It was very organised and consists of eight slides, with the graphics and pictures clearly separate from the script. This is shown in Figure 6 .3.

Figure 6.3 The main storyboard.

Kerry told Robert to make a storyboard about condensation. Robert's storyboard was written in pencil only and divided into seven sections. This is shown in Figure 6 .4 and the process of making the dynamic document is summarised in order to show the kind of interaction and interplay which took place between the children.

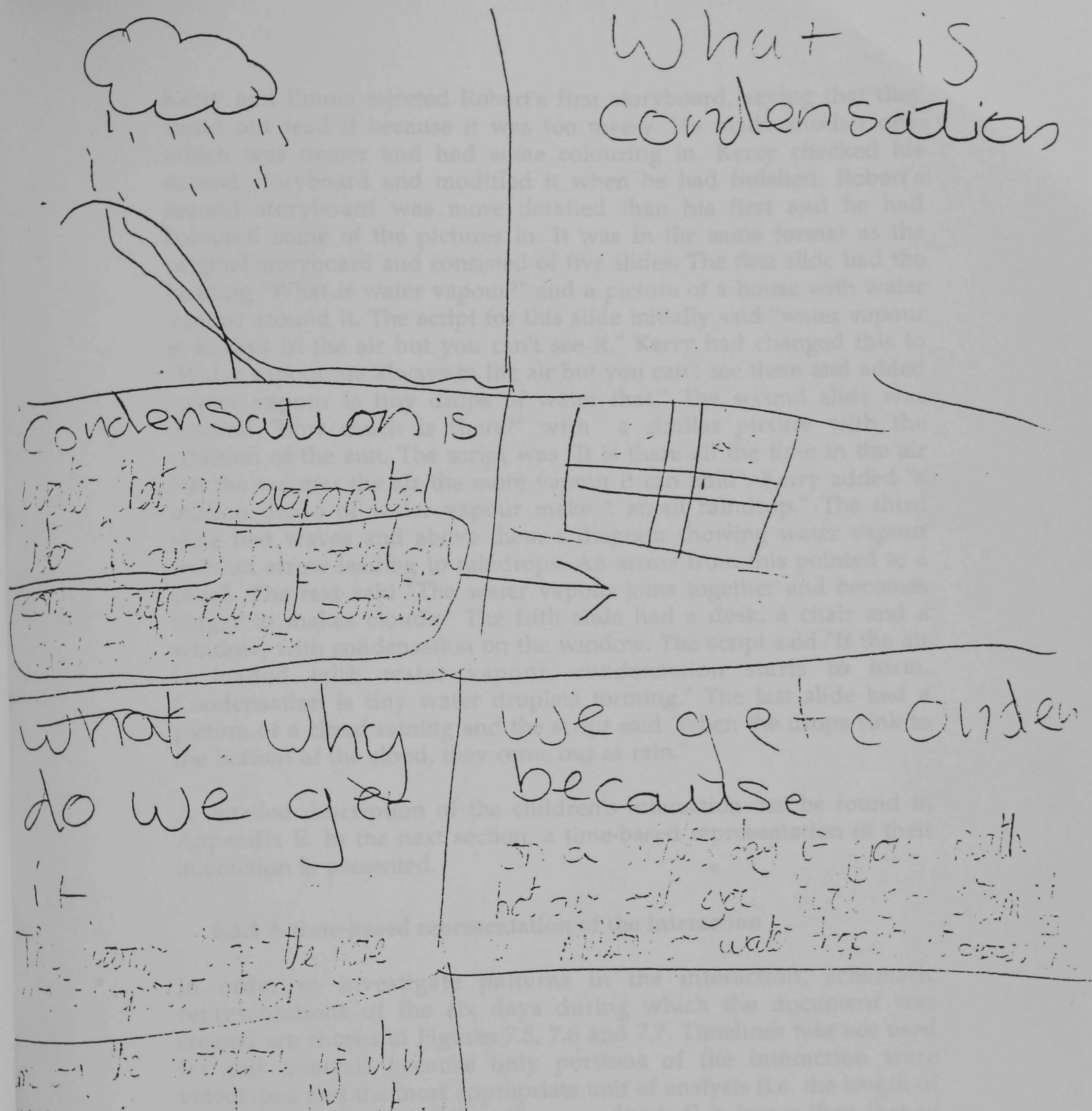

Figure 6.4 Robert's first storyboard.

Kerry and Emma rejected Robert's first storyboard, saying that they could not read it because it was too messy. He made another one, which was neater and had some colouring in. Kerry checked his second storyboard and modified it when he had finished. Robert's second storyboard was more detailed than his first and he had coloured some of the pictures in. It was in the same format as the original storyboard and consisted of five slides. The first slide had the heading "What is water vapour?" and a picture of a house with water vapour around it. The script for this slide initially said "water vapour is always in the air but you can't see it." Kerry had changed this to "Water vapour are always in the air but you can't see them and added "water vapour is tiny drops of water that." The second slide was entitled "how much is there?" with a similar picture with the addition of the sun. The script was "It is there all the time in the air but the warmer the air the more vapour it can hold". Kerry added "a million drops of water vapour make 1 small raindrop." The third slide had waves and above them a diagram showing water vapour with an arrow leading to raindrops. An arrow from this pointed to a cloud. The text said "The water vapour joins together and becomes bigger to makes clouds." The fifth slide had a desk, a chair and a window, with condensation on the window. The script said "If the air is loaded with water vapour, condensation starts to form. Condensation is tiny water droplets forming." The last slide had a picture of a cloud raining and the script said 'When the drops sink to the bottom of the cloud, they come out as rain."

A detailed description of the children's interaction can be found in Appendix E. In the next section, a time-based representation of their interaction is presented.

6.3.4 A time-based representation of the interaction

In order to investigate patterns in the interaction, schematic representations of the six days during which the document was created are shown in Figures 7.5, 7.6 and 7.7. Timelines was not used for this analysis because only portions of the interaction were videotaped and the most appropriate unit of analysis (i.e. the length of time into which the collaboration was divided) is larger than that of the secondary school study and not appropriate for the Timelines software. The interaction is represented by ten minute slots, one for each child. The four stages described by Moar (1994) are represented along with doing other work. The brackets show when the children are actively working with one another and the arrows show when one child went and fetched another child or told them what to do. 'T's represent periods when the teacher was present.

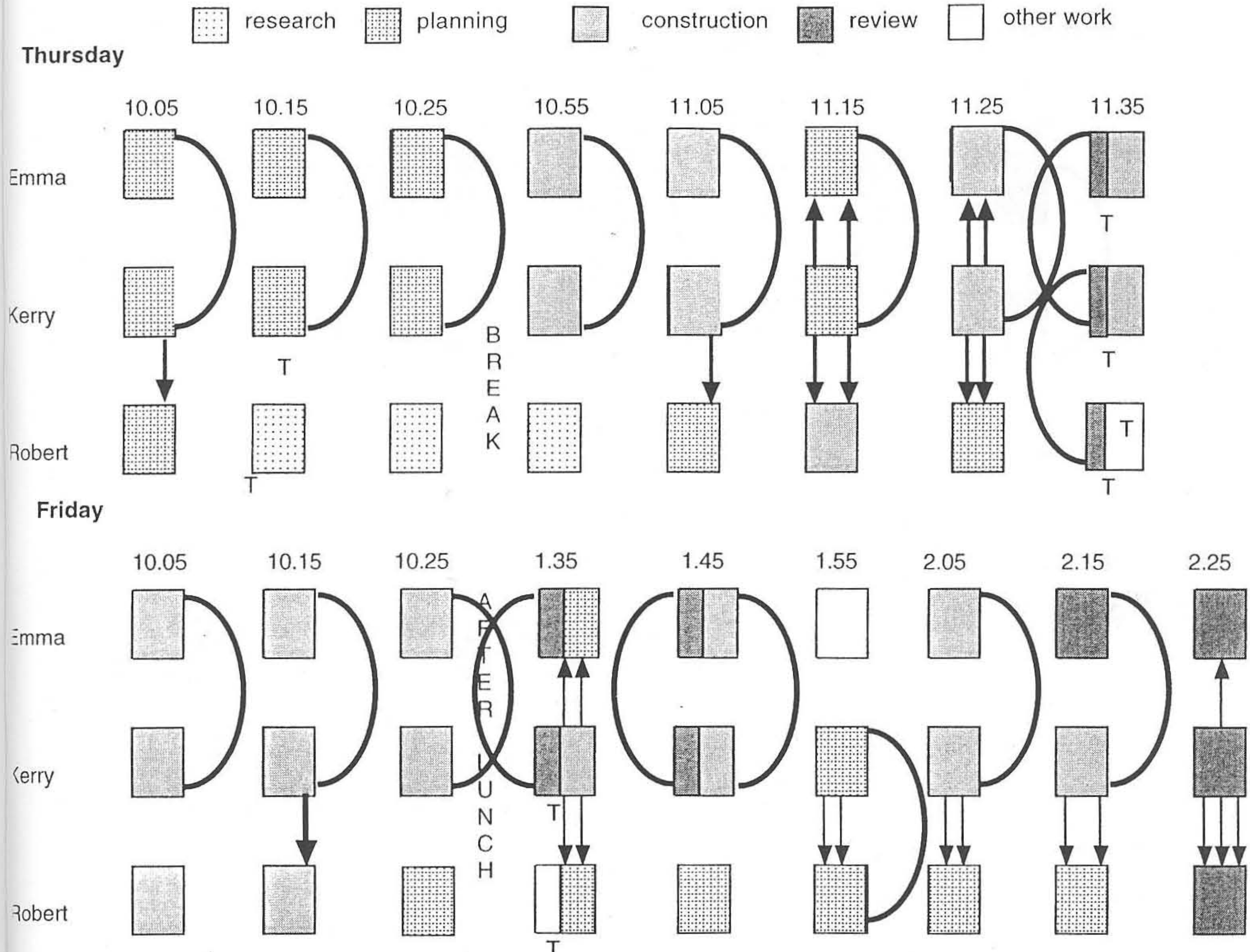

Figure 6.5 Time-based representation of the first two days of the interaction

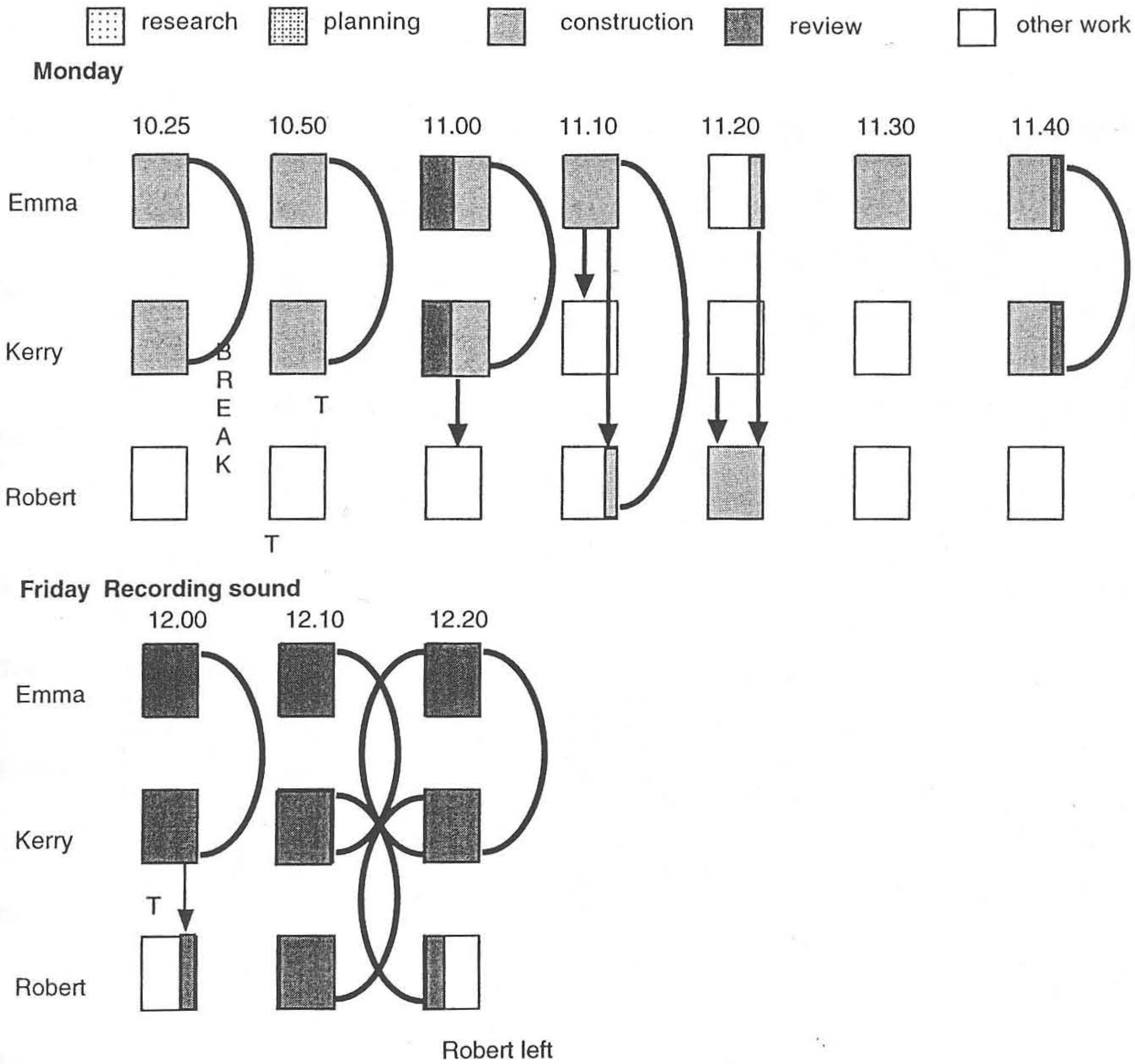

Figure 6.6 Time-based representation of the third and fourth days of the interaction

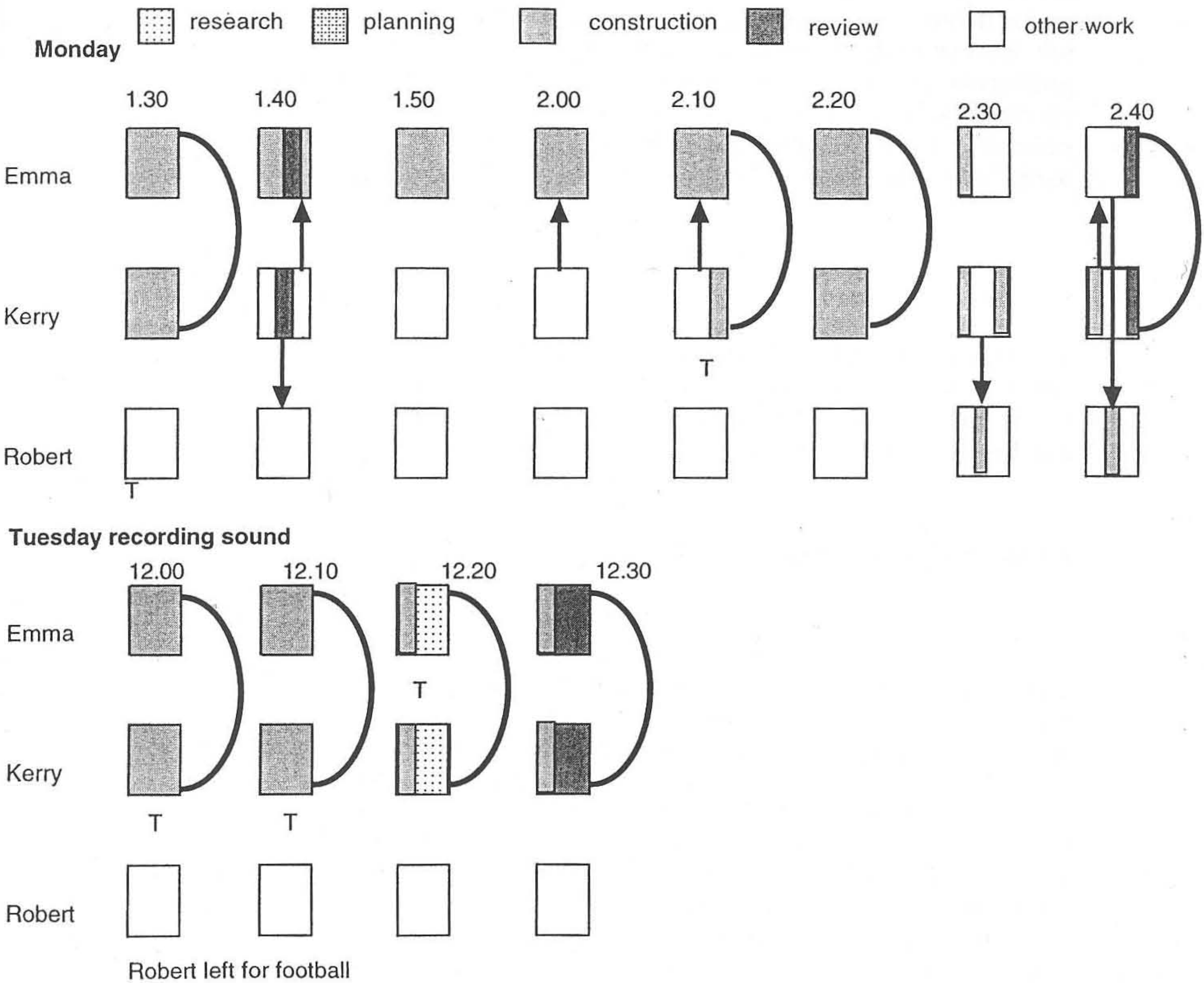

Figure 6.7 Time-based representation of the last two days of the interaction

Looking across the six days of the interaction, collaboration between Kerry and Emma is dominant, with Robert generally working on his own. As the days progress, collaboration breaks down and the children generally do more of their other work. The computer facilitates this, because it is only possible for one child to use the software at a time. The recording of the sound is the time when the majority of the interaction does occur, but Robert was playing cricket in the second session and therefore did not collaborate during this period. Moar's (1994) four phases are interleaved and some research occurs during the last session. Emma and Kerry did the majority of the construction and there is only one occasion where all three children review the show together, and Robert is almost entirely left out of the reviewing process. Kerry's dominance in telling the other children what to do can also be clearly seen. There is relatively little teacher intervention over the period and on only one occasion is this addressed to all three children.

6.4 Discussion

In the last section, the interaction was described. In this section, the collaboration is discussed from a theoretical perspective, and in terms of the nature of the collaboration, their knowledge of the water cycle, the way in which the slide show developed, the children's feelings and perceptions and the impact of the teacher.

6.4.1 Hoyles et al's characterisation of effective pupil-managed interactions

The progress of this group can be discussed in terms of Hoyles et al.'s (1992) characterisation of effective pupil-managed interactions. They discuss these groups as social systems and in a study, compared two groups and found that the group that produced high outcomes was *'characterised by the emergence of a synergy between structured pupil interdependence and pupil autonomy - that is, to a sharing of responsibility for successful task completion but a sharing in ways attainable by each and every pupil in the group'*. They discuss the influence of the task design and the role of the computer. They argue that when computer-based work is combined with other tasks, the group can structure a system of interdependence and the computer allows them to construct and develop their own ideas. For effective groupwork, there must be a minimum level of mutual respect and willingness to cooperate because the working patterns that develop are more dependent on interpersonal relationships than on the task. They suggest that as collaboration progresses, a pupil-teacher emerges and the pupil-teacher must have or acquire high status in the group and be a competent manager, monitor task progress, share knowledge, offer help and exhibit sensitivity to other group members. They also discuss the effects of interpersonal relations and in particular raise the possibility of undesirable outcomes when members work autonomously.

The characterisation of a pupil-teacher seems optimistic for children, and the qualities which Hoyles ascribes to such pupils would not always be found in adults in managerial roles, let alone schoolchildren. It is difficult to believe that in effective collaborations pupils exhibit all of these skills.

The present group can be interpreted within this framework. The task design was different from that used in the Hoyles et al. study and in this task there was the potential for autonomous work both away from and at the computer. The group fairly rapidly developed a working pattern in which the tasks were split and in cognitive terms, this may not have been beneficial. Robert made his own storyboard and Kerry and Emma did not understand some of the conceptual content. This may have hindered their cognitive progress.

Kerry naturally took the pupil-teacher role. She seemed to have had the high status perception from Emma before the interaction, but Robert's perception of her was not as clear. At times, Kerry showed that she could be a competent manager and she did monitor task progress and shared her knowledge. However, although she did offer help, this was not always achieved in the most constructive manner and although she was sometimes sensitive towards Robert and Emma, she did not always act on her sensitivity. On the whole, she stifled Robert and Emma and often redid the work that they had done.

Damon (1984) suggests that the efficacy of peer interactions depends upon the extent to which children are able to negotiate both at the level of social dynamics and at the level of task organisation. This is true of the interaction described in this study, in which both the nature of the individuals and the nature of the task impacted on the nature of their collaboration.

6.4.2 The nature of the collaboration

The nature of the collaboration will be discussed in terms of Kerry's dominance and developments over time.

Kerry's dominance

It is very obvious that Kerry controlled the entire interaction. She was not only the computer expert, but also the strongest character of the three. She controlled the interaction in various ways, illustrated below.

Determining the nature of the slideshow
From the start, she stated what would or would not go into the slide show. She made the initial list of questions and gave Emma and Robert different tasks. For example, Kerry and Emma were trying to work out how to make arrows pointing in different directions. Emma wanted to do them in black, but Kerry decided that they would be better in pink. She made one in pink and then left Emma to do the rest.

Ignoring input from group members
Although Kerry did ask for Emma's opinion, it was often ignored. At one stage, Kerry tried a rainbow background and asked Emma if it was OK. Emma said yes and Kerry said that she liked it anyway, the implication being that Emma's opinion did not make any difference.

Persuading others to do things her way
Robert would sometimes argue with Kerry, but in the end he would always do what she wanted him to. For example, Kerry asked Robert to go and do another storyboard template, showing him his original one which she was not happy with. He said 'no', he wanted to use the computer. Eventually Kerry persuaded him to do it and he went off. Kerry and Emma continued making the slide show.

Allocating jobs
Thus Emma and Robert made storyboard outlines and coloured in the slides in the colours that Kerry wanted. Robert would go off and do research on Kerry's orders and Kerry would even send Emma to tell Robert to do something. At one stage, while Kerry was making a slide, Emma came over and told Kerry that she had done the outline and they discussed the nature of water vapour. Then Emma asked Kerry what she should do next. Kerry told her to tell Robert to do a paragraph on water vapour.

Emma generally did what Kerry said. For example, Kerry showed Emma how to use the keyboard keys that allow you to undo your last action and Kerry used the mouse, while Emma sat with her fingers ready for about 10 minutes.

This was particularly the case when Kerry perceived the task as difficult. Kerry would get Robert and Emma to do the difficult parts. Robert was sent to make a storyboard on condensation, which none of them understood and Emma had to work out what to say about why rain falls, which they had not understood during the creation of the document.

Maintaining control of location of work
All their work was stored in Kerry's folder on the computer.

Taking control rather than helping
Both Emma and Robert would ask Kerry for help with the computer, but she would usually do things for them, or explain after she had done something. For example, Kerry asked Robert if he wanted to make a slide, and he said yes, and asked how. Kerry said "OK I'll do it", and Robert wandered off and Kerry and Emma carried on making the slide. At another time, Kerry told Emma that they must redo one of the slides, but when Emma asked why, Kerry said "You'll see". Emma said that the slides had to be moved. Kerry said "No you'll see what I am going to do". Emma kept asking Kerry what she was doing and Kerry kept saying "You'll see."

Changing other group members' work
Kerry also checked their work frequently and commented on it or changed it to the way that she wanted it. She would also evaluate Emma and Robert's work and congratulate Emma. The following excerpt from the observation notes is typical:
'Kerry sent Emma to get Robert. Kerry said that she and Emma should go and do the storyboard, while Robert does the computer. Emma said that she wanted to stay at the computer, and Kerry sat down, took the mouse and started showing them how to use it. Kerry and Emma left Robert using the computer and started making another storyboard. Kerry was very dominant and just took the pencil from Emma while telling Emma what to do. After a couple of minutes, Kerry went over and started telling Robert what to do and then leant over him and took the mouse from him.

Kerry went from Emma to Robert telling them what to do. At one stage, Kerry patted Emma on the back saying well done. Kerry told Robert she didn't understand his storyboard and sent Robert off to explain it to Emma. Kerry continued on the computer, while Emma was working on the storyboard and Robert was standing around. Robert then asked Kerry if he could copy the water cycle onto a piece of paper. She said yes and he went off to do this.'

Having the support of the teacher
The teacher also seemed to perceive Kerry as the leader, and he would ask her how things were progressing, what was left to do and whose turn it was next. Although he knew that Kerry was bossy, he did not appear to recognise the impact that this had on the group.

On the rare occasions that Robert and Emma worked together, the situation was much more equitable. Emma would help Robert and guide him on tasks that he did not know how to achieve and Robert would point out Emma's errors. However, Kerry would often interrupt this.

Developments over time

In terms of their behaviour at the computer, as the task progressed, there was a very clear development in the way that the children collaborated. Initially all three of them sat at the computer as Kerry made the slides. Kerry then sent Robert off to make a storyboard and Kerry and Emma made the slides. On the rare occasions when Robert did use the computer, Kerry and Emma would go off together, although Kerry usually returned fairly quickly to check on Robert. By the end, they were working on the computer individually, with the other two doing other work. This could be a result of Robert going off when he was not given a chance or a result of Kerry's need to get on with something.

They all had to record the sound together, and although they were all sitting at the computer, the session was dominated by Kerry. Both Robert and Emma showed that they could use the computer, but when Kerry was there, she did not allow them to.

In terms of collaboration, the shift from working together to working as individuals could be described as a breakdown in collaboration. Within this context, one could also argue that it is simply a question of efficient use of time and the group achieving as much as they can over a limited period of time. Given the nature of Kid Pix, only one child can use the computer at a time and therefore it is a more effective use of time for the children to work individually at the computer. Light (1993) discusses the problem of 'whether one should be concerned with effectiveness in terms of how much the learners achieve when working together, or in terms of the learning outcomes for each of the individuals concerned.' While it is not possible to discern the exact impact of the task division that occurred, it seems that Emma and Kerry relied on Robert to deal with the difficult concepts in his storyboard and were largely happy to simply reproduce his work in the slide show. Conversely, Robert allowed the production of the slide show from Emma and Kerry's storyboard without any discussion of its content. Additionally, from the interviews it seems that Robert had gaps in his knowledge, which may not have occurred if the task had not been divided.

Although Kerry initially wanted to control everything that was occurring, especially at the computer, she gradually relinquished this control. This was particularly apparent when they moved onto implementing Robert's storyboard, which she claimed she did not understand. She left both Emma and Robert at the computer on their own and expressed surprise when Emma inserted slides into the slide show without her.

6.4.4 Knowledge of the water cycle

From their draft notes, it appeared that Robert had a greater understanding of the relevant concepts than Emma and Kerry. During the task, Robert was given the more difficult concepts - condensation and water vapour - to explain while Kerry and Emma used the computer. His inability to explain these concepts to Kerry and Emma caused frustration for all of the children.

In interviews after the slide show had been completed, the children were asked about the water cycle. All three showed that they understood the process of water evaporating, forming clouds and raining again.

Kerry's responses were often repetitions of the script from the slide show, although she did seem to understand some of the more difficult concepts. When asked how clouds formed, she said "All the little drops attract to each other or something and when they ... they get together a little bit and then get bigger and bigger until they form a cloud." When Emma was asked the same question, she said "All the water vapour gets pushed together." and when pressed, she could not explain why. Robert said "Water droplets going together." and could not explain why either. When asked what condensation is, Kerry said "There's always like water vapour in the air and when it's really cold outside the contact of the two heats makes all the water vapour that you can see on the windows." and Emma said "It's water drops on windows." and when asked why it forms, she said "Because of the heat and the cold." but could not go beyond this. Robert said that "It's water vapour settling on the window." and when asked why, he said "Cause it's warm inside but it's cool outside and it cools when it goes past a window and as it cools it down then it settles on the window."

Emma and Kerry showed that they understood that clouds rained when it got cold and even though they had not included the fact that clouds rise over mountains and get colder and then it rains in the slide show, they could both reason to reach this conclusion. When Kerry was asked why it rains over mountains, she said, "They don't always - it's just like to show you how ... to give you an idea... oh yes because they have to go up to get over the mountains, they get colder and then it rains." and Emma said "because when the clouds go too high over the mountains, they rain." When asked why they rain when they are higher, she said "because they get cold." Robert said "I don't know, it doesn't always rain on the mountains." When asked why it rains on some days and not others, he said "I don't know ... because of the wind blowing the clouds around."

6.4.5 The development of the slide show

The final slide show consists of 17 slides. The slides in the slideshow are shown in Figures 6.8 and 6.9.

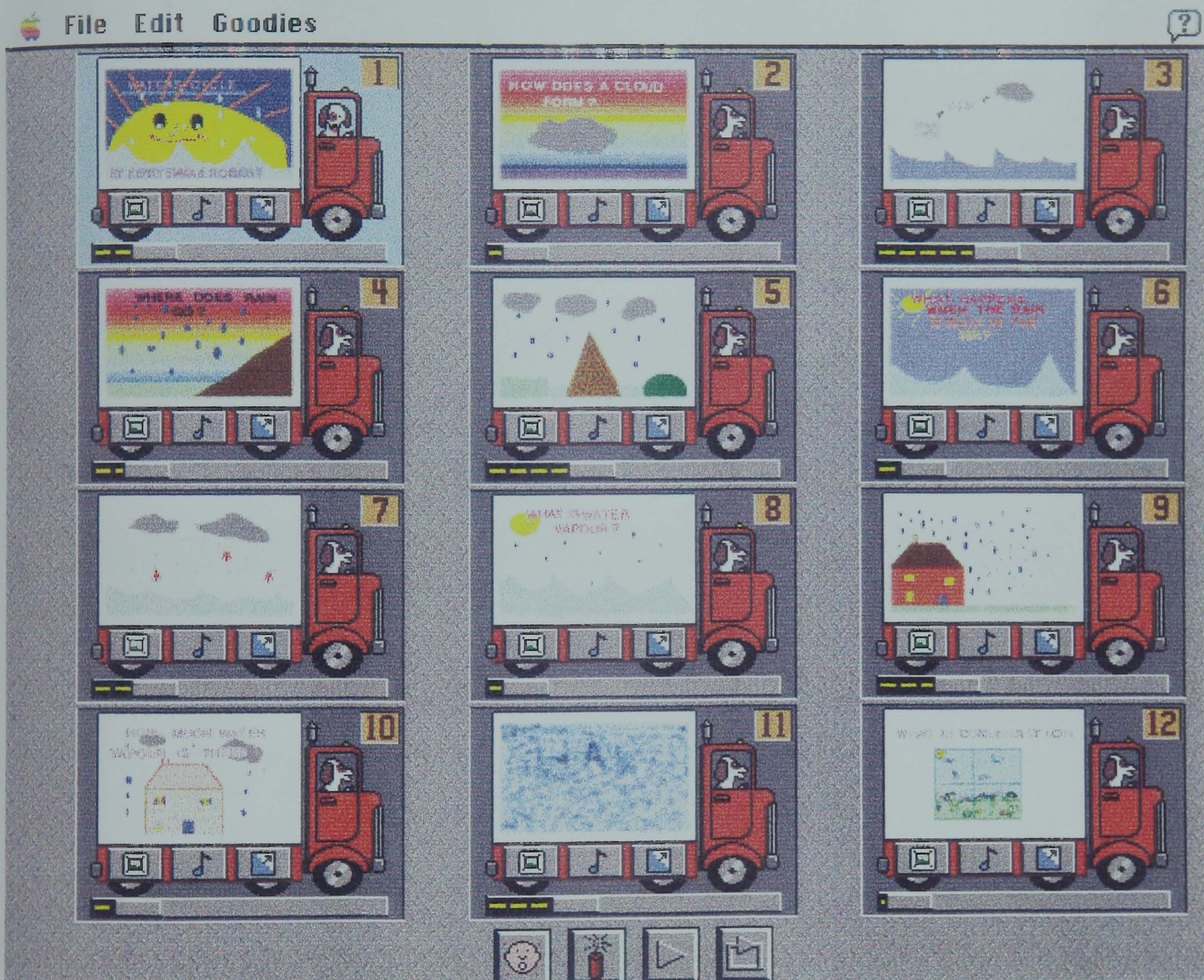

Figure 6.8 The final slideshow

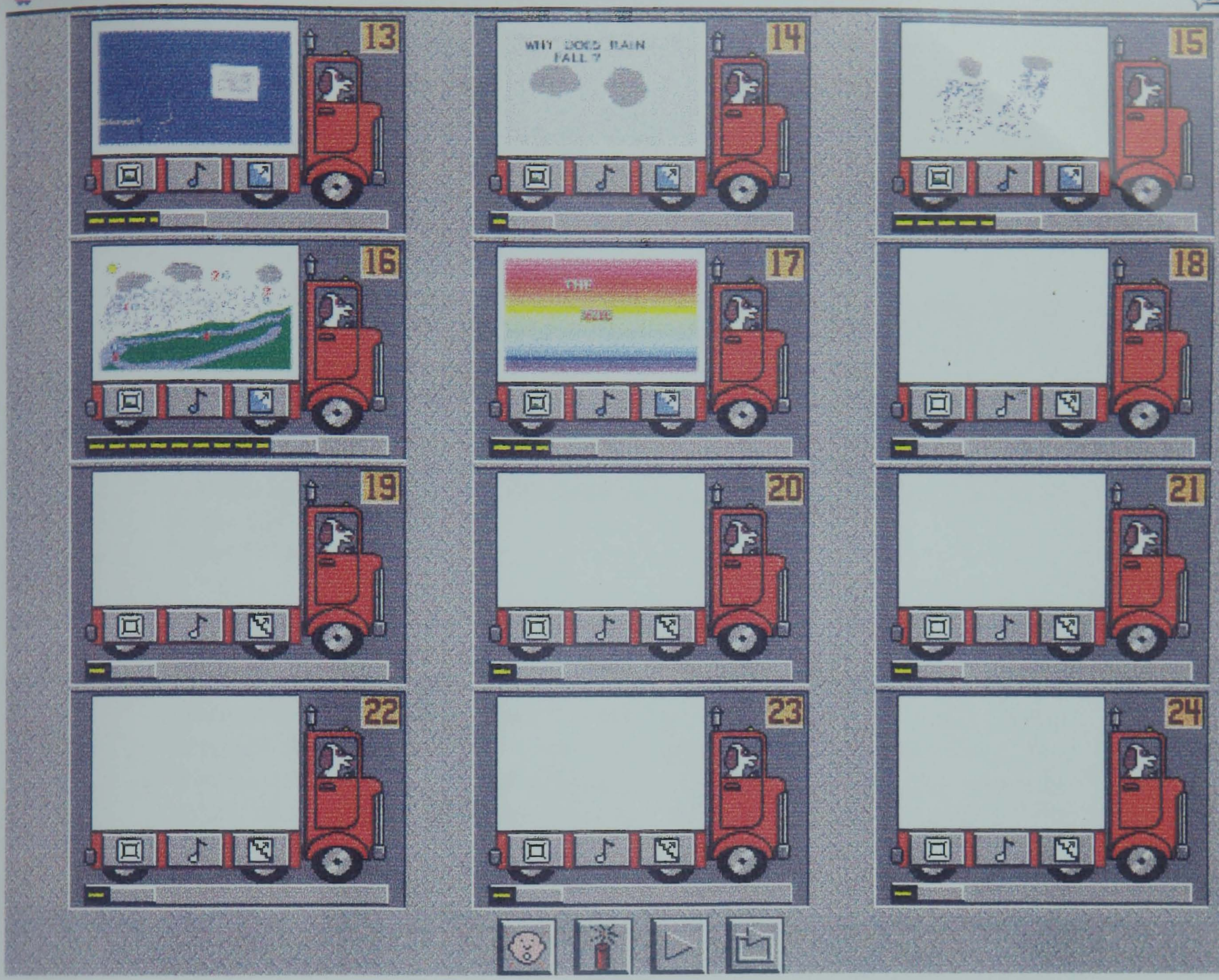

Figure 6.9 The final slideshow

The text and speaker for each slide is presented below.
Slide 1 Kerry "Water cycle by Emma, Kerry and Robert".
Slide 2 Robert "How does a cloud form?"
Slide 3 Kerry "Rain evaporates in water vapour, then they join together to form bigger drops of water vapour, then together again to form clouds."
Slide 4 Robert "Where does rain go?"
Slide 5 Kerry "When the rain falls, it goes in fields, mountains and hills and then it works it's way into rivers and then with the rivers, back to the sea."
Slide 6 Emma "What happens when the rain is back in the sea?"
Slide 7 Kerry "When the rain is back in the sea, it evaporates again and forms clouds."
Slide 8 Robert "What is water vapour?"
Slide 9 Kerry "Water vapour is little tiny drops of water that are always in the air and you can't see them because they are so small."
Slide 10 Emma "How much water vapour is there?"
Slide 11 Kerry "The warmer the air, the more water vapour it can hold. It can hold a million drops of water vapour to one small raindrop."

Slide 12 Emma "What is condensation?"
Slide 13 Kerry "If the air is loaded with water vapour, condensation starts to form. Condensation is tiny water droplets forming on windows."
Slide 14 Emma "Why does rain fall?"
Slide 15 Kerry "When the clouds go too high, they get cold. All the droplets of water form together to make bigger droplets of water which are heavy so rain falls".
Slide 16 Kerry "The water cycle. Number 1 clouds forming. Number 2 the wind blowing the clouds. Number 3 rain falling. Number 4 running of the rivers to the sea. Number 5 water evaporating. This system goes on and on. The rain we see today could be millions of years old."
Slide 17 Kerry "The end."

The slide show was structured in terms of questions and answers, rather than, for example a linear presentation of the processes in the water cycle. While it is not clear why this structure was used, we can speculate that is partly related to the fact that the children were told to prepare the slide show in order to teach the rest of the class. The teacher also encourages the children to structure their science work in terms of questions. Decisions about what should be included in the slide show were largely made by Kerry, but at one stage she sent Emma to ask another member of the class (who can be said to be viewed by the class as the least able pupil) where rain came from and she said the sky. Emma reported this back to Kerry and they decided that since this pupil knew the answer, they didn't need to include it.

The final slide show was a combination of two different storyboards. The initial storyboard ended with the question "What is water vapour?" and this corresponded to the first slide on Robert's storyboard. However, Kerry changed the structure of the final slide show quite significantly, without consulting Emma or Robert. She did not explain this even though Emma was sitting next to her and asking her what she was doing.

The transitions between the slides were changed several times, before Kerry and Emma decided on one particular transition. Kerry would often edit Emma or Robert's pictures and in this sense the graphics developed over time, although there was no evidence that the group evaluated the slide show.

Kerry often changed the script as they were doing the recording. She would also make up new sentences to add.

Overall, although the phases discussed by Moar (1994) were observed in this study, they did not occur sequentially in the way that Moar describes. For example, the children carried out some of their research after the majority of the construction had been completed.

6.4.6 The children's feelings and perceptions

In the interviews, the children were asked about various aspects of the collaboration. Kerry was the most articulate of the three. Kerry and Emma said that they had enjoyed making the document but Robert was not sure. He said that he did not enjoy working in groups (in contrast to his questionnaire) and when asked whether he enjoyed working with Kerry and Emma he said "I don't know." He also said that he wouldn't want to make another slide show with Kerry and Emma.

Kerry was asked if she thought that Emma and Robert understood the water cycle and she said that she did not know. She said "I don't think Robert understands about condensation, I don't think Emma understands either about condensation. I don't think Robert understands about why rain falls." Both Emma and Robert felt that the other two had understood the concepts.

Kerry said that she thought that Emma understood the slide show but that Robert did not understand it at all while Emma felt that Robert could make his own one. Robert wasn't sure if he could make his own slide show and said perhaps with some help.

When asked about how they had helped one another, Kerry said "I don't think we would have been able to do it separately. We had to have Robert, like, because he likes finding things out whereas me and Emma don't, we just like getting onto computers. So like and Emma she has different ... so if we didn't have all of us I don't think we would have got it done. Like we all had different ideas and we had to put them together to get a result at the end." Emma said that she had helped Kerry a bit, "The bit about when the clouds go too high, I explained that bit" and Robert had helped about condensation. Kerry had helped her with drawing the pictures. Robert said that Kerry had helped with using the computer, but Emma had not helped at all. He felt that he had not really helped them.

Kerry was the only one who talked about other group work that the three of them had been doing. They were currently making a bridge with a fourth child and Kerry said "with Robert it's been really difficult on the bridge making because he sort of like me and Emma did the actual bridge bit and he just wanted to use the carving knife so he said 'ooh I need to cut this up' so he cut up the whole thing that we had made just because he wanted to use the carving knife. So me and Emma said OK then you can do it all and we went and sat down. The next day we helped him again and he couldn't make it back together so we had to do it." She said that Robert went away and did the design on his own and when asked whether or not she thought this was a good idea, she said "No it should be all the people and then you combine all the ideas to get the best result at the end." When asked why Robert went off she said, "I don't know, he just did it and we just said OK." When asked about the bridge making, Emma said it was going OK and Robert didn't respond.

When asked about the structure of their work on the slide show, Kerry said "In the end we decided that when we got all the information we needed, we'd do a picture each and then we could do other work so we took it in turns to do the pictures in the end. We found that easier and we got things done quicker as well because we weren't doing the computer 'ooh let me do this' or 'I want to do this' and things like that."

Kerry was asked why she changed the wording from the script to the recording of the show. She said "because it didn't explain it in the end, it didn't really get to what we wanted to say." When pressed she said "Well because when you're like you just thinking straight off your head and you haven't read any books at all, you just think of something and put it down. But by that time we had read lots of other books, so we umm we had better ideas and we had more things in our brain which we could put down."

When asked whether the computer makes a difference to the way that they work together, all three talked about how it is easier to write things and correct things.

They all said that the teacher had helped by giving them the books. Kerry also said "He helped us when we were trying to find out about condensation and let us stay in at lunch for the recording." When asked if she always did what the teacher says, she said "Depends what it is. Like today, he said make it out of plasticine first, then you can make it in clay, but I didn't. I didn't do anything at all. And then he said "Oh, just go and do it in clay."

6.4.7 The impact of the teacher

The teacher recognised that Kerry was the computer expert and relied on her to teach the other children. He also recognised that Kerry was not a good 'teacher' and tended to do things instead of teaching others.

He described Emma as a 'good explainer' and seemed to realise that Emma's good explanations were often overlooked by Kerry or not recognised because of Kerry's extroversion.

He obviously felt that the three children could work well together, because they were also making a bridge in a group of four with another child.

Although the study did not aim to investigate the teacher's interventions, it is pertinent to look at the role that he played. He left the pupils to work on their own and this is common practice in his classroom. His interventions consisted of those to do with how the group was working together, how they were progressing and the conceptual nature of the work that they were doing. However, he did not consistently monitor or follow up his interventions, which contributed to the task division which occurred.

The majority of his interventions were directed towards Kerry and he would ask her what they were doing, who was doing what, whose turn it was and how much they had left to do. He discussed Robert's storyboard about condensation with him and talked to Kerry about her understanding of clouds.

However, his interventions did not always have the required effect and there were two occasions where he talked to the pupils and Kerry told him that it was Robert's turn on the computer, but once he was focusing on something else, Kerry carried on using the computer.

The next section describes a snapshot of other children making a slide show of their experiment about evaporation. This shows that the interaction described in the main body of this chapter is typical of the types of interactions that occur when using this software.

6.5 Snapshot study

The children's collaboration on this experiment was researched by the Collaborative Learning and Primary Science project team and this study presents a section of the children's preparation of their report on this investigation.

6.5.1 Background

The children were making a dynamic document in order to present the results of an investigation that they had done in science. The investigation concerned evaporation and the document had to present the planning, execution and results of their investigation. Three children worked on the slideshow, two boys, Ben and Seb and a girl, Rebecca. They had been working as a group for about three weeks when this interaction occurred. There was no obvious computer expert amongst them.

6.5.2 A description of the interaction

Rebecca and Ben were at the computer. The teacher called Seb over. Rebecca started up the Slide Show. The teacher showed them how to use the slide show. Ben asked the teacher if they should take turns using the mouse. The teacher said that they should take turns doing everything. Only Rebecca and Ben asked questions during the 15 minutes that the teacher was showing them how to use the software. However, Ben did suggest that Seb should say something when they were learning how to record sound.

The teacher suggested that they plan it first using a storyboard of rough sketches, then make all the pictures, then put the pictures into the slide show and then add the sounds. Although the teacher explicitly said that they should do some planning first, Rebecca immediately took the mouse and started drawing. Ben started doing the planning on the paper while Rebecca drew and Seb watched. Rebecca criticised Ben's sketches and he said that Seb should do the sketches. Seb said 'no', so Ben said that Rebecca should do them. Seb started drawing on the computer and Ben and Rebecca got upset about the size of the table he was drawing and made him erase it. They discussed the size of the table that they needed, and Rebecca took the mouse from Seb and deleted what he had done. She then started drawing chairs. A couple of minutes later, Seb took the mouse and Rebecca directed him in the drawing. Rebecca tried to take the mouse from Seb, but he said that he could do it. Rebecca kept telling him that he was doing it incorrectly, and then Ben said "Seb stop it" and made him delete it. Ben said "It's my turn now" but Rebecca took the mouse. Seb suggested doing an overhead view about three times, but this was ignored. Ben then suggested doing a side view.

The teacher returned and said that they must stop using the computer and work out a storyboard. Seb got up and seemed to be leaving and Rebecca said "Sit down" Rebecca and Ben then went to the teacher and Seb started drawing on the computer. Rebecca came back and watched him. The teacher returned and told them to plan. The teacher took the mouse away from Seb, and Rebecca and Ben started doing the planning. Rebecca was drawing and would not let Ben participate. Seb examined the Kid Pix interface. Ben asked Rebecca to explain what she had drawn. She said "Looking for a suitable place, the greenhouse, checking, the incubator." Rebecca decided not to have one of the pictures and crossed it out. Seb started watching what Rebecca was drawing and after a couple of minutes, Rebecca said that they were done. Seb took the mouse and Rebecca wrote down a title. Seb asked about the colour of the letters and they agreed black. Seb was told that his letter was too low and Rebecca tried to take the mouse, but Seb would not let her. Rebecca told Seb exactly what to do. After about 5 minutes, Ben said it's my turn and Seb and Ben swapped seats, but Rebecca took the mouse from Ben fairly rapidly. When Ben said "who's doing this, Rebecca?" Rebecca replied "you" and Ben sat back and folded his arms. Rebecca said "Don't sulk Ben" and gave him the mouse, but took it back after about 10 seconds. Rebecca could not spell effect and tried to send Ben to ask the teacher, but he would not go so they asked the video operator. After another minute, Rebecca gave the mouse back to Ben and continued directing him. They debated where the words should go. After a minute Rebecca took the mouse back in order to do what she wanted to do. Seb seemed to be supporting her by telling her what to do. When she found that she could not do what she wanted to do, she gave the mouse back to Ben. Rebecca tried to take the mouse again and Ben said "Do you mind if I do it?" and Rebecca gave the mouse back to him.

When it came to saving the slide, Rebecca took the mouse and started typing. Ben put his hand on the mouse as she typed but she took the mouse back from him when she had finished typing. Ben directed her in starting up the slide show and moving their slide to Ben's folder. Seb watched intently, but did not say anything or try to get the mouse.

Rebecca started up the slide show and although Ben tried to get the mouse, she wouldn't let him. Seb directed Rebecca on how to insert the slide. Rebecca controlled the mouse throughout this and at the end she asked if they could carry on during lunch.

They then tried out different transitions with Ben and Seb getting Rebecca to try out different ones. In the end, they decide to use the one that Seb liked. Rebecca said that they should try it and she said the title, and put a wow at the end. Ben said that she should not have included the wow. They then tried the different stored sound effects and planned how they could be put with the transitions. The teacher joined them and told them to leave the sound until the end. They previewed the slide show with the teacher who then explained that they needed to save the whole thing. Rebecca saved it and they moved it all into one folder.

6.5.3 Discussion

This interaction does not fit easily into the Hoyles et al. (1992) model (introduced in section 6.4.1). Rebecca was very dominant in all aspects but she did not act in the idealised pupil-teacher role. The children seem to have had equal computer expertise, but Rebecca used the mouse the most and did all the typing and saving. She also did all the planning and drew the entire storyboard. They all had ideas about what the slides should be, but these were often ignored by Rebecca. In particular, Seb would suggest things that were never considered.

During the creation of this slide, the focus seemed to be on using the software and where the words should be placed. The children were not focusing on what was educationally important and were distracted by the presentational aspects of the software, including the colours, the location of words, the nature of the transitions and the sound effects.

The behaviour of these three children, working on naturalistic science investigations has been studied intensively by the Collaborative

Learning and Primary Science project. Their behaviour on the computer seems to be typical of their group behaviour in other situations. Ben and Rebecca bicker with one another and Seb normally tries to be the peacemaker. Seb is generally bossed around by the other children and Ben and Rebecca argue a lot. However, the presence of the computer does seem to have encouraged them to split up the task, in the sense that Rebecca did all the planning on her own and had to explain the storyboard to Ben and Seb.

In terms of Moar's (1994) phases, all their research had been done during their investigation and no research was involved in this study. However, it is very clear that the other three phases, planning, construction and review, were interleaved during this interaction.

The teaching interventions that were apparent in this snapshot did not have their desired effect. In particular, the children were very reluctant to plan before they started using the computer.

Use of the mouse seemed to have been important to the children and they argued about who would be doing what.

The children did not work together while using the computer and the teacher's attempt to ensure that they planned before constructing the documents contributed to their difficulties. However, their behaviour is very similar to that of their normal group behaviour. One of the researchers on the Collaborative Learning and Primary Science project felt that their normal working pattern was simply accentuated by the presence of the computer.

6.6 Conclusions

The chapter has provided a comprehensive description of a naturalistic collaboration involving primary school children creating a multimedia document with a computer. The four phases that occur while making this type of document (research, planning, construction and review) were clearly intertwined and the children split up these tasks during the interaction. The children produced a document which the teacher thought was good and which the other children understood, and learnt about the water cycle. However, the task was split in several ways and the children did not always communicate with one another which left gaps in some of their knowledge. The collaboration was dominated by one child, who was also the computer expert and this may have contributed to the difficulties with collaborating.

For Robert, from an affective perspective, the collaboration was not beneficial. He obviously felt left out and did not want to work with Kerry or Emma again. Although he appeared to still have confidence in his ideas about the water cycle in the interview, he had a negative attitude towards groupwork which was not apparent in the questionnaire he filled in before this interaction. Robert felt that he had not helped the others at all and he missed the praise of the teacher when he went to cricket practice. However, the interaction does not appear to have had such strong effects on Kerry and Emma.

From the time-based representation of the interaction, it is clear that the children developed a way of interacting over time. The collaboration moved away from working together, initially to Emma and Kerry working together and Robert working on his own. When the children started using the computer there was a further shift to working on their own, and all the children spent a considerable amount of time on their own at the computer. The decrease in collaboration was facilitated by the use of the computer because the physical activity of creating a slide is appropriate for one individual. The majority of discussion about the topic occurred away from the computer and although all the children were able to use the computer, one child appeared to have not fully grasped the computational aspects of creating this type of document. The software did not facilitate collaboration and this contributed to the splitting up of the task. The majority of the time spent at the computer was concerned with colours and shading and the positioning of text and graphics.

There were relatively few teacher interventions, and those that did occur did not always have the desired effect. This was especially pertinent in terms of role division and ensuring that the children all had a turn at using the computer.

In terms of whether or not the collaboration was beneficial, the children produced a document which the teacher was pleased with and the rest of the class enjoyed watching. However, the interviews showed that they did not all understand what they had done. Additionally, by splitting up the task, they made efficient use of their time, by doing other work while one child used the computer. The way in which the group organised their joint activity meant that they did not all understand what they had done. It seems that the collaboration did not necessarily contribute to the quality of the product of the interaction and the dynamic document produced was largely the result of individual work.

This points to the distinction that will be made in more detail in chapter 7 (section 7.3.2) concerning the difference between products, outcomes and interactions. Although the product of a collaboration may be thought of as good (by the teacher, the children involved and the rest of the class), it does not follow that the outcomes, both cognitive and affective, for the individuals involved, are good or desirable. Similarly, the nature of the interaction may have not been beneficial to one or more of the individuals involved, but the product and outcomes are still thought of as good. This points to the problem introduced in Chapter 4 of assessing effective learning situations. In particular, the difference between assessing in terms of outcomes and products.

As a consequence of this study, some teacher guidelines can be described. The teacher should ensure that storyboards are agreed and adhered to. The teacher should also check that interventions regarding collaborations are followed and teaching interventions should be addressed to all the children.

In terms of software design, the software does not encourage collaboration, and provides too much potential for focusing on aesthetic features, which appears to have distracted the children from the more conceptual aspects of the task.

From a theoretical perspective, it appears that combining all the children's ideas was not necessarily beneficial to each child. For this group, the way that the children combined all the ideas meant that some children did not understand the whole topic. Additionally, the presence of a computer expert was not beneficial to all the children.

The chapter also provided a snapshot study of three children beginning to create a dynamic document of their investigation into dissolving. The results show some similar findings to the main study. There was very little on-task discussion at the computer and the presence of the computer meant that the task was divided. Much attention was paid to aesthetic factors and the teaching interventions did not have their desired effects.

In this chapter, it was argued that experimental approaches which focus on outcomes, be they affective or cognitive, need to be complemented with studies of the nature of interactions which occur during computer-supported collaborative learning. The value of time-based views of collaborations were also discussed. This chapter has presented a study which has provided a description of a longer term collaboration and emphasised the importance of close analysis of the nature of the interactions taking place during that collaboration.

In the next chapter, the three studies presented in chapters 4, 5 and 6 will be reviewed and discussed in detail.

Chapter 7

Overview of empirical studies

7.1 Introduction

In this chapter an overview of the results and implications of the three studies is presented. After summaries of the three studies, assessing learning situations is discussed with an emphasis on the affective factors. The differences between the products, the interactions and the outcomes of learning situations are also discussed and the description of effective learning situations reviewed. The research methodology is discussed, with an emphasis on pre- and post-testing, naturalist and experimental studies and time-based analyses. Gender differences are discussed and the four perspectives on collaborative learning presented in chapter 2 are discussed relative to the three studies.

7.2 Summaries of three studies

In this section, summaries of the three studies presented in the thesis and their implications are presented.

7.2.1 Secondary School study

In this study, individuals and pairs of secondary school children used a chemistry database to fill in a worksheet about the Periodic Table. There were two different paired conditions, one in which the children shared a worksheet, the other in which each child had their own worksheet. Pre-, post- and delayed post-cognitive tests were carried out, and the students also filled in pre- and post-test affective questionnaires. Their interactions were videotaped and a selection of the videotapes were analysed using an advanced computer-based video analysis tool.

The study found no clear cognitive benefit from working in a pair in terms of pre- to post- and pre- to delayed post-test gains. However, there was a significant advantage to working in a pair, particularly for those sharing a worksheet, regarding on-task performance. This was reflected in significant differences in the amount of factual questions filled in correctly on the worksheets between individuals and pairs. This occurred because the pairs of students were accessing more information than individuals, as was shown by the videotape analysis. However, this was not reflected in the post-tests. It was argued that this was due to the fact that the post-tests were individualised and the fact that the students in pairs worked collaboratively and this inhibited their achievements on the individualised post-tests. Additionally, the study found that students who had high pre- to post-test gains did not achieve significantly higher delayed post-test scores than those who did not have a high pre- to post-test gain. This has implications for research which investigates interactions of students with high pre- to post-test gains and derives prescriptions for optimal learning situations from these results.

Students said that getting on with each other was more important than getting the correct answers, their own success and their group success. There were no significant differences between their perceptions of their own and their group success. The use of the computer did not appear to increase their perceived interest or motivation towards chemistry, but increased their interest and motivation towards computers.

There were very few affective differences between the three different conditions. Surprisingly, there were no significant differences between the individuals and the students who worked in pairs. However, there were significant differences between those who shared a worksheet and those who had their own. Getting along with one another was significantly more important for those who shared a worksheet compared to those who had their own. When students are sharing a worksheet, in Slavin's (1983) terminology, there is a cooperative task structure, but no individual responsibility. It is not possible to ascertain whether the cooperative task structure or the lack of individual responsibility caused this increased emphasis on getting along with your partner. There was a significant decrease in the students' perceptions of how much they helped their peers for the students who did not share a worksheet but not for those who did. Ames' model describes collaboration as having a moral dimension, in which helping behaviour is important. Both these results show that in the condition where pairs shared a worksheet i.e. in which there was a form of collaborative task structure, the moral dimension is more important, and the students made more effort in terms of helping behaviour.

There were also significant gender differences. The girls rated the importance of getting along with one another significantly higher than the other factors, but for the boys no single factor was most important. The boys had significantly higher perceived motivation towards chemistry than the girls in the post-test and this was not apparent in the pre-test. The girls showed an increase in their perceived interest towards computers and the increase in motivation towards computers was largely due to the girls. In the pre-test, the girls perceptions of themselves were significantly lower than the boys', but there was no significant difference at the post-test. The girls' perceptions of how well they get along with their partners increased as a result of the interaction, but this did not occur for the boys. There was no change in the boys' perceptions of how much they helped their peers from pre- to post-test, but the girls' perceptions of helping decreased.

The results of this study were applied to a description of effective learning situations which incorporates both cognitive and affective factors. No significant differences were found between the conditions nor between the boys and the girls. This was attributed to the simplistic nature of the description.

A selection of the videotapes recorded during the study were analysed using an advanced video analysis program, Timelines. The videotapes were analysed in terms of talk and behaviour. Four categories of talk were used: topic, next, control and other. The behaviours that were used are: mouse use, typing, reading, writing, other, researcher present and looking at the Periodic Table. This type of analysis produced summary tables and time-based plots of the talk and behaviour. The analysis was applied to 10 pairs of students and five individuals. The analysis found inter-pair, intra-pair and inter-individual differences and the timelines and summaries from pairs who worked for more than one session, showed developments over time during the interactions (for an overview of this, see Issroff, 1994b). The analysis also showed differences between girl:girl, boy:boy and mixed gender pairs. The results of the analysis were interpreted in terms of the student pre- to post-test gains, and although some relationships were highlighted, these cannot be said to be conclusive because of the small sample used.

7.2.2 Summer School study

This study investigated Open University students carrying out collaborative projects which involved the use of computers at a residential summer school. The students were studying D309, Cognitive Psychology, and attend summer school for one week. During this week, they complete two out of four possible projects on memory, language, artificial intelligence and problem solving. The students have to submit an assignment about one of the projects that they have completed. The study aimed to investigate the affective aspects of these collaborations. The students voluntarily filled in anonymous questionnaires before and after completing their projects.

Sixty one full pre- and post-project questionnaires were analysed. The language and memory projects were generally written up as assignments. Highest computer use occurred in the language and artificial intelligence projects. The students' perceived motivation and interest were investigated and completing the projects had no significant overall effect, but the men's interest was significantly increased. There was also a significant increase in students' perceived motivation and interest towards the language project.

As with the Secondary school study, it was significantly more important to the students to get on with each other than to get the project correct. Women found getting along with other group members significantly more important than men. Overall, the students rated their group success as significantly more important than their own success, in contrast to the results from the Secondary school students. The students' perceptions of the group success and group satisfaction was significantly greater than their own success and satisfaction.

The project interactions had no significant effect on the students' self perceptions and generally increased how highly the students' rated their peers. Additionally, the students' post-project ratings of how well they get on with their peers are higher than their pre-project rating, showing that the project interactions generally increased how well the students get on with one another.

A description of effective learning situations in terms of affective aspects was applied to the data. There was a significant difference between the four topics; however, when the differences between the projects are examined on an individual basis, there was only a significant difference between language and artificial intelligence and language and problem solving.

There were no significant differences in this overall score between men and women neither were there significant differences between those with high and low computer usage. There were significant differences between those projects which were written up as an assignment and those which were not.

7.2.3 Primary School study

This study was a case study of three primary school children making a dynamic document about the water cycle. The children were observed for about seven hours while creating the document on a computer. The group consisted of two girls and one boy. The children's notes were analysed, and parts of their interactions videotaped. The children and the teacher were interviewed after the document had been created.

The document produced is of a high standard. The children's draft notes provide a measure of their knowledge before they created the document and the interviews provide an in-depth description of their ideas after the interaction. Moar (1994) has described four phases that occur while creating this type of document (research, planning, construction and review) and in this naturalistic setting, the four phases are clearly intertwined, with some of the research being carried out at the end of the study. The children split up the task as their interaction progressed. This can be seen in the time-based representation of their interaction. While this is efficient, it led to some of the children having gaps in their knowledge, which were revealed in the interviews. One of the children was particularly dominant and was also the computer expert which led to a lack of cooperation.

The software used did not facilitate collaboration as indicated by the fact that the task was split. Much of the discussion of the topic occurred away from the computer, and most of the talk at the computer was concerned with aesthetic details, like colour and positioning of words. There were relatively few teaching interventions and these did not always have the consequences that the teacher intended.

7.3 Assessing learning situations

In all three studies, an attempt was made to assess the productiveness of the learning situation. Much of the research in the area of collaborative computer-assisted learning focuses on the cognitive aspects of the interactions, largely in terms of pre- to post-test gains. As was demonstrated in chapters 3 and 4, some studies have investigated delayed post-tests and on-task performance. However, relatively few studies have looked at the affective consequences of working collaboratively with a computer. All three studies in this thesis investigated the affective factors and these are discussed in the next section.

7.3.1 Affective factors

Although a description of effective learning situations which incorporated both cognitive and affective factors was proposed and used in the Secondary school study, it is not possible to determine how the cognitive and affective factors are related. Nevertheless, it is important to take into account the affective factors. It was argued that there was a need to do so and the argument has been supported by the results in that students consistently rated the importance of getting along with their peers higher than the importance of getting the correct answer. The Secondary school and summer school studies looked at various aspects of the affective factors. Firstly, they investigated any changes in students' perceived interest and motivation, changes in the students' perceptions of themselves and their peers, the factors that students found important during the interaction, their perceived own and group success and their helping behaviour. These will be discussed in terms of the first two studies which were similar in many respects, followed by a discussion of the third study.

Secondary and Summer school studies

Perceived interest and motivation were examined in order to investigate claims about the motivating effects of working with others and of computers. The rationale was that students' opinions should be assessed in order to further investigate these claims. In the Secondary school study it was found that overall students' perceived motivation and interest towards the subject (chemistry) did not increase. However, their motivation and interest towards computers did increase as a result of completing the task. These results may have been as a consequence of the experimental nature of the study. In the summer school study, increased interest and motivation towards the topic was only found in one project area, language. This raises questions concerning the impact of the motivating effect of computers and how this carries through to the topic of the learning. The story is therefore complex and requires further investigation.

The second factor that was investigated was the students' perceptions of themselves. There were no overall significant changes in this respect, but in the Secondary school study there were significant gender differences which will be discussed in section 7.5. It is worrying that in the summer school study eight students' perceptions of themselves decreased by two or more points on a five-point scale. The extent of this decrease could have a debilitating effect on the students' future work.

In terms of peer perception, there were no significant overall changes in the Secondary school study. The pairings in this study were based on friendship and there was therefore a ceiling effect, whereby the majority of the ratings were at the top of the scale and there was therefore no scope for an increase. Additionally, the experimental nature of the study may have interfered with these results. However, in the naturalistic summer school study, the project interactions significantly increased the students' perceptions of their peers. This is a beneficial effect of working together.

In the vein of Ames' cognitive-motivational theory of different learning situations, the studies investigated the factors that students found important during the interaction. In both studies the students were asked how important it was that they got along with their peers and how important it was to get the correct answer. It was found that students thought getting along with their peers was significantly more important than getting the correct answer. This was particularly applicable to the females (see section 8.5) and has implications for the appropriateness of collaborative learning situations. In the Secondary school study, individual success was more important than group success, but in the summer school study, group success was more important than individual success. The latter finding is consistent with Ames' theory, but the former is not. As previously mentioned, this may be due to the experimental nature of the Secondary school study and the nature of the task.

The students' perceptions of their own and their groups' success was also investigated. In the Secondary school study, there were no significant differences between the students' perceived own and group success, but in the summer school study, the students perceived their group as significantly more successful than themselves. Again, this may be a reflection of the difference in the nature of the two studies, the former being an experimental, imposed collaboration, the latter being naturalistic with consequences for the students' success in the course.

In terms of helping behaviours, the students in the Secondary school study felt that they had helped their peers less than they had expected to, but their peers had helped them as much as they had expected them to. In the summer school study, the students felt that they received and gave less help than they expected to.

Primary School study

The results of the Primary school study are of a different nature to those of the Secondary school study. The results are obtained from interviews with the children and are therefore affected by the fact that some of the children did not talk very much. It seems that Kerry was very satisfied with what she had achieved and felt good about the way that they had worked together. Emma also seemed pleased with what they had done, but this was not true for Robert, who said that he did not want to make another slide show with Emma and Kerry.

Kerry felt that she had helped the other children, and had received help herself, but in a different respect. Emma felt that they had all helped one another, but Robert said that he had had help from Kerry but not from Emma. It may be that the children's perceptions of what constitutes help are different.

This section has discussed the importance of affective factors in assessing learning situations. In the next section, learning situations are discussed in terms of products, outcomes and interactions.

Ames' cognitive-motivational theory of collaboration

The studies reported in Chapters 4 and 6 provide partial support for Ames' cognitive-motivational theory. The primacy of social factors in cooperative situations was reflected in the students' ratings of the importance of getting along with one another. In both studies, this was higher than their ratings of the importance of getting the correct answer. This is particularly important in the summer school study, where the work being carried out is a requirement of the course and considered an important part of the students' learning.

Ames also claims that group success is more important in collaborative situations than individual success. This was not found in the Secondary school study. However in the summer school study, the students rated their group success as significantly more important than their own success.

Both studies found that getting along with your peers is more important for women than for men. This has implications for mixed gender groups and may explain some of the difficulties encountered by these groups. Additionally, cooperative learning situations may not be appropriate for women when the aim is explicitly to complete work correctly.

In the Secondary school study, there were no significant differences between the students' ratings of their own and their groups' success. In the summer school study, the students rated their group success as higher than their own success. This may reflect the different natures of the two studies. Additionally, the results of the open-ended questions in the Secondary school study show that the students may not be able to differentiate between their own and their groups' success.

In terms of helping behaviour, in both studies, the students felt that they had helped their partners less than they had expected. In the Secondary school study, this was significant for the girls and those who had not shared a worksheet. In the summer school study, there was a significant difference between men and women, with the women's ratings decreasing the most, and significant differences in the project areas. The gender differences here may be attributed to the value which women place on getting along with one another.

7.3.2 Products, outcomes and interactions

The distinctions between products, interactions and outcomes are important within the context of evaluating these types of learning situations. The product refers to the piece of work that is completed during the collaboration. In this sense, both the worksheet in the Secondary School study and the dynamic document produced in the Primary School study are the products of the interaction. The interaction refers to the intercourse and communication between the students and between the students and the computer. The outcomes refer to any changes in the students' knowledge or feelings as a result of the interaction. In the Secondary school and Primary school studies, the products, interaction and the outcomes were examined. In the summer school study, only the outcomes were studied. In the Secondary school study the product was the completed worksheets, the results of which have been referred to as a measure of the on-task performance. In the Primary school study the products were the children's notes and the final slide show. Although they were not investigated in this study, the products from the summer school study would be the students' projects.

One of the difficulties of evaluating a learning situation is balancing evaluations of the products and the outcomes. It may be that students produce a very good document, but do not learn anything. Alternatively, the products of a learning situation could be evaluated as poor, but the students may improve on a pre- to post-test, and feel very motivated to work harder.

In the Secondary school study, the pairs achieved more in terms of on-task performance than the individuals, but did not achieve significantly more than the individuals on the post- and delayed post-tests. Although this does not allow one to unequivocally say that working in a pair is more beneficial than working individually, it is necessary to look at the on-task performance of a learning situation in conjunction with the outcomes. For the children in the Primary school study, the document that they produced was impressive and the other children in the class enjoyed watching it and said that it was clear and understandable. However, the outcomes of this interaction were not clearly beneficial to all three students, as exemplified by Robert's lack of knowledge in the post-test and the future of the group as a viable partnership.

The actual interactions were investigated in a selection of the Secondary school students and in the Primary school study. It is necessary to study the interactions if we wish to determine the factors that effect the products and the outcomes. The videotape analysis in the Secondary school study showed similarities and differences between individuals and pairs of students which were related to their pre- and post-test scores and their affective ratings. This provided descriptions of their interactions and facilitated some evaluations of the learning situation. For example, the decrease in next talk and increase in topic talk seen in Donna and Steve's timeline was interpreted as showing that the software became transparent and once they had mastered using the computer, their attention was focused on the task. In contrast, the continuous nature of Sue and Jane's next talk was interpreted as them not mastering the software and therefore not focusing on the task adequately.

The analysis of the interactions in the Primary school study provided a comprehensive description of the collaboration and allowed for explanations about the nature of the product that resulted from the children's collaboration as well as explanations of the knowledge that the children had at their interviews. Therefore, it is necessary to investigate the interactions in conjunction with the products and the outcomes in this type of research.

7.3.3. The description of effective learning situations

A description of effective learning situations was introduced in chapter 4 and applied to the data obtained in the Secondary school study. The description combined both cognitive and affective aspects of learning situations. It was not successful in differentiating between the different conditions in the study, nor between girls and boys. It was argued that this was because of the additive nature of the description and that there is a need to include weightings for the different factors. These weightings could be derived by determining the objectives of the specific learning situation. Additionally, the description, from a cognitive perspective, only incorporated the outcomes of the learning situations, and did not include the product i.e. the students' scores on the worksheet.

The description was also applied to the data from the study of undergraduates at a residential summer school. In this context, it only incorporated affective factors and successfully differentiated between the four project areas and those that were written up as assignments and those that were not.

The study reported in chapter 7 again highlighted the differences between the products and outcomes and the difficulties in assessing effective learning situations in these terms. Although the product was considered a good document, the outcomes were not beneficial to all the children involved. There were detrimental effects on Robert from an affective perspective.

7.4 Research methodology

7.4.1 Pre- and post-testing

The issues of pre- and post-testing are relevant to the Secondary school study. This showed the value of carrying out delayed post-test as well as immediate post-tests and points to the difficulty of drawing conclusions from investigating the interactions of the students who achieve the highest pre- to immediate post-test gains as these may not necessarily be the students who gained the most if a longer term perspective is taken.

Additionally, the study found that pre- to post- or delayed post- gains did not necessarily reflect the strength of on-task performance. Those who performed best on the worksheet were not the students who had the highest pre- to post-test gain. In particular, the pairs achieved more on the worksheet than the individuals and this was not reflected in the post-test scores. It was argued that this may have been because the students had worked together and then filled in the post-tests individually and the fact that they had worked together may have had a detrimental effect on their individualised post-tests. Peer interaction was not beneficial in terms of individual learning outcomes, but the students may have benefited in terms of collaborative activity.

7.4.2 Naturalistic and experimental studies

There are relatively few studies of naturalistic computer-supported collaborative learning, as discussed in Chapter 2. This can be attributed to the lack of naturalistic settings in which this type of study can occur, although computer-supported collaboration is an expanding aspect of education. Additionally, much of the research has been within the context of developmental psychology, in which the traditional methodology has been experimental. This allows for the systematic manipulation of factors and is more useful for theory development, in terms of the mechanisms of collaborative learning, than naturalistic studies. However, the problem with these types of studies is that it is difficult to provide educator guidelines from the results.

The summer school study was a naturalistic study which provided results about the affective aspects of completing projects collaboratively with computers. This led to some suggestions about the structure of summer schools and ways in which the learning situations can be modified to be more effective. The Primary school study was also a naturalistic study and provided a description of the way in which the children created the slide show. This was interpreted in terms of the results of the interviews and allowed for the development of guidelines for teachers. These are aimed at more effective collaborations, both in terms of how much the children learn and their feelings towards themselves, their peers and their learning.

7.4.3 Time-based analyses

Developments over time may be an important factor in the efficacy of collaborative interactions. This is an aspect of computer-supported collaborative learning which has not previously been investigated. There may be an optimal way of working together and this may develop over time - or conversely, students may begin by collaborating effectively but after some period of collaboration, this way of working may break down and the collaboration become inefficient. It is therefore important to look at the nature of the interactions over time.

Time-based analyses were used in two of the studies. In the Secondary school study, an advanced computer-based tool was used to investigate a selection of the interactions. This facilitated graphical representations of the students interactions over time. Consequently, patterns of talk and behaviour were discerned and these were interpreted relative to the products and outcomes of the collaborations.

In the Primary school study, Timelines was not used because it is not appropriate for analyses which involve relatively large units of time. Instead, a hand-made representation of the interaction was created and this provided a description of the interaction as well evidence of patterns within the interaction. For example, from the representation it is apparent that the collaboration broke down over time and the children stopped working with one another and split the task. It shows that the majority of the collaboration occurred while the children were recording the sound. It is also obvious exactly who was working with who, and the teacher interventions can be seen. It also shows the distribution of the four different types of activities associated with this type of interaction. From this, some educator guidelines can be provided.

The time-based analyses described in this thesis clearly show the benefits of this type of analysis. These representations provide a way of describing the interactions and enable us to see patterns in the interactions. This type of analysis facilitates relating products, interactions and outcomes to one another.

7.5 Gender differences

Some of the important differences in this thesis were those found between males and females. There is now a mass of results concerning gender differences both in terms of computer use and in learning situations. This section discusses the gender differences in terms of cognitive factors, affective factors and interactions (for further information on some of these factors, see Issroff, 1994c).

7.5.1 Cognitive factors

The results from the Secondary school study show no significant differences in terms of the pre-, post- and delayed post-tests and on-task performance between the boys and girls. This is surprising considering that there have been many studies that show that boys enjoy an advantage in relation to computers and in relation to science.

7.5.2 Affective factors

Perhaps the most interesting gender differences were found in the analysis of the affective factors. These are only discussed in terms of the Secondary and summer school studies as it is felt that the information obtained from the children in the Primary school study is only pertinent to that particular situation.

In both studies it is clear that the women value getting along with their peers more than the men. These differences could have a detrimental impact on the way in which mixed gender groups collaborate.

There were also differences between the men and women's perceived motivation and interest. The collaborations in the Secondary school study had an impact on the boys' motivation towards chemistry and on the girls' interest and motivation towards computers, while the collaborations in the summer school study had an impact on the men's perceived interest towards the topic, but not the women's. This may have been a consequence of the differing significance that males and females place on different aspects of the interactions.

In the Secondary school study, the interactions had an effect on the girls' perceptions of themselves and increased the girls' perceptions of how well they got on with their peers. There were no corresponding changes for the boys. The girls' perceptions of how much they helped their partners decreased, but there was no corresponding change for the boys.

These gender differences have implications for the use of mixed gender groups and for the use of collaborative learning in general. If women do value getting along with their peers significantly, then it may be inappropriate to use collaborative learning for women when the desired outcome is an increase in their knowledge.

7.5.3 Interactions

In terms of interactions, the interesting gender differences are revealed by the videotape analysis carried out in the Secondary school study. In the mixed gender groups, the boy was always dominant in terms of the hardware. However, this may not reflect overall dominance because the girl may have dominated the interaction by verbally directing the boy in terms of what he should do next. This requires further investigation, and could only be revealed by an in-depth analysis of the dialogues, which was not undertaken in this thesis because the emphasis is not on the nature and analysis of talk.

Another striking finding was that the girl:girl pairs were the only pairs in which overall, there was no hardware dominance. It is not, however, clear that this is necessarily beneficial.

7.6 The four perspectives revisited

In this section, the four perspectives on computer-supported collaborative learning discussed in Chapter 3 are revisited and discussed relative to the studies presented in this thesis.

7.6.1 Is collaboration beneficial?

The Secondary school study was the only study that investigated both pairs and individuals. The results of this study are equivocal - there appear to be some benefits associated with working in a pair, but there were no significant differences between the individuals and pairs in terms of pre- to post-test gains. For example, the students working in pairs achieved better scores on the worksheets, but there were no differences between individuals and pairs on the pre- to post- and delayed post-test scores. From an affective perspective, there seems to be no difference between working in a pair to working on ones own.

In the summer school study, it appears that the collaborations were not beneficial to some students. The fact that eight of the students' self perceptions decreased by more than two points on a five-point scale is indicative of this. When the description of effective learning situations was applied to the data, no single group of students had more effective collaborations although some of the projects were better than others in these terms.

From the Primary school study, it is possible to say that in one sense, all three children benefited - they all improved their knowledge of the water cycle. However, Robert was not very pleased with what had happened and had gaps in his knowledge.

7.6.2 Software design

In terms of the software design, it is only pertinent to talk about the software used in the Secondary and Primary school studies. The summer school study did not investigate any of the specific aspects of the students' use of the software.

The software used in the Secondary school study seemed to be appropriate for the majority of students of this age group. Most of the students learnt how to use the software quickly and had very few problems using it. There was some dominance in the use of the hardware, particularly amongst the boy:boy pairs. However, from the analysis carried out it is not possible to say whether or not this was detrimental to all of the subordinate students.

The software used in the Primary school study seemed to facilitate a lack of collaboration. There was little scope for collaboration while the children were using the computer (which was exacerbated by the expertise of Kerry) and this may have contributed to the children's decision to divide the task, which had detrimental effects on the collaboration. Additionally, much of the topic discussion occurred away from the computer. The talk at the computer was largely concerned with aesthetic aspects of the slide show, in particular what colours to use and where to place different objects in the picture. It might have been helpful if the software had been modified so that there are set colours for text and background and less options for transitions, thus limiting the children's focus on the aesthetic aspects of their document.

It is interesting to consider why the individualistic nature of the software had differing effects in the two studies. Two factors are pertinent. Firstly, in the Secondary school study, the students were using the computer essentially as a way of gaining information in order to fill in the worksheets. In contrast, in the Primary school study, the computer was being used as a tool with which to make a slide show. One possibility is that collaborations can occur when there is something else that the students are using (in this example, the worksheets). However, when the computer is the only tool that the students are using and the task that they are carrying out has been defined, they have to divide the task and cannot easily collaborate around the computer.

The second pertinent factor is the children's age . It may be that older students have a greater capacity to collaborate and more experience of sharing. This enables them to collaborate effectively around one resource. In contrast, the younger children find it difficult to work together and share a tool and they therefore divide the task and work separately.

7.6.3 Mechanisms of collaborative learning

In terms of mechanisms of collaborative learning, it is only pertinent to discuss the results of the Secondary and Primary school studies. It is also important to note that the studies were not specifically designed to test the theories presented in Chapter 2. No systematic analysis of the interactions in terms of the pertinent factors, for example, the number of conflicts or occurrences of scaffolding was carried out. However, several features of the interactions point to some of the mechanisms described in Chapter 2 as being relevant.

In the Secondary school study, it seems that one of the mechanisms that is prominent in terms of comparing the pairs to the individuals is that two children access more information than one. This is demonstrated by the analysis of the worksheets which shows that the pairs got higher factual scores than the individuals but there were no significant differences in terms of conceptual scores. It is also demonstrated in the videotape analysis which shows that the pairs used the mouse and typed more than the individuals, which within the context, represents accessing more information.

The issue of mechanisms in the Primary school study is complex. This is because the study took a broader view of collaboration than the theories that were described. Although within the collaboration there may have been instances of conflict or scaffolding or observation, none of these dominated the interaction. This points to the need for theories which take a broader view of collaborations, and consider the context of collaborations and periods in which students are not necessarily working together.

7.6.4 Educator guidelines

All three studies have implications for guidelines for teachers. This is often a neglected aspect of studies of computer-supported collaborative learning and it is pertinent to discuss these in detail, particularly the results from the two naturalistic studies.

From the Secondary school study, it is not clear that working collaboratively is always more beneficial than working on one's own. Consequently teachers should not be advised that all children should work collaboratively and this aspect requires more research. Additionally, the consequences of sharing a worksheet are not clear cut and considering that this is something that occurs frequently in schools, more research is needed before proper educator guidelines can be provided.

The summer school study points to the importance of affective factors, in particular, getting along with one's peers. Presently, the summer school is organised in a way that requires students to work with people whom they barely know. Additionally, the majority of their learning occurs individually and the students are not used to working in academic settings with other students. They receive no training in collaborative work. It would therefore be advisable that the Open University give students more time to get to know one another before they begin to work and give the students training in collaborative learning before the projects begin. Another problem appears to be the individualistic nature of the assignments. As was seen in the Secondary school study, it may be inappropriate to give the students individual assessments when they have been working collaboratively. This is particularly pertinent given that the students said that the most important thing was getting on with their peers over and above getting the correct answer and that their groups' success was more important than their individual success.

The guidelines derived from the Primary school are of a more specific nature. First, teachers should ensure that their interventions occur when all the members of the group are present. At one stage, the teacher was praising one of the children's slides, but only Emma and Kerry were present and the particular slide was made by Robert. Secondly, teachers should check that what they tell the students is actually carried out. There were two occurrences of the teacher telling the children that it was Robert's turn and then moving onto something else, while Kerry took over the computer. Thirdly, when this type of document is made, the children should have to complete the research and planning together and agree on the exact nature of the pictures and text. In this collaboration, all the children missed out on some of the cognitive aspects of the task because the task was divided and the eventual product not agreed upon. Kerry would often spontaneously make up scripts for the slide show, without consulting the other children. The fourth guideline concerns the presence of pupil experts. The teacher relied on Kerry to teach the other children about the use of the software, but her teaching abilities and sensitivity were not developed enough to adequately help Robert and Emma. This meant that she would often carry out tasks before explaining it to them, or not explain things at all.

The gender differences are particularly important in respect of educator guidelines. From these results it seems that mixed gender groups may have particular difficulties because the males and females have different priorities when working together. The results suggest that collaborative learning for females may not be appropriate for knowledge acquisition as women find getting on with their partners more important in these situations.

7.7 Conclusion

This chapter has provided an overview of the three empirical studies presented in the thesis. These have been discussed from various perspectives. In particular, the chapter points to the necessity to take a wider view of assessing effective learning situations, which incorporates affective as well as cognitive factors and distinguishes between products, outcomes and interactions. The value of time-based analyses was stressed, particularly when investigating collaborations which occur over more than one session.In the final chapter, the research questions presented in chapter 1 are discussed and the contributions and limitations of the thesis are presented.

Chapter 8

Conclusion

8.1 Introduction

In this final chapter, the research questions in Chapter 1 are revisited. Beginning with the nature of collaboration and the role of the computer, each of the initial research questions is considered in light of the research results. Finally, the contributions of the thesis to research in the area are discussed and a number of ideas for future research are presented.

8.2 The nature of collaborations and the role of the computer

What is the nature of students' collaborations with/around the computer? Does the computer aid collaboration? What role does the computer play? How does this impact on the nature of the students' collaborations?

The first set of questions are about the nature of students' collaborations with/around the computer, whether or not the computer aids collaboration and the role that the computer plays in collaborative interactions. In terms of the role of the computer, in the three studies presented, the students were using the computers for slightly different purposes. In the first study, the computer was essentially a means of accessing information for the students. In the Summer school study, the computer was a tool which could be used for a variety of purposes, dependent on the particular project that they were doing and only formed part of the students' work. In the Primary school study, the computer was used as a tool, but was expected to take up the majority of the students' time. The Secondary school and Primary school studies were the two studies in which the nature of the interactions were documented and these will therefore provide the basis for the discussion which follows.

8.2.1 Nature of interactions

The analysis of the interactions in the Secondary school study showed large variations in the ways in which the students worked together. There were variations in the length of time spent using the computer and also variations within and between pairs. The results of the video analysis of a sample of students showed that girl:girl pairs were the only pairs in which there was no overall hardware dominance. Dominance by one partner was not indicative of a high pre- to post-test gain. Additionally, there was some data which suggested that those that went off task the most were students who showed the highest pre- to post-test gain. The timelines created showed developments in collaborations within interactions. For example, for one pair there was a clear decrease in the amount of talk associated with the interface and for the two pairs who worked with the computer for more than one session, there were clear developments in the nature of the interaction, in terms of the hardware use and their writing on the worksheet. The study also compared individuals to pairs. The results of the video analysis show that the pairs were accessing more information than the individuals.

The interaction in the Primary school study was represented using a time-based diagram which clearly showed the nature of the children's work at various times, the ways in which the children split up the task and the collaborations that did occur. Their interaction largely consisted of Kerry and Emma working together and Robert working on his own, or all three children working on their own. Additionally, the description shows how the different phases which occur in this type of work are interleaved.

In summary, the two studies have shown that the nature of collaborations with computers can be widely different between pairs and contexts, and the importance of looking at developments in collaborations over time.

8.2.2 Aiding collaboration

In the Secondary school study, the computer provided a structure within which the students could communicate and a sense of a shared resource and the majority of students did collaborate effectively.

In the Primary school study, the computer did not provide a space in which, nor a means through which, the children could collaborate with one another. In fact, the computer seemed to have a detrimental effect on the students' collaborations. The nature of the software and Kerry's behaviour encouraged the children to split up the task and effectively work on their own. This seemed to be considered appropriate by the teacher and led to situations in which one child would work at the computer and the two other children would do other work in another part of the classroom. However, the children did work together when they were recording the sound.

Therefore, it seems that the computer is not always an aid to collaboration. It can provide a shared space for students to work in, or a means by which students can communicate. Conversely it can act as a way in which to divide up the task, which may be detrimental to some of the students involved. In the next section, the roles of the computer are discussed.

8.2.3 Roles of the computer

In the Secondary school study, the computer was acting as an information provider for the students. However, in the Primary school study, the computer was a tool with which the children created their dynamic document. This did make a difference to the ways in which the students interacted in that the computer was more of a focus for the collaborations when used as an information provider, whereas when it was being used as a tool, it provided a way in which to divide the task.

Thus the role that the computer is playing has a significant effect on the nature of the students' interactions.

The second research question concerned the assessment of effective computer-supported collaborative learning and is discussed in the next section.

8.3 Effective computer supported collaborative learning

How can we study and assess effective computer-supported collaborative learning?

This question has reappeared in several places in the thesis. The thesis has emphasised the need to look at affective factors, in conjunction with cognitive factors, when assessing a learning situation. However this discussion will initially focus on naturalistic studies and the use of pre- and post-tests in this type of research.

8.3.1 Naturalistic studies

Two of the empirical studies presented in this thesis are naturalistic studies. Little research has been carried out on naturalistic computer-supported collaborative learning and there is a corresponding lack of educator guidelines. The Summer school study showed that the students find affective factors important and these have an impact on the students' work which should be recognised in the way that the Summer school is run. The Primary school study showed that the computer can have a detrimental effect on collaboration and teacher guidelines were provided which could aid collaboration.

Overall, the studies show that it is possible to study naturalistic computer-supported collaborations and these studies provide a wealth of information about the collaborative process and students' feelings and perceptions. These studies provide educator guidelines which can be used in real computer-supported collaborative learning settings.

8.3.2 Pre- and post-testing

In Chapter 3 it was noted that the majority of research in this area has used pre- and post-testing to assess the cognitive benefits of collaborative computer-assisted learning. However, the results of the Secondary school study show that results on an immediate post-test do not necessarily reflect either the students' on-task performance, or the long term benefits that they may derive from the collaborative interaction. The results also highlight the difficulties of using post-tests to assess interactions, particularly when the interactions of students showing high pre to post test gains, are interpreted as, and studied in terms of being advantageous interactions. However, the main focus of the thesis was in assessing affective as well as cognitive factors, which is the subject of the next section.

8.3.3 Cognitive and affective factors

Only the Secondary school study assessed cognitive factors. It has been argued that it is important to incorporate both cognitive and affective aspects when assessing learning situations. A description of effective learning situations which incorporated both cognitive and affective factors was proposed. This was applied to the Secondary school data and no significant differences were found. The same description was applied to the Summer school data, without the cognitive aspects, and significant differences were found between subjects and between projects that were written up as assignments. This again supports the idea that affective factors are important in understanding the collaborative learning process and these factors are discussed in more detail in the next section

8.4 Affective Factors

How do students feel about using computers in a learning context? What effect do computers have on students' feelings and perceptions when used in a learning situation? Which aspects of the interactions are most important to students when using computers for learning?

All three studies presented investigated affective factors, but only the results of the Secondary school and Summer school studies will be presented here. Surprisingly, in the Secondary school study, there were no important significant differences between the individuals and the pairs. The most pertinent differences were those found between males and females. Both the Secondary and Summer school studies investigated the changes in the students' motivation, interest and self perceptions. The interesting findings here concern the gender differences. The collaborations in the Secondary school study had an impact on the boys' motivation towards chemistry and on the girls' interest and motivation towards computers, while the collaborations in the Summer school study had an impact on the men's perceived interest towards the subject area, but not the women's. In the Secondary school study, the boys perceived themselves as significantly better at this type of work in the pre-test, but there was no significant difference at the post-test. This was interpreted in terms of the differential significance that males and females place on different aspects of the interactions, which are discussed below.

In both studies, the students were asked how important they found various aspects of their collaborations. All the students said that it was most important to get along with their peers. This provides support for the idea that affective factors are important and it is important to note that this finding occurred at a Summer school which is part of the students' course requirement and the students have to write up the academic work as part of their assessment. However, the interesting findings are concerned with gender differences. In the Secondary school study, the girls' ratings of the importance of getting along with their peers were significantly higher than their other ratings and this was not true for the boys. In the Summer school study, the women rated the importance of getting along with their peers significantly higher than the men. These results represent a possible explanation for the difficulties associated with working in mixed gender groups.

8.5 Contributions and limitations

This thesis has provided:

- A literature review of computer-supported collaborative learning research.
- A literature review of research on affective aspects of using computers.
- An overview of research methodology used in studying computer supported collaborative learning.
- A set of guidelines for the design of experimental studies investigating computer-supported collaborative learning.
- A study of Secondary school children using a computer in pairs and individuals, incorporating both cognitive and affective aspects and time-based analysis of selections of videotapes.
- A study of the affective aspects of Open University students completing projects collaboratively at Summer school.
- A case study of Primary school students collaboratively creating a dynamic document, including a time-based representation of their interactions.
- The difficulties of assessing learning situations were highlighted, and particular reference was made to affective factors and assessment in terms of products, outcomes and interactions.

- Gender differences were found in the three studies and these were discussed in terms of cognitive factors, affective factors and interactions.
- It was argued that the benefits of collaboration are not universal and that current theoretical approaches to mechanisms of collaboration need to be broadened to incorporate the larger context of computer-supported collaborative learning.

Given these contributions to the area, it must nevertheless be pointed out that this research was undertaken within the context of side-by-side computer supported collaborative learning and studies were not carried out on computer-mediated collaborations, or distance collaborations and the results presented represent a limited subset of factors that are relevant to learning situations.

Perhaps most importantly, while the thesis illuminates the importance of investigating developments over time in collaborative interactions, time-based analyses were only carried out on a small sample of interactions using a limited range of categories. This type of analysis merit further attention, particularly in relation to the recent shift in theory towards interest in the development of shared understanding during collaborations. There is a particular problem with time-based analyses of interactions in terms of granularity i.e. the size of the unit of analysis. The two studies presented used very different levels of granularity. The Timelines analysis facilitated the categorisation of various time periods, while the representation used in the Primary school study had ten minute time periods. The optimal level of granularity may ultimately depend on the purpose of the analysis of the interactions.

Finally, in the Secondary school and Primary school studies, in which interactions were videotaped, no extensive transcription or analysis of dialogues were carried out. It was felt that extensive analysis of the dialogues in the Secondary school study was not appropriate because of the experimental nature of the learning situations and because the dialogue consisted of short periods of discussion about the topic area, with relatively little development of conceptual ideas. In the Primary school study, much of the conceptual discussion occurred away from the computer and the talk at the computer was largely concerned with aesthetics, rather than the subject matter. However, in considering the results of the current research, it would, in future be beneficial to investigate the nature of dialogues in depth.

A description of effective learning situations, which incorporated both cognitive and affective factors was presented. However, this was found to be too simplistic. The description needs to be developed further, in particular, by weighting factors and considering the goals and aims of the particular learning situation. This would require extensive research on students' and teachers' expectations and value judgements about the importance of particular outcomes in different learning situations.

8.7 Future Research

Two of the studies presented in this thesis are of naturalistic collaborative computer-based learning environments. The results of these studies show that it is possible to usefully study naturalistic learning environments. These types of studies are particularly useful for providing educator guidelines, which is a neglected aspect of computer-supported collaborative learning research. In the Collaborative Learning and Primary Science project (CLAPS), we are researching naturalistic collaborations in investigative science, with a particular emphasis on gender (see for example, Murphy et al., 1995). The thesis also showed the importance of investigating the ways in which collaborations develop over time. In CLAPS, we are investigating cognitive development over a period of seven weeks and the recurrences of different types of conflict over time and the role of the resolution in patterns of conflict occurrence.

Another factor highlighted in this thesis that deserves more attention is the finding in the Primary school study that the computer can have a detrimental effect on collaboration. Future research should focus on the activities around the computer that may occur in conjunction with the computer-supported work such as planning and assessment, incorporating the broader context of collaborations. The role of the computer in collaborations may be particularly pertinent in this respect. In this thesis, only limited roles were investigated, and in the Primary school study, the children divided the task and ceased to collaborate. Therefore, future research could focus on long-term collaborations and the role that the computer, in various guises, plays in the nature of the interactions.

The thesis did not investigate distance collaborations. However, computer-mediated distance collaborations are occurring in British education and merits further attention. The Virtual Summer School (Eisenstadt et al., in press, Issroff, 1994d) was a Summer school for students who could not attend the conventional OU Summer school. The students worked from home using a computer to carry out the normal residential Summer school projects, which involve a considerable amount of collaboration. The study reported in Issroff (1994d) used the methodology and research instruments used in this thesis to study computer-mediated collaborations. Initial results suggest that students at the Virtual Summer school found collaborations less effective than those at conventional Summer school and this may be attributed to the nature of the task.

8.8 Afterword

This thesis has taken a broad, exploratory approach to studying computer-supported collaborative learning. It has extended the scope of research to incorporate affective factors and developments over time as well as providing studies of collaborations in naturalistic settings. The empirical studies provide examples of ways in which to interpret and analyse very rich and complex situations.

These types of studies are inevitably methodologically complex, but they do provide evidence for the benefits (and disadvantages) of computer-supported collaborations, insights into the mechanisms of collaborative learning, software design guidelines and guidelines to help teachers create and manage effective learning situations.

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Appendix A: Questionnaires, training sheet and worksheet from Secondary School study

Pre-chemistry questionnaire

Name: .... Age:................. Male/Female

1. Name any inert gases you know of...
....
....
....

2. What is the symbol of the element potassium?............................

3. What is the atomic number of the element carbon?.....................

4. What is an electron?..
....
....
....

5. What kind of elements are best for protection at high temperatures?..
....
....
....

6. Lithium has an atomic number of 3. What is it's electronic configuration?..

7. What is the relationship between the atomic number and the electron configuration of an element? ....
....
....

8. What is the symbol of the element iron?.....................................

9. What do you understand by thermal conductivity? ....
....
....
....

10. What do elements with the same classification have in common? ....
....
....
....

Post-chemistry questionnaire

Name: .... Age:................. Male/Female

1. Name any inert gases you know of...
....
....

2. What is the symbol of the element potassium?............................

3. What is neon used for?..
....
....

4. What is an electron?..
....
....
....

5. What kind of elements are best for protection at high temperatures?..
....
....

6. Beryllium has an atomic number of 4. What is it's electronic configuration?...

7. What is the relationship between the atomic number and the electron configuration of an element? ....
....
....
....

8. What is the symbol of the element iron?.....................................

9. What do you understand by thermal conductivity? ....
....
....
....

10. What do elements with the same classification have in common? ....
....
....
....

Pre-affective questionnaire (individual)

Name ....

Age .... Male/Female ....

Please circle one dot in the following questions.

How often do you use computers to learn from in school?

more than once a week	once a week	once a month	less than once a month
•	•	•	•

How interested are you in learning from the computer?

very interested		average		not interested at all
•	•	•	•	•

How interested are you in learning chemistry?

very interested		average		not interested at all
•	•	•	•	•

Would you have chosen to do this if your teacher had given you the choice?

yes	no
•	•

What is your favourite part of science? ....
....
....
....
....
....

Which lessons in science have you enjoyed the most and why?................
....
....
....
....
....

How motivated are you towards learning from the computer?

very motivated		average		not motivated at all
•	•	•	•	•

How motivated are you towards learning chemistry?

very motivated		average		not motivated at all
•	•	•	•	•

How good do you think you will be at this kind of work?

very good		average		very bad
•	•	•	•	•

What do you want to get out of this? ....
....
....
....
....
....

Post affective questionnaire (individual)

Name ....

Age ....   Male/Female

Please circle the appropriate dot in the following questions.

How interested are you in learning from the computer?

very interested		average		not interested at all
•	•	•	•	•

How interested are you in learning chemistry?

very interested		average		not interested at all
•	•	•	•	•

How motivated are you towards learning from the computer?

very motivated		average		not motivated at all
•	•	•	•	•

How motivated are you towards learning chemistry?

very motivated		average		not motivated at all
•	•	•	•	•

How successful do you think you were in the session?

very successful		average		very unsuccessful
•	•	•	•	•

Why do you think this?...

....

....

....

....

What goals did you have for the session? ....
....
....
....
....

Did you use any special strategies? ....
....
....
....
....
....

How frightening did you find the session?

very frightening		average		very unfrightening
•	•	•	•	•

Would you have rather had the session with someone else?

definitely		maybe		definitely not
•	•	•	•	•

How important is it to you that you get the answers correct?

very important		average important		very unimportant
•	•	•	•	•

Were you trying to:

a. answer all the questions
b. beat the computer
c. learn about the Periodic Table
d. have fun
e. other ....

Do you feel pleased with what you have done?

very pleased • • average • • • not pleased

Do you think that you are good at this kind of work?

very good • • average • • • very bad

Would you come back at break and use the computer to do some more work?

definitely • • maybe • • • definitely not

Why do you think this?...
....
....
....
....
....
....

What do you think you have achieved? ....
....
....
....
....
....
....

Pre-affective questionnaire (pairs)

Name .... Age .... Male/Female

Please circle one dot in the following questions.

How often do you use computers to learn from in school?

more than once a week	once a week	once a month	less than once a month
•	•	•	•

How interested are you in learning from the computer?

very interested		average		not interested at all
•	•	•	•	•

How interested are you in learning chemistry?

very interested		average		not interested at all
•	•	•	•	•

How motivated are you towards learning from the computer?

very motivated		average		not motivated at all
•	•	•	•	•

How motivated are you towards learning chemistry?

very motivated		average		not motivated at all
•	•	•	•	•

What is your favourite part of science? ....
....
....
....

Which lessons in science have you enjoyed the most and why?.................
....
....
....

Would you have chosen to do this if your teacher had given you the choice?

yes	no
•	•

How well do you get on with your partner?

very well		average		not well at all
•	•	•	•	•

How good do you think you will be at this kind of work?

very good		average		very bad
•	•	•	•	•

How good do you think that your partner will at this kind of work?

very good		average		very bad
•	•	•	•	•

How much do you respect your partner?

very much		average		very little
•	•	•	•	•

How much do you want to help your partner?

very much		average		very little
•	•	•	•	•

How much do you think that your partner will help you?

very much		average		very little
•	•	•	•	•

What do you want to get out of this? ....
....
....
....
....

Post-affective questionnaires (pairs)

Name .... Age .... Male/Female

Please circle one <u>dot</u> in the following questions.

How interested are you in learning from the computer?

very interested		average		not interested at all
•	•	•	•	•

How interested are you in learning chemistry?

very interested		average		not interested at all
•	•	•	•	•

Did you get on well with your partner?

very well		average		not well at all
•	•	•	•	•

How motivated are you towards learning from the computer?

very motivated		average		not motivated at all
•	•	•	•	•

How motivated are you towards learning chemistry?

very motivated		average		not motivated at all
•	•	•	•	•

How important do you think <u>your groups</u> success is?

very important		average important		very unimportant
•	•	•	•	•

How successful do you think your group was in the session?

very successful		average		very unsuccessful
•	•	•	•	•

Why do you think this?..
....
....
....

How important do you think your success is?

very important		average important		very unimportant
•	•	•	•	•

How successful do you think you were in the session?

very successful		average		very unsuccessful
•	•	•	•	•

How did you judge this?..
....
....
....

How satisfied are you with your groups performance during the session?

very satisfied		average		very unsatisfied
•	•	•	•	•

Why do you think this?..
....
....
....

How satisfied are you with your performance during the session?

very satisfied		average		very unsatisfied
•	•	•	•	•

Why do you think this?...

....

....

....

What goals did you have while you were working? ....

....

....

....

Did you use any special strategies? ....

....

....

....

How frightening did you find the session?

very frightening		average		very unfrightening
•	•	•	•	•

Would you have rather had the session on your own?

definitely		maybe		definitely not
•	•	•	•	•

How important is it to you that you get the answers correct?

very important		average important		very unimportant
•	•	•	•	•

How important is it to you that you got along well with your partner?

very important		average important		very unimportant
•	•	•	•	•

Were you trying to:

a. answer all the questions
b. beat the computer
c. learn about the Periodic Table
d. have fun
e. impress your partner
f. other ....

Do you feel pleased with what you have done?

very pleased		average		not pleased
•	•	•	•	•

Do you think that you are good at this kind of work?

very good		average		very bad
•	•	•	•	•

Would you come back at break and use the computer to do some more work?

definitely		maybe		definitely not
•	•	•	•	•

Do you think that your partner was?

very good		average		very bad
•	•	•	•	•

How much do you respect your partner?

very much		average		very little
•	•	•	•	•

How much do you feel that you helped your partner?

very much		average		very little
•	•	•	•	•

How much do you feel that your partner helped you?

very much		average		very little
•	•	•	•	•

Why do you think this?...
....
....
....
....

What do you think you have achieved? ....
....
....
....
....

Training sheet

This exercise is about using the computer to learn about elements in the Periodic Table. We are going to use the database in the computer to find the answers to questions about elements.

Here is a step-by-step example which explains how to find information using the database.

Ordinary salt is composed of two elements, sodium and chlorine. The compound is called sodium chloride. Let's find the atomic number and symbol of the two elements that make up salt.

Steps:

1. Go to the Database Menu and choose 'Query'.
2. Click the mouse at the 'Element Name' button in the Select Field section.
3. Click the 'Equal to' button in the Select Comparison section.
4. Enter 'sodium' in the criterion edit field.
5. Select 'Go'.

At the bottom of the Query Window this message will be displayed:

Selected elements = 1

6. Click the 'Done' button and go to the Database Menu and choose 'Data Screen Scan'. The data screen window will display

the facts for sodium. Fill these into the table and answer the question.

ELEMENT	SYMBOL	ATOMIC NUMBER
sodium		

What are the uses for sodium

?...

....

....

....

....

7. Click the "stop" icon.

Now repeat the exercise for chlorine.

Steps:

1. Go to the Database Menu and choose 'Query'.

2. Click the mouse pointer at the 'Element Name' button in the Select Field section.

3. Click the 'Equal to' button in the Select Comparison section.

4. Delete the 'sodium' in the criterion edit field and enter 'chlorine' instead.

5. Select 'Go'.

At the bottom of the Query Window this message will be displayed:

Selected elements = 1

6. Click the 'Done' button and go to the Database Menu and choose 'Data Screen Scan'. The data screen window will display the facts for chlorine. Fill these into the table and answer the question.

ELEMENT	SYMBOL	ATOMIC NUMBER
chlorine		

What are the uses of chlorine ?...
....
....
....
....

Now use the same method to answer the following questions:
What is the atomic number of the element which has the symbol Cu?...
Which elements have melting points greater than 3000°F ? Use the hand icon to move throught the elements that you have selected....................
....
....
....
....
....
....

Worksheet

Name: ....   Age:.................   Male/Female

WORKSHEET

Please answer as many of these questions as you can with the help of the computer. The questions marked with a star (*) are ones which you might find more difficult but do try them if you can. Please make some attempt at all the ones without stars.

1. What is the symbol for the element iron? ....

2. How would you classify the element potassium? ....

Here are some questions about electron configurations of elements. You will be asked to find the electron configuration of an element. An electron is a subatomic particle which moves around the nucleus of an atom within an electron shell. An electron shell is a region of space in which electrons move around the nucleus of an atom. The electron configuration is a group of numbers which shows the arrangement of the electrons in an atom. The numbers are the numbers of electrons in each electron shell starting with the innermost.

3. Fill in the following table:

ELEMENT	ATOMIC NUMBER	ELECTRON CONFIGURATION
Sodium		
Magnesium		
Aluminium		

*4. Silicon has an atomic number of 14. Predict its electron configuration without using the computer..

Now check your prediction on the computer. Write down the correct electron configuration. ....

Is this the same as your prediction? If not, why not?...............................
....
....
....

*5. What does the atomic number of an element represent?....................
....
....
....

---

6. What is the symbol for carbon?...

7. Which element has a boiling point of 4.215° F?...................................

*8. Which element would be better for protection at high temperatures, magnesium or aluminium? Use this space to make any notes you need.
....
....
....
....
....

Give a reason for your answer..
....
....
....
....

9. Name all the elements classified as inert gases.

1...
2...
3...
4...
5...
6...

10. Fill in the following table:

ELEMENT	ATOMIC NUMBER	ELECTRON CONFIGURATION
Lithium		

Sodium		
Potassium		

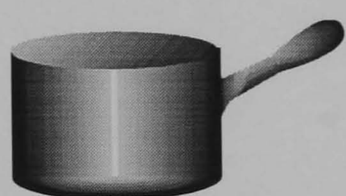
11. What is the pattern of the electron configurations of these elements?...
....
....

*12. What do these elements have in common?......................................
....
....
....

Can you think of anything else that they have in common?.....................
....
....
....

13. Which are the uses of calcium?...
....
....
....

14. What is the symbol of gold? ....



*15.

The thermal conductivity of an element shows how well the element conducts heat. Would copper or aluminium be a better metal for saucepans? Use this space to make any notes you need. ....
....
....
....
....
....

Why?...
....
....
....

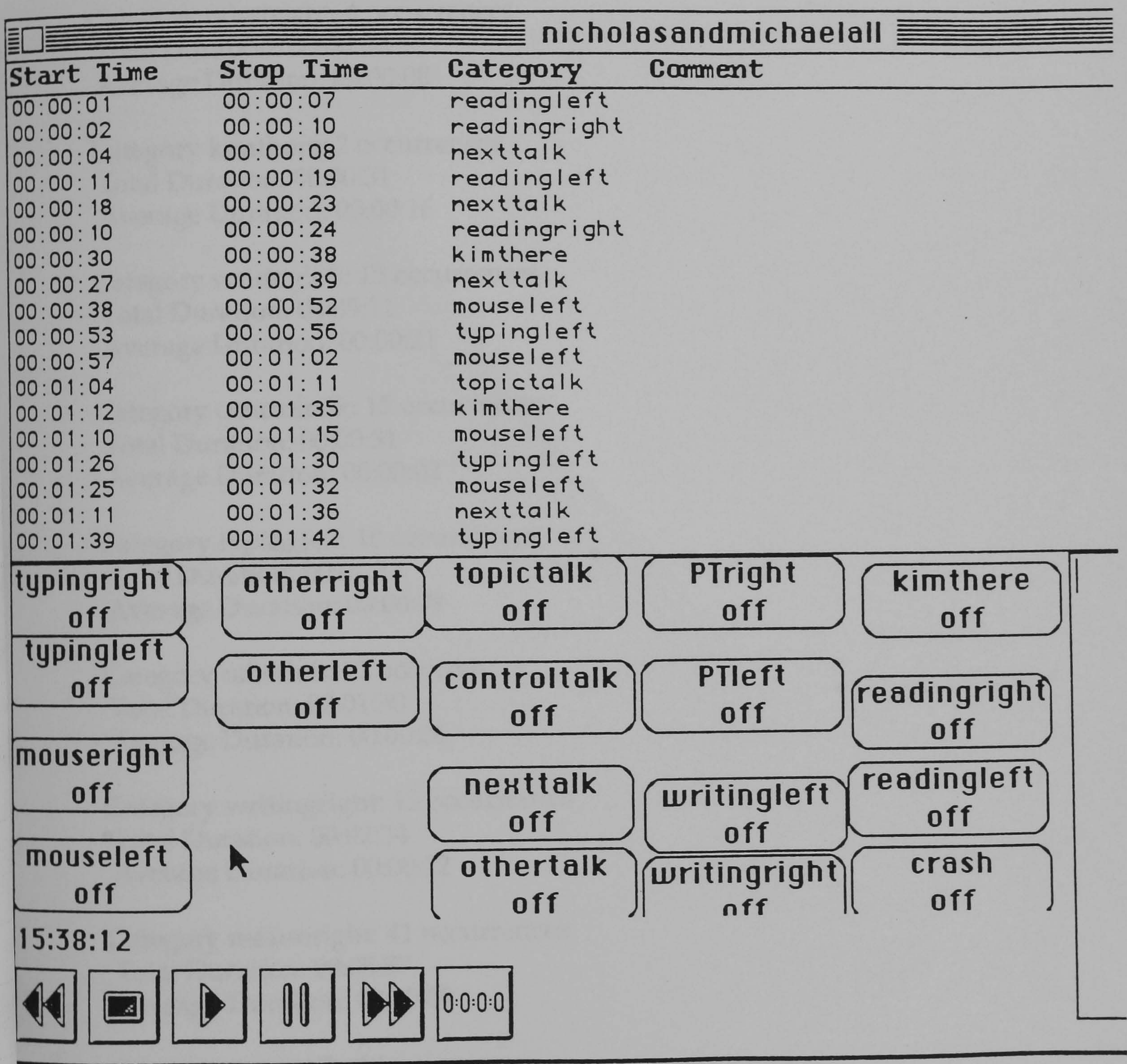
*16. Which elements have atomic numbers less than 5? ....
....
....

17. Draw the crystal structure of oxygen.

18. Think of two questions that you think would be good to get someone else to do using this database?..
....
....
....
....
....
....

Appendix B Timelines information

Timelines Interface



Sue and Jane's Summary

Number of entries: 322

Number of categories: 15

Number of colours: 1

Category otherright: 4 occurrences
Total Duration: 00:00:30
Average Duration: 00:00:08

Category kimthere: 2 occurrences
Total Duration: 00:00:31
Average Duration: 00:00:16

Category writingleft: 15 occurrences
Total Duration: 00:05:11
Average Duration: 00:00:21

Category controltalk: 15 occurrences
Total Duration: 00:00:31
Average Duration: 00:00:02

Category typingleft: 10 occurrences
Total Duration: 00:01:33
Average Duration: 00:00:09

Category otherleft: 12 occurrences
Total Duration: 00:01:30
Average Duration: 00:00:08

Category writingright: 13 occurrences
Total Duration: 00:02:34
Average Duration: 00:00:12

Category mouseright: 41 occurrences
Total Duration: 00:05:57
Average Duration: 00:00:09

Category topictalk: 48 occurrences
Total Duration: 00:07:42
Average Duration: 00:00:10

Category typingright: 13 occurrences
Total Duration: 00:01:02
Average Duration: 00:00:05

Category mouseleft: 33 occurrences

Total Duration: 00:06:10
Average Duration: 00:00:11

Category nexttalk: 45 occurrences
Total Duration: 00:06:44
Average Duration: 00:00:09

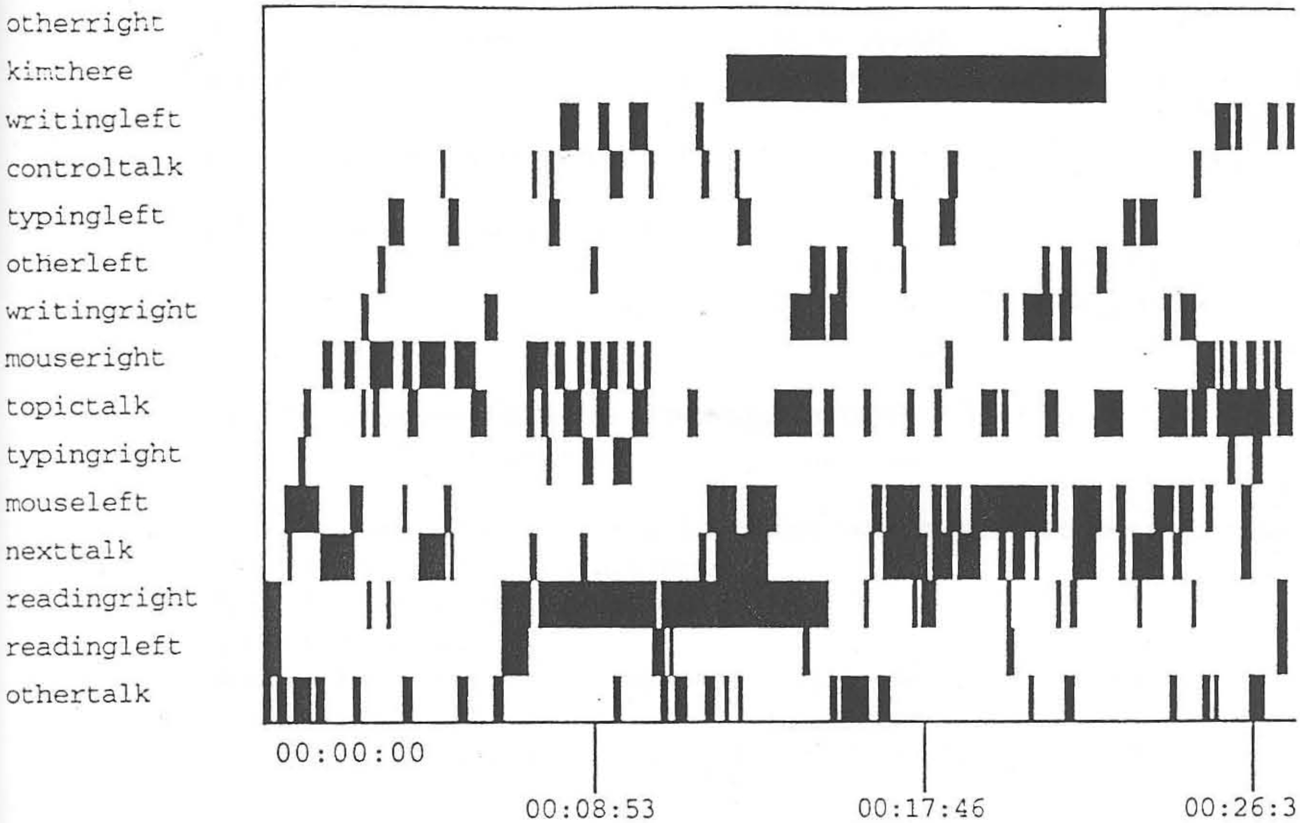
Category readingright: 23 occurrences
Total Duration: 00:03:15
Average Duration: 00:00:08

Category readingleft: 12 occurrences
Total Duration: 00:01:33
Average Duration: 00:00:08

Category othertalk: 36 occurrences
Total Duration: 00:03:38
Average Duration: 00:00:06

Colour black: 322 occurrences
Total Duration: 00:48:21
Average Duration: 00:00:09

Sue and Jane's overall timeline



Appendix C: Questionnaires from the Summer School study

Pre project questionnaire

Please fill this in during the first morning of your project.

Group nom de plume:	Male/Female
Module:	Nom de plume:

Please circle one dot in the following questions.

How often do you use computers normally?

more than once a week	once a week	once a month	less than once a month
•	•	•	•

Have you done any OU home computing courses? Yes/No
If yes, which course/courses? ....

If you use a computer at work, which of these statements describes your situation?

I use computer controlled equipment	1
My work is data entry/form filling	2
I do word processing	3
I use general application packages eg spread sheets	4
I use CAD/CAM packages	5
I program in one language, excluding programming at home	6
I program in several languages	7
Programming is a major part of my job	8
I work in systems software or computer operations	9

Are you a teacher/instructor working with computers? yes/no

Do you have a computer at home? yes/no
If yes, which of the following activities have you used it for?

Programming in Basic	1
Programming in various languages	1
Applications such as word processing or graphics	1
Running games packages	1
Not really used it much at all	1

How interested are you in the project you are studying in the next 2 days?

very interested		average		not interested at all
•	•	•	•	•

Do you have any experience of working in groups in your everyday life? ....
....
....
....
....

How motivated are you towards the project you are doing over the next 2 days?

very motivated		average		not motivated at all
•	•	•	•	•

How well do you get on with your group members?

	very well		average		not well at all
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

How good do you think you will be at this kind of work?

very good		average		very bad
•	•	•	•	•

How good do you think that your group members will be at this kind of work?

	very good		average		very bad
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

How much do you respect your group members?

	very much		average		very little
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

How much do you want to help your group members?

	very much		average		very little
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

How much do you think that your group members will help you?

	very much		average		very little
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

Please use the back of this sheet to write down some of your expectations about doing this project.

Post project questionnaire

Please fill this in after you have finished your project, but before the plenary.

Group nom de plume: Male/Female
Module: Nom de plume:

Please circle one <u>dot</u> in the following questions.

How interested are you in the project you have been studying?

very interested		average		not interested at all
•	•	•	•	•

How well did you get on with your group members?

	very well		average		not well at all
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

How motivated are you towards the project you have studied?

very motivated		average		not motivated at all
•	•	•	•	•

How important do you think <u>your group's</u> success is?

very important		average important		very unimportant
•	•	•	•	•

How successful do you think your group was in the project?

very successful		average		very unsuccessful
•	•	•	•	•

How important do you think your success is?

very important		average important		very unimportant
•	•	•	•	•

How successful do you think you were in the project?

very successful		average		very unsuccessful
•	•	•	•	•

How satisfied are you with your group's performance during the project?

very satisfied		average		very unsatisfied
•	•	•	•	•

How satisfied are you with your performance during the project?

very satisfied		average		very unsatisfied
•	•	•	•	•

What goals did you have while you were working? ....

....

....

....

Did your group split up the task? If you did, how did you do this and which parts did you complete? ....

....

....

....

....

....

....

Would you have rather worked on your own?

definitely		maybe		definitely not
•	•	•	•	•

How important is it to you that you complete the project correctly?

very important		average important		very unimportant
•	•	•	•	•

How important is it to you that you got along well with your group members?

very important		average important		very unimportant
•	•	•	•	•

Do you feel pleased with what you have done?

very pleased		average		not pleased
•	•	•	•	•

How good do you think your group members were at this kind of work?

	very good		average		very bad
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

How much of your time did you spend using the computer?

less than 25% but less than 50%	more than 25% but less than 50%	more than 50% but less than 75%	more than 75%
•	•	•	•

How much of your groups time was spent using the computer?

less than 25% but less than 50%	more than 25% but less than 50%	more than 50% but less than 75%	more than 75%
•	•	•	•

Do you think that you are good at this kind of work?

very good		average		very bad
•	•	•	•	•

How much do you respect your group members?

	very much		average		very little
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

How much do you feel that you helped your group members?

	very much		average		very little
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

How much do you feel that your group members helped you?

	very much		average		very little
person1	•	•	•	•	•
person2	•	•	•	•	•
person3	•	•	•	•	•
person4	•	•	•	•	•
person5	•	•	•	•	•

What do you think you have achieved? ....

....

....

....

....

Are you going to write this project up for your TMA? yes/no

If you have any additional comments, please use the back of this sheet.

Appendix D: Detailed information about the students.

The First Five Pairs

In this Appendix, each pair is described in general terms giving their age, their ability and motivation ratings and their friendship ratings[1]. The individual's pre-to post-test gain is given and other pertinent information is presented.

The first pair of students, Steve and Donna, are 14 years old. They are both rated as having high ability and motivation by their teacher. Steve and Donna were given a friendship rating of 4 and are one of the few mixed gender pairs that the teachers perceived as friends who could work well together. Steve's pre-to post gain in test scores was high, but Donna's test score decreased. At the delayed post-test, they scored equally well.

In contrast, the second pair, Nick and Mike were given low friendship ratings. Nick is 13 years old and is acknowledged as the cleverest person in the class, by both the teacher and other members of the class, with high ability and motivation ratings. The teacher explained that he was more mature than the other pupils and had begun to distance himself from them. Mike is 14 years old and had been at the school for about two weeks when the study was carried out. His ability and motivation was rated below average and they were given an average friendship rating of 1.7. Mike got nothing correct in the pre-test and this did not improve after the interaction. Nick had a very high pre-test score which improved after the interaction. Both Nick and Mike said that they would rather have worked on their own in contrast to most of the other individuals who worked in pairs. In his questionnaire after the interaction, Mike said "*Nick was good but I think I was pretty bad at it.*" and that his goal was "*to get it over with*".

The third pair, Sue and Jane, shared a worksheet. Sue is 14 years old and Jane is 13 years old. They are both rated as having below average ability and motivation, with Sue having particularly low motivation. They shared a worksheet and received a low friendship rating (2). However, this rating was obtained about a month after they had used the computer, and they had had a big argument in a lesson the day before the ratings had been solicited. At the time of the empirical study, they were very good friends, who chose to work together. Sue's immediate post-test score was less than her pre-test score, whereas Jane made some progress.

David and Andy are both 14 years old and received very high friendship ratings (4.7). David was rated as having average ability and motivation, while Andy was below average. They are both disruptive, and David was

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[1] The teachers rated the students' motivation and ability on a five point scale. The friendship ratings were obtained from three randomly chosen students in each class who rated the friendship of each pair on a five point scale. The average rating is given.

expelled but allowed back into the school during the course of the empirical work. They had the highest pre-to post gain scores of all the pupils. However, they both appear to have difficulties with written English. They used the computer for two sessions.

Kara and Debbie are both 13 years old and rated below average on ability and motivation. They both claim to hate science, predominantly because their mothers think it is pointless. They received high friendship ratings (4.6). They are both disruptive in class and walk around while the teacher is talking. They were very eager to use the computer and kept asking to use it again after their sessions. Like Sue and Jane, they shared a worksheet and their use of the computer extended into two lessons. After the sessions, Kara wrote "*I think Debbie helped me very much, I probably wouldn't have done so much if she wasn't here with me.*" Debbie wrote "*We worked quite well together and we helped each other understand about the computer apart from when we were fighting to have a go.*" Both Kara and Debbie improved significantly from pre-to post-testing.

The Second Five Pairs

Alys (13) and Mark is (14) and have a high friendship rating (5). Alys is rated as having high ability and average motivation. Mark is rated as having average ability and low motivation. Mark's father has two Macs but Mark only uses them for games, while Alys has no computer at home. Mark performed better in the pre-test than Alys, but Alys improved more than Mark. Mark wrote that "I think I have achieved a better understanding of computers and my partner." Alys wrote "I think Mark and I worked well together, helped each other and took turns in using the computer."

Nicholas (13) and Josef (14) also have a high friendship rating (5). Although they are both rated as having very high abilities, Nicholas is rated as having very low motivation, while Josef's is rated highly. Nicholas is disruptive in lessons and will argue with the teacher about anything. They both showed pre-to post improvements in their test scores. The research notes from this session were as follows: "both very bright and over boisterous and I could not stop them from taking part in the rest of the lesson. They found it very easy and did everything very quickly." When asked about his expectations, Josef wrote "get off the lesson" and Nicholas put "????????????"

Gabby and Rina are both 13 years old and have a high friendship rating (5). Gabby is a refugee from Eastern Europe who was rated as having high ability and motivation, while Rina is rated as being below average in ability and motivation. They both showed a pre-to post improvement. When asked about her expectations, Rina wrote "I want to learn about a lot of things on this because you don't have to copy from the board about the work and not understand but learn from a computer and understand at the same time. "Gabby rated her own satisfaction as very satisfied and when asked why, she wrote "because she helped and worked together."

Arthur is 14 and James is 13. They have a friendship rating of 4 and are both rated as having very high abilities but James' motivation is rated as average while Arthur's is rated below average. Arthur did not answer any open-ended questions after the session, while James wrote "he's an idiot" referring to Arthur. The researcher wrote "both naughty but bright boys but they got on with it and did quite well. They really did persevere." Both Arthur and James showed pre-to post-test improvements, but James' improvement was greater than Arthur's. They shared a worksheet. When asked about his expectations, James wrote "have fun - don't get homework' and Arthur wrote "A free lesson".

Hetal and Ursula are both 14 years old and have a high friendship rating (5). Hetal is rated as having above average motivation and ability while Ursula is rated as having average motivation and ability. They both showed a pre-to post-test gain, but Hetal's was greater than Ursula's. Ursula rated her group success as average because "we communicated and got quite a bit of the work done." Ursula rated herself as very satisfied with what she had done because "at certain times I could communicate with my partner and I would get a much clearer answer in my head and I could also help my partner with what I found easy and what I remember." When asked about how much her partner had helped her, she said "average" and wrote "I think this because we are both in the same science lesson but little things that I don't understand my partner can help me with and vice-versa and if not we just go and ask our teacher." When asked whether or not they had used any strategies, Hetal wrote "No, me and my partner discussed the answers before we wrote them down. We took it in turns to type and use the mouse."

The five individuals

Nathan (14) is rated as having above average ability, but below average motivation. After the interaction, Nathan did not want to use the computer again although he had high motivation and interest towards computers and chemistry. When asked how successful he thought he was, Nathan rated his success highly, but also wrote "I don't see how you can be successful or unsuccessful in copying off a screen."

Brenda (14) is rated as having above average motivation and ability. She distinctly prefers working on her own. After using the computer, Brenda wrote "I have learnt something new and I feel that it would help a lot of people with learning difficulties as I help my brother who is handicapped and he could use it to his benefit."

Bhina (13) is rated as being below average in motivation and ability. She showed an average pre-to post improvement.

Gemma (14) is rated below average in motivation and ability. Gemma did not want to use the computer, especially on her own, but after using the computer, she wrote "after a while I started to like it." She found the session frightening and said that she would rather have worked with someone else. She showed a pre-to post improvement but asked for help from the researcher 3 times, taking up 2.09 minutes.

Wayne (14) is rated as having below average motivation and ability. He showed some pre-to post-test gain. Wayne was very reluctant to use the computer on his own. He said that he preferred learning from the computer, but did not think that you learnt as much as you could from a teacher. Wayne wrote that his goals were to "finish the sheets".

Appendix E: A description of the interaction between Robert, Kerry and Emma

The document was made over a two week period and this took about seven hours. This appendix will describe the main events of the interaction in a diary form.

Thursday (10 - 10.35, 10.55 - 11.45)
Initially, Kerry and Emma worked on a list of items, then their draft storyboard and then their main storyboard. Although Robert tried to join them in this work, Kerry would not let him. She sent him off to make another storyboard on condensation, which he discussed with the teacher. This seemed to be the start of role division and the children began working separately.

Emma and Kerry then started implementing their storyboard, while Robert made his own. Robert had now moved to the back of the classroom, away from the computer and the table where they had initially started working together. Kerry was very dominant at the computer. When they had created most of their storyboard, Kerry sent Emma to get Robert and told him that she and Emma would do the storyboard while he used the computer. Although Emma wanted to use the computer, she and Kerry went off to do the storyboard, leaving Robert at the computer. Kerry then went from Emma to Robert, checking what they were doing. Kerry then sent Robert to explain his storyboard to Emma and started putting the slides into the slide show. Emma joined her and they reviewed the show, calling Robert over afterwards to show it to him. Kerry then asked Robert to explain his storyboard, and when he couldn't, she got the teacher and Robert went to the computer. The teacher came over and as Robert tried to explain condensation to the teacher, Kerry remade Robert's picture. With the teacher, they decided that they needed more research on condensation.

Friday (10.05 - 10.35, 10.55 - 11.45)
Kerry and Emma started at the computer, Robert sat slightly away, daydreaming or playing with the microphone. During the first 20 minutes, Kerry and Emma made the slides and Robert's suggestions were usually rejected.[1] Kerry sent Robert to make a new storyboard template, even though he wanted to stay at the computer. He moved to a far corner of the classroom, behind a bookshelf.

After lunch, Kerry and Emma used the computer and Kerry sent Emma to get Robert. The teacher called Robert over, and asked if he had had a turn. Robert said no. The teacher asked Kerry who had made it all and Kerry said that it was now Robert's turn. Although the teacher seemed to be reassured, Kerry carried on using the computer and Robert wandered off.

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[1] For example, he asked about putting parachutes onto the raindrops, but Kerry said no, they are going up, it is evaporation not rain, and they would need a rocket booster.

When Robert started using the computer, Kerry and Emma left to start making a new storyboard. However, Kerry returned, watched Robert for about a minute and took control and changed the work that he had been doing. When she had showed him exactly what she wanted, she left him and returned to Emma but after about 5 minutes, she returned and Robert retreated to the corner. Emma asked him what he was doing and he didn't reply. Kerry also went and asked him what was wrong. He said that he was doing his own slide show. Kerry said that Emma was too and that he should talk to her. He didn't do this.

Kerry and Emma watched the show for the second time. They discussed what Robert was doing. Emma said he was doing water vapour although he wanted to do condensation. Kerry and Emma then printed out a story of theirs while Robert sat in the corner doing his storyboard from a book. He had added colour to this storyboard. Ten minutes later Kerry said that she was going to help Robert. She read his first slide and said that they had already done that ('what is water vapour?'). She said it didn't explain and started writing on it. Robert looked upset and bored. Kerry read her changes out loud and gave it back, then she gave him more things to do. 'What is condensation? How does it form? Why does rain form?'

Emma finished printing and looked at the whole show. Kerry came over and took the mouse and changed the transitions. Kerry then went over and took Robert's storyboard. She told him that they had finished the first one and asked about the house in his storyboard. She took the mouse and started making a slide. Kerry then gave Robert a turn, but she was critical and kept taking the mouse from him. At the end, she had taken over. At the end of the day, the teacher discussed with Kerry what remained to be done.

Monday (10.25 - 10.35, 10.50 - 11.50)
Emma started at the computer, Kerry immediately took over, and Robert watched. They started on Robert's storyboard, Kerry criticised it, saying that he had done it wrong, Robert walked away and started doing other work. The teacher discussed Robert's work with him and then asked Kerry how she was organising the group. Kerry said that they were taking turns. By now there was total task division and Emma was making a slide, while Kerry and Robert were doing other work. Emma finished her slide and told Kerry, who told her to save it and go and get Robert. Robert started making a slide, but Kerry continuously checked on him. Robert asked Kerry for help with saving, and she told him to ask Emma. It seemed that now that they had moved onto Robert's storyboard, Kerry had lost interest. When Kerry finished what she was doing, she went over to the computer and started directing Emma.

Friday (12 - 12.30)
They recorded the sound during a lunch period. The three children sat at the computer together, and they all took part but Kerry still dominated. The teacher was with them most of the time. He stopped Kerry and asked

her to explain to Robert what she was doing but Robert wanted to go and play football and did not want to say anything. They agreed that he could say the questions that were shorter. He did this but his voice was very soft and it was often rerecorded. Kerry made up her own script and deviated from the storyboard. At one stage, Emma and Kerry were giggling and after they had tried to record the script five times, Robert decided that he should read out the script. Kerry and Emma left the classroom and Robert recorded it. When they returned, Kerry rerecorded it. Towards the end, Kerry said that Robert could go and he left. The teacher then previewed the show with Kerry and Emma. He discussed one of the slides which he thought was very good. This was a slide that Robert had designed and made, but never received praise for. Other changes were discussed with the teacher.

Monday (1.30 - 2.50)
Emma and Kerry continued at the computer, while Robert was doing some other work. Kerry instructed Emma and left. After about 20 minutes, Kerry returned and took over control of the computer. Kerry returned to Emma's slide and changed the aesthetic aspects of Emma's work. Emma told her that she was doing it wrong and explained how to do it and Kerry took up Emma's suggestion. After about 5 minutes, Emma asked where Robert was. Kerry said that Robert should do a slide saying the end. She then sent Emma to tell him to do this. Robert came over and Kerry told him what to do. She then said "I'll show you" and did the background and one letter. Then she told him where the words should go. He finished the writing but Kerry took the mouse and moved the words. She then told him that he could go and do something else. Kerry then inserted the slide, called Emma over and told her to get Robert. They reviewed the slide show and Robert left. Kerry then moved all the files around in her folder.

Tuesday (12 - 12.40)
They recorded more sound during lunch time. Robert had cricket and was 'given permission' by Kerry to go, even though the teacher had sent someone to get him. Kerry then started recording the next slide but she started giggling so Emma did it instead. Kerry then redid it. They discussed why clouds rain and realised that they didn't really understand it and need to do more research. With the teacher, they decided to do the sound for the water cycle before they did the research. When they had finished recording the sound, they previewed the show and made some changes.

They found some books about weather, and a book on the Ancient Egyptians. Kerry told Emma to find information about why rain falls, while she looked at the book on Egypt. The teacher discussed condensation and why rain falls with them. They consulted more books and then recorded 'we don't know why rain falls'. The teacher encouraged them to look for more information. They appeared very confused, but Emma did have an acceptable explanation, which Kerry did not understand. The teacher tried to lead them to the correct explanation. They eventually reached an acceptable explanation and Emma started writing the script.

They checked it with the teacher and discussed changes. Emma then re recorded the new script, but Kerry stopped her and took the script and recorded her own script, which deviated from the agreed script.

At the end, Emma said it was finished and Kerry said that they needed to show it to Robert. The teacher explained to them that they would be showing it to the class and then they could change it to make it easier to understand and then present it at shared assembly.

After lunch they showed the rest of the class their work. The class were sitting on the floor in front of the computer. Emma and Kerry were sitting next to the computer, Robert a bit to the side of them. The teacher introduced it, and asked them if they wanted to say anything. Emma said "It's about the water cycle." Kerry started the show and they looked very embarrassed. When the show had finished, there was silence. Eventually one girl said that the explanations were clear and one boy said that he liked the pictures and asked how they had made them. The teacher asked them to explain how they made the slide show. Kerry started explaining and the teacher suggested that they should get their notes. One boy then asked about how clouds form and said that he had a different idea. The teacher said that their explanation was simplified. Kerry had now got all the pieces of paper and they stood up holding the pieces of paper. Kerry explained about the storyboards and notes that they had made. The teacher asked about what they should change for the shared assembly. The only comments were about the sound level. One child commented that not all of what they said was clear, but the pictures were brilliant. Kerry asked him which bits, and it seemed that his problem was to do with the sound level. Kerry then collected up all the pieces of paper and they discussed whether or not to show it in shared assembly. Then Kerry showed the rest of the class how slide show worked on the computer. Emma watched and Robert looked bored.