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Investigating conditions for higher order thinking in telematics environments

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USE OF THESIS

Investigating conditions for higher order thinking in telematics environments

By

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Abstract

Telematics, or audiographic conferencing, enables synchronous communication via telecommunications. A telephone link and computer communications allow students in distributed classrooms to participate in an extended, or virtual classroom. Telematics is widely used as an instructional medium for the delivery of curricula to students in rural and remote parts of Western Australia. Previous studies of learning mediated by this technology have shown limitations on the forms of interactivity, tasks and learner engagement. Students typically have been found to assume a passive role, often listening to a distant and invisible teacher, but not engaging in cognitively demanding tasks. The tendency for teachers to display didactic forms of teaching has been noted in a number of studies.

In 1996 an initiative was taken by the Education Department of Western Australia (EDWA) to extend the Academic Talent Program via telematics delivery. This meant that, for the first time, teachers would have to pursue the objectives of higher order thinking via telematics. The curriculum to be delivered, while covering the core curriculum areas, was also intended to enrich and extend students, and to develop independent thinking strategies. For the teachers involved, this presented a real challenge as they had no prior experience of teaching via telematics, or of fostering higher order thinking. This setting provided the context for this study which consisted of improving the learning environment in order to achieve the outcome of higher order thinking (HOT).

The central aim of the thesis can be expressed through two overarching research questions which the study was designed to resolve. These were:

- How can teachers support higher order thinking in telematics classrooms?
- How can the technology be used to support HOT?

In answering these specific questions, the study also focussed on the question of how to provide teachers with an operational definition of higher order thinking, which they could apply to telematics classrooms.

Participants in the study were five teachers, each with a distributed classroom consisting of several sites linked by modems and telephone. The five classrooms of the study were identified by disciplinary area as follows: Mathematics, Science, Italian,

English and Social Studies. The achievement of the goal of higher order thinking was orchestrated through a formative experiment, where successive interventions were made to transform the teaching and learning environments of the classroom. All interventions that occurred were conducted within the authentic context of the curriculum objectives, and there was no attempt to manipulate or control any aspect of classrooms. The teachers collaborated with the researcher in a 'research partnership', and adopted a scaffolding approach to higher order thinking, where they made higher order thinking the explicit instructional intention, communicated this intention and offered guided support to students, and fostered higher order thinking through a range of teaching strategies.

The study involved three observational phases during which classrooms were videotaped, interaction observed and dialogue recorded. Following the interventions, higher order thinking was observed to occur in student discourse, in particular contexts of scaffolded teaching. Accompanying the increase in higher order thinking there were changes observed in participation rates of students, including increased participation in classroom talk and discourse patterns where forms of collaborative and argumentative talk occurred.

The findings have led to a number of assertions to guide classroom practice in fostering higher order learning via telematics. These were to affirm the central role of the teacher in scaffolding learning, to enable students to represent and share ideas through the visual medium of the computer and to make higher order thinking an explicitly instructional goal which is communicated to students.

The study has implications for the design of virtual learning environments supported by technology as it emphasises the communicative and social nature of learning and the importance of 'guided participation' for learners striving towards higher order thinking.

Declaration

"I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution in higher education; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text."

Signed: [redacted]

Date: 26/2/1998

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Table of contents

Part I: Developing and refining a research focus

Chapter 4 : Context of the research questions 40

Part II: Theoretical framework and operational definition of higher order thinking

Chapter 5 : Theoretical framework: socio-cultural theory 47

Chapter 6: Sociocultural perspective on higher order thinking (HOT) 67

Part III: Research design and methodology

Part V: Summary of results with discussion and conclusion

List of Tables

List of Figures

References

Appendices

Part I

Developing and refining a research focus

CHAPTER 1

Rationale for the study

Introduction

The use of interactive technologies in open and distant learning is now a widespread phenomenon. Expectations of interactive media have continued to outpace effective instructional design and appropriate methodologies to fully exploit their educational potential.

Across Australia, a considerable number of schools use audiographic technology to teach classes in rural and isolated areas. According to the Victorian Ministry of Education and Training Report (Conboy, 1991), the term telematics is described as: *electronically based equipment and the processes and strategies used to enable interactive teaching and learning between two or more geographically remote locations.* In Western Australia, however, the term 'telematics' is used to describe the particular use of audiographic technology to teach students at a distance. In this research the term telematics is used, not in the generic sense described by Conboy (1991) but as a description of the use of audiographic conferencing for delivery of distance education. In this thesis, the terms 'audiographics' and 'telematics' are used interchangeably.

In an audiographics teaching environment there is a physical and geographic separation of students and teacher, with a teacher sometimes delivering the lesson to one or more sites. Three forms of technology enable the interactive link to be set up and maintained. The telephone provides interactive voice contact and a two-way communications link. A computer is used to share visuals and graphics. The screen can provide a number of interactive supports for learning:

- immediate feedback to students when used as a blackboard;
- visual stimulation;
- a flexible, editable page;
- shared reading and writing; and
- a record of written work that can be saved and printed.

Audiographics classrooms are distributed, asynchronous learning environments which depend for their success on the maintenance of a two-way audio communication link via the telephone. Without the audio link, it would not be possible for the lesson to

proceed as it is the medium through which classroom management and rapport is established. While computers at two or more sites are linked, giving teachers and students a view of the same information on the computer screen, the teacher uses the audio link to manage the lesson. Dialogue is critical to telematics environments and it is through verbal interactions with a teacher and peers that students participate in learning at a distance. The development of effective listening and speaking skills is therefore fundamental to both teachers and students participating in telematics classrooms.

There are many advantages of voice contact to learning and thinking critically, and research on learning with technology (eg., Wegerif & Mercer, 1996; Mevarech, 1993) affirms the importance of dialogue and communication for cognitive development through:

- sharing ideas and concepts;
- exposing multiple ideas and viewpoints;
- developing skills of argumentation;
- discussion and sharing of ideas; *and*
- collaboration and problem solving.

Audiographics environments have the capacity to support various interactions, as the communication can be both verbal and textual. While other modes of communication between teacher and learners (eye contact, gestures and facial expression) are constrained by the medium, the visual and verbal modalities can be used to maximum effect. In addition, students at each remote classroom may develop rapport with their colleagues than with the teacher, who is physically absent from the classroom. The potential of telematics to deliver interactive and efficient instruction to remote sites is documented in the literature (eg., Oliver & Reeves 1994a, 1994b; Rehn, 1994; Stacey 1993; Oliver & McLoughlin,1997).

Throughout Australia there has been extended use of audiographics for delivery of special educational programs and curricula to students in rural and remote areas. Increasingly, there are greater demands and expectations of such technology supported programs. In Western Australia for instance, the extension of audiographics delivery for academically talented students is not just a program oriented to provision of curriculum content. The educational goal of fostering higher order cognition and independent thinking skills in students is now explicitly stated in curriculum documents (EDWA, 1996). Generic thinking skills, information literacy and inquiry skills are emphasised across a range of educational contexts (Tinkler, Lepani &

Mitchell, 1996). It is expected that students will develop competencies in a range of competencies including:

- independent learning strategies;
- information handling and synthesis;
- independent learning;
- reflection and analysis to generate and refine knowledge;
- question generation and analysis;
- presentation of arguments;
- effective communication; and
- participation in group work.

While the aim of achieving higher order thinking is widely endorsed in the learning outcome statements for secondary schooling across Australia, there has been little attention paid to teaching practices with technology through which such outcomes can be fostered, or to the role of technology in supporting the types of higher level thinking processes that the curriculum statements endorse.

The debate about how best to integrate computers into the curriculum-based culture of schooling in not confined to Australia. In the UK it has been commented that computers are used in a way that is "decoupled from the mainstream of classroom life" (Crook, 1994, p. 29). In face-to-face classrooms where the teacher is present there has been a great deal of research into the use of computers to support group work and collaborative dialogue (Repman, 1993; Jonassen, Davidson, Collins & Campbell, 1995; Anderson, Tolmie & McAteer, 1993). In contrast, distance learning settings which support synchronous communication have received much less research attention, and the computer is often regarded simply as a hardware to enable geographically separated students to interact and share texts and resources (Wagner, 1994). This thesis will argue that technological link-ups and interaction between sites does not ensure learning and higher order cognition. There must also be the instructional intention to move beyond the technical link, to develop systems to support students to think independently, reason, communicate, and share ideas. In this sense, the present research can be seen in the context of the larger debate on how best to utilise technology in a distributed classroom.

While the potential of telematics to deliver interactive and efficient instruction to remote schools is documented in the literature (Oliver & Reeves, 1994b; D'Cruz,1989; Oliver & McLoughlin, 1997) these studies also signal the limitations of the technology. Among these are controlling and didactic aspects of teacher pedagogies (McLoughlin & Oliver, 1995b) and limited use of the technology to support dialogue between

students and to foster the generic thinking and communicative skills that are emphasised in the curriculum (Oliver & McLoughlin, 1997).

Aims of the study

Recent studies of audiogrpahics classrooms in WA have indicated constraints that occur in these environments that may impinge on learning (Oliver & Reeves 1996; Oliver & Reeves, 1994a). From descriptive studies on the patterns of interaction and teacher approaches to classroom management during audiographics lessons, one problem that emerges is the teacher-centred, interrogative nature of the teaching approach. Didactic teaching leads to passive learners. Three attendant issues which need to be addressed as a result of these findings are:

- whether the dialogue that typically occurs in telematics classrooms can be said to promote effective learning and higher level cognitive interactions;
- whether the teaching and learning processes can be implemented to support the learning process and promote higher order thinking; and
- whether the technology can be exploited and used to support learner cognition and higher order thinking.

There has yet been no long term study of how learning can be fostered in these environments, or of the role of the technology in supporting learning. Despite the general acceptance of computers in classrooms, there remains much uncertainty in how to best to apply them in support of learning, and how to conceptualise their educational role.

This thesis responds to these issues and to the concerns raised by recent studies in telematics classrooms (Oliver & Reeves, 1994a). It addresses the call for an examination of technology in support of higher order thinking, and it provides an intensive and analytic study of teacher practices in the telematics classrooms *in situ*, investigating actual classrooms, and authentic settings where audiographics is used to mediate the learning process. Through intervention and evaluation of authentic classrooms, the study aims to offer practical guidelines on how particular practices can be used to foster higher order thinking, and how teacher pedagogies can best support processes.

The research conducted to achieve these aims was neither experimental nor contrived, but was a long term study of teaching in progress, an ethnographic account of teaching and learning in telematics classrooms in Western Australia to bring about a particular learning outcome, ie., the achievement of higher order thinking. A further aim of the present study was to increase our understanding of the social organisation of telematics classrooms by investigating how teacher-student interactions are achieved and how students, tasks and technologies contribute to the development of higher order thinking. The research was intended to contribute to both teaching research and practice, by investigating the dynamics, interactions and learning events in telematics classrooms and to address the question of how to maximise learning in contexts where technology is used to mediate instructional processes at a distance.

Significance of the study

The fundamental questions addressed in the present study focussed on gaining an understanding into how higher order thinking can be achieved in telematics classrooms and to plan instructional interventions to bring about such outcomes. There is an educational imperative to investigate the learning potential of telematics environments as they are now an integral part of the educational delivery system to rural and remote schools across Australia. The application of technologies and information technology to learning at a distance is likely to continue for the foreseeable future.

The context of the study was the need to achieve higher order thinking outcomes in schools participating in the Academic Talent Program via telematics. Higher order thinking is now a recognised educational outcome in WA schools (EDWA, 1996), and there is a particular emphasis on this outcome in special programs to support talented students from rural and remote areas. By undertaking research with the intention of contributing to an existing educational need, and supporting the achievement of curriculum outcomes, this research presents an authentic, ethnographic, contextualised account of telematics classrooms, teachers and pedagogies, and the successive stages of achieving higher order thinking. In the broader educational sphere there has been much debate on the importance of developing self-regulated learners, capable of complex thinking (Boekaerts, 1997; Candy, Crebert and O'Leary, 1994), and this study contributes in a unique way to an understanding of teachers and students engaged in this process.

Through detailed observations and micro-analyses of interactions, the study provides a unique insight into the teaching and learning dynamics of classrooms where students

learn at a distance, and uses the findings to improve teaching in a situated context. While individual studies have made recommendations for pedagogic change (eg, Oliver & Reeves 1996; Stacey 1994), there have been no empirical studies to date in telematics classrooms which have documented teacher-student interactions and learning processes, or monitored technology use to show the potential of audiographic conferencing to enable students to engage in higher order cognitive activity. Existing research has indicated that the technology is used to didactic effect, for example the shared computer screen is used by teachers as a point of reference or agent of control to maintain group attention on a predetermined lesson (Evans & Nation, 1992; Squires & Sinclair, 1993; Oliver & McLoughlin, 1997). However, there is little process data on the communicative and interactive dimensions of teacher-student discourse, or on strategies to support higher order thinking. These are important questions as they impinge on considerations of how the learning experience can be improved for students in telematics classrooms.

A further aspect of current research is the absence of a strong theory of how communications technologies function to support the learning processes in telematics classrooms. A significant contribution of the study is the adoption and application of an integrated conceptual framework to investigate teaching and learning processes. The present study adopts a social and communicative perspective on learning, as this is arguably the most appropriate for telematics environments where communication and dialogue are paramount.

For teachers engaged in teaching in a distributed environment supported by telecommunications, there is a need to plan instructional strategies in a systematic manner so that the full potential of the technology is utilised and exploited. This research contributes to current theory and practice on learning in technology supported environments through an in-depth analysis of the activities, interactions and technology usage that occurs. The data gives an accurate insight into the culture and context of learning at a distance, and also provides a basis on which pedagogic practices and technology use can be reconceptualised.

The study relates to ongoing research on converging technologies which aim to mainstream communications technologies into education delivery. In addition, the research contributes in an original and substantial way to understanding telematics environments by designing a teaching-learning framework to support higher order thinking in school-based environments. In this way the practical outcome of the research is to make reliable and systematic observations, on which recommendations for real world practice can be based. In this sense, the research can be regarded as "socially responsible" (Reeves, 1995).

A further contribution of the research has been to develop an operational definition of higher order thinking which can be used to inform and guide classroom practice. The study shows how a coherent socially-based interpretation of thinking can inform educational practice and sustain higher order thinking outcomes, without reducing pedagogies in telematics environments to technology driven solutions.

Overview of the thesis

The thesis is divided into five parts. The first part focuses on a review of literature on higher order thinking with the aim of unveiling the complexity of the term and the need to develop an operational definition which is relevant to the classrooms of the study. Part 1 also provides an overview of the research on telematics classrooms and the constraints on the teaching practices that characterise these contexts. This research is used to focus on the immediate context of the study and the evolution of the research questions.

Part 2 provides an overview of the theoretical framework of the study, and describes how socio-cultural theory can be applied to the interpretation of higher order thinking, to teaching and learning relationships and to technology use. This theory provides a unifying thread in the study, and integrates the processes of higher order thinking, teaching and learning practices into a communicative, socially based framework where discourse and communicative processes are central. Part 2 also develops an operational definition of higher order thinking which is informed by the theoretical perspective of socio-cultural theory, and related to the curricular context of the study.

Part 3 describes the research design and issues concerning methodology, planning of the main study, data collection techniques and methods of analysis. The research design is linked to the theoretical framework of the study, and combines an interpretivist paradigm with qualitative approaches to data collection and analysis. In order to achieve the objective of fostering higher order thinking, a formative experiment was planned, in collaboration with teachers. The emphasis in the research design was to foster social and communicative processes in teaching and learning in telematics classrooms, and to encourage teachers to plan for higher order thinking.

Part 4 describes the phases of the main study and the results of each classroom observation. The observations of classrooms were conducted in phases. The first phase was an exploratory or observational study of the telematics classrooms, the results of which contributed to the planning of interventions in order to bring about

increased levels of higher order thinking (HOT). The results of this observational study (Phase 1) are reported. Teachers were then introduced to an operational definition of higher order thinking consistent with their own curriculum goals, and planned appropriate pedagogies to scaffold higher order thinking in their classrooms. Phase 2 observations followed, and the results are again reported. A further intervention was planned in order to improve HOT, after which the Phase 3 observations took place. The results of Phases 2 and 3 are also reported in Part 4 to show how teacher talk and teaching strategies changed from Phase 1, and how students engaged in language behaviours indicative of higher order thinking.

Part 5 contains the discussion and conclusions. The results are summarised and discussed, as are the changes in quality of technology use, student talk and teacher practices. The discussion section interprets the findings and proposes that environments that are intended to support higher order thinking should have a number of enabling characteristics, including appropriate employment of technology, teacher scaffolding of thinking processes and the fostering of dialogue conducive to higher order thinking. A number of assertions are made to guide teaching and learning in telematics classrooms. Finally, the limitations of the study are drawn, and the implications for further research are presented.

CHAPTER 2

Overview of telematics environments

Introduction

The use of interactive communications technologies in open and distance learning is bringing about a change of focus in a range of educational issues. Considerations of instructional design, appropriate selection of technologies and pedagogies that best fit the delivery of teaching resources are currently the subject of research (Mason, 1994; Laurillard, 1995). Many rural schools and distance learning environments now depend on a range of technologies, including conferencing technologies (Gunawardena, 1990; Hilz, 1994).

Teaching via audiographics is conducted to enable rural and remote students to access curriculum areas where there is no teaching provision in their own school, or when specialist areas of the curriculum, such as languages other than English (LOTE) or gifted programs need to be delivered. The use of audiographic conferencing in Western Australia (WA) has therefore expanded beyond merely providing access for rural and isolated students. The technology has been recognised as having the capacity to motivate students and provide a range of enhanced educational experiences.

The purpose of this chapter is to provide a rationale for the study by:

- outlining the distinctive features of telematics classrooms and their constraints;
- providing a critical review of research on telematics classrooms in WA and the wider context;
- relating technology mediated learning to the development of higher order thinking skills; and
- identifying gaps in both theory and practice that the present study will address.

Telematics environments and the technologies utilised

In an audiographics environment, teaching and learning is achieved through a telecommunications link between computers and an audioconferencing medium using telephone communications. Standard telephone connections are used to connect a

teacher to students at remote locations with two-way voice and graphic communications. Both the teacher and students can view and manipulate the same information on their computer screens using an appropriate software package. In most classroom contexts, extensive use is made of the Australian software package, *Electronic Classroom* (Crago, 1992). The screens are used as the chalkboard while the two-way audio communication is used for the normal student-teacher interaction. A typical setting sees a teacher connected to several remote sites and the establishment of a simulated face-to-face environment through the technology. There are now over 150 rural schools in Western Australia with the technology enabling them to support audiographics teaching and learning.

As a delivery system for distance education, audiographics is well documented in the literature (eg., Stacey, 1994; Oliver & Reeves, 1996). A number of papers have addressed the technical requirements for successful audiographics systems (eg. Rehn 1994) and yet others have investigated such issues as instructor profile and training (eg. Evans & Nation 1992; Conboy, 1990). While the technology has received positive reviews in many studies in the local context (eg., Rehn, 1992; Oliver & Reeves, 1994b), others have raised some concerns about the many factors which impinge on instructional effectiveness and learning outcomes (Oliver & McLoughlin, 1997).

The medium provides the means for teachers and students at a distance to communicate in ways that are common to conventional face-to-face teaching. Interactivity through talk is seen as the principal characteristic of an audiographics learning environment (Oliver & Reeves, 1996). Dialogue is therefore critical and it is through verbal interactions with a teacher and peers that students participate in learning at a distance. In addition, there is the potential for visual interactivity, as the computer screen provides the basis for shared visual input by all geographically distributed participants. Usually, however, the software enables the teacher to control this facility, and to allocate usage of the drawing tools to students at each remote site.

This medium appears to offer many advantages over other interactive media such as live interactive television, computer-mediated communications and computer-based learning applications due to the synchronous nature of the communication it supports. However, previous research has suggested that the medium is often not used to its full advantage and that many potential learning opportunities are being lost (eg. Oliver & Reeves, 1994b; McLoughlin & Oliver, 1995b).

The potential of communications technologies, including audiographics, to offer both interactivity and independence has been the subject of wide discussion (Jonassen, Campbell & Davidson, 1994; Juler, 1990). The remote learners are linked to a teacher

and other learners via the audio and computer link, and the learning experience has all the potential elements of multimedia experience with text, colour and photographic images together with two way audio provided by standard telephone lines. All the media can be utilised by both students and teachers, though, as Rehn, (1994) observes, the success of the interactivity achieved is determined by the degree of competence that the instructors and users demonstrate, together with the 'telepresence' of the teacher. This social presence, or degree of empathy and rapport that teachers are able to establish with remote learners may be one ingredient to successful teaching via this medium, and research has attested to the varying psycho-social behaviours exhibited by learners in computer-mediated communications (Walther, 1992).

As the teacher and students are physically separated and communications are mediated electronically, there is a need to understand the form, nature and effectiveness of technology and pedagogy in telematics environments in order to evaluate their educational impact (McLoughlin & Oliver 1995a; Stubbs & Burnham 1990; Catchpole 1993). This is essential to the present research, which aims to plan interventions to improve teaching processes in order to support higher order thinking.

In contexts where communication is mediated through technology there has been much debate on how learning takes place, and how communication and interactivity are established and supported (Laurillard, 1993b; Anderson & Garrison, 1995; Wagner, 1994). Learning at a distance differs in important ways from learning in face-to-face, teacher fronted classrooms. The physical absence of a teacher and the use of communications technologies to support interaction are the most basic differences. The loss of visual contact between teachers and students is a significant feature of learning via audiographics, and one that has been found to determine particular styles of teaching. Where there are few non-verbal features and contextual channels to support communication, the dependence on oral discourse is increased (Thompson, 1996). Where talk is taken as a sign of connectedness, silence may be regarded as lack of rapport, and several studies have found that a great deal of teacher talk fills telematics classes (eg., Oliver & McLoughlin, 1997), sometimes perhaps to the detriment of opportunities for students to express their ideas or to engage in discussion.

Research from various disciplines has recognised the importance of dialogue and interaction to education, and the need to establish communication between the parties involved (Fulford & Zhang, 1993; Frampton, 1994). This research suggests that the question of teacher-learner interaction is likely to be more important where the environment is distributed, and learners are geographically distant from the teacher.

Constraints and limitations in telematics classrooms

In telematics classrooms, there are a number of constraints that may apply to learning, due to the limitations of the software and the nature of the mediated communication links. Firstly, only the teacher can allocate control of the computer to students, and reclaim it without requesting hand-over of control. Use of the computer is therefore restricted and confined to teacher initiatives rather than student choice. Secondly, when one or more sites are connected, communication protocols are required in order for all students to be given an opportunity to participate. This sometimes means that a teacher has to call on students by name, rather than allowing students to self select speaking turns. A further limitation is the amount of planning required to enable students to communicate with each other. The audio link provides this possibility, but planning is required and teachers have to know how to orchestrate student to student interaction. It is not surprising to find that in many telematics classrooms there is usually little, if any, student-student interaction (Oliver & McLoughlin, 1997).

There are also constraints that operate because of the lack of non-verbal features to support dialogue. Explicitness and clarity in speech may sometime lead teachers into directive styles of interaction. In addition, students may misunderstand, or be apprehensive about using the technology. In their distant classrooms, students also have to cope with technical breakdowns, new communication protocols for audio-based interaction and the development of new social skills (Gunawardena, 1992). For teachers, the distinctive features of teaching via audiographics are as follows:

- physical separation of student and lack of eye contact;
- use of technology to mediate communication;
- simultaneous technological links to geographically separated classrooms; and
- reliance on computer technology to provide a shared visual reference.

In telematics classrooms, the teacher must be sensitive to the communication and technical problems of students, plan activities in the event of a computer breakdown and apply pedagogic practices to enable all students to participate. These additional demands also mean that teachers have to be technologically competent and aware of the impact of the technology on teaching style and the social climate of the classroom.

It may be that the use of technology to mediate communication and the dependence on computer links for the visual dimension often produce impediments to spontaneous conversation and interaction. As a consequence, telematics teaching is often regarded

as a second choice, or less than satisfactory alternative to face to face teaching (Hill, Meulenberg et al, 1991).

Critical review of the research on telematics environments

This summary of findings from the research on telematics classrooms will focus on three issues which have motivated the present study:

1. findings on the characteristics of teaching and learning in telematics environments;
2. research linking dialogue, interaction and learning; and
3. research documenting limitations of teaching and learning in telematics classrooms.

From the available published research, only those teaching-learning issues relevant to the present study will be discussed. These concern the questions of student-teacher interaction, teaching strategies and the problem of fostering greater student autonomy and implemented student-centred teaching practices.

Recent research has also suggested that often the teaching and learning with this technology has failed to take full advantage of the many forms of interactivity that are possible. The forms of interactivity most commonly employed in lesson delivery appear to be used mainly for management, communication and student engagement (eg. McLoughlin & Oliver, 1995a; Oliver & Reeves, 1994a; McLoughlin, 1996).

Findings of studies

As a broad overview, studies have been conducted in the following aspects of telematics teaching:

1. evaluation studies which look at the overall effectiveness of telematics teaching using participant and non-participant observation approaches (Oliver & Reeves, 1994a; Squires & Sinclair, 1993),
2. research into teachers' attitudes to learning and implementing the audiographic technology (Stacey, 1994);
3. staff development projects and reports on their outcomes (Conboy 1990; Conboy, Elliott & Martin, 1992), and

4. descriptive studies involving profiles of cross-sectoral usages and the application of staff development strategies (Hill, Meulenberg et al. 1991).

Many of the guides to telematics teaching stress the need for a facilitating role for the teacher (eg. Elliott, 1992; Conboy 1990; 1991) and a consequent reliance on student responsibility, resource based approaches and expectations that students will assume responsibility to a greater extent than they would in a classroom. It has also been observed that students must take more responsibility for their own learning as the physical absence of the teacher means that students have to take the initiative to ensure that equipment is functioning and provide feedback to the teacher on how the lesson is being received (Burge & Roberts, 1993). For teachers, some of the difficulties documented included:

- conducting an effective lesson without eye contact;
- trying to get to know students without seeing them;
- communicating with the absence of feedback from students,
- feeling of pressure and stress in trying to involve all students actively; and
- the lack of instant visual and graphical communication.

One of the contradictions that emerges from the research on telematics teaching is that while teachers depend on highly motivated co-operative students for the success of the lessons, they rarely make their lessons fully learner-centred, and persist in retaining control over the pace and sequence of interactions at all stages (McLoughlin & Oliver, 1995b). The inherent contradiction between the desire to achieve a motivating, interactive learner-centred environment and the effort made by teachers to maintain control over all aspects of teleteaching is another striking feature of reports on telematics classrooms.

In these environments, limitations on interactions often result from the technology, teacher management strategies, or a combination of both. Evans & Nation (1992) reported that their observations confirmed that teachers felt compelled to use the audio link to compensate for lack of visual cues and this resulted in the lessons being didactic and interrogative. The adoption of a teacher centred approach was evident in teachers' persistent questioning of students. Clearly, the main agenda for teachers was maintaining control and discipline in their teaching and the computer was used to support this approach.

These findings are confirmed by Oliver & Reeves (1994a) who reported that teachers exerted control over the dialogue through :

- leading questions that required no answers;
- questions that were answered by the teachers after short delays;
- questions that could not be answered;
- setting routine tasks for students; and
- directives to individual students that required minimal cognitive input.

It was also observed that there was an inverse relationship between teacher dialogue and student verbalisation throughout the lesson (Oliver & McLoughlin, 1997). As student responses diminished, teacher talk increased, resulting in a decrease in interactivity and a tendency towards didacticism. These findings are related to the critical link between teacher control and interactivity (Kinzie, 1990). If there is asymmetry in teacher student control of dialogue, student-teacher and student-student dialogue is less likely to occur. Teacher control therefore constrains the potential for students to take the initiative in inquiry and questioning, which are fundamental to higher order thinking (Paul, 1994).

Didactic pedagogies

In discussing teachers' experiences, Squires & Sinclair (1993) reported that teachers very strongly felt the absence of visual cues. Given the importance of non-verbal exchanges in communications generally, this is hardly surprising. The issue of effective control and management strategies is particularly crucial in site to multi-site contexts, where the teacher carries responsibility for the conduct of several physically separated classes. In such contexts there is a greater pressure on the teacher to exert controlling strategies. However, in site-to-site audiographics teaching, pedagogic strategies reported by instructors included:

- reliance on diagrams to display content;
- need for clear instructions;
- increased verbalisation;
- accurate time allocation and management;
- questions directed at particular students; and
- advance planning to ensure coverage of curriculum.

Reports and evaluation studies showed little uniformity in the strategies adopted by teachers, except for unanimous agreement that telematics teaching was stressful and required planning. It was also reported that teachers needed models of student-centred learning as they believed that many problems were beyond their control (Stacey 1994).

In a study of telematics classrooms in Western Australia, Oliver & McLoughlin (1997) investigated the form, nature and purpose of interaction that occurred between teachers and students and the extent to which the computer was used to support learning. Using a framework derived from content analysis, the authors identified a range of communicative behaviours that occurred. The study concluded that:

- in all classes there was a much higher rate of teacher initiated than student initiated dialogue, reflecting a dearth of learner control;
- few cognitive interactions were found, and most communication centred on exposition and explanation of content by teachers; and
- computer use was sparse and what did eventuate exploited only the display functions of the computer.

Overall, while the lessons appeared to engage and motivate students, there was little evidence that higher levels of engagement by students were either intended by teachers or feasible, given the limited and asymmetric nature of the communications that occurred. The findings from these studies confirm that the technological hitches that occur necessitate a teaching approach where there is mutual reliance and co-operation between teachers and pupils. In the literature on telematics there have been few studies which have systematically documented the interactional strategies and patterns of communication which constitute this teaching environment, which has been acknowledged to be heavily dependent on the aural and verbal interactions for its success.

To summarise, existing research has indicated that the technology is used to didactic effect. For example, the shared computer screen is used by teachers as a point of reference or source of control to maintain group attention on a predetermined lesson (Evans & Nation, 1993; Squires & Sinclair, 1993). Moreover, there has been little research on the student-teacher interactions in telematics classrooms, learning processes of students and ways to maximise use of the computer to generate collaborative work and higher level cognitive processes. These are important questions as they impinge on considerations of how the learning outcomes can be improved in telematics environments.

Consideration of the social context of telematics classrooms is another dimension of effective pedagogy and student learning at a distance which has not been the subject of research. The next section will look at research findings on the link between forms of social interaction in telematics classrooms and how these relate to higher order thinking outcomes.

The social organisation of telematics classrooms

Few studies of telematics classrooms have given attention to the social aspect of learning and how context may affect learning outcomes. Every classroom functions as a social context for learning. This context is not merely the physical and concrete details and hardware, which may be more accurately be described as the *setting*. Context is created by talk and by goals and expectations that teachers set for students, and by the mutual understandings that are achieved when teachers and students interact. Conversation reflects the degree of understanding that participants in dialogue have, and the context is created partly by the expectations of students and partly by how the teacher frames the learning experience. It is possible to access the social context of telematics classrooms by looking more closely at the tasks and activities that occur and how they offer particular 'discourse' opportunities for students, where ideas can be expressed (Mercer, 1994; 1996)

Telematics classrooms are often compared to face-to face teaching contexts and found to be less effective learning environments. This is not to say that the latter are ideal learning environments. Indeed research has shown the opposite, that constraints on the types of interactions are frequent due to teacher control of turn taking, and that there is an atmosphere of competition rather than collaboration in most classrooms (Mehan, 1979; Edwards & Mercer, 1987). However, the observation that many telematics classrooms rely on teacher questioning, didactic teaching and apparent control of student initiatives has led to the conclusion that these environments could be much improved (Oliver & McLoughlin, 1997). But there is still a lack of process data on the actual context of learning, and no micro-analyses have shown participant structures in telematics classrooms.

A review of extant research shows that there are few studies of what might be considered effective or creative practice for telematics environments, and this is an issue addressed in the present study. For example, instructional strategies to increase the sense of group interactivity have not featured a great deal in the research on telematics classrooms. Yet the social environment does have an impact on learning processes and outcomes. As learning requires communication and dialogue, it is a social rather than an individual activity. Teaching strategies that have been shown to increase group cohesion and collaboration in technology supported environments are:

- designing learning tasks that can be done collaboratively and directed towards achieving consensus;
- designing activities that help learners to understand the social conventions of working together in small groups;

- creating a classroom climate where students understand the social rules of working together and learning from each other; and
- arranging for participants to have different conversational partners so that the dialogue is not merely teacher initiated.

(Goldman & Newman, 1992; Hoyles, Healy & Sutherland, 1991)

The research of Greeno, (1997) also suggests the need for participant structures, where roles of teachers and students are seen to overtly support and foster collaboration and a sense of participation in a wider, distributed community of learners. This is particularly important in contexts where individuals and small groups of students are engaged in learning at a distance, where there are constraints on the kinds of interactions that are possible in face-to-face teaching. These findings have not however, been applied to telematics classrooms.

One of the few empirical studies of social context in audiographics classrooms has been conducted by Gunawardena (1992), who reported on changes in social interaction that occurred when a change of teaching style was adopted. As the audio medium does not support a lecture style pedagogy without reducing students to boredom, she decided to abandon knowledge transmission approaches and focus instead on learner initiated inquiry and exploration. This learner-centred pedagogy resulted in a change in the social organisation of the classroom and students began to take responsibility for initiating discussion and collaborating.

The necessity for inclusion of the social context in learning and of creating appropriate contexts for learning is recognised in social- interactionist accounts of learning of learning (Vygotsky, 1978; Crook, 1994). In such theories, learning involves language use and social interaction, as these are universal in most formal learning settings.

The fostering of higher order thinking in telematics classrooms was recognised in an investigation by Anderson & Garrison, (1995) who directed their attention to establishing an appropriate social context for learning in an audiographics classroom. This was the 'community of inquiry' approach of Lipman (1991), where the classroom became a forum for cooperation and collaboration rather than competition and individual achievement. The social rule that operated was that participants learnt together, and from each other with a teacher providing support when needed. Students learnt to internalise the dialogue that they have participated in, for example providing reasons for solutions and expanding or explaining their perspectives. Anderson & Garrison (1995, p.33) explained this as developing, extracting and refining existing knowledge from the group, rather than transmission of knowledge from teachers to students. The social context of the community of inquiry approach was

intended to develop students' higher level thinking skills by giving them control, initiative and opportunities to create mutual understandings. This approach changed the dynamics of learning in the following ways and led to:

- knowledge was created among the group;
- learner-learner interaction increased;
- no directive learning packages were used;
- consultation and negotiation were essential; and
- student initiative was the starting point for activity.

Against this background of research on the importance of the social context of learning, the dimensions of learning in telematics environment can be seen.

Interpersonal, social and educational settings can either support autonomy or exert a controlling function depending on events like feedback, questioning strategies, and opportunities offered for students to take control of their own learning (Peterson & Swing 1992; Wang & Peverley, 1987). These interrelating elements are represented in Figure 2 .1 which illustrates the interrelationship between the social context, instructional processes and learner self-regulation.

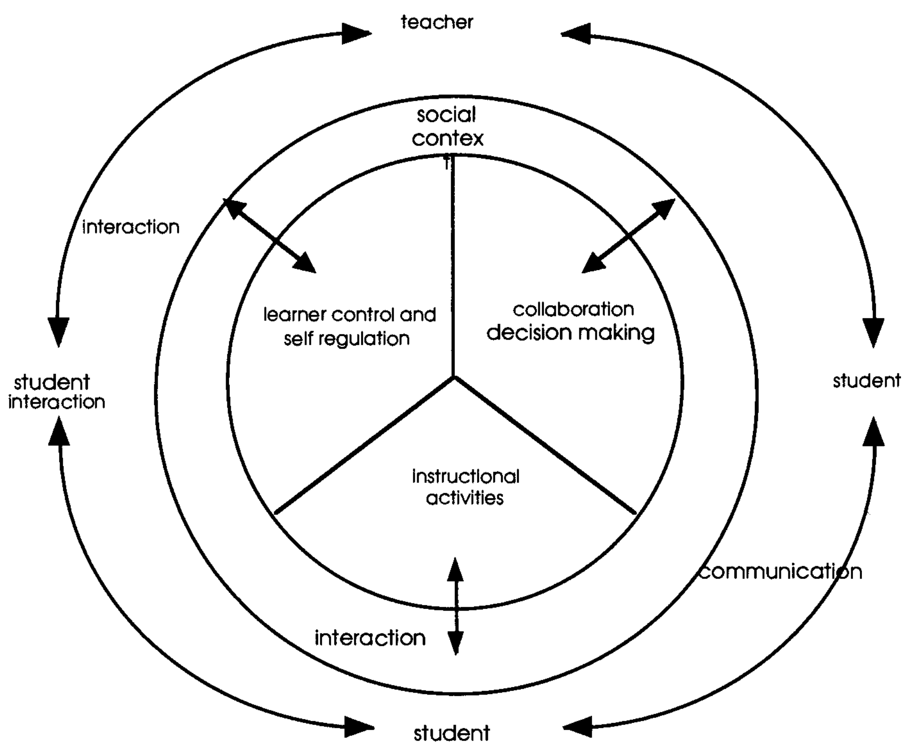


Fig. 2.1: The social and communicative context of learning

Social interaction is seen as the one aspect of conventional face-to-face teaching that has traditionally been absent from open learning and distance education environments

(Juler, 1990). There have been several attempts to provide a conceptual framework that describes the role and influence of interactions on learning outcomes in the teaching and learning process. Laurillard (1995) provides a framework that uses a conversational metaphor to discuss the different forms of interactivity that learning entails. In this framework, she uses descriptions of the role of the teacher and learner to provide an insight into the use of dialogue and conversation to support learning. Through discussion, interaction and adaptation of ideas, learners can not only initiate dialogue but also learn how to think at higher levels. Laurillard's (1993) framework is later discussed in relation to the theoretical framework of the study (Chapter 5) and in the analysis of computer use to support higher order thinking and learning (Chapter 10).

In summary, while the social aspect of learning has been recognised in much research on computers, this has not been applied to telematics environments, which partly accounts for the lack of a coherent theory of learner activity which could inform practice. Dialogue is critical to learning in telematics classrooms, and it is through verbal interaction with teachers and peers that students engage in learning at a distance. Yet, research on telematics environments has not yet incorporated the social dimension into an account of effective teaching and learning which would foster higher order thinking. The more general issue of whether communication media can support higher level cognition will next be discussed.

Can communications media support higher level thinking skills?

Different views on how technology and media support learning have been much debated in the literature and while there is little consensus to be found, a number of perspectives can inform the present debate on how higher order thinking can be fostered in telematics environments.

Discussions on the application and use of technology in learning environments reveal a surprising range of perspectives. Clark (1983) declared that educational technologies and media were mere conveyances that deliver content but have no influence on learning. He used the metaphor of technologies as 'mere vehicles' to deliver instruction. Evans & Nation (1993, p. 198) state that "technology and pedagogy are, and have always been fundamental and inseparable elements of education". This view can be supported by research which shows how the use and application of technologies in schools has been imbued with theories, pedagogies and strategies as teachers strive to use technology to achieve educational outcomes (Underwood & Underwood, 1990).

In 1994, Clark again reiterated that media would never influence learning, but simply provide access to learning. He also maintained that any teaching method could be supported by any number of media, with similar results, and that claims that particular media could enhance learning were unfounded. On the other hand, Kozma (1994) sees learning as occurring in harmony with technology, because of particular combinations of technologies and the initiative of learners operating in contexts where a range of resources were available. He asks: "In what ways can we use the capabilities of media to influence learning for particular students, tasks and situations?" (Kozma, 1994, p. 18) While Kozma is concerned with learning via media, Jonassen, Campbell & Davidson (1994) are concerned with the wider issue of distributed learning environments, where resources, technologies, teachers and learners are part of the overall context, and that the focus of attention should be on how media support, rather than control learning. Their view is that media are also part of the learning environment, and that learning is situated in the social context.

A more explicit social and communicative role for technology has been developed by a number of researchers (Laurillard, 1993a; Mercer, 1993; Light, 1993; Crook, 1994) based on the work of Vygotsky (1978). Among these theorists there is common ground: an increased recognition that talk and interaction between learners working at computers can be advantageous, as talk makes thinking visible and also leads to reasoning and revision of ideas. These social dimensions of learning in technology supported environments are explored in the theoretical framework of the study in Chapter 5.

In telematics environments, there is another dimension to interaction and learning. Most telematics lessons have two-way interaction between teacher and students. In addition, there is the potential for student-student interaction, student-computer interaction, and student-teacher-computer interaction. Though the telematics technology is extolled for its capacity to provide real time interaction between teacher and students, the actual quality and nature of this interactivity and how it contributes to learning remains ambiguous. Moore (1989) distinguishes three kinds of interactivity: the interactivity between teacher and student; student -to-student interaction and student -text interaction. (See Figure 2.2.)

With reference to the extensive literature on interaction and interactivity, the usefulness of the term as a construct for assessing the success or otherwise of the technology has been brought into question by Frampton (1992) and Thompson & Jorgensen (1989).

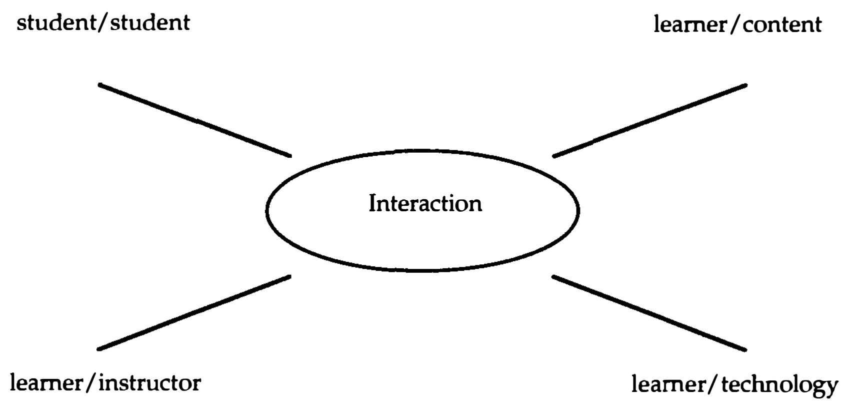


Figure 2.2: Types of interaction in distance settings

Further research by Sims (1994) showed that the most successful technologies were those allowing multiple levels of interactivity, learner control and reciprocity. These studies adopt a view of interaction as reciprocal communication and dialogue where students have participatory rights. Telematics environments would seem to be ideal locations in which to investigate dialogue and interaction among teachers and students. However, investigations of how interaction and cognitive talk can be supported through various forms of social interaction have not occurred in relation to school-based delivery of programs. This is one further gap in the current literature on telematics classrooms.

The preceding review of empirical studies of telematics environments in Australia provides a good background against which to indicate areas which need further investigation. The considerable reliance on audiographics technologies in Western Australia and throughout Australia, (eg, Victoria and Queensland) provides a rationale for research which will seek to improve opportunities for interaction and learning afforded by this technology, to maximise its benefits and to devise appropriate instructional approaches.

Several dimensions of learning need to be accounted for in order to arrive at a complete understanding of how learning takes place in telematics classrooms. The research that has already been conducted signals the need to exploit the technology to its greatest educational advantage and to provide teachers with models and strategies which will sustain interaction and dialogue (Evans & Nation, 1992; McLoughlin, 1996; Oliver & Reeves, 1996). However, without a strong, unifying and coherent theory of how social interaction and dialogue function to support learning processes in telematics environments, the obstacles to effective learning cannot be identified. A theoretical framework based on socio-cultural theory is explored in Chapter 5, where interaction, dialogue and technology are integrated into a pedagogic approach capable of fostering higher order thinking.

Summary and conclusions

The need for research on teaching and learning processes in telematics is signalled clearly in the existing literature. That communications technologies have the potential to support independent learning and provide equitable access to education is recognised (Lundin, 1992; Lowe & Pietsch, 1993). There is less agreement on what constitutes effective instructional planning for learning via audiographics and the literature reviewed indicates that future research is imperative in order to maximise educational delivery via communications technologies (Conboy, 1990; 1991; Oliver & Reeves 1994a; 1994b).

Four major issues have emerged from this review of research on telematics classrooms and provide a rationale for the study. First, there is evidence that telematics environments lend themselves to forms of didactic teaching, (Oliver & McLoughlin, 1997) but this occurs as a result of pedagogic approaches, and it not inherent in the technology itself. While there has been much criticism of teacher led discourse in telematics classrooms these studies have not provided a sufficiently constructive alternative agenda. There is clear evidence that teachers control classroom discourse and that teaching strategies tend to be directive and content driven and that teaching strategies to redress this are needed.

Second, in telematics classrooms, while studies reviewed have documented teacher-centred approaches to teaching, there is little process data available which can be used to isolate and identify the controlling features of dialogue and interaction, or which could be used as the basis for constructing an alternative approach to teaching and managing learning. While individual studies have made recommendations for pedagogic change (Oliver & Reeves, 1996), there are no empirical studies in telematics which show the nature of constraints on interactivity, how these constraints are a function of teacher dialogue and what potential the technology has to enable students to engage in higher order cognitive activity.

Third, there appears to be no coherent theory of teaching and learning with technology which could be applied to telematics classrooms, and used to guide and support the learning processes that occur. There is a need for a theory to encompass technology based learning environments, which links the attributes of technology with the social processes at work in the classroom.

Fourth, conferencing media such as audiographic conferencing are recognised in the literature as logistically important (Evans & Nation, 1993; Lowe & Pietsch, 1993) but

these studies have not investigated the quality of student learning, or how higher levels of cognition can be fostered. From descriptive studies on the patterns of interactions and teacher approaches to classroom management (Oliver & Reeves 1994a) the problem that emerges is the teacher-centred, interrogative nature of telematics classrooms. Three attendant issues which need to be addressed as a result of these findings are:

- whether teaching strategies that occur in telematics classrooms can be changed to promote effective learning and higher order thinking;
- whether the telematics classroom can be structured more effectively to support the learning process and promote higher order thinking; and
- how technology usage can support higher order thinking.

The emphasis on higher order thinking as an educational outcome raises the question of exactly what such thinking involves, and what its parameters are. Some indications of how the term is used in curriculum documents has been provided, but these are general and global statements, rather than achievable educational goals. In order to achieve outcomes that support higher order thinking, an operational definition of the term was needed which could be translated into classroom practice. These issues are discussed in the next chapter.

CHAPTER 3

The debate about higher order thinking (HOT)

Introduction

As many of the curricula in place in Australian schools now espouse and advocate the development of higher forms of cognition and thinking, it is essential that these concepts are clarified. In the course of this discussion the term 'higher order thinking' (HOT) is analysed as the literature shows that many definitions of the term are found. The search for common ground among these definitions was the purpose of this review of literature, as was the aim of developing an operational definition that would be relevant to this study.

The ability to think and reason is regarded as the defining quality of an educated mind, an educational goal which is undisputed (Paul, 1993; McPeck, 1990). Nevertheless the term had proved elusive and ambiguous. While advances in cognitive psychology (Resnick & Klopfer, 1989) have enlightened us about cognition, effective teaching and learning skills and approaches to pedagogical practice, the term higher order thinking has not yet been clearly defined. One often cited view is that while we are able to recognise higher order thinking skills when we encounter them, they are difficult to define in exact terms (Resnick, 1987).

The review of literature in this chapter will suggest that while there are different views and interpretations of thinking, few of these provide sufficient guidance to teachers who must translate their understanding of theoretical constructs into practical strategies for classroom application.

Besides giving a summary of the main interpretations and approaches adopted by theorists, this chapter will clarify some of the main issues surrounding the term higher order thinking, and why the term is not clearly defined. Other aspects of higher order thinking reviewed are:

- how thinking skills are defined and the multiple meanings attributed to the concept;
- whether such skills are general or context-based;
- what criteria can be used as indicators of higher order thinking and what the outcomes of higher order thinking are; and

- what specific behaviours can be said to qualify as higher order thinking.

The overall aim of the chapter is to present a case for an operational definition of the term higher order thinking so that the social, interactive and communicative nature of learning in telematics environments is taken into account. Ultimately, this discussion seeks to integrate the operational definition into an overall theory of teaching and learning which can be applied to telematics classrooms for this study.

Definitions of higher order thinking

While thinking is a natural function, much of what we would consider to be higher order thinking is not. Perkins, cited by Beyer (1988, p. 27) emphasises this point:

> Everyday thinking, like ordinary walking, is a natural performance we all pick up. But good thinking, like running the 100 yard dash, or rock climbing, is a technical performance.... In a number of ways, good thinking goes against the natural grain. People tend not to consider the other side of a case, look beyond the first decent solution that presents itself, or ponder the problem before rushing to candidate solutions...

With a multiplicity of meanings, it is sobering to remember that the problem is not that there is an infinite number of thinking skills, but that there are many different names for the same thing, with each investigator having his or her own preferred set of names (Sternberg, 1990). What this amounts to is the absence of a clear definition. Discussion of what constitutes higher order thinking is like entering a theoretical minefield, picking a path that steers clear of conceptual traps and jargon, while trying to emerge with a holistic, concise, and operational view of the processes involved.

What distinguishes higher order thinking from other forms of thinking? There is a growing body of literature in Australia and overseas on the need for citizens who are self-directed, lifelong learners (National Board of Employment, Education & Training 1995; 1996; Zuboff, 1988). The characteristics of the lifelong learner as depicted by Candy (1995) are reflected in many definitions of higher order learning that emerge from this review of the literature. The lifelong learner is said to exhibit these and other characteristics (NBEET, 1996, pp. 81-82):

- An inquiring mind, characterised by:

  - a love of learning;

- a sense of curiosity;
- a critical spirit;
- comprehension monitoring and self-evaluation.

- A sense of personal agency as shown by
  - a positive concept of oneself as able and autonomous.

Throughout the literature the recurrent themes are that learners need to become autonomous, self-directed and flexible, which are all indicators of higher level thinking (Mulcahy, Short & Andrews, 1991; Costa 1991). There is also support for improving higher-order thinking by special programs, and research directed at promoting quality learning in the context of the school so that such skills can develop (Biggs, 1991). Students may for example, approach tasks with different ambitions which affect the strategies they use, and which impact on their development of thinking skills. Biggs (1991) has classified these behaviours as *surface*, *deep* and *achieving* approaches to learning. Only a deep approach is intrinsically related to understanding and the search for meaning and higher levels of understanding. Both surface and achieving approaches are concerned with reproduction of information in pursuit of extrinsic rewards such as passing examinations.

Surface and deep approaches are similar to the distinction drawn between principled and procedural knowledge (Edwards & Mercer, 1994). This perspective suggests that higher order thinking skills are *principled* understandings of what actions, expressions and concepts are appropriate and correct while *procedural* knowledge is merely saying and doing what is required, either because the teacher expects it, or because there is an extrinsic reward for this knowledge (Edwards & Mercer, 1987).

Definitions of critical thinking and higher order thinking are abundant and there are numerous characterisations of its forms and manifestations. Nickerson (1989) comments on this as follows: "If there is one point on which most investigators agree, it is that thinking is complex and many faceted and, in spite of considerable productive research, not yet very well understood". In searching for a definition of higher order thinking Lipman (1991) describes it as 'cognitive excellence', a term which is intended to combine critical thinking with creative thinking. Other descriptions used by Lipman to describe higher order thinking is that it is recursive, metacognitive and reflective.

This review of the term 'thinking' shows that finding a well founded definition is a difficult task, but the problem of defining it should not hamper our efforts to foster it in students. This statement can be interpreted as supporting the need for an

operational definition. The next section looks at the plethora of meanings offered for higher order thinking, including the supposed difference between higher and lower order thinking.

Multiple meanings for higher order thinking

A broad definition offered for higher order thinking is that it is a search for understanding, an attempt to make sense of experience (Beyer, 1988). Such a generality provides little or no substance to the term, and certainly gives no direction for teaching and fostering effective thinking in the classroom. In fact, many of the present problems surrounding the definition of higher order thinking are to do with the confusion of terms such as 'higher order thinking', 'critical thinking' and 'problem-solving' and the apparent ease with which they are used interchangeably. Lewis & Smith (1993) provide an enlightening discussion on these terms and attributes the confusion that often arises to the differing perspectives of philosophers and psychologists on thinking.

Traditionally, philosophers have always stressed the importance of critical judgement, of weighing evidence and guarding against false assumptions and inappropriate conclusions. For philosophers, one attribute of higher order thinking is defined as *critical thinking*, and at the heart of such thinking is the search for the attributes of objectivity, relevance, consistency and defensible reasons, or evidence for beliefs. The work of Lipman (1991) provides an example of higher order thinking which entails reasoning based on evidence, standards, rules and publicly acknowledged criteria. The label 'complex-thinking' (p. 23) is also used to mean that it is a combination of thinking about subject matter and about procedures or methods, and therefore includes metacognition.

Some psychologists, on the other hand, are more concerned with how to solve problems, and with the question of how cognitive skills can be harnessed to planning and structuring experience. Higher level thinking is viewed by them as a skilled performance in which specific kinds of operations are executed (Sternberg, 1990). For example, some cognitive psychologists maintain that thinking consists of discrete operations and strategies used in combination with each other to achieve certain purposes (de Bono, 1985). Thinking strategies may be conceived of as problem solving approaches, decision making skills, conceptualising, classifying and interrelating categories (Glaser, 1984). Acquiring problem solving skills, would, from this perspective qualify as higher order thinking. These principles are exemplified in the work of De Corte (1990), Sternberg (1996), Nastasi & Clements (1992). Learning

environments designed to foster problem solving are based on a view that learners need mastery of various categories of skills, such as:

- flexible acquisition of a domain specific knowledge base;
- heuristic methods (ie., techniques for problem identification and analysis;) and
- metacognitive skills (ie., knowledge of one's own cognitive strategies, self-monitoring and regulation).

In the West Australian context, the Education Department has cited the work of Ennis (1987) in their definition of higher order thinking cited in the *Stepping Out* curriculum framework (EDWA, 1995, p. 9.2).

> Critical thinking is reasonable reflective thinking that is focused on what to believe or do. Note that this definition does not exclude creative thinking. Formulating hypotheses, alternative ways of viewing a problem, questions, possible solutions, and plans for investigating something are creative acts which come under this definition.

Here Ennis (1987) adopts a broad definition of critical thinking, which includes creative thinking, problem solving and critical thinking. Other theorists claim that the term critical thinking is coming into common usage to encompass both problem solving and handling critical analysis and evaluation (Lewis & Smith, 1993). However, for others the term has connotations that link it with philosophy, or abstract thinking.

While the contributions of both psychology and philosophy to the discussion of higher level thinking are valuable, neither, according to Lewis and Smith (1993, p. 132), can be said to be complete as both perspectives tend to exclude skills and attributes integral to the other. A more balanced perspective is now emerging in the literature, which attempts to combine the insights of both disciplines, and includes problem solving skills, verbal reasoning, cognitive strategies and metacognition (Means & Voss, 1996; Perkins, 1997; Young, 1997).

Broader descriptions of the thinking process abound in the literature. Such views often emphasise the thinking individual as an independent, purposeful, competent, self-directed thinker able to function effectively in any environment. In addition the thinker is described as curious, willing to risk and incorporate criticism (Paul, 1993). There is no doubt some validity in these widely expressed observations, but they do not advance the teaching of thinking as they are dispositions found in many individuals, in diverse contexts and are not defining characteristics of the thinking processes, but of individuals.

Talk of higher level cognitive processes evokes different views and perspectives from researchers. There is, nevertheless some consensus that when we speak of higher order thinking processes we refer to thinking which is complex, multi-faceted and self-directed, and in which the learner plays an active role (Resnick, 1992; Coles, 1995; Nastasi & Clements, 1992).

Another aspect of the debate about higher order thinking is to distinguish it from lower order thinking.

Higher vs lower order thinking

Some theorists see higher order skills as related to reasoning, the capacity to think critically and to solve problems (Mayer 1992; Newman 1990). We are reminded by Resnick (1992), however, that the most important message of modern research is that thinking skills are not limited to advanced levels of development. Resnick contends that the existence of 'higher order skills' does not imply that 'lower order skills' such as displaying knowledge, routine application of skills, repetitive and drill sequences (associated with the lower end of Bloom's (1956) taxonomy) need to precede or lay the foundation for higher order skills. Resnick's view is that there is no fixed sequence involved in progression from to lower to higher order thinking, as both forms of thinking may occur simultaneously. Cognitive processes involved in learning to read and write for example, involve inference, abstraction and manipulation of structures at complex levels and are therefore meaning construction processes and forms of higher level cognition.

Other theorists have firmly distinguished lower from higher order thinking, and these are summarised by Lewis & Smith (1993) in an attempt to unravel the complexities of the debate and establish some definitive meaning for the term higher order thinking skills. There is some value in this approach, and as the present study will seek to identify attributes, instances and occurrences of higher level thinking, it is imperative that a workable definition is arrived at. Lipman (1991) and Newman (1990) also distinguish between higher and lower order thinking and see this distinction as fundamental to the ability to identify higher order thinking processes. In order to distinguish higher order thinking, one approach is to show how such forms of thinking are distinctly different from other forms of routine thinking. Lipman (1991) lists several facets that differentiate higher order thinking from lower order thinking:

- complexity;

- the search for unifying threads;
- use of evidence;
- the search for meaning; and
- reasoning and judgement.

Newman (1990) sees lower order skills as routine knowledge application and memorisation of material. Higher order thinking demands interpretation, analysis and manipulation of ideas, this interpretation has marked similarities with Resnick's (1987) criteria cited above.

There is general agreement that thinking skills are learnable and teachable behaviours and may be cultivated or inhibited by classroom experiences. Routine or lower order thinking may also be the result of learned behaviour, or teacher expectations that do not promote deep or searching intellectual activity. Classroom research, for instance (Wood, 1992; Dillon, 1988) claims that teachers typically ask closed factual questions which fail to promote intellectual activity, and even inhibit it. Higher order questioning, on the other hand, demands and encourages the student to analyse, interpret or synthesise information. Nevertheless, higher order thinking is not tied to advanced levels of development, or expertise in a subject matter. In performing tasks, lower order skills are not always a separate and preliminary step towards higher order thinking, and both are required as for example, in the writing of an essay, where the analytic skills of composing are required as well as the ability to use a dictionary to check spelling (Resnick, 1987; 1992).

The conclusion reached by Lewis & Smith (1990, p. 134) that it is possible to differentiate higher from lower order thinking, but tasks usually require both simultaneously. The two processes are quite unique, and higher order thinking is distinguished by its quality, scope, extension and application of principled understanding. Nevertheless, both forms of thinking may occur in the process of learning, or in problem solving. A further dimension to the debate on thinking skills is whether they are general or context based.

Are thinking skills generalisable or context specific?

Some theorists maintain that general thinking skills can be taught as a set of generic skills and that each content area has its own skills, thinking approaches and forms of discourse (Nickerson et al, 1985; Adey & Shayer, 1993).

Research conducted by psychologists in the area of problem solving has shown that certain thinking skills commonly occur, and these are regarded as context-independent abstract structures of thought. One of the best documented research is that of Schoenfield (1985) in the area of Mathematics. He maintains that the application of a set of heuristics as well a control strategy to help the learner decide when to use it, will suffice in all areas of problem solving. However, a major complementary finding of this research was that problem-solvers also need to master a domain specific knowledge base (De Corte, 1990; Glaser, 1984). The reason is that the problem solving approaches, while having clearly defined approaches need to be applied to specific organised bodies of knowledge. This constitutes a significant argument against programs claiming to teach general thinking skills.

Resnick (1987) reports that certain thinking processes are found in analyses of task performance. These are described as self-regulatory roles, or metacognitive strategies used by learners. Effective learners and problem solvers appear to have similar repertoires of executive control strategies.

The issue is whether thinking should be taught as a single body of general, transferable skills or a sets of skills attached to, and embedded in subject contexts has been much debated. The motivation behind creating an inventory of skills (Ennis, 1987; Paul 1993) is that identification of the major components of critical thinking is in fact the first step towards teaching people to be critical thinkers. Following on from this, if thinking can be distilled into general skills and strategies and taught, it is believed that learners can transfer such skills from one subject area to another. Most of the evidence suggests that thinking is more often context bound than context free (Nickerson, Perkins & Smith, 1985; Presseisen, 1988) and that 'packaged' thinking skills programs are not the best way to foster higher order thinking. This view has gained much theoretical support as situated cognition has demonstrated the importance of the social context to learning and thinking (Collins, Brown & Newman, 1989).

In summing up the evidence against a model of general thinking skills Perkins & Salomon (1989) conclude that there is a lack of evidence to support it. They say that:

> the case for generalisable, context-independent skills and strategies that can be trained in one context and transferred to other domains has proven to be more a matter of wishful thinking than hard empirical evidence (1989, p. 19).

Further evidence in favour of a context-based situated view of HOT is the interdependence of domain specific and general thinking skills recognised in the literature (Salomon & Globertson, 1987; Alexander & Judy, 1988). Higher order

thinking necessarily involves a combination of *procedural* knowledge (knowing how) and *declarative* knowledge (knowing that) according to Alexander & Judy (1988). Domain or declarative knowledge must be available for consideration, and this content knowledge is summoned up in support of procedural knowledge which are cognitive strategies applied to planning performing an evaluating the task. In addition, metacognitive processes enable students to control and monitor their own performance. Flavell (1979) was one of the first to introduce the concept of metacognition and this is a now recognised component of higher order thinking. Figure 3.1 shows the interrelationship between procedural, declarative and metacognitive knowledge and higher order thinking.

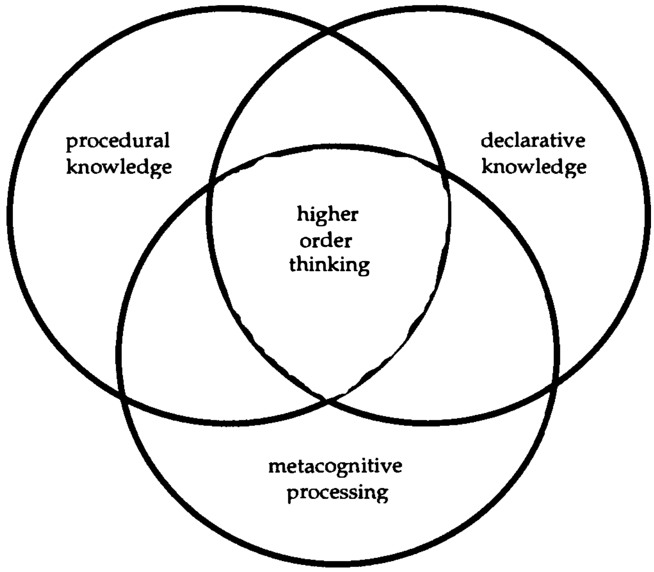


Figure 3.1: Interaction of procedural, declarative and metacognitive knowledge

Alexander & Judy, (1988) and Perkins & Salomon, (1989) maintain that there is a synthesis between the two positions of context-bound specificity and context free generality. Both acknowledge the importance of domain specific understanding and concepts to thinking, and conclude that thinking skills must be woven into context specific instruction. While passive understanding of facts, information and content is not equivalent to higher order thinking, the learner must possess a certain level of knowledge relevant to the task. Thinking always occurs in a context, and in the classroom the boundaries of these contexts are to a large extent set by the curriculum, the pedagogy and the tasks in which students are engaged.

Paul (1993) retains a deep commitment to thinking in the general sense, and he is critical of discipline based educational practices. Instead he maintains that procedures

and principles of reasoning transcend the particularity discourse forms found in disciplines. Paul is challenged by McPeck (1990) who maintains that "through the use of their general concepts and rich language, the disciplines provide the most fundamental and inescapable cognitive requirements for being rational" (1990, p. 41). Paul contends that the disciplines are too narrow, and that their compartmentalisation is not helpful to everyday thinking, which he sees as multilogical and interdisciplinary in nature.

Rather than pursue the philosophical question of whether the disciplines can provide the best context for development of thinking , it is expedient and pragmatic for the present study to assume that thinking is linked to domain knowledge, as this is usually the case is schools. Most theorists are in agreement that a knowledge base is essential to thinking, as thinking does not take place in a vacuum. Having established the contextualised nature of thinking, the literature is next analysed for insights into criteria for recognition of higher order thinking.

Higher order thinking: criteria for identification

Theorists have sought to establish criteria to help identify instances of critical thinking (Resnick, 1987; Lipman, 1991). This would appear to be one prerequisite to the provision of a functional definition of critical thinking: if behaviours are to be categorised as critical thinking, there should be criteria established against which such behaviours can be judged. What are the criteria for higher order thinking?

Resnick (1987) claims that higher order thinking is *non-algorithmic.* It goes beyond the application of a pattern or procedure, and no specific heuristic or algorithm can be applied to all situations. Lipman (1991) supports this definition, but adds that higher order thinking may utilise heuristics but is not bound by such procedures. Others agree that higher order thinking is complex and multi-faceted and that there is no fixed sequence of steps to be followed (Paul, 1994). A further dimension of higher order thinking is that it produces *multiple solutions*, rather than one fixed answer. Different problems may require different definitions, procedures and perspectives. In trying to arrive at a judgement, learners will have to search for, and consider alternatives, as knowledge is complex and multifaceted. There may be many alternatives to be considered and evaluated. Tishman et al. (1993) support this non-algorithmic view of higher order thinking. They maintain that learners must demonstrate the quality of open mindedness and the ability to explore alternative solutions.

There is substantial agreement that *judgement and interpretation* are brought to bear on the question. While Lipman (1991) and Resnick (1987) are in accord on his aspect, neither provides exact details. Judgement, according to Lipman (p. 52), rests on sound understanding, and can be arrived at by systematic inquiry and deliberation. A more specific example is provided by Underbakke & Borg (1993) for the classroom context. When presented with problems, higher order thinking skills are demonstrated in the ability to identify the nature of the problem and evaluate approaches or solutions. Because higher level thinking involves complex issues and problems, learners must extrapolate, make approximations and even take risks when they are uncertain.

A further point of agreement on criteria for higher level thinking between Lipman (1991)and Resnick (1987) is that thinking involves *multiple criteria.* Thinkers who are competent and responsible will not rely on one criterion to the exclusion of others. Because of the uncertainly surrounding complex task definition and solution, consideration of many dimensions of an issue or question is essential, as is the evaluation of different approaches.

Another defining criterion of higher order thinking is *self-regulation* of the thinking process. This means that the individual must demonstrate some initiative, and be aware of the processes involved. Lipman (1991) argues that self-regulation is closer to self-monitoring, which is a metacognitive process. While Resnick (1987) emphasises the autonomous self governing nature of higher order learning, Lipman prefers to use the term 'self-corrective' which means that the thinker tries to discover if her/his thinking is open to revision and correction. This implies the open-endedness of the thinking process, and the continual search for alternative definitions and perspectives. Both are essential to HOT, and are quite distinctive attributes, according to the authors cited above. According to Lipman, 'self-correction' entails the ability to consider multiple criteria, and to make judgements and interpretation, so in a sense it overlaps with the skill of self-regulation. Both critical and creative thinking, which are the components of higher order thinking, are amenable to self-regulation and self-correction, and though Lipman and Resnick emphasise distinct elements, they are in agreement that the learner should be self-regulating.

The emphasis on metacognition is found elsewhere in the literature (eg. Salomon & Globertson, 1987) who state that learners sometimes lack this ability to self-regulate, and that the quality of *mindfulness* must be cultivated if we want learners to achieve higher levels of cognition. Mindfulness involves higher level functions or metacognition, processes that can serve to monitor learning. To explain further, Salomon & Globertson (1987, p. 625) state:

> When mindful processes are activated, the individual can be expected to withhold or inhibit the evocation of a first, salient response, to examine and elaborate situational cues and underlying meanings that are relevant to the task to be accomplished, to generate or define alternative strategies, to gather information necessary for choices to be made, to examine the outcomes, to draw new connections, and construct structures and new abstractions made by reflective type processes.

Clearly, the concept of *mindfulness* distils many of the criteria that Lipman(1991) and Resnick (1997) attribute to higher order thinking. The processes of mindfulness and self-regulation all involve metacognitive processes. Mindfulness, as an overarching or superordinate term describes a cluster of attributes which we call metacognition. Self-correction (Lipman, 1991) involves reflection and self-validation, which may involve seeking multiple criteria and making judgements. Another, perhaps more straightforward way of identifying self-regulatory skills is to rename them 'flexibility and awareness' (Underbakke et al, 1993, p. 143). In practical terms this means the ability to modify one's strategy or construct a plan in the event of failing to solve a problem, rather than persist with strategies that do not work.

A final aspect of higher order learning proposed by Resnick (1987, p. 3) as follows: 'higher order thinking involves imposing meaning, finding structure in apparent disorder'. Lipman (1991) agrees that higher order thinking involves the search for structure, relationships and connections by various means such as comparison and contrast, evaluation, inductive and deductive reasoning. While both theorists are in agreement on most aspects, Lipman does not agree that higher order thinking has to be *effortful*, as someone could expend a large amount of time and effort on a relatively trivial problem and yet not engage in higher order thinking.

This review of the literature indicates that the concept of higher order thinking has given rise to a wide range of interpretations and meanings. Yet, there are some agreed criteria by which higher order thinking can be judged. Overall there is substantial agreement that HOT is thinking which:

- is creative and not merely algorithmic;
- is multifaceted and complex;
- involves judgement and reasoning;
- involves self-regulation and mindfulness; and
- imposes meaning and structure.

While there is some common ground in the literature on thinking, the research reviewed does not enlighten one as to what skills students should demonstrate to qualify as higher order thinking, and how thinking can be effectively fostered in classrooms.

Conclusion: the need for an operational definition

This review of the literature suggests that definitions of higher order thinking vary according to philosophical or psychological perspectives, and that while there is much common ground, there is still a lot of controversy about terminology, skills, and criteria. There is a need to establish a comprehensive and wide ranging definition of higher order thinking that is applicable in the context of the present study, and one that can inform teaching practice. There is considerable agreement that it is possible to distinguish higher from lower order forms of thinking, and that the former is not merely learned behaviour or the mechanical application of heuristics. The research reviewed suggests that outcomes of higher order thinking are the achievement of new understandings and purposes which go beyond simple reproduction of facts and information learnt or memorised. Lipman (1991, p.125) maintains that it is not enough to initiate students into heuristic and algorithmic procedures, as these alone do not constitute higher order thinking. Rather, the most consistent indicator of HOT that emerges from the literature is that students should be able to reason, thinking independently, defend views and justify them (Paul, 1994; Tishman & Perkins, 1997; Perkins, 1977; Ennis, 1993).

While this brief review of literature has produced some insights into the nature of higher order thinking, it is likely that 'the great debate' (Weinstein, 1993) will still probably continue. For classroom practice, there is a need for a comprehensive and operational view of higher order thinking that is applicable in the language based, communicative environment of telematics. Without recourse to an operational definition of higher order thinking, teachers may find that they remain uncertain about its application and meaning in the day-to-day planning of their teaching. Theoretical debates on rationality, critical thinking and logical argument abound in the literature on higher order thinking, but are far removed from the realities of day-to-day teaching.

Consideration of the characteristics of higher order thinking in the literature shows that thinking is a complex, active process, occurring in social contexts. It may take many different forms, and is recursive, complex and manifest in verbal behaviour and in dispositions or attitudes to learning. The complexity of the term means that many

teachers may have only partial understanding of the concept, and may assume that it will automatically occur in the course of their teaching without the application of particular strategies to support it.

In the present study, there was a need to go beyond the debate about definitions of higher order thinking to find an operational definition which was applicable, relevant and transferable to the classrooms of the study. In addition it was essential to link this definition to a coherent theoretical framework which would guide educational decision making and lead pedagogical practice for the teachers involved in the study. This issue is addressed again in Chapter 6, where an operational definition is developed that is both relevant and appropriate to the telematics classrooms of the study. In the next chapter, the actual context of the research is described, and the research questions which motivated the study are presented.

CHAPTER 4

Context of the research questions

Introduction

This chapter aims to set out the context of the research questions and the scope of the study. While chapters 2 and 3 gave a general overview of research on telematics classrooms and higher order thinking, this chapter synthesises these findings in order to illustrate how the research questions evolved.

The chapter is divided into several sections which develop the context of the study as follows:

- the need for applied research and process data on interactions in telematics classrooms;
- the case for specific teaching and fostering of higher order thinking;
- the absence of an operational definition of higher order thinking; and
- the immediate context in which the research questions evolved.

Need for applied research on telematics classrooms

Existing research on telematics classrooms has not provided sufficient insight into characteristic patterns of interaction between students, or between students and technology. Smaller scale studies conducted (eg., Oliver & Reeves 1994a; Oliver & Reeves, 1994b) have provided indicators that a good deal of didactic teaching occurs with high levels of teacher direction. These studies have indicated that further investigation needs to be carried out in order to make recommendations on instructional strategies and models that will enable teachers to use audiographic technologies in ways that encourage cognitive interactions among participants.

Two other aspects of teaching and learning have been signalled in the literature as important for telematics environments. First, the research to date has pointed out the narrow range of instructional strategies used by teachers to exploit fully the interactive potential of the technologies. In most cases, the computer is used simply as a screen on which the teachers project the content to be learned, without consideration of student

engagement. It is important that technology use is motivated by the learning needs of the students and that it provides them with opportunities to participate, rather than observe. The specific use of technology to support higher order thinking has not been explored in telematics classrooms, and teachers have been found to use the computer screen simply to display lesson content. Often, telematics classrooms rely heavily on the audio link to conduct lessons (eg., Oliver & McLoughlin, 1997). This has been attributed to the fact that audio interactions provide stronger communicative elements and enable the teacher to control events, give directions to students, allocate turns and manage the distant classroom in much the same way that they would a face-to-face classroom.

Second, little attention has been given to the actual dynamics of interaction between students and teachers, and the relative amount of student talk as opposed to teacher talk that occurs. Oliver & McLoughlin (1997, p. 51) report a study which found that telematics learning environments had low levels of learner control and learner autonomy, and that lessons were strongly teacher directed. The authors concluded that "few teachers used instructional models that would enable them to promote higher order learning outcomes". These findings are consistent with an earlier study conducted by Oliver & Reeves (1994a) where interactions tended to be centred on low level questions and exchange of information, rather than engagement in task which involved problem solving and reasoning.

Coupled with this, explanations of how aspects of teacher verbal behaviour influence students' communicative action have not been the subject of investigation. Given the intrinsically verbal and aural nature of audiographic teaching and learning, research that examines the different communicative and interactive functions of talk would seem imperative, as these interactions support the teaching-learning relationship, define roles and influence how and what students learn. By investigating the interactions between participants in the classroom, the research focus would take on a different perspective, described by Greeno (1997) as 'participation structures'. This would mean looking closely at how teachers and students interact, as it is through these interactions that most learning outcomes are achieved.

> Methods of instruction are not only instruments for acquiring skills; they are also practices in which students learn to participate. In these practices, students develop patterns of participation that contribute to their identities as learners, which includes the way they take initiative and responsibility for their learning . . ..
>
> (Greeno, 1997, p. 9).

If a required outcome of learning in telematics classrooms is the achievement of higher order thinking, then the manner in which students participate in class is important. If a learning outcome is to enable students to become independent, self regulated learners and autonomous thinkers, experiences in the classroom must prepare them for these roles. Asymmetric forms of interaction where teachers talk and students merely listen, are not conducive to developing autonomous thinking skills. Previous research on telematics classrooms has not addressed the question of which forms of interaction and activity will best support student learning and higher order thinking.

The case for active teaching for higher order thinking

One of the most important issues to emerge from educational research is the need to foster learners' higher order thinking (Mercer, 1995; Greeno, 1997; Costa, 1994; Paul, 1994). We cannot assume that these skills will simply happen in the classroom. Teachers need to plan for thinking and apply appropriate strategies to enable students to demonstrate these skills. Clearly teachers must take the initiative for creating an atmosphere where students have the scope to think, reason and consider and evaluate alternative perspectives. Mercer (1994, p. 30) concludes:

> Children do not necessarily take as self-evident the need for challenging ideas, for making arguments explicit, for justifying them and for attempting a consensus only after adequate explanation has taken place.

Similar research by Bennett & Dunne (1991) who investigated classroom talk found that task-related talk predominates, and that this is largely in response to task demands. Abstract, or higher order talk occurs when demands are made on learners to produce it. These authors also conclude that often assumptions are made by teachers that practical tasks and tasks requiring application of knowledge in problem solving (for example, in mathematics) will develop higher order thinking

> .....through a demand for hypothesis, reasoning or justification. However, this has been shown by the analyses not to be true. Children appear to refer only to the action needed to advance through the program; no assumptions can be made about the use of higher thought processes.
> (Bennett & Dunne, 199, p. 117)

These conclusions suggest the need for specific interventions to bring about higher order thinking, the creation of learning environments conducive to thinking and reasoning and the application of particular pedagogies by teachers. Many programs in

existence which claim to teach children to think creatively, argue a case and develop the skills of verbal reasoning (Craft, 1991). However, research as yet has provided no insight into how such skills can be fostered in environments where learning takes place at a distance, or where technology is used to mediate communication. Teachers are often in the invidious position of having to meet curriculum objectives couched in terms of content coverage, while at the same time achieving higher order, global outcomes in the form of independent thinking skills in students. These demands are not easily met, particularly if teachers do not have a clear and well defined notion of what higher level thinking requires in terms of student action and behaviour. In telematics environments the question of fostering higher order thinking and how it can be achieved has not been addressed in any extant research.

Context in which the research questions evolved

The immediate context of the study was the telematics classrooms of Western Australia, where audiographic conferencing is used extensively for delivery of education to rural and remote schools. Delivering to several sites simultaneously, teachers have to use whatever resources are offered by the technology and combine these with both pedagogy and curriculum objectives. In developing a research focus, one of the concerns was to build on existing materials and resources that teachers have access to in their schools, and to develop practical strategies which would complement the curriculum orientation and teaching approaches that were already in place. This necessitated developing an operational definition of higher order thinking which teachers could relate to and apply in their own classrooms, while being consistent with the curriculum goals and objectives currently in place for schools.

So far, several motivating factors for the research have been outlined. These were the apparent gaps in the literature on higher order thinking, the lack of process data on telematics environments, and narrow range of instructional strategies used by teachers in exploiting technology and interacting with students. There was a further rationale for investigating how telematics environments could more effectively foster higher order thinking skills.

In 1996 an initiative was taken by the Education Department of WA (EDWA) to extend the Academic Talent Program via telematics delivery. This meant that, for the first time, teachers would have to pursue the objectives of higher order thinking via telematics. The curriculum to be delivered, while covering the core curriculum areas, was also intended to enrich and extend students, and to develop independent thinking strategies. The stated aims of the curriculum as laid down in the *Curriculum Framework*

(EDWA, 1996) documents was to develop both content knowledge and understandings and to enrich students so that they could demonstrate a range of higher level cognitive skills such as:

- a knowledge of the ways in which language varies according to content, purpose, audience and context;
- the capacity to develop reasoned arguments about interpretation and meaning;
- the capacity to apply problem-solving capacities in a purposeful ways, including situations requiring critical thinking; and
- the capacity to plan and organise activities, sort out priorities and monitor one's own performance.

For the teachers involved, this presented a major challenge. The Academic Talent Program via telematics was a new venture, and teachers who were called on to participate did not have previous experience in teaching at a distance via telematics. Not only had they to teach via technology, and at distance, but they also had to develop teaching strategies to enable them to develop programs to extend, enrich and accelerate students in programs tailored to their needs. The provision of such a program via telematics presented other challenges insofar as it demanded that teachers use the technology to achieve a level of communication and interaction that would extend learners' thinking skills.

This setting offered a unique opportunity to observe, intervene and plan teaching strategies in an authentic classroom context where:

- higher order thinking was the principal objective;
- the teachers were novices with the technology, and were seeking assistance;
- the students were engaged in the actual school curriculum, and were learning at a distance via audiographic conferencing;
- the cooperation of both teachers and students was achieved though a common focus, ie the achievement of higher order thinking; and
- external assistance and guidance was sought by the teachers in achieving the goal of higher order thinking.

The researcher was involved with the project from its inception early in 1996, to the conclusion of the pilot program, at the end of 1996. During this period, the objective was to assist teachers to achieve the learning outcome of higher order thinking in their classrooms using audiographics conferencing. It was in this context that the research questions evolved.

The research questions

In the interest of clarity and logical progression, the research questions are presented in the temporal order in which they occurred. Because of the nature of the research, which involved actual teaching contexts and students pursuing educational goals, it was essential from the outset to keep in mind the achievement of the learning outcomes of higher order thinking, as these were the stated curricular outcomes.

The research began with the initial general concern to observe the classrooms, analyse the interactions that occurred and then plan appropriate strategies where opportunities for HOT were maximised through supportive teacher practices. The central aim of the thesis can be expressed through two overarching research questions which the study was designed to resolve. These were:

- How can teachers support higher order thinking in telematics classrooms?
- How can the technology be used to support HOT?

In answering these specific questions, the study also focused on the question of how to provide teachers with an operational definition of higher order thinking, which they could apply to telematics classrooms.

It was anticipated that these questions would progress from an initial observation stage (Phase 1)where classrooms would be observed, to an active participatory stage, where the researcher would cooperate with teachers in achieving the stated outcomes of higher order thinking. The research was iterative, in the sense that the initial questions, once answered, would inform interventions to improve higher order thinking. In the event that higher order thinking was not observed in the classrooms in Phase 1, it was planned to assist teachers to achieve the objective of HOT though the planning of particular strategies and approaches which were amenable to implementation in telematics classrooms.

Achievement of this goal can be stated as a series of research questions which guided the study. In Phase 1, the research questions were:

1. What are teachers' perceptions of higher order thinking and its attainment in the classroom?
2. What patterns of teacher-student discourse are evident in telematics environments?

3. What are the relative participation rates of teachers and students?

4. What evidence of higher order thinking can be observed in student talk?

5. How did teachers support and foster higher order thinking in their students?

6. How was the technology used to support learning and higher order thinking?

In Part 2 of the study, the theoretical framework is developed, and related to this, an operational definition of higher order thinking is proposed for adoption in the classrooms of the study.

Part II

Theoretical framework and operational definition of higher order thinking

CHAPTER 5

Theoretical framework: socio-cultural theory

Introduction

In order to develop a well founded operational definition of thinking to inform the research, it was necessary to adopt an appropriate theoretical model of learning and instruction and to be able to link practices in telematics environments with theoretical accounts of learning with technology. It was essential to have a consistent interpretation of the interactions that occurred and of the teaching practices which were advocated. This chapter will argue that the adoption of social-interactionist theory of learning and cognition offers a coherent and explanatory framework for understanding interaction and learning in telematics classrooms and a principled account of teaching and learning.

The chapter critically reviews the literature on teaching and learning with technology and examines the contributions offered by a socio-cultural perspective to the present study of telematics classrooms. The main issues explored are:

- changing perspectives on technology use in education;
- learning as a communicative, social process;
- how teachers support learning;
- the role of the learners in constructing their knowledge; and
- socio-cultural framework and its potential contributory power in linking theory and methodology.

Following the analysis of changing theoretical perspectives on teaching and learning, the chapter concludes by arguing that socio-cultural theory offers a robust theoretical basis for investigating learning in telematics classrooms and also provides a coherent and unifying theory for the present research.

Changing perspectives on technology use in education

As educational technology is used to support teaching, it will also embody a theory of learning. Learning with technology is characterised by a number of theoretical

perspectives, which have influenced the role technology plays in relation to teaching and learning.

Until the 1980s the success of computer assisted learning was attributed to its capacity to individualise instruction (Säljö, 1994). Computer software of the drill and practice variety was designed according to the behaviourist principle that learning is best achieved by an individual practising tasks in a repetitive manner until mastery is achieved. The computer was regarded as a teacher, giving immediate feedback on responses and enabling further practice. Such software (eg spelling tests) can achieve high levels of task engagement, at least for short intervals and free up the teachers' time which would otherwise be spent grading and preparing routine tasks for practice. While there is a place for this type of software in the classroom, it is limited in terms of engaging students in higher level cognitive processes such as comprehension, hypothesis formation and reflection. It is also driven by a behaviourist paradigm which sees skilled behaviour resulting from repeated individual practice and feedback. Computer tasks of this nature may limit educational goals to the attainment of lower order skills such as remembering, reciting or producing isolated segments of information.

Other perspectives on the relationship of theory to computer use in schools emphasise a constructivist view (Knight & Knight, 1995; Duffy & Jonassen, 1992) whereby children learn by discovery and experiential learning. One of the best known applications of constructivism is the work of Papert (1980) with LOGO environments. Papert's work was driven by a vision of children controlling computers, of creating microworlds as settings where learners can apply knowledge in a creative way. This perspective treated the computer as a tool; through programming the learner was able to control the technology and generate responses. Turtle Logo is an example of a microworld environment where children can issue instructions that cause the turtle to move, thus creating patterns. The rationale was that by issuing programming commands, learners would acquire a toolkit of general problem-solving skills. Programming is a special form of problem-solving, and it demands mastery of a family of subskills such as rigorous thinking, explicit instructions, debugging an imperfect solution and awareness of problem-solving skills.

Papert's conception of constructivist learning closely followed Piaget's (1970, p.715) view that "each time we prematurely teach a child something he (sic) would have discovered himself, the child is kept from investigating it and consequently from understanding it completely". Premature teaching was pre-empted by the constructivist approach: indirect support of learning through provision of objects to

think with (hardware) was envisaged as sufficient to enable learners to attain higher levels of thinking.

The constructivist view of learning does not fully take into account how social processes such as peer interaction, collaboration and language use contribute to learning. Radical constructivists would argue that learners construct their own reality by interpreting experience through mental abstraction (Shotter, 1995). The emphasis of constructivism is on individual development through the use of resources, and accommodation of new experiences to existing understanding (von Glaserfeld, 1990; 1995). In environments where children work together, social interaction is almost certain to occur, yet constructivism sees the benefits of dialogue and communication as incidental rather than central to cognitive progress.

The role of the teacher in a constructivist learning environment is to facilitate learning through provision of tasks and to support individual development by creating microworlds. By providing contexts for learning, the teacher merely activates the learner's latent understanding. There is no specific place for language, dialogue and communication in cultivating higher order thinking, whereas these are processes are recognised by many educationists as important to learning (Barnes, 1992; Mercer, 1996).

In reality, environments which utilise technology (eg, telematics) are usually collaborative because students have to share resources and communicate about tasks. In addition, much educational use of computers takes place in schools which are social venues where language use and interaction are prevalent (Light, 1993). Consequently, much of the activity that takes places around computers is collaborative, and involves learners in sharing, negotiating and interacting verbally. Theoretical support for the collaborative and social aspects of learning with computers is essential if pedagogical approaches are to be developed to improve learning in technology supported environments. It is suggested that a communicative framework based on socio-cultural theory (Wertsch & Toma, 1995; Vygotsky, 1978) is relevant for understanding how learners can achieve higher order thinking in telematics environments.

Learning as a communicative, social process

One rationale for the recent emergence of the socio-cultural paradigm voiced by Säljö (1991) was the increased pluralism of modern societies, and the recognition of cultural influences on perceptions and beliefs. The cultural and social contexts in which we learn are no longer separate variables or extrinsic factors in how we learn, but instead,

are immediate and observable forces which influence perception and learning (Forman, Minick & Stone, 1993). Essentially, socio-cultural theory provides a contextualised and communicative perspective on teaching and learning. Learning is culturally influenced and a social rather than an individual process. Vygotsky believed that "human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them" (1978, p. 89). Socio-cultural theory emphasises that language plays a vital role in enabling the learner to participate, interact with others and solve problems, and is therefore essential to learning. Language is not just a means of communication, it is a cultural tool for making sense of the world.

The increased emphasis on social and communicative aspects of learning and the ascendancy of socio-cultural approaches to learning has had an impact on how technology is perceived to support of learning. Observation of children working with computers (eg, Nastasi & Clements, 1993; Wild & Braid, 1996) and an increased interest in Vygotskyan ideas has led to a shift in thinking about the role of computers in classrooms. Evidence from observational studies (Hoyles, Healy & Pozzi, 1994) indicates that there are positive effects on motivation, learning and problem-solving behaviours as a result of collaborative work around computers. The social dimension of learning has gained increased prominence and computers are recognised to be part of the social context of classrooms, where the products of students' work provide a focus for discussion and exchange of views (Crook, 1994).

Support for a communicative theory of computer use may be due partly to a reaction to fears that computers exercise an unwanted antisocial influence on children. The preoccupation with the computer as a sinister, compelling addiction may not have substantial empirical evidence to support it, but nevertheless there have been warnings of its antisocial impact. Cuban (1986, p.89) states that:

> ... in the fervent quest for precise rationality and technical efficiency, introducing to each classroom enough computers to tutor and drill children can dry up emotional life, resulting in withered and uncertain relationships.

In fact, computers have been shown to achieve the opposite effect, and there are many empirical studies which attest to close collaborative work on computers and the growth of cooperative tasks through talk (Light, 1993). Hoyles, Healy & Sutherland (1991) describe the role of language in computer assisted learning environments as follows:

> Talking provokes a representation of one's thoughts, a process which inevitably raises them to a more conscious plane of awareness so they can become the objects of reflection and modification.

This public display of thoughts can only occur in environments which encourage discussion and exchange of ideas, and where technology is used to support communication. There is substantial evidence that talk, communication and verbal interaction have an important part to play in the context of computer supported learning, and that opportunities for talk arise when there is groupwork around computers (Light, Littlejohn & Messer, 1994; Hoyles, Healy & Sutherland, 1991). Most of this research points to the ways in which computers can lead to profitable interaction between learners, when computers are shared.

The contributory role that technology plays in supporting communicative and social interaction is particularly relevant to telematics classrooms, where computers are not only shared among students at the same location, thereby generating conversation, but also the visual outputs of the computer become starting points for sharing and discussing views among students from diverse locations.

Socio-cultural theory

At the heart of the Vygotskyan approach there is a concern with social processes and their relationship to development. (Figure 5.1 depicts three contrasting theoretical perspectives on computer use in education.) The principal tenets of socio-cultural theory are as follows:

1. The essentially social nature of cognitive change is emphasised in two important ways. Acquiring a language enables the child to think in new ways, and language is therefore a tool for thinking.

2. Learners are socially oriented, rather than individuals coping in isolation with the environment. Part of the social nature of learning is realised through interaction, with adults and supporting others, in the *zone of proximal development* (ZPD). This is a metaphorical term used to describe an area of cognitive growth, in which the learners can develop through the support of others, particularly teachers and peers.

3. The role of language in mediating thought is fundamental. From this perspective, language and thought are intertwined, and thought is formed and

shaped through words. In social contexts, language is the key communicative function and in Vygotsky's own words " the relation between thought and word is a living process; thought is born through words" (Vygotsky, 1986, p. 255). Conceptual development is tied to understanding and use of language. In social contexts, the need to express thoughts in language clarifies thought and propels thinking towards higher levels of conceptualisation.

4. Cultural tools, such as computers and technology are social and cultural resources that learners can appropriate to support their learning. They also mediate social participation.

Recent and broader interpretations of socio-cultural theory are found in the work of Moll & Whitmore (1993), Cobb (1995) and Mercer (1995). These researchers regard the classroom as a socio-cultural system and investigate learning though a study of the discourse that occurs. Their research depicts classrooms where teachers use interactive and communicative practices and 'scaffold', or assist learners to achieve higher levels of competence (Forman, Minick & Stone, 1993).

In socio-cultural theory the learner is regarded as an apprentice in a culturally defined, socially organised world. Intrinsic to this notion of apprenticeship is the recognition that asymmetric relationships are beneficial to the child's development. Adult-child interaction scaffolds or assists the emerging competencies of the learner. Learning therefore becomes a form of assisted performance. Vygotsky's theory gives substance to the teaching-learning process, which is clearly expressed as learning in *the zone of proximal development* (ZPD) (Brown & Ferrara, 1985). Learning therefore becomes a co-ordinated activity with more than one participant responsible for completing the task or solving the problem.

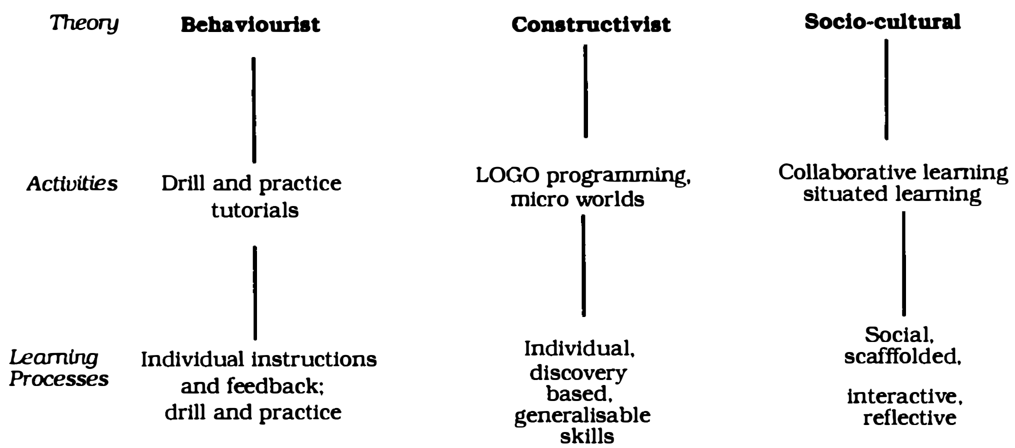


Figure 5.1: Theoretical perspectives on computer use in learning

Within the ZPD, the teacher may scaffold the learner's understanding to enable higher levels of cognition. Language serves three enabling functions in this process. First, scaffolding necessitates dialogue between teacher and learner, as language mediates thought and is the means of communication. Second, through language a shared conception of the task is reached; and third, the expression of thought in language enables the learner to internalise the experience.

The socio-cultural model offers a theory of language and learning that recognises a significant role for the teacher. Vygotsky reaffirmed the social and interpersonal dimensions of learning, emphasising qualities in the educational experience that educators and researchers value ie., that learners need assistance or scaffolding to progress. Thus, socio-cultural theory offers a framework that can assist in understanding and conceptualising much of what happens in schooling (Konold, 1995; Pontecorvo, 1990).

Of paramount importance however, are the communication processes in learning and problem-solving, the communicative exchanges that teachers and learners engage in as they construct understandings. Learning is facilitated through purposeful dialogic exchange, verbalisation of thought processes, reciprocal understanding and negotiation of meaning, all of which are mediated by social interaction and language. (In Chapter 6 the relevance of socio-cultural theory for amplifying and clarifying a definition of higher order thinking is addressed.)

Interaction and learning with technology

Studies on the interaction of students working in groups and dyads at computers have shown that interactions frequently facilitate talk which supports cognition and thinking processes (Bennett & Dunne, 1991). These findings are relevant to telematics classrooms where geographically distributed learners work together. Task related verbal interaction promotes social harmony and working relationships (Clements & Nastasi, 1988; Tudge & Winteroff, 1993). Inter-pupil discussion serves a scaffolding role as learners work towards making generalisations (Hoyles, Healy, & Sutherland, 1991). Research on learning in collaborative settings indicates that students who verbalise their thinking are more likely to learn and demonstrate understanding (Webb & Farivar, 1994; Webb, Troper & Fall, 1995). Students working together enjoy peer support and increased verbal exchange leading to higher levels of task involvement and problem solving behaviours. Not only are these behaviours positively related to

improved learning outcomes, but they also lead to increased motivation (Nastasi & Clements, 1993). Light, Littleton, Joiner et al., (1994) reviewed a number of studies on pair work on computers and concluded that style of interaction is most significant in cognitive achievement than initial difference in perspective. They found that when learners have to make plans explicit through language, to make decisions and to interpret feedback, the processes of problem-solving and thinking are facilitated.

These findings lead to the conclusion that social interaction and peer presence are important predictors of task related interaction and conceptual change. If we accept that this is the case, how can verbal interaction relate to improved learning outcomes with computers? It has been proposed that a socio-cultural theory of learning is the most appropriate framework for technology supported learning environments as it:

- endorses the fact that learning takes place in a social context;
- recognises that language use is fundamental to learning;
- acknowledges that learners need support and assistance to learn; and
- recognises the potential of technologies to support learning and thinking.

All of these elements are integrated in socio-cultural theory, and provide the basis for investigating and maximising learning in technology supported environments, such as telematics classrooms.

Didactic or communicative pedagogy?

Within socio-cultural theory, instruction is more than just didactic teaching, with a teacher explaining and demonstrating through language. Effective forms of teaching require that learners take an active role in the process (Rogoff, 1990; Lave, 1991). Scaffolded, or assisted learning does not mean teacher initiated discourse and learner dependency. The role of the teacher is to provide support at strategic points in the learner's development, so that full autonomy is reached. The student learns through guided practice, and although there is psychological asymmetry in the teaching-leaning relationship, it is not of the traditional 'chalk and talk' type. Instead, socio-cultural theory advocates scaffolding as a kind of strategic help offered when the learner needs it, and is withdrawn when not needed, so that in effect the teacher assists the learner to accomplish the task and assume responsibility for it.

In order to characterise the ideal teaching-learning relationship, and the social, communicative nature of learning, Laurillard (1993) utilises socio-cultural principles to propose conversational framework to describe the interactions that occur between

teacher and learner. Laurillard (1993, p.15) maintains that "student learning is not just about acquiring high level knowledge", it also involves social interaction. Drawing on Vygotskyan theory that reflective thought is social conversation internalised, Laurillard suggests that participants (teacher and learners) must engage in a meaningful exchange of ideas for cognitive change to occur. Four essential activities comprise the learning transaction, and are achieved through language. These are displayed in Figure 5.2 and are explained as follows:

Discussion: The learner and teacher must exchange understandings so that interpretation of the task is jointly reached.
Adaptation: Participants can, where appropriate, adapt the each others' ideas and so experience knowledge from different perspectives.
Interaction: Learners should be actively engaged in interaction throughout the learning experience.
Reflection: Learners should be given opportunities to reflect on their experience and to internalise them.

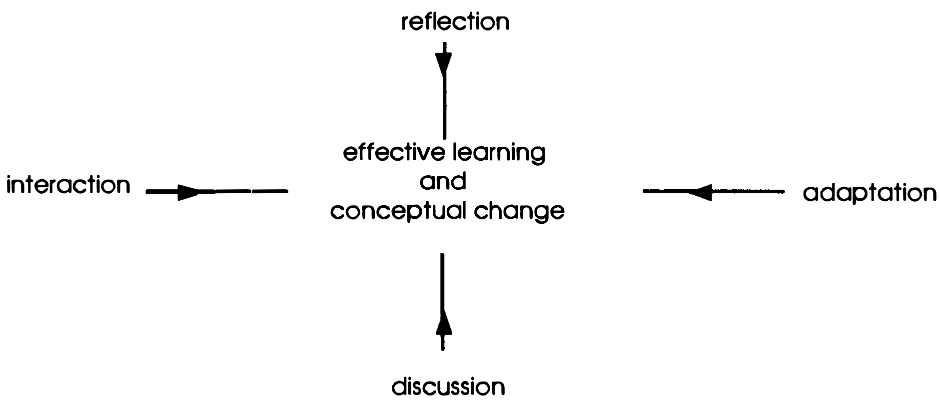


Figure 5.2 : Dimensions of the conversational framework

According to Laurillard, these activities are all essential components of the learning process and should be present in an educational encounter if learning is to take place. In this sense, teaching becomes a form of learning conversation and it is the responsibly of teachers to create environments where such understandings can occur, and to mediate learning.

Laurillard (1993a; 1995) presents one of the few coherent theoretical frameworks that encompass how dialogue and technology are part of learning in a social context. Clearly, the conversational framework is not a didactic view of teaching whereby the teacher imposes meaning or dominates. The conversation requires reciprocity and mutual understanding and this is achieved through talk, discussion, and negotiation.

In environments supported by technology, learning can be planned through interaction, dialogue, reflection and conversation, and in this way the technology supports student-student interaction and teacher-student interaction.

Later in this thesis it is proposed that the dimensions of interaction, discussion, reflection and adaptation are an appropriate way to evaluate technology use in telematics classrooms (Chapter 10). Taken together, these activities reflect the social, interactive and communicative nature of learning that occurs in these environments and provide an analytic approach which shows how conversational acts relate to a particular situation and represent knowledge construction processes.

Teacher roles in supporting learning

As the major focus of the present study is on teaching and learning in telematics classrooms, some discussion of how the teaching role is conceptualised in socio-cultural theory is essential. It is the conceptualisation of the teaching-learning interaction that is particularly useful in understanding the interactions that occur in classrooms. In telematics classrooms the teacher plays a vital role, but this is different in scope to what occurs in face-to-face classrooms. There is for example, greater reliance on the oral/verbal mode rather than non-verbal cues and gestures, as the teacher is not physically present. Learning with assistance is an essential aspect of Vygotskyan theory, and the teacher's role is to scaffold or assist the emerging competence of the learner. Operating in the learner's developmental zone, the teacher provides assistance that is just ahead of the child's developmental level. Understanding is achieved through language-based social interactions where both the teacher and the learner achieve 'intersubjectivity' that is, a shared understanding of the task. It is this form of mutual understanding that underlies effective instructional exchanges (Crook, 1994). To achieve this understanding two-way dialogue is critical, as opportunities for discussion, interaction and reflection must be given to students.

Socio-cultural theory provides a means of analysing the role of the teacher in supporting learning. The metaphor of scaffolding to describe the teacher's role in tutorial interactions was first used by Wood, Bruner & Ross (1976). Since then, other researchers have explored the nature of the support that another party can offer to help a learner perform a task, and ultimately engage in higher order learning. Scaffolding, as defined by Wood, (1986, p. 90) is the 'process that enables a child or novice to explain a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts'. The term is also related to the concepts of 'cognitive apprenticeship' (Collins, Brown & Newman, 1989), 'legitimate peripheral participation'

(Lave & Wenger, 1991), 'guided participation' (Rogoff, 1990), and 'reciprocal teaching' (Palincsar & Brown, 1984). All these terms are linked with the socio-cultural perspective on learning and share a common focus: the learner takes an active role in learning with the assistance of an expert other.

Cazden (1988a) upholds the metaphor of scaffolding as a powerful means of describing the assistance offered to learners by a teacher, and claims that the structure of all learning environments fits the scaffolding metaphor. The original model of scaffolding proposed by Pearson & Gallagher (1983) depicts how, at the initial stages of instruction, the teacher assumes a number of active discourse roles, through modelling, scaffolding, demonstration and coaching. (See Fig 5.3).

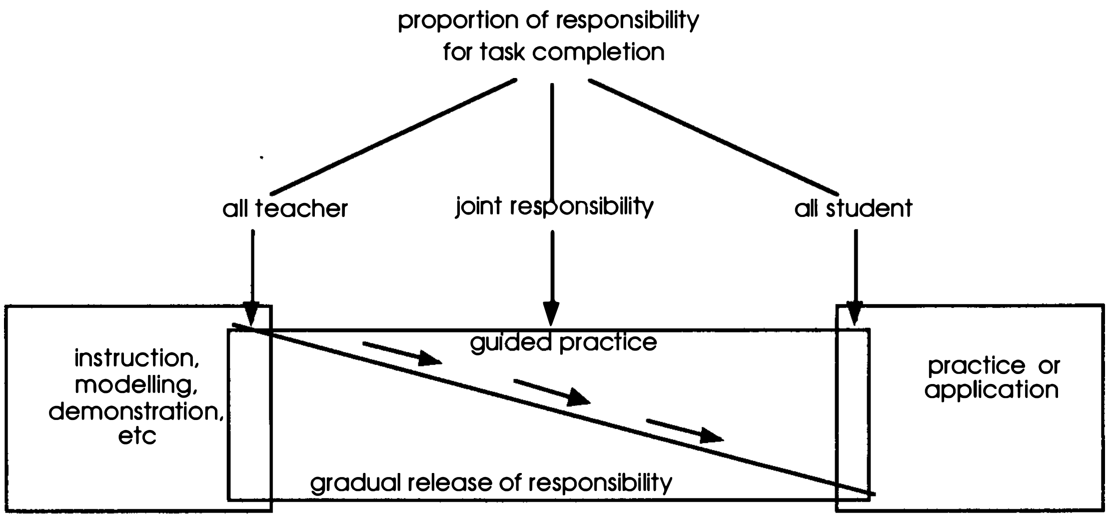


Figure 5.3: Teacher and student roles in scaffolded instruction

Teaching progresses through a stage where the participants jointly assume responsibility, and eventually, when the learner is fully competent, the teacher hands over control, or gives the student the independence necessary to complete the task unaided. At this stage, the learner can be regarded as an independent thinker, though at a later stage, when new material is encountered there may be a return to assisted learning.

Other theorists have emphasised the temporary, adjustable, and interactive nature of scaffolds (Maybin, 1992; Palincsar, 1986). More recent work (Forman, Minick & Stone, 1993) emphasises the role of dialogue in instruction. In the ZPD, the learner's developmental zone, there is participation by both the learner and the adult. The adult must be sensitive to the learner's developmental level. Thinking skills develop

through the learner's activities in the social context, in addition to particular forms of assistance offered by adults and peers.

Although the notion of scaffolding is often equated with the concept of the *zone of proximal development*, (ZPD) the two constructs are not identical. The concept of the ZPD is the developmental distance between what the child can do alone and what the child can do with the assistance of an experienced collaborator (Vygotsky, 1978). This concept recognises the essential asymmetry of the teaching learning relationship and acknowledges and justifies the special role assigned to parents and teachers in guiding and supporting younger members of society toward independence. This is not a role concerned only with transmission of content, but also with activating the learner.

Empirical studies of scaffolding learning

Scaffolding is a term which has been applied and redefined in a number of ways to describe effective teaching. Several empirical studies have examined how teachers intervene to assist learners achieve higher order learning outcomes. The examples cited here exemplify how the Vygotskyan notions of scaffolding and its relationship to cognitive development are real aspects of the teaching-learning dynamic, not theoretical constructs. The studies cited here are relevant to technology supported environments, such as telematics, as the teacher is always present, though at a distance. Several studies of teaching and learning (Bickmore-Brand & Chapman, 1996; Emihovich, 1988) have focused on the role of the teacher in supporting learning through modelling, scaffolding and coaching. The power of scaffolded instruction is evident in studies which show that :

- Teachers can help learners make a transition from present knowledge to new skills. For example, a learner may not be able to perceive links between what they already know and what new tasks are demanded (Maybin, Mercer & Stierer, 1992).

- By providing structure and context for a learner's problem solving behaviours, tutors support the learning process and help learners to focus on the learning activity (Cobb, Wood & Yackel, 1993).

- Although the learner is engaged initially in out of reach problem solving and tasks, the teachers provision of guided participation ensures that from the outset, learners participate fully and actively (Rogoff, 1991).

- Effective scaffolding ensures that the teacher transfers control to the learner. This is described as handover of control and is an essential phase in the development of higher order thinking and independent learning (Edwards & Mercer, 1987).

- Guided participation helps learners to develop competence, and characterises the teaching-learning relationship. In everyday tasks, guided participation may not be deliberate on the part of adults or older peers. However, in classrooms, the notion of guided participation involves the deliberate use of strategies by the teacher to assist learning.

In studies within the socio-cultural framework, the teaching-learning relationship has been defined by a number of writers (Tharp & Gallimore, 1988; Edwards & Mercer, 1987; Laurillard, 1991; Crook, 1994). These studies reveal that teaching is no longer didactic but is *guided, responsive, socially shared, reciprocal* and *Socratic* (Brown & Palincsar, 1987; Wertsch 1991; Forman & Cazden, 1985). These descriptors indicate the social, interactive and communicative elements of learning. Learning is supported and scaffolded by the teacher, and dialogue and interaction lead to the development of cognition and understanding.

Further discussion of scaffolding and how it relates to fostering higher order thinking in telematics environments will be addressed in each of the phases of the study (Chapters 11-14). It is argued here that while scaffolding is a useful concept in understanding how learning is assisted by teachers, it is also necessary to consider the role of the learner in the traditionally asymmetric dialogue that occurs between students and teacher in the classroom. While previous research has found that teachers using audiographic conferencing technology take a directive and authoritative approach (eg, Oliver & Reeves, 1994a), no research has been undertaken to recommend forms of teacher scaffolding to enable greater student participation and opportunities for learning. One of the major concerns of this research is to investigate ways in which higher order thinking can be scaffolded, and the theoretical model of socio-cultural theory provides an appropriate framework for this investigation.

The socio-cultural framework and technology use

The present study has adopted a communicative socio-cultural theory of teaching and learning to conceptualise the role of computer in supporting higher order thinking in telematics classrooms. Theories of learning which have influenced computer-assisted learning have evolved from diverse perspectives and theoretical accounts of learning

as Figure 5.1 illustrates. One of the attractions of the socio-cultural framework for researchers is the fact that it can provide an overarching theory of teaching and learning (Mercer, 1993; Crook, 1994). Many theorists and practitioners argue that it provides a comprehensive view of teacher-student interaction (Brown & Ferrara, 1985 ; Beed, Hawkins & Roller, 1991) and is particularly relevant to studying learning in technology supported environments where communicative processes mediate learning.

An essential aspect of the socio-cultural framework relevant to the present study is its inherently social nature, and emphasis on learning through social interaction (Rogoff, 1990). Vygotsky placed a great deal of emphasis on learning by sharing knowledge through communication. As Mercer & Fisher, (1992, p. 340) state:

> The essence of this approach is to treat learning and cognitive development as culturally-based, not just culturally influenced, and as a social, rather than individualised process. It highlights the communicative aspects of learning, whereby knowledge is shared and understandings are constructed in culturally-formed settings.

In telematics environments, the technology, particularly the computer, can be viewed as part of the social context , and this role is recognised by the theoretical basis of the study. Technologies are cultural artefacts, or mediational means, through which understanding grows, are part of the social world of learning. Through the use and application of cultural tools (instruments, tools, devices and technologies), human action is amplified, shaped and modified. Technologies may extend human cognition, when they are used as tools to support social interaction (Salomon, Perkins & Globerson, 1991). Once the language-based, social dimensions of learning are recognised, the role of the computer in telematics classrooms can be viewed as more than a medium through which the teacher and students can communicate. The potential of the technology for supporting cognition can be recognised if it is regarded as a means of supporting dialogue, enhancing interaction and helping students to share and revise ideas. These dimensions are recognised by Laurillard (1995) in her conversational framework for learning with technology (Figure 5.2).

Crook (1991a; 1991b) has taken the social-interactionist view a little further by emphasising the interpersonal nature of classroom learning, showing how computer based activities must be harmonised into the social context. This can be achieved by organising group interactions *around* computers rather than individual tasks *with* computers. If students work around computers, they will necessarily have to use language to share ideas, collaborate and think collectively. In accordance with the

socio-cultural account of learning, talk generates ideas and assists development. Cognitive strategies may be first encountered socially, between individuals. The learner internalises these functions and they become intra-individual experiences.

From the socio-cultural perspective, use of computers in telematics classrooms should reflect their ability to enhance social interaction and collaboration. For example, when the computer is a shared resource among students it may become a focal point for conversation, group work and collaboration. However, extant research has not focussed on this aspect of learning via telematics.

Technologies can contribute in particular ways to social learning experiences and foster language and communication in telematics classrooms. The shared visual resource of the computer is not just a tool to display the teacher's lesson structure, it can become also become a 'cognitive tool' to help learners display their understanding (eg., Lajoie & Derry, 1993). These ways of supporting thinking are explored throughout the thesis. Examples of visuals created by students are reported in Chapters 12 and 13, to show how students jointly construct their understandings of subject matter, and use these screens as springboards for discussion.

Changes have been observed to occur in learning environments where computers are employed: there is increased emphasis on students learning by collaboration rather than by competition. Computers lack the authority status of teachers and students may feel less constrained to talk and explore ideas when working with computers. They seem to create the kind of problem solving environment that teachers want to see happening: an ideal intellectual atmosphere where students can cooperate without constant teacher supervision and yet achieve significant outcomes. In creating opportunities for learning, the empirical research on computer-supported learning environments points to the necessity of social and interactive tasks to support discourse and higher order thinking processes (Light, 1993).

The pedagogical setting of the telematics classroom offers opportunities for language use and social interaction which lead to learning. For example, group work with computers has been found to provide support for:

- relatively autonomous learning on the part of the students (Laurillard, 1991):
- increased collaboration and negotiation (Light & Mevarech, 1992; Repman, 1993);
- a higher quality of 'exploratory talk' and cognitive discourse (Mercer, 1994);
- discussion, change of perspective and higher order thinking (Nastasi & Clements, 1992); and
- externalisation of thought processes through language (McMahon & O'Neill, 1993).

All of these strategies require learners to use language to find, resolve and agree on problem solving procedures, and to justify approaches adopted. Learning around computers therefore entails new discourse roles for teachers and students, as they engage in discussion, interaction, reflection and adaptation of ideas. The relevance of these findings for telematics classrooms is that the computer can be regarded as a resource that offers opportunities for dialogue and communication between teachers and learners, and thereby supports higher order thinking. These processes are depicted in Figure 5.4.

The quality of learning with computers is not entirely dependent upon the interface between learners and the technology. Instead, it is related to the whole social climate of the classroom and the opportunities created for interaction and exploratory talk between participants in the learning process. This is as true of telematics classrooms and learning at distance as it is of face-to-face classrooms.

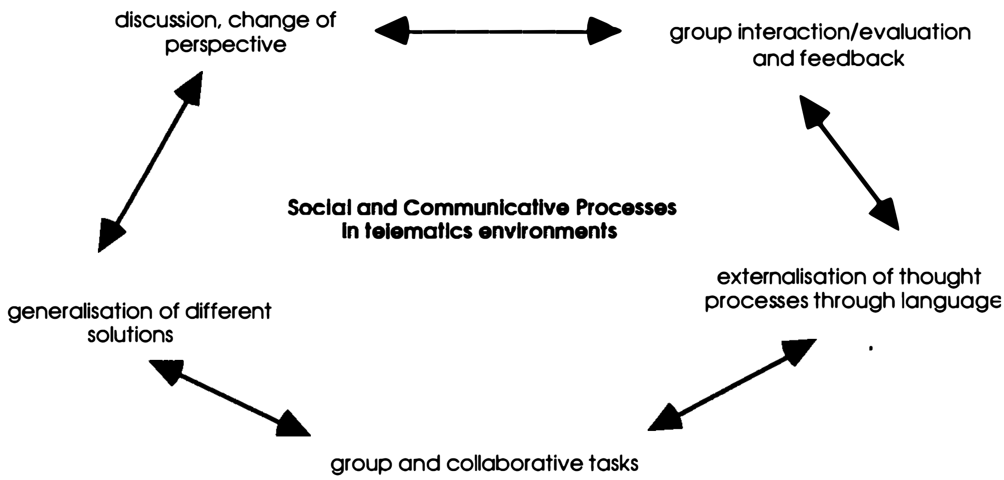


Figure 5.4: Social and communicative processes in learning with technology

Overall, the research suggests that there is compelling evidence of the benefits of verbal interaction and communicative task-related talk in computer supported environments. There has been no extension of research informed by socio-cultural theory so far with telematics environments. The present study aims to fill this gap, and demonstrate that higher order thinking outcomes can be fostered in telematics classrooms, with technologies utilised not merely as conveyances for information, but also to support cognition.

Methodological implications of socio-cultural theory

Many aspects of socio-cultural theory have implications for the overall theoretical framework of this study, and to the methodological decisions that were made in designing the study and analysing the data. The direction in research based on socio-cultural theory is to investigate learning in social contexts, where language and cultural influences contribute to learning. This has two major implications for the present study.

First, as cognitive development is socially based, the emphasis is on learning through interaction and dialogue in classroom settings where the learning experience is primarily communicative and social. The model of classroom learning implicit in Vygotskyan theory is discourse based, and context-dependent. This entails studying learning and thinking processes in authentic settings where social interaction is the primary developmental impetus for cognitive change (Moll & Whitmore, 1993). It also means that the unit of analysis is not the individual, but the individual acting in the social context.

Second, the social and cultural aspects of learning impinge on the relationship between theory and research methodology. As socio-cultural theory emphasises the importance of talk and interaction for transforming understanding, cognitive change must be investigated in authentic contexts. Naturalistic observational methods are preferred to experimental design, as learning is shaped by the particular social environment in which it takes place (Smagorinsky, 1995; Jacob, 1992).

Third, the socio-cultural perspective considers talk and interaction to be central to sharing and developing knowledge and understanding, and therefore analytic methods which investigate discourse and interaction among participants are better suited to analysis of learning and thinking in telematics classrooms. In this study, discourse analysis was chosen as an analytic approach to understanding the teaching and learning interactions in telematics learning environments. Learning is a socially grounded experience, and this is likely to be the case even when learning environments are supported by technology, as they are in the present context. Computer use can therefore be interpreted as a form of communication and social interaction which has specific interpersonal and knowledge construction goals.

The three core elements of Vygotskyan theory, social context, dialogue and assisted performance, provide the link between theory and research methodology, and necessitate a holistic approach to studying learning in social contexts. Socio-cultural theory regards learning as best achieved with assistance, and as a guided,

participatory experience for learners. To understand learning, we must also consider teaching, as they are reciprocal processes. All aspects of the socio-cultural perspective were integrated and applied to the analysis of the telematics classrooms of the study. (Methodological issues are discussed in depth in Chapters 8 and 9).

Summary and conclusion

In summary, sociocognitive theory provides an integrating theoretical perspective for the study as it provides a coherent framework in which:

- cognition is socially grounded;
- technological and cultural tools mediate and support thinking;
- learning and teaching are interrelated experiences;
- learning takes place initially as a form of assisted performance, with the learner assuming full control when competence is attained; and
- learning and thinking are located within social settings.

Table 5.1: Linking theory and methodology in sociocultural theory

Theoretical construct		Methodological Implication
• social basis of learning	➔	unit of analysis is social, not individual
• talk is the medium for sharing knowledge and developing understanding	➔	analysis of classroom learning involves analysis of talk and social interaction
• assisted learning	➔	analysis of teacher roles in scaffolding learning
• talk and interaction build understanding and lead to higher order thinking	➔	developing an operational definition of higher order thinking means recognising the link between talk and thinking
• teaching and learning must be accounted for in cognitive development	➔	both teacher role and student roles must be accounted for in explaining cognitive change
• technology and other tools are part of the cultural resources of the learner	➔	technology can be used to support learning by integrating it with the social language based activities

Sociocultural theory recognises that talk has special significance in learning. It is not only a means of communication, but also a means of engaging in a form of thinking.

Through talk ideas are shared and extended, hypotheses are generated, alterative points of view are presented, and common understandings are built up (Edwards & Mercer, 1987).

In telematics both verbal and written communication are fundamental to the learning interaction, as it is through the audio/voice link that the lesson is commenced and sustained. In addition, socio-cultural theory offers a coherent model of classroom learning with links between theoretical constructs and research methodology. Table 5.1 illustrates these links. This chapter has also emphasised the intrinsic link between teaching and learning and the indivisibility of these functions in cognitive development. Understanding how learners think and learn therefore entails analysis of the reciprocal roles of teachers and learners as they interact.

Sociocultural theory also provides the basis from which to develop a coherent and communicative account of higher order thinking, and this is the subject of Chapter 6. It was essential to consider the link between discourse and thinking in developing an operational definition of higher order thinking that was relevant to the context of the study.

CHAPTER 6

A sociocultural perspective on higher order thinking (HOT)

Introduction

This chapter develops an operational definition of higher order thinking which is linked to the theoretical framework of the study. As socio-cultural theory conceptualises learning as social and cultural, and cognitive development is mediated through language, thinking can be defined as engagement in particular social contexts where communicative rationality is required.

In Chapter 3, it was concluded that if curriculum objectives for telematics classrooms required higher order thinking, an operational definition was essential so that teachers could develop a sound understanding of the principles involved and apply them in their teaching. While theoretical accounts of HOT indicate that such thinking involves creativity, complexity, judgement and reasoning (Resnick, 1987) it is necessary to amplify these descriptors and to flesh out a definition that is appropriate to the context of the study.

The chapter is divided into several sections:

- analysis of higher order thinking and how it relates to socio-cultural theory;
- discussion of the relationship between talk and higher order thinking;
- a review of contexts for development of higher order thinking; and
- an outline of a socio-cultural view of thinking in different subject areas.

The aim of the chapter is to situate the development of thinking within the socio-cultural paradigm, to link language and thinking and to provide an operational definition which is relevant and applicable to the classrooms of the study.

The socio-cultural view of higher order thinking

The socially grounded perspective of socio-cultural theory challenges many of the assumptions surrounding higher order thinking. More recently, socio-cultural theory has been applied to critically review the basic principles of cognitive science, which sees learning as individualistic (Newman, Griffin & Cole, 1989).

Cognitive psychology too, is searching for a new framework of learning and instruction, with the realisation that information processing accounts of learning and development are limited. Vosniadu (1996, p. 103) looks towards socio-cultural theory to provide the explanatory power needed for a new interpretation of learning.

> ..... Behaviour including learning and cognition, should be investigated as interactions between social agents and the physical environment in which they live. Situativity theory emphasises the distributed nature of cognitive activity - the fact that cognition involves activity shared with others in cultural situations that also requires the use of the tools and symbols of the culture.

If learning and cognition are based on social interaction, it follows that thinking processes too are linked to social contexts and manifest in the interaction that takes place between people. Thinking is therefore not only a private act, but a public and shared way of functioning.

The sociocultural perspective on higher order thinking can be summed up in the following quotation:

> ...human thinking- and higher psychological processes in general- are primarily overt acts conducted in terms of the objective materials of common culture, and only secondarily a private matter. The origin of all, specifically human, higher psychological processes, therefore, cannot be found in the mind or brain of an individual person but rather should be sought in the social *extra cerebral* sign systems a culture provides.
>
> (Vygotsky, cited by van der Veer & Valsiner, 1991, p. 222)

Thinking is therefore tied to both social interaction and to the products of a culture, such as the technologies it has produced. Vygotsky (1978) also draws a distinction between natural elementary mental functions and higher (social) mental functions. Basic mental functions operate according to a natural line of development and are biologically controlled. In addition, there is a lack of conscious realisation. Higher mental functions follow a cultural line of development, and are influenced by social factors. Thinking, reasoning, problem-solving, voluntary attention and logical memory are thinking functions. According to Wertsch (1985) higher mental functions are characterised by the individual's increasing control over these processes, and conscious awareness of how to apply them.

Vygotsky was most concerned with higher mental functions which he regarded as indicative of the superior mental life of human beings. His work had been reinterpreted by sociocultural theorists who emphasise cognition and the development of higher order thinking as a social achievement, or form of enculturation fostered by teachers (Moll, 1990; Moll & Whitmore, 1993; John-Steiner, Panofsky & Smith, 1994; John-Steiner & Mahn, 1996). In social settings where language is used to communicate ideas, the learner engages in particular socio-cognitive operations, such as generalising, hypothesising, and inferring. Thinking therefore arises in functional and social settings where language is used communicatively.

Children do not initially achieve higher levels of thinking without assistance, but through interpersonally scaffolded activities. These scaffolds may be indirect, such as joint activity with peers, or direct, as when a teacher provides a model which the learner can follow. Vygotsky justified social interaction as essential to thought, by claiming that individual thinking was in fact the internalisation of social speech encountered in interaction with others. Vygotsky (1978, p. 145) proposed that in learning to think:

> Every function on the cultural development of the child appears twice, on two planes. First on the social plane, and then on the psychological; first between people, and then inside the child.

A classroom based on Vygotskyan principles would ensure that activities provided communication and social interaction for learners, and that they would be exposed to disciplinary ways of thinking. Chapter 7 looks in greater depth as the kinds of scaffolding that foster higher order thinking.

Talk, reasoning and higher order thinking

From a socio-cultural perspective, there are three different levels at which thinking must be reconceptualised. All of these have relevance to the telematics environments of the study. First, sociocultural theory requires that thinking be regarded as social rather than an individual activity. This requires attention to the context in which thinking occurs, and to the planning of tasks and activities where students collaborate with teachers and peers in developing understanding.

Second, socio-cultural theory questions the idea that thinking is essentially formal and abstract. As thought is embodied in social interaction, thinking is not an abstraction,

nor is it exercised by individuals thinking in isolation. Vygotsky (1978) emphasised how learners interacting together can scaffold each others' thinking to higher levels. Group work and collaborative dialogue create the contexts for thinking, and enable learners to 'leap frog' across each other and achieve higher orders of thinking that would not be possible for if they studied alone. Processes of social interchange, communication and expression of ideas constitute the context for fostering thinking skills.

Third, socio-cultural theory regards thought as embodied in social interaction and that to talk is to engage in a social mode of thinking (Pontecorvo, 1993). There is a reciprocal link between thinking and talking, as language is the tool for communicating with others and at the same time it is a social activity. Higher order thinking has to be practised spontaneously in social exchange, through language, before it becomes as internal conscious act. As students talk and argue with each other, viewpoints and information are shared, alternative perspectives are offered and ideas are challenged and modified. These forms of talk led to revision of ideas and are the basis for reasoning strategies and the essence of higher order thinking. Telematics classrooms are ideal environments for the investigation of such talk, as dialogue is the basis of interactivity and keeps the lesson in progress.

Mercer (1995) explains that the socio-cultural perspective provides a solution to the goal of developing higher level cognition and self-regulation in classrooms. This solution has direct implications for the goal of developing of higher order thinking in the telematics classrooms of the present study. Mercer (1995, p.80) sees thinking as an objective for *all* students when he says:

> The important goal of education is not to get students to take part in the conventional exchanges of educational discourse, even if this is required of them on the way. It is to get students to develop new ways of using language to think and communicate, "ways with words" which enable them to become active members of communities of educated discourse.

This view of participation in 'communities of discourse' is one approach which may have potential application to the telematics classrooms of the present study (Coles, 1995). Educated discourse requires understanding and use of particular forms of reasoning, awareness and use of evidence, and the ability to challenge and defend particular points of view. 'Communities of discourse' is a concept which emphasises that the collective insights and ways of reasoning in the disciplines are modes of thinking and talking (Brown, 1997; Brown & Campione, 1994). However, a more

precise definition of higher order thinking is needed if is to guide teaching strategies in telematics classrooms.

Reasoning in the classroom

In Chapter 3 it was concluded that while higher order thinking could be broadly identified as complex, creative thinking, involving mindfulness and reasoning, there was still a need to operationalise the concept. Galotti (1989, p. 333) attempts to distinguish among the various functions described as thinking, reasoning and decision making. She defines the term reasoning as "the mental activity that consists of transforming given information (called the set of premises) in order to reach conclusions". Reasoning in academic contexts is different from everyday language because speakers are expected to make their ideas accountable and provide reference to established evidence, facts and ideas.

In reasoning, there is an attempt made to consider information, make connections and arrive at a conclusion. An oral or written argument must also, for example follow the conventions for presenting information, or arguing a case. Each subject or discipline has its own discourse and mode of argumentation, and higher level thinking requires recognition of these conventions and rules. The essential link between discourse and thinking is distilled in this short extract which describes higher order thinking as: "thinking that is constituted by general canons of argument, by objection from one point of view and reply (from another), by case and counter case, by debate not only about the answer to the question, but also about the question itself" (Paul, cited by Weinstein, 1993, p. 106).

Other more complex discourse strategies, such as argument, hypothesis formation, negotiation and conflict resolution play an important role as reasoning strategies in the subject areas. This implies that patterns of discourse operate as ways of thinking about and expressing ideas, for example in Science. These forms of thinking occur in the contexts of the classroom, if the social climate (eg expectations of the teacher) and the task set stimulates these forms of discourse. In addition, the teacher may have to model and show students these new discourse forms.

Research had shown that even young children have the capacity to reason. Metz (1995) affirms that primary school children have the capacity to engage in abstract reasoning, even though their knowledge base is limited. Her study found that young children were able to engage in authentic science by posing questions, gathering and interpreting data and revising their theories. In a study of Australian school children

aged 5-7 years, Diezmann & Watters (1997) found that after several weeks in a classroom which modelled problem solving and inquiry behaviours, the children were able to challenge each others' beliefs and engage in higher order thinking.

Similar research was conducted in the UK under the title of *Spoken language and the new technology (SLANT)* (Mercer, 1994; Fisher, 1993a). The SLANT project was an empirical study of children working in small groups at computers. One of the outcomes of this project was a typification of the ways in which children talked and reasoned together. These patterns of verbal exchange have been summarised by Mercer (1995) as:

- **Disputational talk**: Talk is characterised by disagreement and individual decision making.
- **Cumulative Talk**: Talk in which speakers build on what each other say, but in a critical manner.
- **Exploratory Talk:** Learners engage critically with each other, challenge and counter challenge. Challenges are justified and alternative proposals are offered.

According to Wegerif & Mercer (1996) exploratory talk embodies higher order thinking, because knowledge is more accountable and reasoning is more visible. These categories of talk, however, do not accommodate all talk, but offer a useful frame of reference for different modes and levels of talk. Exploratory talk has been found to be significant in the development of higher order thinking in learners, as it reflects the kinds of reasoning skills and processes that are associated with conceptual change.

In conclusion, higher order thinking can be expected of learners from a young age and it is not beyond their capacity. The social context remains instrumental in fostering or hindering reasoning and thinking. This review of research suggests that verbal forms of argument, reasoning and evaluation of beliefs based on evidence are core skills in higher order thinking.

Higher order thinking defined operationally

In developing an operational definition of higher order thinking a wide range of literature was analysed and evaluated. There are several well recognised taxonomies of thinking skills (eg., Ennis, 1987; Paul, 1993) which may be useful as descriptions of the range of skills students need in order to achieve academic success. While this may be a tidier approach and one that is less demanding, it fails to takes into account the social context of talk and how ongoing dialogue and discussion supports the emergence of new and more complex ways of reasoning.

Barnes (1992) along with numerous other researchers (Coles, 1994; Fisher, 1993a; 1993b) affirms that not all talk is related to learning, or supportive of higher order cognition. In fact, some talk may not contribute to learning or reflection in a real sense, as it is merely repetition of teacher talk, or mere rote learning. A great deal of talk and writing at school may simply be repeating ideas, or regurgitating facts learnt in textbooks. Barnes (1992) suggests a simple functional division of student talk into two dimensions, depending the orientation of the speaker. When the speaker's attention is focused on merely providing an answer to a question, in the talk is *presentational.* If instead, it is concerned with expanding knowledge and understanding, or trying out ideas, in which case it is *exploratory*. Other categorisations of talk reflective of higher order thinking processes may be found in the work of Coles (1995), Fisher (1993b), Lipman (1991) and Azmitia & Montgomery (1993). Examples of higher order thinking (HOT) are displayed in Table 6.1. Areas of commonality are in evidence: all three theorists include questioning, challenging and evaluation of ideas as components of HOT.

Table 6.1: Categories of higher order thinking

Fisher (1993b)	Coles(1995)	Azmitia & Montgomery(1993)
clarifying a position	restating, clarifying	drawing inferences
questioning	elaborating	questioning
suggesting	criticising	challenging
challenging	questioning	thinking independently
modification of ideas	justifying ideas	considering alternatives
evaluation of ideas	reconsideration of	offering options
summarising	ideas	using evidence
reasoning	identifying	summarising
	assumptions	making judgements
	reasoning	

Throughout these descriptions and those of other researchers on higher order thinking (Ennis, 1993; Resnick, Levine & Teasley, 1991; Fisher, 1996) there is a constant theme that higher order thinking involves reasoning, supporting conclusions and using evidence. These thinking processes often emerge in argument and engagement with others in social contexts. An argument is in fact a form of communication, the purpose of which is to persuade others and to make clear one's own thinking on a particular matter.

Lipman (1991, p. 95) states that:

> Higher order thinking, then, is rich in mental acts, which may cooperate or collide with one another as we build upon each other's ideas or compete with each other intellectually or criticise each other's reasons in the course of our deliberations.

Several researchers have explored the discourse of shared reasoning as it occurs in school (Resnick & Resnick, 1992; Lemke, 1990; Pontecorvo 1993; Roschelle & Teasley, 1995). In Lemke's study of school science, reasoning is described as "a way of using language"(1990, p. 121). For Mercer (1995, p. 106) higher order thinking involves use of language "which embodies certain principles of accountability, of clarity, of constructive criticism and receptiveness to well argued proposals". This definition recognises that thinking is exercised in social forums where discussion and exchange of ideas occurs, and where sound reasoning rests on the use of evidence.

For the present study, the concern was to develop an operational definition of higher order thinking that would be relevant to the curriculum objective and the social context of telematics classrooms. As the outcome of achieving independent thinking was expressed in the curriculum documents, it was important to emphasise both the process outcomes and the social aspect of higher order thinking in telematics classroom.

The operational definition of higher order thinking adopted for the study was based on a sociocultural perspective, the immediate context of the study, and the curriculum requirements as specified in the syllabus documents. It was intended to have relevance and ecological validity for the study. The definition is as follows:

The critical factor is not the transmission of any particular content of body of knowledge or skills, but the development in learners, through social contexts, self-regulated, reflective and critical inquiry that will enable them to exercise judgement, reasoning, interpretation and demonstrate processes such as cognitive accountability in the form of conclusions, decisions and inferences based on sound evidence and sensitivity to context.

There may be several manifestations or processes in this operational definition of thinking, but primarily the reasoning processes are communicative interactions that learners engage in with peers in social contexts to enable them to express ideas and develop understanding. The operational definition of higher order thinking covers a range of skills and verbal behaviours clustered under four categories defined by the researcher as:

- cognitive accountability, involving use or reasons or evidence for beliefs;
- interpretation of ideas and text;
- reflection and awareness (of one 's own learning); and
- critical inquiry, or questioning of ideas.

These forms of reasoning are supported by a wide range of literature (Ennis, 1987; Resnick, 1991; Paul, 1993; Coles, 1995; Fisher, 1996). What makes this particular operational definition distinctive is that it combines both skills and dispositions of higher order thinking, and is inclusive in the sense of incorporating critical thinking, creative thinking, problem solving and metacognitive skills, all of which are recognised as being fundamental to a broader view of higher order thinking (Resnick, 1987; Lewis & Smith, 1993; Ennis, 1993; Perkins, 1997). Each of the components of higher order thinking in the operational definition, ie., cognitive accountability, critical inquiry, reflection and interpretation, can be further operationalised and defended as essential skills of reasoning and knowledge construction.

Cognitive accountability

Lipman (1991. p.125) maintains that it is not enough to initiate students into heuristic and algorithmic procedures, as these alone do not constitute higher order thinking. Rather, the most important indicator of higher order thinking is that students should be able to reason, to defend their thinking and justify it. As language is used to frame thinking, and to express reasoned arguments, learners need to be aware of the importance of showing responsibility in their thinking. This has been described as 'cognitive accountability', and it means that students need to be able to justify and defend their reasons, beliefs and approaches to knowledge and recognise the particular forms or genres demanded by disciplinary knowledge.

In the school context, a particular form of argument-based reasoning is essential to conceptualising evidence in subject matter domains, such as Science and Mathematics. Some examples of reasoning as higher order thinking are :

- the use of reasons to support conclusions;
- the use of evidence to test conclusions; and
- the weighing of alternative perspectives in decision making tasks.

This view of reasoning, or critical thinking is supported by Lipman (1991) Voss (1990) Means & Voss, (1996), who claim that sound reasoning can be judged according to :

- the acceptability of the supporting reason;
- the relevance of the supporting reason; and
- the extent to which counter arguments are considered.

For the present research this form of reasoning has been called *cognitive accountability,* as it requires students to justify their beliefs, reasons and views by using evidence to support their claims. This term was based on the emerging consensus from the literature that effective educational talk requires reasoning to be made explicit and that views be supported by valid evidence (Fisher, 1996; Wegerif & Mercer, 1996).

Critical Inquiry

Another essential category in higher order thinking is critical inquiry, or questioning, in which learners challenge, or investigate the relevance or validity of concepts or beliefs expressed. Donaldson (1979, p. 67) remarked that " We are by nature questioners. We approach the world wondering about it, entertaining hypotheses which we are eager to check". Questions are a form of 'transactional language' (Azmitia & Montgomery, 1993) where students engage in reciprocal dialogue, share knowledge and construct their own version of events. This is achieved when students ask each other transactive questions, such as requests for clarification, justification or elaboration. These can take the form of direct questions such as *Why do you think that?* or *Can you explain what you mean?*, which engage the learners in extended explanatory dialogue. Empirical research has also affirmed that active construction of knowledge can be achieved through verbalisation of thought, investigation of new ideas and generation of questions (King, 1992; 1994; Meloth & Deering 1994; Graesser & Person, 1994).

Reflection

Forms of higher order thinking that are recognised in the literature are language awareness and metacognition, which help the learner to clarify a complex situation and show awareness of alternatives. This is a form of reflection described by Gee (1990) as 'metatalk', or 'metaknowledge'. A metastatement may denote that the student is aware that thinking deeply about the subject is important, and shows awareness of his/her own comprehension, or lack of comprehension.

Laurillard (1995) includes reflection as an essential component in the conversational dialogue that constitutes learning. Research has confirmed the importance of metacognition or knowledge about one's own mental processes and control over these

processes to achieve particular goals (Garner, 1987; Pressley, 1995). For example, when students receive feedback they should be given time to reflect on, and express what this means in terms of their own learning, or their experience of the learning activity. This form of awareness or metacognition has been called 'reflection' for the purposes of the present research.

Interpretation

Much of the talk that occurs in the classroom consists of students endeavouring to express their understanding of texts and concepts. It is often marked by utterances which refer to the texts as the source of information or meaning, signalled by the expression *it says that*, *it means that*, or *I mean*. Research has shown that interpretative talk, where students express their thoughts to the teacher and to each other and give explanations is related to learning and understanding (Teasley, 1995; Wilson & Haugh, 1995). The centrality of interpretation to thinking and learning is affirmed by Paul (1993, p. 537) who states:

> All learning involves personal interpretation, since whatever learn we must integrate into our own thinking and action. What we learn must be given meaning by us, be meaningful to us, and hence involve interpretive acts on our part.

The inclusion of interpretation as a form of higher order thinking is consistent with the socio-cultural framework of the study, as it involves students in active construction of their own meaning of events and classroom knowledge. Also, through verbal expression and explicit explanation, thoughts become open to negotiation and sharing, and learners may revise ideas following discussion. According to Pontecorvo (1990) this fulfils the linguistic game of sharing knowledge, making explicit one's statements, supporting them with arguments and justifications, and so participating in the communicative dialogue that constitutes learning in the classroom. Mercer (1995. p. 75) also supports a communicative view of learning where talk is used to support and convey ideas.

> A great deal of learning is how to use language to represent ideas, to interpret experiences, to formulate problems and to solve them. ...Through conversations with parents, teachers and other 'guides' we acquire ways of using language that can shape our thought. These ways of using language provide us with ways of using language that can shape out thoughts... and provide us with frames of reference with

which we can recontextualise our experience .. and apply these frameworks to interpret observations, information and events. "

By interpreting situations and texts for themselves, students learn to express ideas in language, explain their own perspectives and become aware of others' views.

In schools much emphasis is placed on reading and understanding of texts, distinguishing what texts mean in particular contexts and drawing inferences from them (Chang-Wells & Wells, 1993). Understanding and interpreting written and oral texts is therefore an essential component of higher order thinking in schools.

Dispositions to thinking

These four components of thinking have a number of associated attributes. Throughout the literature, the qualities of good thinkers are debated and discussed at length. Good thinkers are said to have a desire to explore, inquire, take intellectual risks, think creatively and imaginatively, self-evaluate and reason (Lipman, 1991; Resnick 1987; Tishman et al, 1993). These characteristics can collectively be described as having the disposition to higher order thinking (Resnick, 1987, p. 40). From the literature already reviewed certain dispositions suggest themselves as being more essential that others. These include:

- open mindedness, or the ability to search for alternative viewpoints and perspectives
- self-regulation, or the ability to monitor one's own thinking and to be reflective;
- decision making skills, the ability to make and execute plans and work towards outcomes;
- seeking and evaluating reasons, being alert to the need for precision, evidence and justification of decisions and weighing multiple alternatives;
- desire for clarity and understanding and being alert to errors, misunderstandings and conceptual confusions; the ability to pose appropriate questions;
- being guided by precision, organisation and defensible criteria; being alert to possible error; and
- sensitivity to planning and strategic thinking; recognising aimless thinking and recognising different frames of reference.

While this is by no means an exhaustive list of dispositions which are important , it constitutes a distillation of the thoughts of researchers (Lipman, 1991; Resnick, 1991; Tishman et al, 1993). These attributes or abilities are made evident in the talk and interaction between learners, how they execute tasks and in classroom dialogue. In order to investigate instances of higher order thinking it is essential to consider the patterns of dialogue that surrounded these events and link thinking episodes with social encounters.

A socio-cultural view of thinking in subject areas

The operational definition of higher order thinking was influenced by socio-cognitive theory and by consideration of a wide range of literature. Essentially higher order thinking is a form of reasoning that is linked to social and language practices in order to achieve the goal of knowledge construction. If we consider the scope and extent of higher order thinking it becomes apparent that social and discourse-based perspectives on thinking have been influential in refining notions of what can be expected of students.

Increasingly, contemporary educational practices adopted in Science and Mathematics education are influenced by socio-cultural perspectives and the relation between verbal interaction and learning (Lerman, 1996). How knowledge is perceived will influence the pedagogies teachers adopt and their expectations of learners. If classroom knowledge is regarded as the transmission of a prescribed set of facts enshrined in the curriculum, a transmissive view of teaching is almost inevitable. The teacher is there simply to 'cover' the content, and didactic methods of instruction enable the teacher to transmit this body of information. Criticism of this decontextualised knowledge and restrictive pedagogy are found in the literature (Lemke, 1990; Cazden, 1988a; 1988b). Increasingly, there is consensus among educationists that learning in school must be reconceptualised as social, communicative practice, and many plead for an education that teaches students the ability to think critically and independently (Schratz & Mehan, 1993; Laurillard, 1993; Mercer, 1996; Paul, 1993; Coles, 1995). Such an education would bring about a change in classroom talk from information dissemination by an expert teacher, to a culture of learning where student independence is valued, and where teachers can support processes of inquiry and higher order thinking. In the subject areas, there has been significant reconceptualisation of how knowledge is constructed, the kinds of reasoning skills that students require, and the implications of this for learning in school.

Researchers in many disciplines have adopted a sociocultural perspective and defined the meaning of higher order thinking in school subjects, providing further evidence for the validity of the operational definition adopted for the study. Examples are drawn from Mathematics, Science and Humanities education, as these subject areas were taught in the telematics classrooms of the study.

Science

Science teaching has undergone significant changes in perspective during the last five years. In what has now become a seminal article, Kuhn (1993) claims that argumentation is now a crucial tool in the construction of scientific knowledge. The perception that science was all about discovery and exploration and that all children are natural scientists because of their natural curiosity is no longer sufficient to inform teaching strategies. Instead, real science requires high level thinking and strategies. According to Kuhn (1993, p. 320) the process is one of debate, discussion and argument:

> To participate, an individual scientist must analyse the evidence and its bearing on the different theories as a means of argument to the scientific community in support of his of her view. Scientists are well aware that explicitly justified arguments are needed in order to convince the scientific community, and they become accustomed to thinking in these terms.

Everyday reasoning is based on informal argument, and it is this form of thinking that is most evident in people's everyday lives, in their conversations and judgements. Social argument requires speakers to recognise opposite viewpoints and to weigh evidence in favour of one or other assertion and arrive at a conclusion. The same skills are required in rhetorical argument and in Science it is necessary to generate and evaluate evidence in support of theories. To help learners to become scientists, it is essential to engage them in the practice of thinking, asking them for evidence to support their assertions, and to examine alternative theories and counterarguments (O'Loughlin, 1992).

It was argued above that the skill of cognitive accountability was an essential aspect of thinking at higher levels, and Kuhn's views of science supports this assertion, pointing to social argument as a powerful vehicle for developing thinking. For example, overt verbal interaction and social dialogue "offers a way to externalise those internal thinking strategies that we would like to foster within

the individual" (Kuhn, 1993, p. 334). This socio-cultural approach to science teaching has been applied to empirical classroom research by Richmond & Striley (1996) who studied ways in which students learnt to communicate scientific knowledge through the construction of scientific arguments. They found that through discursive interaction in groups, students were able to develop the skills to articulate scientific knowledge, and the assumption of social roles gave them responsibility for their own learning.

Another science educator, Howe (1996) emphasises the impact that Vygotskyan theory has had on the role of language in the science classroom. A sociocultural approach means that language becomes a tool to support thinking, and a means of encouraging students to think about and reflect on how their context-bound discoveries fit into the larger system.

While science may have its own particular concepts and ways of describing the world, a sociocultural pedagogy focuses on the way that language is used to construct meaning in science. Lemke (1990, p. 7) supports the notion that disciplines are social processes and ways of thinking and that:

> Whenever we do science, we take ways of talking, reasoning, observing, analysing and writing that we have learned from our community and use them to construct findings and arguments that become part of science only when they become shared in that community. Teaching, learning and doing science are all social processes; taught, learnt and done as members of social communities, small (ie classrooms) and large. We make these communities by communication, and we communicate complex meanings primarily through language.

Lemke also investigated how school science was taught and describes reason as "a way of using language" (1990, p. 121). He argues that science has its own ways of using words or thematic patterns in much the same way that other subjects construct thematic patterns. Lemke adds that learning science involves learning certain genres or ways of talking. For example, key words often have an everyday meaning and a particular scientific meaning, which needs to be taught as part of the vocabulary of science.

Elsewhere in the literature, a socio-cultural view of Science has been gaining ground (Roth & Bowen, 1996; Shymanky & Kyle, 1992; O' Loughlin, 1992). O'Loughlin (1992) strongly supports the adoption of a socio-cultural pedagogy in which students have a voice and are included in the construction of knowledge through discussion, debate and exchange of ideas. He maintains that if we want students to think scientifically,

we need to overcome the lack of personal and social agency that students often have in the traditional classroom, where they are observers rather than participants. Talk must be treated as a thinking device, not as a medium for transmission of content, and that a dialogical classroom environment should be established where questioning and multiple perspectives are cultivated and valued. The first step towards changing didactic pedagogies is to ask "who is doing the talking?" so that the dominance of the teacher's voice can be recognised and addressed through alternative forms of discourse. In science classrooms in Japan, for instance, teachers have developed procedures of constructive group interaction which give students a greater sense of agency (Hatano & Inagaki, 1991).

Recurring emphasis on dialogue and argumentation is found in the work of other science educators. In developing software support for science education, (Cavalli-Sforza, Weiner & Lesgold, 1994) argue that the most important skills to develop are those related to argumentation, which is described as the "process of proposing, supporting, criticising, evaluating and refining ideas, some of which may conflict or compete, about a scientific subject" (p. 578). Furthermore, these authors support a communicative view of thinking about learning, and propose "knowledge building conversation" as a medium of conceptual change. This view has much in common with Laurillard's (1995) conversational framework, though Cavalli et al., (1995) place a stronger emphasis on the process of argumentation. Overall, both perspectives are informed by the socio-cultural view of knowledge as socially constructed. This review of current approaches to science teaching reinforces the operational definition of the study and affirms the centrality of reasoning, cognitive accountability and interpretation of evidence.

Mathematics

In Mathematics education, the influence of constructivity theory (Piagetian) has been quite strong, but is undergoing change. For example, Driver (1983), claimed that students construct their own knowledge, but this has now lost some of its appeal with the recognition that individual construction must be combined with enculturation into communities of mathematicians who have developed particular ways of working mathematically and of talking about mathematics. Cobb, Wood & Yackel (1993) have acknowledged that their initial teaching of mathematics was originally constructivist, but changed to incorporate Vygotskyan perspectives so that individual mathematical constructions were integrated with communal mathematical practices.

The sociocultural view of learning and thinking as engagement in discourse is supported in mathematics education (Lerman, 1996; Cobb, Wood & Yackel, 1993;

Schratz & Mehan, 1993). Lerman, for example describes social settings and interaction as central to developing mathematical understanding, and that such concepts are socially determined and socially acquired. Teachers of mathematics are "concerned with students acquiring the language and concepts of the community of mathematicians.... (and) aim to structure the classroom activities and the style of discourse in order to facilitate this appropriation and participation" (Lerman, 1996, p. 145-146). Through language based practice and a culture of inquiry in the classroom, the learner is initiated into the community of mathematicians and learns to participate in various discourses.

The theories of Vygotsky have found practical application in mathematics classrooms where talk and discussion are regarded as scaffolding understanding (Hoyles, Sutherland & Healy, 1991). Socio-cultural theory provides an essential epistemological support for group work and discussion in mathematical problem solving which:

> .... throws up lines of development and reasoning which can be understood but not constructed by an individual alone, and 'push' participants towards generalisation and abstraction-processes at the heart of mathematics.
> (Hoyles, Sutherland & Healy, 1991, p. 163).

In this study student language and discussion were taken as fundamental processes in fostering understanding and forms of higher order thinking in mathematics. This approach is consistent with socio-cultural theory.

In conclusion, there is widespread evidence that educational practices in mathematical understanding have embraced the principles of socio-cultural theory, not only in the conceptualising the subject, but also in pedagogic approaches.

English and Humanities

In both English and Social Studies, there are sociocultural perspectives on the kinds of thinking skills and social practices that students engage in when learning. The socio-cultural framework emphasises the creation of authentic contexts in which children try out their ideas and use language to talk, collaborate and make meaning. The teacher's role in these contexts is to mediate meaning and to enable learners to assume control over thinking processes and use of language.

Moll & Whitmore (1993) conducted a study of primary school students learning about Native American Indians. Adoption of a socio-cultural approach entailed the following changes in pedagogy and learner activity:

- joint development of ideas;
- a sense of classroom as community;
- different levels of interpretation of the subject; and
- learner responsibility for their own academic development.

Studies in the areas of English and Social Studies emphasise a range of thinking skills that are required by students to participate in educated discourse. The sociocultural approach has permeated research on the teaching of literacy skills by incorporating social sources of development and contexts which support transaction (Stierer & Maybin, 1994). Rogoff (1990, p. 27) refers to the social nature of learning as the "mutuality of individual and environment".

Mercer (1995) has investigated how students learn in Social Studies and literacy classes by applying a pedagogy of 'guided participation', based on Vygotskyan principles, where the teacher allowed and facilitated student choice, expression, and negotiation of ideas. In joint tasks, students have the opportunity to use language as a social mode of thinking. Through shared insights, students check their own interpretation of ideas, and begin to monitor their own progress. In this way, language serves a validating function as learners can exchange and compare ideas.

Both analytic and expressive skills are demanded of students in the Humanities area, and these are best fostered by supporting inquiry, dialogue and investigation through language.

Summary

Essentially, the socio-cultural approach as outlined in the work of Lev Vygotsky (1978; 1986) regards the origins and definitions of mental processes to be grounded in social and communicative settings. The theoretical core of the socio-cultural position is that thinking processes emerge from social interaction (Resnick, Levine & Teasley, 1991). This chapter has provided an operational definition of higher order thinking where cognitive accountability, interpretation, critical inquiry and reflection are processes that emerge in social contexts of language use and interaction.

In the world of education, orientations to the teaching of science, mathematics and literacy have adopted the socio-cultural perspective on knowledge building (Lemke, 1990; Kuhn, 1993). Understanding of subject matter requires communicative processes and dialogue, as scientists and mathematicians in the world outside the classroom create new knowledge through investigation, hypothesis, and discursive activity. This

suggests a communicative and social direction for the development of higher order thinking in the disciplinary areas, where students share and discuss ideas, evaluate multiple perspectives and develop argumentative forms of thinking (Johnson & Johnson, 1994; Tishman & Perkins, 1997).

For example, reasoning and questioning of ideas are widespread in the practices of discourse communities where argumentation, refutation and challenge are indicative of critical inquiry and similar patterns of thinking are encouraged in science classrooms (Lemke, 1990; Swales, 1990). Increasingly, across a range of subject areas it is recognised that the practices of inquiry and questioning are fundamental to developing thinking and understanding right across the curriculum (Chang-Wells & Wells, 1993).

While definitions of higher order thinking vary according to philosophical or psychological perspectives, there was a need to combine both insights in order to establish a comprehensive and wide ranging definition of higher order thinking for the telematics classrooms of the study. There was considerable support in the literature for the adoption of a sociocultural perspective on higher order thinking, where the skills of reasoning *(cognitive accountability),* constructing meaning *(interpretation),* questioning and independent thinking *(critical inquiry)* and self awareness *(reflection)* were defined as key components in school-based reasoning.

These thinking processes are associated with dispositions or attitudes which are manifest in social contexts where reasoning skills are demanded. For the study of telematics classrooms, the operational definition was related to the theoretical framework of socio-cultural theory, and the social contexts for its expression was emphasised so that communicative strategies underlying higher thinking were foregrounded. (The communicative and linguistic indicators of HOT are discussed in Chapter 10.)

The contexts for the development of higher order thinking are investigated in the next chapter, so that forms of teacher support and appropriate environments can be identified. This was further stage in the research process, as it was necessary to review the literature on how higher order thinking is supported so that appropriate interventions could be planned for the classrooms of the study. Chapter 7 will detail how teaching and learning are interrelated in fostering higher order cognition and how socio-cultural theory leads to particular pedagogical approaches which value interaction and language.

CHAPTER 7

Scaffolding higher order thinking

Introduction

In this chapter, the pedagogical aspects of developing and supporting higher order thinking are analysed by examining the concept of scaffolding more closely. In Chapter 5 the theoretical framework of the study described how our knowledge of teaching is derived from several sources, notably from theories of learning and development. In analysing the work of Piaget and Vygotsky, what emerges are two quite different perceptions of learning, and contingent upon this, two different perspectives on teaching roles. For Piaget (1928), the learner is a lone constructivist, and though interaction with the social world is part of development, it is not the major part. Maturation, inward construction and adaptation to new experiences account for learning. According to Piaget, all the teacher can do to assist the child is to provide materials and contexts so that the learner can discover implicit contradictions in her/his own thinking. As a result of actions and cognitive conflict with the world, the learner conceptualises and constructs meaning.

The contribution of socio-cultural theory is to propose that learning is assisted performance, with the learner making use of cultural tools, language and social interaction to progress to higher levels of thought. The role of the teacher is to support or scaffold development.

The purpose of this chapter is to explore further the role of instruction and teaching within the theoretical framework of the study in order to:

- identify teaching and pedagogies which support higher order thinking;
- critically review pedagogic approaches which lead to effective learning and higher order thinking; and
- evaluate the usefulness and flexibility of the concept of scaffolding for telematics classrooms.

These issues are related to the research question of how best to support and foster higher order thinking in telematics classrooms.

Scaffolding as cognitive support

The concept of scaffolding is at the heart of the teaching relationship in socio-cultural theory, which means that the teacher provides students with the temporary support necessary to help them operate at the upper limits of their competence. Scaffolding, or cognitive support has been applied in many teaching contexts, and has been demonstrated to be an effective method of teaching, and an alternative to didactic teaching (Brown, Campione & Webber, 1992; Brown & Palincsar, 1989; Wood & Wood, 1996). Through scaffolding, learners can attain independent skills acquisition, and self regulation and critical inquiry. As teachers in the present research project were aiming to develop higher level thinking, it was essential to characterise their teaching approaches in appropriate ways. The metaphor of scaffolding had both intuitive and theoretical appeal, as it encompassed the notion that teachers intervene successfully in students learning, and that their presence facilitates development.

The basis of scaffolding is social interaction as Resnick (cited by Cazden, 1988a, p. 5-6) points out:

> Traditional views of the way in which social interaction affects learning focus on the adult as provider of new information, as a modeller of correct performance, as a selective reinforcer of children's tries at producing performance... A different view of social processes in learning is attracting increased attention. Vygotsky (1978) has argued that cognition begins in social situations in which a child shares responsibility for producing a complete performance with an adult. The child does what he or she can, the adult the rest. In this way, practice on components occurs in the context of full performance. In naturally occurring interactions of this kind, the adult will gradually increase expectations of how much of the full performance the child can be responsible for.
>
> (Resnick, cited in Cazden, 1988b, p.5-6)

According to socio-cultural theory, teaching and learning are mutually supportive and integrated activities. The teacher creates a supportive communicative setting and provides resources and tasks so that children can be successful by virtue of participating at a level at which they are capable. Lave & Wenger (1991) called this 'legitimate peripheral participation'.

Ideally, the teacher adapts instruction to meet the level of the learner but nevertheless keeps the learner advancing by tailoring instruction just ahead of understanding.

Scaffolding the learners' understanding within the *zone of proximal development* until autonomous performance is attained is a view of successful teaching supported by several theorists (Tharp & Gallimore, 1988; Collins, Brown & Newman, 1989). Nevertheless, despite agreement on the importance of scaffolding in learning, there have been different interpretations of how this is best achieved. A brief review of the literature is therefore in order.

Types of scaffolding

It would appear that since language is the major channel of communication, the success of scaffolding would depend partially on the quality of the interpersonal relationship between participants. This dimension had particular relevance for telematics classrooms which depend for their success on higher levels of verbal interaction. Various levels and degrees of explicitness have been suggested by researchers as providing optimal forms of scaffolding. For example, Wood (1986) claims that contingent control of learning is most effective, with the level of help varying with the success of the learner in executing the task. Beed et al (1991) suggest a succession of strategic scaffolding which leads to independent action. Through contingent scaffolded instruction, teachers can help learners to progress to the point where scaffolding is not needed. These communicative strategies are displayed in Table 7.1.

Table 7.1: Communicative strategies used to scaffold instruction

Author	Type of scaffold	Strategy
Wood & Wood (1996)	**Contingent instruction**	assistance is offered according to the failure or success of the learner
Collins, Brown & Newman (1989)	**Modelling and coaching**	novice observes and practises expert behaviour
Stone (1993)	**Prolepsis**	speaker makes a presupposition to challenge the listener
Wertsch (1985)	**Directive instruction**	instructor breaks the tasks into goals and sub goals
Palincsar & Brown (1986)	**Reciprocal teaching**	guided practice in strategies for understanding text ie; *questioning, summarising, clarification & prediction*
Beed et al (1991)	**Strategic scaffolding**	strategies to enable the learner to solve problems posed by the task
Tharp & Gallimore (1988)	**Cognitive structuring, questioning and instruction**	provide structures to enable students to learn

The study of Bliss et al. (1991) is similar to that of Emihovich & Miller (1988), who have focused on the teacher's use of mediated strategies in the instructional process. They maintain that children's progression from other regulation (by the teacher) to self-regulation should be reflected in the discourse structure. This would be evident in, for example, more student initiated questions, challenges and better task orientation. Stone (1993) insists that instruction should make demands on the learner though 'prolepsis', a form of dialogue which requires the participants to infer the presuppositions of the speaker. In studying the development of cognition and the growth of self-regulatory processes in young children, Wertsch (1979;1985) postulated four successive stages in the transition from other regulated to self-regulated learning.

These stages are indicators of cognitive growth and can be recognised in the discourse moves of both the learners and the teacher. Wertsch (1979) characterises the different stages as follows:

- at stage one, the learner displays limited understanding of the task and both participants may have different interpretations. The teacher provides strategic assistance, but this does not always scaffold understanding, and the learner does not usually have a precise definition of the task;

- at stage two greater understanding is demonstrated by the child, and there is increased adult-learner understanding. At this stage, the learner is not yet an independent problem solver;

- at stage three, the learner can make the inferences needed to understand and interpret the adult's directives and begin to self-regulate performance;

- at stage four, the learner takes on more responsibility for the task, and the teacher no longer needs to specify all the steps which must be followed to interpret a directive. The teacher supports and encourages the learner throughout the activity and there is a shared definition of the task. The process of transition from other regulation to self-regulation is complete. The learner is able to perform the task unaided.

What makes possible the transition to independent skills are the communicative strategies of the adult. Successful intervention takes the learner beyond present competence expressed as follows: "They (teachers) use directives which require a definition of situation beyond the child's level and then coach the child in how to respond" (Wertsch, 1979, p. 20).

While such sequences of behaviour are teacher-directed, Wertsch (1985) maintains that directives which elicit appropriate behaviour and actions are an important tool to help children progress through the zone of proximal development. This is yet another interpretation of the teaching learning relationship, one which gives emphasis to 'directives', rather than merely to 'structured assistance' as in Tharp & Gallimore's (1988) study. Three procedures for assisting learners through the ZPD are suggested by Tharp & Gallimore (1988): modelling, contingency management and cognitive structuring.

Modelling requires the teacher to demonstrate the full task and to offer explicit explanations and guidance. Contingency management is a means of assisting performance by rewarding, praising and encouraging the desired behaviour and discouraging the unwanted behaviour. Cognitive structuring assists the learner by providing explanations and structures that enable the learner to perceive the structure and interrelatedness of fields. All three strategies are linguistic means of assisting performance. Cognitive structuring means that the teacher assumes a more directive role rather than expecting students to learn on their own. In criticising the occurrence of these themes, Hobsbaum, Peters & Sylva (1996) have commented that there is little evidence for these procedures in ordinary classrooms, and there has been little empirical work conducted to confirm that these strategies are successful in supporting higher level cognition. In a later publication, Tharp (1993) concludes that there is little real teaching (in the Vygotskyan sense of assisting performance) to be found in education, and reiterates the need to employ questioning, cognitive structuring, modelling and contingency management in a meaningful dialogue or *instructional conversation* (Tharp, 1993, p. 273). These views have a lot in common with the approach to teaching and learning advocated by Laurillard (1993a; 1993b), who sees learning as an instructional conversation involving discussion, adaptation, reflection and interaction (Chapter 5).

In the reciprocal teaching method, devised by Palincsar & Brown (1984) teachers and students take turns leading discussions about reading material. There are four language activities involved: asking questions, summarising, clarifying content and predicting upcoming content. Students take an active role in peer teaching and each teaching session involves negotiation of roles. The rationale for these activities is to provide a socially supportive context for learners, to use language-based activities and to create conditions for joint problem solving. The reciprocal teaching method scaffolds learning by providing temporary and adjustable support for learners through dialogue.

What links all of these views of scaffolding is the social interaction between teacher and students, and mediation by language. Essentially, each theorist listed in Table 7.1 recognises that learning is a form of communicative transaction, and that both teaching and learning are realised through discourse and social interaction (Laurillard, 1995). Table 7.1 provides an overview of the communicative strategies that may scaffold learning. These strategies have direct relevance for the study as they provide directions for pedagogic practices to support higher order thinking and enable comparisons to be made with the results of the present study. In telematics environments, which utilise oral and aural channels of communication, there is a great dependence on verbal communication to bridge distances, establish rapport and express understanding. Few if any of the strategies listed in Table 7.1 have been investigated in telematics classrooms, nor have the particular and unique ways that teachers scaffold learning in these settings been documented.

When is teaching effective?

So what is the nature of effective instructional support? There have been different answers to this question, and within telematics environments, the questions have not been raised, let alone answered. Oliver & Reeves (1996) propose various dimensions of effective learning via telematics, which may be useful theoretical parameters, but do not provide practical insights into how teachers could support higher order thinking. In the absence of guidelines based on empirical research, do teachers simply evaluate understanding on the spot and have ready made strategies for each individual learner? The notion of scaffolding is a useful starting point which suggests ways in which teaching should be carried out in recognition of the learner readiness, task focus, progression to new levels of understanding and active participation in the 'dialogue' which constitutes learning and thinking.

In discussing effective instructional interventions, Crook (1994) emphasises the concepts of flexibility and subtlety of instruction, and the capacity of the teacher to interpret the learner's state of mind and level of understanding during the actual process of teaching and learning. Crook also suggests that the metaphor of *provocation* rather than *assistance is* more apt, as the learners are prompted by the teacher to express their inward thoughts and cognitive processes and their interpretation of events in the classroom. Obviously the age and competence of the learner will determine how explicit or otherwise the instruction should be. Assessing a learner's understanding is a difficult task, as learners are not transparent, and it is only through language that the teacher can arrive at an understanding of their perspective. This confirms the essential role of dialogue to both the diagnostic and supportive roles of

the teacher. Scaffolding is not, however, the same as a formula-based approach to teaching as, for example in programmed instruction. Crook (1994, p. 92) continues:

> Effective instructional support is not always a question of teachers successfully formulating their interpretations of what learners are doing and then delivering effective unambiguous direction.... Instead, the remarks that may be most helpful are those that are studiously chosen to be incomplete or otherwise imperfect: chosen because they are *provocative of further engagement* by the learner.
>
> (Italics mine)

The point made here is that effective instruction is not a matter of being maximally informative, but rather a stimulant of further action and thought on the part of the learner.

Wood & Wood (1996) propose that effective scaffolding has much to do with issues of control and responsibility. As the learner gains competence, the teacher yields more responsibility to the learner. This is called 'contingent teaching', and is marked by the principle of offering more help when the student needs it and less once they gain proficiency. Contingency is hard to establish in teaching, as teachers find it difficult to be adaptive to the developing competence of learners, and as a construct it does not help in making specific recommendations for practice.

The studies reviewed illustrate that scaffolding makes use of a variety of communicative strategies to foster learning, and while researchers differ in the explicitness and degrees of structuring there is broad agreement that learning is accomplished with assistance. This seems to be the case for all age ranges. For example, Beed (1991) and Wertsch (1985) worked with junior school children aged between 6 and 8, and so their approach is very explicit. Reciprocal teaching (Palincsar Brown & Campione, 1993) has been used with various age groups, and appears to be applicable to both primary and secondary contexts. At tertiary levels, the approaches of cognitive apprenticeship (Volet 1991; Teles, 1994) have been productive of higher order thinking skills such as metacognition.

The issue of scaffolding and effective teaching has been the focus of recent research on self-regulated learning. Boekaerts (1997) equates control with external regulation, which leaves the learner with little autonomy or responsibility for the learning process, and is therefore an anathema to the development of higher order thinking. On the other hand she states that "the scaffolding metaphor captures the idea of an adaptable and temporary support system that helps an individual during the initial period of gaining expertise (eg., training wheels is a good example)" (Boekaerts, 1997, p. 171).

As the learner grows in skill, the support that is given is modified, and the learner is accorded only as much responsibility as can be managed. In this sense, the Vygotskyan model of instruction is likened to an apprenticeship.

Another study by Chang-Wells & Wells (1993) shows how children acquire school-based literacy and thinking skills through social activities in the classroom. These authors support the view that what is needed is the creation of conditions under which the scaffolding role of the teacher serves to support cognitive development. As there have not yet been ethnographic studies of telematics classrooms, the present research provides some interesting insights into the nature of teacher support in these environments. The next section will deal specifically with the issue of how higher order thinking can be fostered through scaffolding.

The role of the learner in scaffolding

There have been many empirical studies of teaching as scaffolding, some of which are reviewed here. Some researchers have set up intervention studies in which either students or teachers have been taught cognitive strategies or provided with various forms of scaffolding. Most of these studies veer away from didactic patterns of teaching and make demands on the learner. Emihovich & Miller (1988), for example, created a series of instructional scaffolds for teachers to use, which they called 'cognitive teaching acts', involving cuing and prompting learners to expand their contributions. Classroom patterns of talk showed that though teacher talk occupied a large proportion of the total discourse, the pattern of student talk changed to include many initiations, elaborations and questions, where previously these had been minimal. In another study, Brown & Palincsar (1989), formulated successful scaffolding through reciprocal teaching, a form of instruction in which learners gradually take over most of the initiative in understanding text. Four strategies were taught to students: clarification, question generation, summarisation and prediction. Initially, teachers modelled these strategies, and gradually students took over the functions, assisted by procedural prompts.

Cognitive advancement can be achieved by making demands on the learner, by communicating in a way that presupposes some understanding. This is implied by the term *prolepsis* (Forman, 1989) in which interpretation of the message requires an understanding of the speaker's presuppositions. Instead of being maximally explicit for, example, the teacher may use inferences and cues to lead the learner ahead and to induce independent thinking. In order to understand the message, the listener must actively construct it for himself/herself. Forman, (1989, p. 58) has stated that:

when prolepsis dominates, then the knowledge that is conveyed is primarily informal, fluid, and implicit. When explicit demonstration of explanation dominates, then the cultural transmission of an objectified body of knowledge would result.

In other words, when the teacher explains in depth and is very explicit, the orientation is towards explaining a body of content. On the other hand, where a teacher seeks to cultivate independent thought, communicative and cognitive demands are made on students by more indirect forms of assistance and by ensuring that the learner constructs part of the message.

Teachers who are aware of their own pedagogies can therefore moderate teaching strategies according to the student's level of understanding. By observing the processes of instruction and the explicitness of the teacher's messages, it would be possible to judge the degree to which the learner is self-regulated or regulated by others, and whether the teacher helps to engage the learner in higher order thinking (Stone & Wertsch, 1984). This was accomplished by Beed et al (1991) in an empirical study of scaffolded instruction.

The success of proleptic instruction can be assessed dynamically (Forman, 1989) through changes in the explicitness of communication between teacher and learner. As the learner moves towards independent thought and more skilled performance, the level of prolepsis increases. This is one way in which successful teaching and learning can be assessed (Figure 7.1).

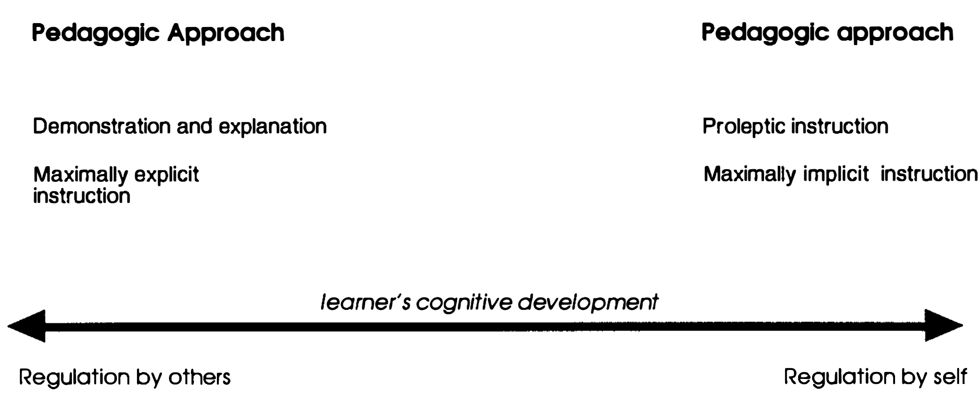


Figure 7.1 : Continuum from explicit to implicit instruction and learner self-regulation

The learners' active involvement in generating knowledge is central to the development of thinking skills, which require a degree of autonomy. Therefore a gradual movement towards proleptic instruction, giving the learner more autonomy

would seem to be one pedagogic approach which makes more demands on the learner and encourages higher order thinking.

The progression from regulation by others to self-regulation is shown in Figure 7.1, and pedagogies that foster each of these tendencies are described as 'demonstration and explanation' as opposed to 'proleptic instruction'. These views are supported by Edwards & Mercer, 1987) who emphasise that teachers need to recognise that the growth of autonomy and self-direction are part of the development of higher order thinking, and that teachers need to 'hand-over' control.

> Children do not simply acquire knowledge and vocabulary. They acquire at the same time the capacity for self-regulation. Just as verbal thought originates as social discourse, so self-regulated behaviour involves a gradual handover of control from teacher to learner, as the learner becomes able to do alone what could previously be done only with help. (Edwards & Mercer, 1994, p.201)

Often, as a result of teacher control strategies, students rarely experience handover of control (McLoughlin & Oliver, 1995). If teaching is overly directive or didactic, students will not have opportunities to develop reasoning skills and the communicative competence that higher order thinking requires.

The scope and nature of support offered by teachers through modelling and scaffolding has been the subject of classroom investigation by Jarvela (1995) and Bliss, Askew & Macrae (1996). What is evident from the studies is that the entire social context must also be arranged to support learning and that even with the most favourable conditions, many opportunities to scaffold learning are missed. These studies conclude that scaffolding joint activity is a difficult process, especially with the pressures to cover a syllabus. Teachers have to keep classes moving and pupils active, and in scaffolding group activities may miss opportunities for individual development. Student input is essential if scaffolding is to be successful.

> Much school knowledge (concepts such as negative numbers, fractions and conservation of energy), initially exist as part of the teacher's (but not the pupils') knowledge. It is abstract, takes time to communicate and, thus, is hard to scaffold. The effect of trying to scaffold this knowledge turns the interaction into a pseudo one, or bypassing, rather than joint negotiation, missing the pupils' input. Further investigation is needed into ways of scaffolding socially constructed knowledge.
> (Bliss, Askew & Macrae, 1996, p. 58).

Mercer (1995) has investigated scaffolded instruction and how learners use talk to jointly construct their own understandings of events. While he acknowledges the value of teacher-initiated question and answer routines for teaching and learning, he still argues for the use of a wider repertoire of communicative strategies in order to enable the learners to contribute in ways that will extend their thinking. He concludes:

> Learners need to get involved with new knowledge in order to consolidate their own understanding, and this cannot be done just through hearing information being presented clearly and logically by an expert. They will almost certainly need to use it themselves, under different conditions, if they are to make knowledge their own.
>
> (Mercer, 1995, p. 19).

Scaffolding therefore may require asymmetric forms of interaction, where the teacher initiates and supports the learner through modelling and coaching. However, the learner is active during this stage and becomes more independent of the teacher as competence and skill are gained. Other forms of interaction may be scaffolded by peers. In a study which employed discourse analysis techniques, Chang-Wells & Wells (1993, p. 64) explored how thinking skills are developed through scaffolded conversations with more experienced others.

> As children talk with more expert members of the literate community about texts, created either about themselves or others, they encounter, externalised in discourse, the knowledge that is called on in literate thinking about the topic of the text. This includes propositional knowledge about the topic, and procedural knowledge about how to engage appropriately with the text; it may also involve metacognitive discussion about those procedures or about the nature and organisation of their propositional knowledge on the topic. ... It is thus through talk about texts that children construct and develop facility in the mental activities that are involved ... in the construction of scientific knowledge.

The version of thinking that the authors describe is akin the nature of higher order thinking defined in this research (see Chapter 6), as such thinking requires participation in a discourse community and engagement through language, in reasoning and cognitive accountability.

From this review of the literature, it can be concluded that for higher order thinking to occur, the learner must be active, and act as co-participant or partner in dialogue and engage in reciprocal action while progressing towards self-regulation.

Classrooms contexts that scaffold higher order thinking

There have been several empirical studies directed at discovering optimal forms of scaffolding, and these are essential to consider in the context of the present study. Some writers believe that use of scaffolding is particularly appropriate for higher level thinking outcomes (Rosenshine & Meister, 1992). Telematics classrooms always have the teacher at a distance managing the class, but few studies have actually outlined what the teacher's role is, or how it can support and foster higher order thinking.

Research has also pointed to the creation of supportive contexts for higher order thinking, where students engage in exploratory talk, and so learn to argue, reason and develop communication skills which reflect higher level thinking. These studies are also relevant for the present research as the principal focus is the development of higher order thinking (eg., Teasley, 1995; Roschelle & Teasley, 1995).

For many teachers, there is a constant dilemma to be faced: the choice between traditional, didactic approaches to learning which ensure curriculum coverage, and more progressive methods where students collaborate through group work and engage in autonomous learning but may not cover the curriculum. For teachers in the present study, this was a real issue, as they were expected to develop self-directed learners and cover the prescribed syllabus while teaching via an unfamiliar medium, audiographic conferencing.

Wertsch (1991) suggests that it is essential to provide a richer description of how different patterns of interaction might lead to distinct forms of mental functioning. In formal schooling, for example, where there is usually an imbalance in power and status, Wertsch suggests that the usual pattern is *univocal*, ie concerned with the transmission of meanings, concepts and knowledge. The second form of discourse is called *dialogic*, and is concerned with generating new meanings, challenging ideas and constructing knowledge. These concepts have implications for the study of dialogue in telematics classrooms, and it is through *dialogue*, rather than *univocal* patterns of dialogue that higher order thinking would be most likely to develop.

An empirical application of these concepts is found in a study by Hatano & Inagake (1991), which reports on the how patterns of discourse in a Japanese classroom act as a scaffold to higher level cognition. Japanese teachers of science frequently apply what is known as the Hypothesis-Experiment-Instruction (HEI) method. This method, which has been used in Japan over the last two decades, involves a sequence of procedures to be followed in science lessons. First, students are presented with a question, several

explicit but alternative answers, and a concrete means of receiving feedback on the accuracy of their answers. During the lesson, different kinds of teacher pupil and pupil-pupil discourse occurs, and both *univocal* and *dialogic* forms are observed. For example, when students are asked to give their answers so that the teacher can write it on the board, it is univocal, concerned only with exchange of information. However, in another part of the lesson, students are expected to explain, defend and discuss their answers with each other, the language becomes dialogic. Hatano & Inagaki conclude:

> In general it is reasonable to conclude that when the dialogic function is dominant in classroom discourse, pupils will treat their utterances and those of others as thinking devices. Instead of accepting them as information to be received, encoded, and stored, they will take an active stance toward them by questioning and extending them, by incorporating them into their own internal and external utterances, and so forth. When the univocal function is dominant, the opposite can reasonably be expected to be the case.

In other words, these authors are suggesting that if teachers are to support higher order thinking, they must engage students in different patterns of interaction than is usual in classrooms. It has been acknowledged by researchers, teachers and educators that classroom social organisation has given rise to ritualised patterns of interaction, in which the teacher is the central figure, students engage in a narrow range of verbal activity, and that teacher talk and questions take up more than three quarters of the total interaction time (Edwards & Westgate, 1994; Mehan, 1979; Edwards & Mercer, 1987; Carlsen, 1991; Cazden, 1988a). In most classrooms, including studies of telematics classrooms (Oliver & Reeves, 1994a) the norm for students is to listen and accept what the teacher says, and not to question, raise issues or even initiate discussion on the task being undertaken.

There are obviously strong social and institutional constraints on the forms of dialogue in classrooms, some of which arise due the status differential and may be due the question of managing large groups of students and the professional expectation for teachers to be 'in control' and maintain discipline. In a major study of interaction patterns, Sinclair & Coulthard (1975) found that most dialogue occurred in a standard format, which they called the Initiation-Response-Evaluation (IRE) exchange. In this three part exchange, the teacher initiates dialogue usually by questioning, the student responds and the teacher then evaluates the students' contribution. This exchange structure leaves little scope for student initiated talk or investigation, and serves to limit student participation in the lesson.

One suggestion proposed by Wertsch (1991) is that through instruction, we try to create 'an institutionally sanctioned space' (p. 173) for dialogic forms of discourse, which give students opportunities to express ideas and construct viewpoints without explicit direction from teachers. These views are echoed by Mercer (1995) who calls for greater awareness for students, and a sharing of goals so that knowledge becomes a joint construction in a real sense, with students sharing the teacher's goals for initiation into educated discourse.

Overall, the research on classroom discourse highlights issues of the imbalance of talk and shows how classroom conventions and the authority status of the teacher can constrain opportunities for inquiry and dialogue, which in turn, open up opportunities for higher order thinking. In recognition of this, several theorists have adopted an approach to fostering thinking which alters these traditional patterns of interaction.

Community of inquiry approach

An approach to supporting higher order thinking in classrooms contexts is the called the 'community of inquiry' approach and is supported by the work of Lipman (1991) and by Coles (1995). Lipman developed his approach for children aged 7 upwards, aiming to improve their capacity to reason. The course is based on special materials which present topics for discussion and debate. The students must listen to each other and must give reasons for what they say, while allowing everyone to participate. The teacher's role is to intervene in the discussion in order to make it more balanced and rational. Lipman's course is based on teaching children philosophy and the course is taught separately from other subjects.

Coles (1995) adopted the community of inquiry approach with children in a normal school setting, and this involved changing the usual patterns of teacher-student interaction. By creating rules that were applied in the classroom, students were able to initiate discussion and also develop higher order thinking. In order to create conditions conducive to higher order thinking, it was essential to have:

- agreed rules: where one person speaks at a time and everyone listens;
- shared input: where everybody gets a turn;
- time to think: the teacher allows time for discussion and reflection; and
- time to discuss: each student has the opportunity to express ideas.

The teachers delegated various thinking functions to students. These were determining the assumptions of the speaker, judging their consistency and following the argument. The most important aspect of the learning experience was that "participants reproduce

in their own thoughts the structure and progress of discussion"(Coles, 1995, p. 167). Verbalisation and discussion at group level were found to assist students to develop individual thinking skills.

One criticism made of this approach or of teaching 'exploratory talk' where students learn to exchange ideas and argue a point, is that in many of the studies reviewed, thinking skills remained a separate subject apart from the rest of the curriculum (Craft, 1991). This does not mean that the skills of thinking would transfer to other areas of the curriculum, or to subject areas where similar skills are needed. While the approach to fostering thinking is consistent with the socio-cultural paradigm, the teaching of thinking as a discrete subject would not be applicable or relevant to the telematics classrooms of the study, where thinking was integrated in all subject areas across the curriculum, rather than taught as a separate subject. Nonetheless, the 'community of inquiry' approach has many social and interactive qualities which can contribute to the planning of better social contexts for student inquiry.

Identifying scaffolding in telematics classrooms

What exactly is scaffolding and how can it be described in terms of dialogic moves and teacher-student interchanges? That scaffolding has intuitive appeal is without question, since it affirms the social aspect of learning, and emphasises that good teaching is responsive to the learner. The socio-cultural framework of the study emphasises the transactional nature of learning rather than the transmission of content from teacher to learner. It also recognises that context, teachers and learners need to be studied in conjunction with each other, as learning takes place in social contexts.

It is necessary to go beyond elusive descriptions however, if scaffolding is to be translated into the practical context of the classroom. Some helpful definitions are offered which can be applied to identify scaffolded instruction. Maybin, Mercer & Stierer (1992, p.188) suggest that scaffolding is "not just any assistance which might help a learner accomplish a task. To know whether or not something counts as scaffolding we would need to have at the very least, some evidence of a teacher wishing to enable a child to develop a specific skill, grasp a particular concept, or achieve a particular level of understanding". A further criterion would be to see whether the teacher is tuned in to the learners' actual level of understanding.

Scaffolding is therefore different for didactic teaching, or just telling a student the information. For example, Cazden (1988b) identified more open-ended kinds of

teacher-pupil talk as scaffolding pupils' development and thinking. Discourse patterns in classrooms can tell us about opportunities for expression and investigation of ideas, collaborative discussion among students and levels of involvement among students. For example, Mercer & Fisher's study (1992) used a conceptual framework based upon Vygotskyan theory to analyse sequences of classroom activity. Various segments of classroom talk were analysed in order to determine whether they scaffolded higher order thinking. The following criteria were used to describe 'scaffolded' assistance by the teacher:

- whether teachers reduced the degrees of freedom of the task (ie provided structure and definition to the task);
- whether interventions helped assist learners to demonstrate HOT; and
- whether students showed independent competence, or the capacity to think independently, thereby providing evidence of internalisation.

Teacher discourse was examined against these criteria and various types of scaffolding were recognised. This form of analysis showed quite clearly that the role of the teacher did not have to be didactic. The research of Mercer & Fisher (1992) and Emihovich (1988) also provides relevant examples of the how cognitive change is brought about by teachers using a scaffolded approach to learning. There have been few empirical studies of scaffolded instruction in schooling contexts, perhaps due to the problematic nature of observing and recording instances of scaffolding. In an empirical study of teacher-student interactions, Bliss, Askew & Macrae, (1996) found that many opportunities for scaffolding were preempted by :

- directive teaching;
- students being given the initiative without direction;
- student contributions being minimised; and
- teachers missing the opportunity to scaffold.

The study by Bliss et al. (1996) provides an insight into misfired scaffolds, and indicates that scaffolding is in fact quite problematic for teachers.

More structured approaches to identifying scaffolds have been provided by Wood, (1986; 1992), who puts the learner at the centre the stage, as their active involvement is necessary in order to achieve understanding. Several functions are suggested which characterise scaffolded instruction, ie.,

- recruitment, or task induction, which gets the learner started;
- reduction of degrees of freedom, which limits the scope of the task;

- direction maintenance, which structures the activity; and
- marking critical features, or giving focussed feedback.

These studies provide possible avenues to the analysis of scaffolding episodes in telematics classrooms. There is some area of agreement among the research studies reviewed that teaching has to meet certain criteria before it is recognised to be scaffolding. These are that:

- the teacher has some specific skill in mind;
- that the teacher is aiming at a new level of competence; and
- that the learner could not have achieved the task without assistance.

These criteria can be applied to any context and in the present study and offer guidelines by which teacher scaffolding can be investigated. In all the studies reviewed in this chapter, language data were the main sources for analysis and investigation of scaffolding. In the present study it was also decided to adopt a discourse analysis approach to scaffolding and to look at the function and types of cognitive support offered by teachers to learners, as this approach was consistent with the theoretical framework of the study.

Summary

In summary, this review of literature suggests that teaching which fosters higher order cognition and thinking must display particular features which engage the learner actively. Scaffolded instruction should satisfy these criteria:

- support gradual self-regulation of activity by the learner;
- progress from explicit support to implicit support;
- enable students to be active communicators, and to display reasoning skills;
- create forums for joint activity where learners can build understanding through collaboration; and
- encourage new competence and self regulation.

These findings can inform teaching practices in telematics classrooms and signal interventions to enhance teacher pedagogies in support of higher order thinking. In the first place, the criteria help to identify forms of scaffolding and their impact on student thinking processes. Second, by looking at patterns of interaction in telematics classrooms, other means of supporting higher order thinking were investigated, and compared with the findings from these studies. From the socio-cultural perspective,

the social and communicative interactions of telematics environments provided the data through which teacher scaffolding of higher order thinking was investigated.

On a more general level, the telematics classrooms of the study provided a unique setting for an analysis of teaching interactions and also an opportunity to reconceptualise and extend the notion of scaffolding. There were two additional dimensions which needed to be explored in the present research:

- The original concept of scaffolding applied to dyadic interactions classrooms, with the teacher and student or a mother and child acting in close collaboration (Elbers, Maier, et al., 1992; Elbers, 1996). In contrast, telematics classroom involve clusters of schools gathered in one virtual classroom to learn together. Students in a distributed classroom constitute a virtual learning community and they have the potential to develop their own particular ways of interacting and supporting each other. Scaffolding interactions may also take place between students as they collaborate and work in groups.

- The students in telematics classrooms can also utilise non-verbal channels for their learning, such as the computer link to scaffold their thinking. For these reasons, the present research needed to consider whether the notion of scaffolding extended beyond the support offered by the teacher. Schematically, the multiple forms of scaffolding possible in telematics environments are depicted in Figure 7.2.

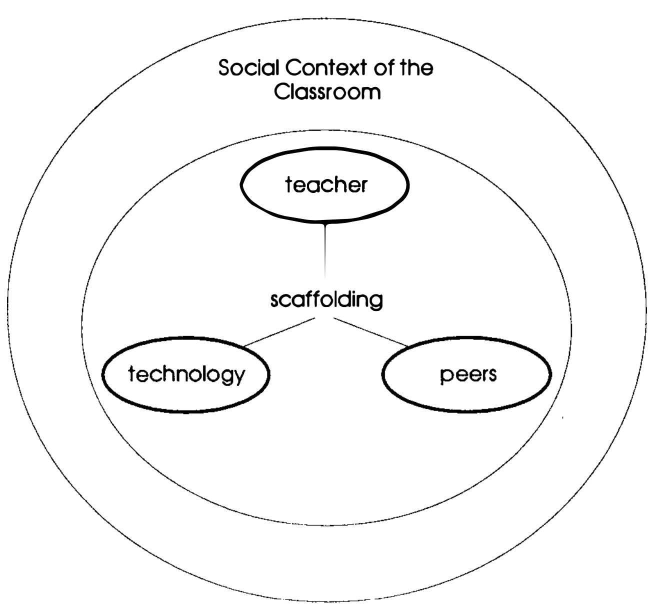


Figure 7.2: Potential types of scaffolding in telematics classroom

Finally, in telematics classrooms, the notion of the teacher assisting students to learn and acquire new levels of competence was part of the rationale for the study where teachers aimed to foster higher order thinking. In these classrooms, scaffolding was adopted as a central concept to enable the researcher to determine how higher order thinking might be fostered. This was the case because telematics teaching always involves a teacher, and because the concept of scaffolding:

- conceptualises the way teachers intervene in distributed classrooms to promote understanding;
- entails the goal of independent task performance and self-regulation by the learners, and is intrinsic to higher order cognition;
- recognises the contribution of instruction to learning and is a dynamic concept and that the degree of assistance offered to the learner fades as the learner gains competence;
- helps to distinguish effective teaching from didactic teaching, or other forms of 'help' offered by teachers to learners;
- implies that, with the right kind of assistance, the learner can develop and progress;
- requires the learner to be active, to construct her/her own meaning and to contribute to joint understanding through dialogue;
- implies a temporary support which is gradually withdrawn, as learners develop autonomy and independent thinking, together with responsibility for their own learning.

In addition, the research focus sought to explore whether the quality of support offered to learners changed over time, and if the teacher handed over control to the learners. This aspect of instruction was regarded as essential to the identification of conditions for higher order thinking, as students were eventually expected to display independent competence, initiative, judgement and reasoning in their interaction.

Conclusion

Part 2 of the study has presented a case for the adoption of a socio-cultural view of higher order thinking, where learning is regarded as a social, communicative process and learning is viewed as assisted or scaffolded development. It has been argued that socio-cultural theory provides the most comprehensive framework for the study, as it recognises the social, interactive and communicative aspects of learning, and has relevance to telematics classrooms for several reasons.

- It is a social rather than individualistic theory of development and is particularly suited to the study of learning in social contexts, and to situated learning with technology.

- Socio-cultural theory offers a theory of learning and instruction. Teaching and learning are related activities and the quality of teaching is reflected in the learning activities and discourse that occur in classrooms.

- Socio-cultural theory deals directly with the social and communicative aspects of learning, and is based on the view that communication with others through speech is to engage in a social mode of thinking. The operational definition of the study also draws on socio-cultural theory for expression of the four dimensions of higher order thinking defined for the study: cognitive accountability, interpretation, critical inquiry and reflection.

- The concept of scaffolding is particularly suited to classroom research, as it describes the process of active teaching, and the ways in which teachers support learning.

- While the concept of scaffolding has not been fully explored in relation to telematics classrooms, the research questions outlined in Chapter 5 signal that the direction of the present study is towards investigating appropriate conditions, including scaffolding, for the development of higher order thinking.

Having outlined the theoretical framework of the study, Part 3 looks at the research design and methodologies adopted, and integrates the study with methods of inquiry and approaches to data analysis consistent with the study of learning and interaction in social settings.

Part III

Research design and analysis of data

CHAPTER 8

Methodological issues in the design of the study

Introduction

This chapter justifies and accounts for the design of the study through a critical evaluation of relevant methodologies, and through exploration of the distinctive qualities of research approaches which are consistent with the socio-cultural framework. Overall, the research orientation is interpretivist in perspective, as described by Lincoln & Guba (1985) and more recently by Jacob (1992, p. 294):

> By interpretivist principles, I mean a perspective towards research that includes attention to the meanings that humans create and use to guide their behaviour, a recognition that in any situation meanings can vary and create multiple realities, an assumption that researchers should build meaningful generalisations from detailed understandings of specific contexts, and an understanding that the components of social life are mutually influencing.

An interpretivist approach was chosen as this was considered to be the most appropriate to the social and interactive quality of learning in telematics classrooms, and also because of its consistency with the socio-cultural perspective of the study.

The chapter is divided into several sections as follows:

- the paradigm debate, the qualitative-quantitative approaches in research, and how these can be integrated to give greater insight into learning processes;

- methodologies for the study of classroom learning and discourse which have emerged from a socio-cultural perspective;

- the need for triangulation of methods of data collection and analysis; and

- the research design and the specific issues that had to be considered in planning the study.

Each section is related to the context of the study, so that the decisions made about methodology are based on their applicability and relevance to the classrooms where the research was undertaken.

The paradigm debate

In educational research, there are two major traditions in research design and methods. One is the empirical experimental approach based on controlling variables and utilising quantitative data analysis which was particularly common during the 1960's in educational research. Quantitative, or experimental designs rely on statistical procedures to produce verifiable outcomes. These models of educational research do not easily provide techniques and means of investigating the impact of social context on student learning.

Since the 1970's there has been a movement away from experimental designs towards more naturalistic observational methods which do not attempt to control all variables, or to exclude the social context. Qualitative research methods such as ethnography, case studies and action research have flourished and, as defined by Miles & Huberman, (1994, p.1) "are a source of well grounded rich attempts and explanations of processes in identifiable local contexts".

Debate on the underlying epistemologies of the quantitative-qualitative debate has continued unabated (eg, Denzin & Lincoln, 1994; Lecompte & Milroy, 1992). Reliance on empirical experimental designs is said to reflect the assumption that learning and development of understanding are acontextual, and that social interaction does not affect cognitive change.

The 'paradigm wars' refers to the rift between quantitative and qualitative approaches in goals, questions, assumptions and methods of data collection and analysis. Hammersley (1992) uses the term 'qualitative-quantitative divide' to focus attention on these differences.

Cazden (1986), describes the opposition between approaches with reference to research on classroom learning. Quantitative approaches are labelled process-product research because of their focus on abstract coding schemes which are said to influence learning outcomes. Experimental designs contrast with the other main research tradition which is descriptive and based on actual transcripts of classroom talk, and qualitative, or interpretive in focus. Cazden's main aim is to illustrate that the deductive process of applying precoded categories to classroom talk is quite different from the inductive

process of deriving categories from data. Besides these oppositions in quantitative and qualitative research, Cazden maintains that both approaches to analysis of classroom discourse are reflective of a wider debate within educational research between positivist and interpretivist paradigms. Eisenhart (1988) suggests that combining both approaches might be problematic as they embody different assumptions about human nature, and about the educational process in particular. It is important, Eisenhart states, in the decisions about which methodology to use in conducting research, to adopt an integrated epistemology and theoretical perspective to guide the work, and not to lose sight of the fact that both quantitative and qualitative approaches do carry different underlying assumptions about the educational process.

Each methodology speaks a different language, poses questions in distinct ways and pursues different goals through research. The polarisation is strengthened as people become socialised into different ways of perceiving research, conducting investigations and reporting findings. However, some theorists argue that discussion should not be aimed simply at methods employed and at the different assumptions about reality embodied in each research perspective, but about finding and using a methodology that works (Howe, 1988).

Notwithstanding the divide between the two approaches, it is argued that there are benefits to be derived from integrating both qualitative and qualitative approaches in educational research. The research questions of the study demanded a comprehensive investigation of learning and thinking processes in telematics classrooms, and although quantitative data on participation rates of students and teachers was important in determining patterns of interaction, there was also a need for in depth analyses and qualitative insights into the types of activities and roles that were seen to influence higher order thinking. The need for appropriate methods to investigate the social context and interaction patterns of telematics classrooms prompted the researcher to investigate methodologies with a focus on capturing social dynamics.

Approaches to the study of learning in a social context

Neo-Vygotskyan research refers to research that took place in the 1970's and 1980's when Vygotsky's ideas reached a wider audience. At that point the tendency was for researchers to include insights from disciplines such as sociology, anthropology, linguistics and psychology in educational research, in order to situate the study of learning and instruction in its cultural and social context. Two immediate changes in orientation to research occurred. First, approaches became more interpretive, or

multidimensional, and second, researchers began to recognise the impact of social forces on cognition.

According to Merriam (1988, p. 11 & 28) an interpretivist approach provides rich, thick descriptions of the phenomena under study. These rich descriptive data are used to develop conceptual categories or to illustrate, support or challenge theoretical assumptions held prior to gathering data. To achieve this focus, the researcher is expected to become familiar with the phenomena under study, to work closely and collaborate with participants. Unlike controlled experimental designs, where detachment and control of variables produce a result, which is supported by numerical data and scientific evidence, methodologies in the interpretivist tradition rely on evidence which is descriptive, contextual and takes into account how people construct and understand their social space. In a critique on instructional technology research, Reeves (1995) notes the dearth of interpretivist articles, and calls for a new "socially relevant research agenda" with meaningful research which addresses issues in real, situated contexts. Reeves (1995, p. 10) is critical of many of the approaches and methods of much experimental research and calls for a "foundation of sound learning theory and rededicated concern for the social impact of our research". While these criticisms do not imply that *all* experimental research is narrow or irrelevant to social concerns, the appeal for research in socially situated contexts can be interpreted as support for educational research which has relevance to the quality of teaching and learning, and which is situated in real, as opposed to contrived contexts.

There are several approaches to research which recognise the impact of social forces and interaction on learning. For example, Lave (1988) used ethnographic techniques and participant observation to investigate how mathematics is used and applied in everyday life. Other researchers have used discourse analysis, classroom ethnographies and participant observations to capture the dynamics of interaction in classroom learning (eg. Mercer, 1994; 1993; Moll & Whitmore, 1993). Another area of interest that has emerged from socio-cultural theory is how interactions between novices and experts (mother-child dyads, teacher-student dialogue) promote cognitive change. Several studies have achieved prominence in this area, notably Rogoff's (1990) study of how mothers interact with their children to scaffold learning.

The present study of higher order thinking in telematics classrooms could not have been accommodated within a narrowly defined experimental study, as this would have excluded analysis of the social context of the learning, and of the interactions that contributed to learners' thinking behaviours. In view of this, consideration of studies of classroom teaching provided examples of possible research approaches which could be applied to telematics classrooms. Such studies are important, as they illustrate how

qualitative and quantitative approaches can be combined within a socio-cultural framework.

Studies of classroom learning

Several seminal research studies are cited in order to illustrate the power and capacity of the socio-cultural framework to inform methodologies and enable investigation of classroom learning. Palincsar & Brown (1984) based their approach to learning, the reciprocal teaching method, on Vygotskyan ideas of learning through interaction. In the original study on reciprocal teaching, the researchers (Palincsar & Brown, 1984) used quantitative measures of students' reading performance before the training intervention on strategy use, and incorporated qualitative data on students' exchanges to show how they progressed in reading strategies. This combination of qualitative and quantitative approaches enabled the researchers to assess the impact of reciprocal teaching as a technique. In a more recent volume of research by Forman, Minick & Stone, (1993) the authors acknowledge the interdisciplinary nature of much of the research conducted within the Vygotskyan framework. Contributors to the volume have integrated insights from psychology, education, linguistics and sociology in the various studies of situated cognition and cognitive development based on mastery of culturally defined ways of speaking, thinking and acting. The methodological means for exploring links between social interaction and learning are described by the various contributors. At both local and global levels there is observable behaviour which can employ ethnographic methods such as participant observation and interviews with learners and instructors, and so provide insights into learning and cognitive development.

What is noteworthy in these studies is the relationship between theory and research methodology. Social interaction and contextual changes are captured by participant observation and interpretation of classroom talk and interaction. Both qualitative and quantitative approaches are combined, but the emphasis is on understanding the social processes underlying interaction, and how these impact on student learning.

Other studies grounded in the Vygotskyan theory of social learning illustrate how the larger socio-cultural context can influence the development of shared understanding or common knowledge in the classroom. Edwards & Mercer (1987, p. 62-63) describe their perspective as follows:

> We suggest that education is best understood as a communicative process that consists largely in the growth of shared mental contexts and terms of reference which the various discourses of education (the various subjects

and their associated academic abilities) come to be intelligible to those who use them.

Edwards & Mercer (1987) emphasise that understanding takes place against a background or context. Context is a social phenomenon, invoking past experience, perceptions, prior knowledge and what the participant sees as relevant. The authors employed discourse analysis to investigate how teachers and students construct understandings of events and create contexts. For example, teacher control over turns at talk showed how teachers validate what was understood, what past experiences were invoked and what stories and anecdotes were accepted as part of classroom knowledge. In addition, discourse analysis together with insightful observation, showed how teachers scaffolded students' understandings, and helped to bridge the gaps between old and new knowledge. Edwards & Mercer analysed talk as situated discourse, bounded by the context of the classroom, participant roles and teacher expectations. Analysis of these dimensions required adoption of qualitative methods of research and analysis, which recognised the centrality of social, cultural and linguistic factors. In this study, the value of adopting a qualitative approach to classroom learning was emphasised.

Ethnographic approaches to development of understanding recognise the social and basis of learning cultural and employ qualitative techniques for framing questions, collecting data, investigating participants' perspectives, analysing discourse and theorising about cognitive change. Several other approaches consistent with Vygotskyan theory were analysed in order to situate the research approach to be adopted for the present study. While the approaches reviewed were capable of capturing the dynamics of interaction and of undertaking observational studies, a more interventionist role for the present study was required in order to create optimal conditions in telematics classrooms for the development of higher order thinking. The research questions focused not only on what actually happened in the telematics classrooms of the study, but also on how these environments could maximally support thinking. Socio-cultural theory thus provided a sound theoretical basis and several research approaches, such as ethnography, could be applied to telematics learning contexts, to go beyond the surface description of such environments to enable the researcher to investigate factors contributing to thinking and cognitive change (eg., Peshkin, 1993; Griffin, Belayaeva & Soldatova, 1993).

Integrating qualitative and qualitative approaches

If qualitative and qualitative paradigms were mutually exclusive and based on conflicting epistemologies, then the decision over which to use would be quite straightforward: the choice would be based on the approach which best supported one's theoretical framework and epistemology. However, the choice is not that simple, and many researchers advocate a judicious integration of both, according to the different stages or demands of the research task.

Snyder (1995, p. 45) disagrees with the polarisation of quantitative and qualitative paradigms. Instead she argues that "the two research traditions are not mutually exclusive; rather they are inextricably linked". As both quantitative and qualitative traditions are valid, each can bring insights that serve to complement, or strengthen each other. In support of her viewpoint, Synder discusses her own research on computer-based writing, in which the adoption of both qualitative and quantitative research designs gave different insights, a more comprehensive understanding of the performance of the subjects and a richer description of the computer mediated teaching environment. Snyder combined a quasi-experimental approach with ethnographic observation, and created an eclectic analysis which allowed her to present multiple views of the participants, the setting and the problem under investigation. In addition, it enabled her to make strong claims about the validity of the findings, as she was able to link quantitative findings to detailed analyses of classroom events. Snyder (p. 57) concludes that "the most useful perceptions derive from studies which aim at multiple perspectives".

While there has been a great deal of experimental work on learning in technology mediated learning environments, only a little of this has investigated the development of higher order thinking (eg., Nastasi & Clements, 1992; Repman, 1993). However, such studies have employed experimental conditions and control groups. Nastasi & Clements, (1992) created research environments in which children worked with either LOGO or computer based writing environments, and were assigned to treatment with teachers to bring about higher order thinking. Videotapes were made and events were recorded in order to identify target behaviours. It was found that social processes in LOGO environments, such as the resolution of conflict and cognitive change emerging from discussion was supportive of higher order thinking. However, the classrooms in these studies were not authentic, and the interventions and conditions were controlled in order to produce results. Applicability and transfer of the findings to real classrooms is always a question in such instances.

Support for the eclectic or multiple perspectives approach is found elsewhere in the literature. Edwards & Westgate (1994) state that appropriacy and relevance to the research questions are the most important considerations: the methodology should serve the researcher and the goals of the study. Hammersley too, (1992, p. 168) is critical of the paradigmatic split, and finds it unhelpful to the researcher, and because it only hides the range of strategies available. He tries to unite the two approaches, or at least to suggest that both are necessary and valid: "It seems to me that all research involves both deduction and induction in the broad sense of those terms; we move from ideas to data as well as from data to ideas". Hammersley also emphasises the reality that all research has different moments and different demands for example, formulating problems, selecting cases, producing data and communicating findings.

Each of these research moments, or stages can be approached through a variety of strategies. These views echo those of Denzin (1989) maintains that no single research method will ever capture all the changing features of the environment under investigation. In view of the dynamism and fluidity of telematics classroom environments and the evolving nature of teaching practices, there would appear to be a strong argument in favour of multiple methods.

Combining multiple methods in an investigation has evidently been the subject of much debate, and the present study adopted the use of multiple approaches in investigation, data collection and analysis. This was partly in recognition that a socio-cultural framework demands recognition of the whole context: social, cognitive, organisational and cultural, and that multiple methods of investigation would unravel the complexity of higher order thinking in the classroom, including the conditions which supported learners and the ways teachers scaffolded thinking in the classroom.

The research questions of the present study focused on how to support thinking through teaching practices and technology use, both of which required qualitative and long term observations of teaching in progress. For these purposes, qualitative methods based on classroom observation over an extended period of time were needed to collect the data, and multiple methods were needed to explore the classroom interactions in depth. The research was developmental in the sense that the initial observations were the basis on which initiatives were taken to change teaching practices in order to improve higher order thinking in learners. This required a dynamic approach, capable of providing a framework for interventions and change in the classrooms of the study. Socio-cultural theory provided such a methodology.

Formative experiments

Interventions into classroom learning are attempts to improve learning by involving a researcher to design and evaluate the intervention, and achieve outcomes that go beyond the comprehension of academic content. Other aspects of intervention studies, according to Hattie, Biggs & Purdie (1996) are that the 'intervention' is an innovation and a departure from normal teaching, involving a formal experimental design, and focuses on independent variables that increase student performance. In the meta-analysis of classroom interventions conducted by Hattie et al. (1996), the authors also tried to identify features that had been found to succeed in the studies they reviewed, and the various theoretical stances that can be supported by these studies. The authors concluded that :

> the results ... support the notion of situated cognition, whereby it is recommended that training ... should be (a) in context, (b) use task within the same domain as the target content, and (c) promote a high degree of learner activity and metacognitive awareness
> (Hattie, Biggs & Purdie, 1996, p. 135).

In the present study, it was not possible to conduct an intervention in the sense intended by Hattie et al (1996), simply because the context in which the study was conducted was authentic and school-based. The students were studying a syllabus and were expected to achieve particular outcomes. It would have been neither ethical nor feasible to conduct an experimental study or impose other research goals in this context which would have distracted the teachers from the objectives of the curriculum that students were pursuing. In the classrooms therefore, an 'intervention' occurred when the researcher collaborated with teachers to amend or change a particular teaching strategy or aspect of the environment in order to provide better conditions for achieving the prestated goal of higher order thinking. All interventions were negotiated and consistent with the educational objectives of the curricula being followed by each classroom.

Another important difference between the context, present study and those described by Hattie et al (1996) was that the study was conducted in real classrooms where the outcomes were those stated in the curriculum. Context, participants' goals and interactions and the social context of talk were a focal point of inquiry. For example, in studying learning in telematics classrooms, the context of learning with technology had to become a focus for inquiry. Experimental and quantitative approaches to classroom interaction *exclude* consideration of contextual variables and do not consider socio-linguistic forces which impact on learning, such as how teachers and students

build up mutual understandings through dialogue. Therefore, a controlled experimental design was not appropriate to the context of the study. In a formative experiment, variables are not controlled, and the entire context becomes part of the investigation.

Scott, Cole & Engel (1992) have proposed a way of looking at teaching/learning issues as cultural systems which can be influenced by social and pedagogical change. Once cognitive development is regarded as a *formative* process, the contexts that contribute to thinking and learning can also be modified to achieve results. A *formative experiment* sets a pedagogical goal and then makes successive interventions in order to achieve a desired outcome. In other words, a formative experiment is concerned first and foremost with changing the environment to achieve a particular pedagogical outcome.

This approach matched the goal of the study which was to bring about conditions for higher order thinking in telematics classrooms, and therefore was adopted as a research approach. It was also consistent within the goals of socio-cultural theory, as the whole environment, social, cultural and organisational is regarded as part of the developmental process. Also, a formative experiment is conducted in recognition of the social aspect of learning and its mediation by technological tools, which means that the computer is put to actual use in instruction. Classroom interventions are planned through a formative experiment which considers the entire culture and social relationships of the participants. Newman (1990, p. 10) explains:

> In a formative experiment, the researcher sets a pedagogical goal and finds out what it takes in terms of materials, organisation and changes ... to reach the goal. Formative experiments aim at a particular outcome and observe the process by which the goal is achieved.

Ultimately the goal is to create an environment in which students and teachers work towards achieving a common pedagogical goal, and organisational changes (eg., in patterns of classroom organisation) are part of the experiment. While the outcomes and goals of a formative experiment may be prespecified and planned, the researcher must be prepared for unexpected directions, changes and developments as the participants are operating in real time with their own goals and agendas. Figure 8.1 shows the various stages and processes involved in a formative experiment. At each stage, observations are made and data is collected which is used to inform the changes that are planned.

Since the environment, rather than the technology is the unit of analysis, all aspects of how the environment changes need to be observed. This includes interaction patterns,

changes in teacher role and student behaviour. Newman (1990) suggests that another way of conceptualising changes in the environment is to see them as changes in support for cognition, that is, as new zones of proximal development for learners. To achieve the goal of bringing about cognitive change, research must combine qualitative methods of observation and investigation with interventions in learning situations (Jacob,1992).

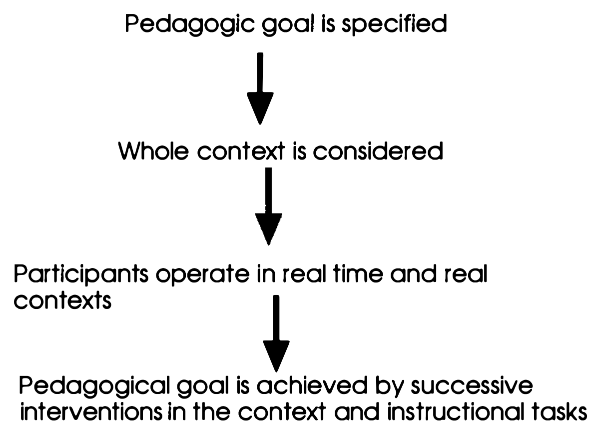


Figure 8.1 : Stages and processes involved in a formative experiment

Formative experiments provide unique settings for investigating learning and teaching, as several studies illustrate. Newman, (1990) set out to increase the frequency of collaborative work among students using networked computers to study science. The pedagogical goal of the researcher was that students learn to communicate the way real scientists do, for example, to share ideas, discuss and collaborate. In order to achieve this objective, the researchers intervened in various ways in the natural learning environment of the students. For example, they conducted staff development, modified materials and changed the social organisation of the classroom. Changes were observed and documented using qualitative techniques, such as ethnography, participant observation, and videotaping of lessons to identify problems and to plan interventions. For this to succeed, the unit of analysis had to shift from the individual to the social context, and to use real settings over a period of time in order to monitor changes in the environment. This required the use of ethnographic techniques where the researcher observed the whole organisation of the classroom, its social, pedagogical and cognitive dimensions and the respective roles of teachers and learners.

Another formative experiment was conducted by Newman, Griffin & Cole (1989, p. 2) who worked on the premise that "cognitive change is a process of interactive construction" which required consideration of the social environment of learning. At the heart of this approach was Vygotsky's concept of zones of proximal development which they saw as a functional system enabling the learners to interact in a manner likely to bring about cognitive change, if the task and support were appropriate. Newman et al. (1989) applied the ZPD concept to assessment, and observed how much support learners required to complete a task, instead of measuring the change against some kind of predetermined standard. As the authors explain:

> We reasoned that it would be possible to assess the amount of support that the teacher provided in the children's first encounter with the task and then compare it with the amount of support that she provided on the second encounter. Decrements in the amount of support would indicate an increase in the children's ability to carry out the task.
> (Newman, Griffin & Cole, 1989, p. 81).

In this particular formative experiment, the children entered the classroom with different concepts and understandings of mathematical operations. Teacher interventions at various critical stages enabled learners to understand and participate in the mathematical processes being taught. These interventions consisted of offering varying amounts of support or scaffolding until the students achieved mastery. Through analysis of discourse the researchers were able to monitor the process of cognitive change. Qualitative methods were used to collect and analyse data, as these were more reliable in giving insight into the social and interactive aspects of the experience rather than simply testing the students.

Linking these studies to the inquiry needs of the research questions showed that the formative experimental approach had validity and relevance to a research model aimed at creating conditions for higher order thinking in telematics classrooms. The pedagogical goals of the research on telematics classrooms were clear and required a developmental approach. Therefore it was essential to adopt a methodology where it was possible to create conditions conducive to higher order thinking outcomes, and to plan systematically for these outcomes. The strengths of the formative experimental approach were assessed more directly by comparing it with experimental methods.

Formative experiments and experimental methods compared

Formative experiments provide an example of how research can be conducted within the scope of the socio-cultural framework and employ qualitative methods and procedures for analysis. Notably, the unit of analysis changes from individuals to social settings, from isolated tasks to tasks in a real cultural context. Jacob, (1992. p. 324) in her review of formative experiments concludes:

> This perspective has led to an increasing use of methods of discourse analysis to help understand how social interaction contributes to cognitive change. It has also led to the implementation of formative experiments that seek to move from *documenting what is, to exploring what could be.* (Italics mine)

The observational research approach and naturalistic data collection procedures of formative experiments are consistent with the socio-cultural framework of the study and embody the Vygotskyan concept of development through social interaction. These contrast with the procedures of experimental design where control of variables is essential. More important however, was that the goals of a formative experiment should be consistent with the aims of the research on telematics classrooms, that is, to bring about changes and improvement in student learning and thinking.

The formative experimental approach can be illustrated by comparing it with studies conducted utilising experimental techniques. Repman's (1993) study of collaborative learning was designed to increase the level of elaborated interactions among students in a computer-based learning environment. Two groups participated in the treatment and both were asked to work on collaborative tasks. One group was given an unstructured task, while the other was given a protocol sheet to guide their activities. The collection of data was typical of experimental designs, where pre and post tests of critical thinking were administered, data collection and analysis was rigorously scientific, and observational data was coded according to categories designed to analyse verbal interactions.

However, the findings of the study showed no significant difference between the groups in measures of critical thinking. The author, in an admission of the limitations of experimental designs remarked that:

> It was recognised from the outset of the study that use of a standardised instrument for the assessment of critical thinking is problematic ... and that students working in collaborative settings may need more time to learn thinking and problem-solving skills. (Repman, 1993, p. 159).

This statement is itself a sufficient indictment of experimental approaches which attempt to foster thinking skills. The missing ingredient, one that not easily accessible or measurable in experimental designs, was the quality of social interaction. It would seem that such designs are so highly influenced by the conditions of the laboratory or controlled environment that they are not applicable to everyday classroom contexts.

Although there have been some useful insights from experimental designs, in particular the findings that have emerged regarding the active, verbal and questioning role that learners must assume in order to enhance their learning (King, 1994; Chi, Leeuw, Chiu & LaVancher, 1994), experimental designs cannot accommodate or account for social and contextual variables.

In contrast, the formative experimental approach, based on successive interventions into the learning environment, approaches the task of improving conditions for learning that would be outside the realm of experimental research. The whole organisation and social environment, the participants and their agenda, the technology and its impact are considered as part of the totality of the research context. There is no attempt to manipulate, control or eliminate variables. The approach to setting up a formative experiment resonated closely with the aims of the present study, that is, to achieve a pedagogical goal. For the telematics classrooms of the study, this entailed exploring the means to support higher order thinking.

One aspect of adopting a formative experimental approach that was a source of concern was that, in previous studies, interventions tended to be imposed on participants by an external researcher, or expert. The present research on telematics classrooms had to be more sensitive to participants, particularly teachers, who ultimately had responsibility to their students and had their own pedagogical goals in terms of covering the syllabus. From the outset, it was clear that it would not be possible to intervene in the telematics environments without full support and collaboration of the teachers. For these reasons, consideration of other approaches was necessary as the researcher had to work closely with teachers in implementing the curriculum, working with technology and monitoring change. This dimension brought the researcher closer to what is called practical inquiry, or action research (Tomlinson, 1995).

Action research

One major division between the quantitative and quantitative research designs is the nature of the settings. In experimental designs, the environment is controlled, and events within this artificial setting are observed and recorded. On the other hand, classrooms are natural and real environments, although they are socially constructed and apart from everyday life. Teachers, in the course of their professional development become accustomed to evaluating their own teaching, building up repertoires of skills and strengthening their management of events. In this sense, teachers are always researchers of their own practice. Action research simply formalises this teacher self development, by encouraging teachers to take centre stage in the investigation, evaluation and reflection on their own practice. In addition, action research, or practical inquiry encourages teachers to share ideas with others in the field.

Anderson, Herr & Nihlen (1994) add that in addition to systematic and sustained identification of problems, teachers are also committed to improving the quality of action in that setting. Carr & Kemmis (1986) advocate that teachers form a self-reflective critical community in order to develop better practice.

Certain characteristics of the action research model (Brubacher, Case & Reagan, 1994) were relevant to the design and execution of the present study, which sought to explore how teachers bring about higher order thinking in their own classrooms. Aspects of the approach that were relevant to the inquiry were as follows:

- research is undertaken in a real educational setting;
- action research is systematic in documenting and presentation of evidence;
- the practitioner becomes part of what is studied;
- the immediate goal is to improve the quality of the learning experience;
- the goal is to develop and take informed action beneficial to learners;
- all stages involve reflection by the action researcher and by practitioners;
- the research employs numerous methods, especially qualitative methods;
- findings are reported in the language of the practitioner.

However, two limitations of the action research model were considered. One was that the action research model seems to celebrate awareness among teachers themselves and give them a heightened sense of control and responsibility as researchers in their own territory, the classroom. Secondly, the model as explained by Carr & Kemmis (1993) sets itself up as an answer to more detached forms of research, and defines interventions by external researchers as invasive and a possible threat to the autonomy

of teachers. Mercer (1995) also suggests that action research does not fully consider the interest that other practitioners besides teachers have in evaluating teaching. Therefore, it tends to minimise the need for expertise and professional input by researchers who are not professionally tied to the learners, but have the detachment and skills to complement the expertise of teachers who have first hand knowledge of their learners.

Confining research on learning to within the teaching profession necessarily limits the perspectives and scope of critical input from other professionals. For this reason, Mercer (1995, p. 119) proposes that a model would extend the action research model outwards into the community, so that practitioners and teachers work together in what is called a 'research partnership'. In this model, each party, teachers and researcher, collaborate and share expertise in pursuit of a common goal. This approach to bringing about change was considered to have the enormous potential for the present research, where the researcher was engaged in assisting teachers to achieve the curriculum outcome of higher order thinking.

Research partnership model

This research partnership approach to research was adopted to overcome the limitations of the formative experimental approach and to extend the action research model further. Through joint collaboration, teachers and researcher could share expertise and goals and work towards planning intervention to achieve better outcomes. Mercer (1995, p. 120) adds that "there has to be some negotiation of what aims and agenda are being pursued, and of course, the relationship has to be one of mutual trust." The research partnership model supports the practices of action research and is a process of systematic reflection and intervention to change features of the learning environment to achieve a pedagogical objective. For the present project, the pedagogic objective was to support the development of higher order thinking, reasoning and cognitive accountability through a working partnership with teachers involved in telematics delivery.

The research partnership model supported the socio-cultural framework of the study as it:

- regarded talk as contributing to cognition;
- viewed knowledge as jointly constructed;
- regarded social dynamics as fundamental to learning;
- viewed learning as scaffolded instruction;
- included the perspectives of all participants in the sharing of knowledge; and

- employed data collection techniques to illustrate the roles and perspectives of participants.

Having decided to adopt a research partnership approach which was consistent with the aims of the study, another consideration was to approach the tasks from multiple perspectives and to ensure triangulation of data.

Need for triangulation

The research partnership approach and data collection procedures required an integration of approaches and methods. The issues surrounding the use of both different paradigms discussed suggests that use of a range of methods is more likely to overcome bias or limitation than the adoption of a sole methodology. This approach is called 'triangulation' (Denzin, 1978). In the studies cited above, (eg., Synder, 1995) qualitative and quantitative methods were combined effectively to increase validity, improve the generalisability of findings, and provide greater applicability of the research findings. Snyder (1995) used ethnographic analysis with statistical analysis of students' performance using two writing techniques. Maor (1993) investigated how students developed inquiry skills using a multimedia database. The study used participant observation, case studies and measures of student performance on a thinking skills test to contribute different perspectives. Both studies employed multiple methods of data analysis and are cited in support of the triangulation methods applied in the present study.

Denzin (1978, p.15) concludes:

> If each method leads to different features of empirical reality, then no single method can ever completely capture all the relevant features of that reality. Consequently [researchers] must learn to employ multiple methods in the analysis of the same empirical event.

Continuing the debate of triangulation, Denzin & Lincoln (1984) advocate that there are four types of triangulation:

1. data triangulation which includes temporal aspects, participants and location;
2. investigator triangulation which uses more than one investigator;
3. theory triangulation which combines more than one theoretical perspective; and
4. methodological triangulation which involves using more than one method.

Further to this they recommend one or more forms of triangulation within the same study. The present study satisfies these requirements adequately. In the discussion of the theoretical background, and in defining an operational definition for higher order thinking, theoretical triangulation is evident in the consideration of social constructivist and socio-cultural views of cognition. Data triangulation, in the form of multiple sources of evidence, both primary and secondary, were collected. In addition, there was triangulation in the methodology used for analysis and categorisation of classroom interaction, which included both a qualitative and a quantitative component. This is discussed in Chapter 9. The issue of investigator triangulation was also considered and it was decided to use a form of inter-rater reliability to check and confirm the categories of talk used for analysis of data (Chapter 9).

In the next section, the research approach of the study is described with reference to the contextual background, setting and participants.

Research design

Contextual background

The research questions emerged from an actual educational setting and a curriculum need to foster higher order thinking among rural and remote students via telematics (Chapter 4). In 1996 the decision was made to extend the Academic Talent Program to rural students in Western Australia, and to pursue a curriculum where higher order thinking outcomes were a priority. It was within these initial events and perspectives that the researcher was able to establish a research partnership with teachers and to work towards achieving higher order thinking in the telematics classrooms of the study.

The stated objective of the curriculum as laid down in the *Curriculum Framework Documents* (EDWA, 1996) was to develop understanding about content knowledge and understandings and to extend and enrich students so that they could demonstrate a range of higher level cognitive skills such as:

- a knowledge of the ways in which language varies according to content, purpose, audience and context;
- the capacity to develop reasoned arguments about interpretation and meaning;
- the capacity to apply problem-solving capacities in purposeful ways, including situations requiring critical thinking; and

- the capacity to plan and organise activities, sort out priorities and monitor their own performance.

These extracts from the curriculum documents presented teachers with a pedagogical challenge ie, to teach effectively via telematics, covering content and syllabus and yet to enrich and extend students in order to attain higher order thinking outcomes. Nevertheless, in conversations with the teachers, it was clear that they had different and sometimes hazy notions of what higher order thinking was, how it could be achieved and what kinds of teaching approaches were likely to be productive in fostering higher order thinking in via telematics. In this context, the approach of a formative experiment was considered most appropriate, as it would apply a developmental and progressive approach to achieving these outcomes in the actual classrooms, and monitor change at each observation in order to plan further interventions. The research design is represented schematically in Figure 8.2.

Phase 1 would involve an observation of all teachers with their classes, in order to gain an initial impression of how students and teachers interacted, and also to collect baseline data on whether or not there was evidence of higher order thinking. Following the initial observation, it was intended to collaborate with teachers in order to plan interventions and bring about pedagogical change so that higher order thinking would be achieved by students.

The first intervention was intended to focus on changing pedagogies by enabling teachers to become aware of planning for higher order thinking, and utilising the technology to support HOT. The first intervention was planned and followed by Phase 2 observation which spanned several lessons, and aimed to monitor changes in teacher roles, student activity and levels of higher order thinking. A final intervention was planned, to consolidate teacher practices, followed by a Phase 3 observation. From these observations conclusions could be drawn about conditions conducive to higher order thinking.

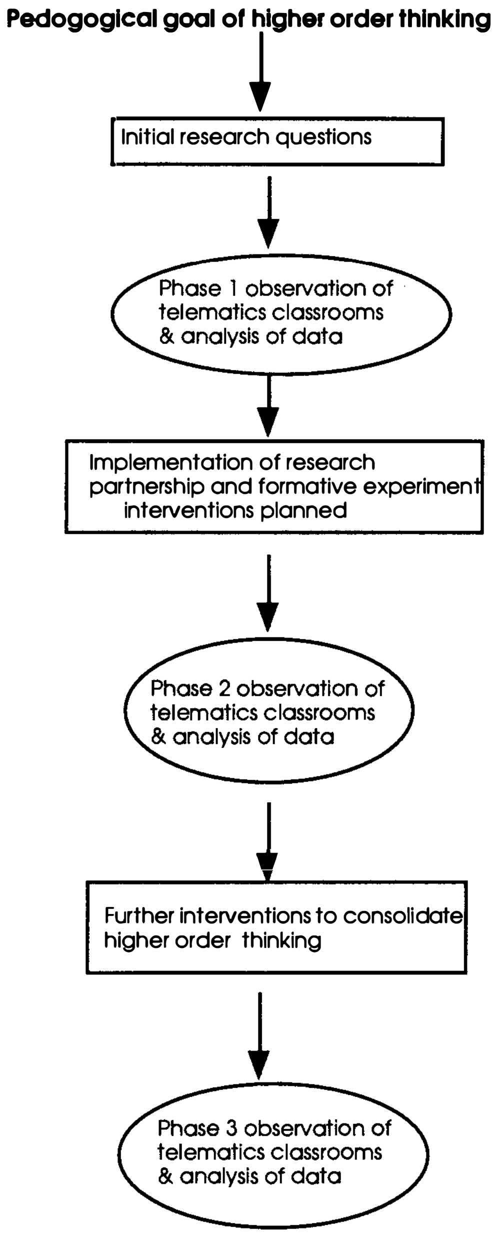


Figure 8.2: Research design of the study

Participants in the study

Five teachers participated in the study, one for each of the subject areas Mathematics, Italian, Science, Social Studies and English. Each teacher taught to two or more schools simultaneously, although classes were small. Teachers taught lessons from their own schools in the Perth Metropolitan area and the receiving schools were in rural areas of Western Australia.

Student numbers for classes in each of the subject areas were as follows:

English:	7 students: 2 sites
Social Studies:	7 students: 2 sites
Italian:	7 students 2 sites
Maths	5 students 3 sites
Science	5 students 3 sites

The same students studied English and Social Studies, while Maths and Science formed another cluster with the same students taking both subjects. Students studying Italian also studied English and Social Studies.

As class sizes in the rural schools were small, students were not usually supervised, and they had to make a rapid adjustment to a learning context where the teacher was absent, and where communication was mediated electronically. The voice link used a standard telephone line, and students had a hands free phone at their school so that they could hear the teacher without holding a telephone. The computer provided the visual link, and each school had to link up with central distant computer before they could receive graphics from the teacher. Other equipment at the schools included a fax machine. Most teachers sent printed materials to students in advance of the lesson so that students had these available for reference during the lesson. The schools receiving Italian, English and Social Studies had a graphics tablet, enabling students to quickly draw, paint or write ideas on the screen instead of using the keyboard. This was a useful resource for students, as it was easy to use and did not require keyboard skills. Maths and Science students had to rely on the keyboard to send images to the teacher.

The researcher attended all training sessions with the teachers and the briefing sessions conducted while teachers were introduced to the Curriculum Framework documents (EDWA, 1996) for their disciplinary areas. These interactions with teachers helped to forge the collaboration necessary for a research partnership.

Stages in the research

At the beginning of the school year, the project commenced with the group of five teachers, recently trained in using telematics for delivery of lesson, each with the task of delivering a curriculum to students in the Academic Talent Program via telematics. Each of the five teachers was based at a different school in the Perth Metropolitan area, and each had the task of teaching at a distance to clusters of 2 or more rural schools, each with several students. Initially the teachers' main concerns were with management of technology, in particular how to overcome the many technical problems involved in transmitting a lesson using computers, modems and telephone lines. At the same time teachers were concerned that, despite delays caused by

technical failures, they had to cover a syllabus, demonstrate that their students were being enriched, extended and accelerated by the materials, and also construct the syllabus as the term progressed.

At the early stage, conversations between the researcher and the teachers revolved around how best to exploit the technology to achieve curriculum goals. The teachers had quite different perceptions of what a successful lesson meant. For some teachers, a bad lesson was a failed connection, when the modems 'went down' and they had to teach via the audio link. When the connections did work, some teachers perceived this to be a successful lesson, regardless of how the technology was utilised or what objectives were attained. Technology and teaching seemed to have become entangled and inseparable. There was nevertheless a common focus: the intention to achieve higher order thinking outcomes in the students participating in the study.

In the first few days of the school term in which the study commenced, the researcher discussed with each individual teacher their objectives for the program, and about how they wanted to approach the development of higher order thinking with their students. Dialogue and communication between the teachers and researcher became an integral part of the monitoring and evaluation of lessons, and it was through cooperation and joint decision making process that the interventions were ultimately planned and executed.

The dialogue between the researcher and the teachers can itself be seen from a socio-cultural perspective, a conversation in which interests were shared, discussed and defended and new understandings and plans were forged. Instead of the researcher imposing new teaching practices or pedagogies, the aims and goals that emerged were discussed and negotiated with teacher so as to be:

- consistent with the curriculum objectives of the teachers;
- jointly articulated; and
- in line with the expectations of teachers and schools with respect to enhancement of independent thinking.

The subsequent sections of this chapter deal with other aspects of the research design, such as participants and sources of data.

Sources of data

In the present study the primary sources of data were video and audio tapes of lessons. Whenever possible, lessons were observed, either at the point of delivery, with the

teacher, or at the receiving school. Because the telematics lessons were received at various rural sites simultaneously, it was not possible to observe all lessons. Lessons were videotaped, and the video recordings gave a concrete view of what transpired during lessons. Other methods of data collection were used to supplement the corpus of data and to consolidate the triangulation. These data sources included:

- rough field notes of classroom observations;
- audio tapes of lessons;
- semi-structured interviews with teachers and students; and
- written responses from teachers on their evaluation of the telematics program and methodologies chosen.

Secondary data sources included:

- artefacts such as textbook chapters, course outlines, worksheets, laboratory exercises;
- computer screens and print-outs of telematics lessons;
- curriculum documents; and
- notes recorded from conversations with teachers, supervisors and parents.

These data source were considered secondary because they did not constitute data that could be analysed in depth; instead they were used to support and extend the primary data analysis. The use of multiple layers of data enabled the researcher to triangulate analyses across sources, and helped to reduce bias and subjectivity. In addition, as the research progressed, drafts of the ongoing analysis and changing student behaviours were shared with teachers to enable them to reflect on their own experiences and to discuss further interventions to bring about higher order thinking.

Data collection

Observations of teaching and learning commenced early in the first term, and videorecording of lessons commenced several months later. By that stage teachers had become familiar with the technology and while technical hitches still occurred, there was a reasonable chance of recording entire lessons. For Phase 1, three lessons from each of the five subject areas (Science, Maths, English, Social Studies and Italian) were recorded. Video cameras were set up in the remote schools so that classroom activities and student behaviours could be monitored.

There were three observation phases in the study, with different purposes as follows:

Phase 1: Conducted to gather baseline data;
Phase 2: Conducted following the first intervention, to monitor change in teacher behaviours and occurrences of HOT in student talk;
Phase 3: Conducted after the second intervention, to monitor change and observe the occurrence of higher order thinking.

Teachers were told that videorecording would be done on random lessons, and that there was no need to prepare special lessons. This was important as the videotapes were intended to record typical lessons and interactions. Transcripts of all lessons were made and used as the primary source of data. Of the fifteen lessons recorded and transcribed at each phase, ten were analysed in depth for patterns of teacher talk and student talk. In all, a total of forty five hours of lessons were observed, and thirty hours of videotaped instruction was transcribed and analysed. This was sufficient to obtain an overview of the data and to answer the research questions.

Data were also collected through conversations with teachers and students, collection of curriculum documents and teaching materials. Graphics accompanying each lesson were analysed and teachers were asked about the purpose and goal of each lesson, so that the researcher could interpret data with an informed perspective.

Table 8.1: Classrooms and numbers of recorded lessons during all phases of the study

Classroom	Phase 1	Phase 2	Phase 3
Italian	Italian 1 Italian 2	Italian 3 Italian 4	Italian 5 Italian 6
Mathematics	Maths 1 Maths 2	Maths 3 Maths 4	Maths 5 Maths 6
Science	Science 1 Science 2	Science 3 Science 4	Science 5 Science 6
English	English 1 English 2	English 3 English 4	English 5 English 6
Social Studies	Social Studies 1 Social Studies 2	Social Studies 3 Social Studies 4	Social Studies 5 Social Studies 6

Phase 1 lessons were numbered 1 and 2, with the same numbering for each subject in Phase 1. Table 8.1 shows the classrooms and numbers of lessons at each phase of the study. Two lessons from each phase were analysed, giving lessons coded numerically. For each of the subsequent phases, the number changed to indicate the phase, so the second phase of lessons were coded 3, 4, and the third phase 5 and 6, as Table 8.1 shows.

Summary

This chapter has outlined theoretical issues behind the choice of a methodological framework for the study. Having critically reviewed a range of studies on classroom interaction, the most appropriate research approach was described as a socio-cultural research partnership, which combined elements of a formative experiment with an action research approach. The essential ingredients of the approach were:

- a developmental approach to improving teaching and learning for higher order thinking;
- collaboration and joint action as a source of decision making;
- setting a pedagogical goal and intervening in the learning environment to achieve this goal;
- recognising the different perspectives and agendas of participants; and
- using multiple sources of data to analyse diverse social, cognitive and cultural aspects of the learning environment.

This research partnership model based on the work of Mercer (1995) offered the best approach to explore interaction in the telematics classrooms of the study, and to support the development of higher order thinking in learners through informed teacher pedagogy and decision making. This approach was consistent with Vygotskyan theory, which sees learning as a form of assisted instruction, in which teachers scaffold their students' emerging skills.

At another level, the research approach was reflexive, as it accounted for the research process itself, which was yet another form of knowledge construction conducted through collaboration with practitioners in the field, involving dialogue and conversation. The research partnership was a microcosm of the entire research project, since it used the same procedures of collaborative dialogue and situated investigation to improve understanding of learning in telematics environments. The operational definition of higher order thinking proposed in the study regarded as fundamental the mutual understandings achieved through dialogue, where learners were able to

reason, infer and create new understandings which were the essence of higher order thinking. In much the same way the researcher proceeded to build up insights about teaching and learning in telematics classrooms, so that through cooperation and dialogue with teachers, a new perspective on achieving higher level thinking was formulated. In both scenarios, new insights and richer forms of understanding were achieved through jointly constructed understanding and exchange of views.

The chapter has also given some attention to the need for triangulation, and has emphasised that multiple perspectives were brought to bear at each stage of the research process. It was considered important to have multiple sources of triangulation, for example, theory triangulation, data triangulation and methodological triangulation in order to enable multiple perspectives on data, participants and context and to give the findings greater generalisability.

The next chapter focuses on how classroom talk was analysed and how multiple perspectives were integrated to achieve a multilevel understanding of higher order thinking in the telematics classrooms of the study.

CHAPTER 9

Analysis of data: Methods and procedures

Introduction

An investigation of the context and social conditions which supported higher order thinking in telematics classrooms was the main concern of this study. The study began with an investigation of verbal interactions across several telematics classrooms and progressed to the staging of interventions, through a formative experiment, intended to improve the quality of learners' higher order thinking.

In Chapter 5, an operational definition of higher order thinking proposed that it was a form of reasoning and a social, language-based phenomenon, realised in communicative contexts of knowledge construction, where mastery of conventions such as asking for and giving reasons, justifying, inferring and specifying aims are valued and emphasised. Furthermore, the interpretation of higher order thinking was based on the socio-cultural view of knowledge construction which maintains that talk and interaction in social contexts provide opportunities for, and at the same time may lead to higher forms of thinking (Vygotsky, 1978; Coles, 1995). It was also proposed that in the context of telematics classrooms, an appropriate operational definition of higher order thinking was: *not the transmission of any particular content of body of knowledge or skills, but the development in learners, through social contexts, of self-regulated, reflective and critical inquiry that will enable them to exercise judgement, reasoning and problem solving skills and demonstrate as outcomes, cognitive accountability in the form of interpretation, decisions and inferences based on sound evidence and sensitivity to context.*

From this operational definition, the major indicators of higher order thinking were summarised into four major patterns of learner language activity which indicated:

- interpretation of ideas and texts;
- reflection;
- critical inquiry; and
- cognitive accountability.

In order to establish whether these forms of thinking were manifest in student talk, it was essential to choose an appropriate method of analysis. Initially, the task was to review some of the major approaches to analysis of verbal data, and then choose a

method or combination of methods consistent with the research framework of the study. As Chapter 8 has described, the primary sources of data consisted of videotapes of forty five lessons recorded over a year, which were fully transcribed. This verbal data had to be analysed in order to uncover teacher-student dynamics and the levels and forms of higher order thinking among students.

The purpose of this chapter is to:

- set out the methodological framework for analysis of the data on telematics classrooms;
- propose an approach to the analysis of data in order to combine the strengths of both qualitative and quantitative approaches;
- define and defend the units of analysis proposed for the study; and
- outline the procedures used in the analysis of data.

The focus of this critical evaluation is to present a case for both qualitative and quantitative approaches to data analysis, and to show that the data required a combination of approaches that would allow the researcher to systematically analyse the discourse that occurred in the telematics classrooms of the study.

Social and language-based data

In keeping with the socio-cultural framework of the present study, the data of most value to the study of thinking were displayed through classroom language and social interactions. The debate on the relationship of thought to language is discussed in Edwards (1993) who contrasts language as 'representation', an account which is related to cognitive psychology, and 'language as action', which treats talk as situated action. The view adopted in this study is that language is a form of social action and so students' cognitive orientations and thought processes are realised in discourse. This means "taking seriously the content of what they say for what it tells us about what they think, know or believe"(Edwards, 1993, p. 209). Adopting this approach meant that transcripts of lessons could be examined for indicators of learners' thinking.

The socio-cultural approach to learning requires close examination of the contexts in which the learning occurs, and is illustrated in the work of a number of practitioners and researchers (Mercer, 1995; Forman, Minick and Stone, 1993; Säljö, 1994; Laurillard 1994) and reflected in the words of Säljö (1994; p. 91) who states that " .. it is important to consider seriously the role of communication and interaction for learning, and to employ analytical perspectives in which the natural habitat for individual action is

shared human activity". Figure 9.1 shows the relationship between the theoretical framework of the study and the research design and methodology.

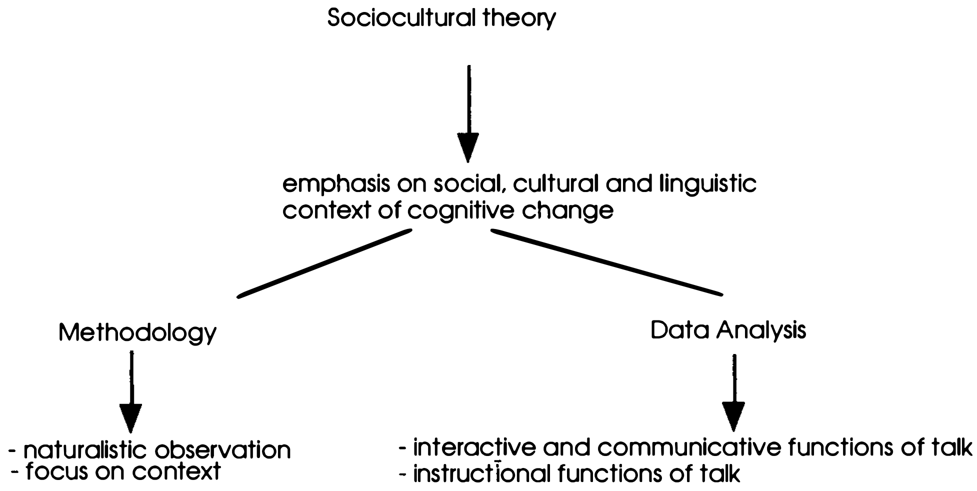


Figure 9.1: Link between theory, research methodology and data analysis

In order to capture all levels of activity and the complexity of the telematics classrooms, a multi-level analysis of the social, language based interactions utilising a qualitative, conceptual coding approach was adopted. The approach was based on analysing classroom language and interactions as evidence of higher order thinking, and as evidence for teacher strategies and roles. However, as the research design was not experimental, but interpretive, both qualitative and quantitative methods were used to present the findings of the analysis.

The subsequent sections consider the strengths and weaknesses of different approaches to the analysis of talk in educational settings. This discussion was necessary to justify the discourse-based approach for analysis of student talk, teacher talk and interactions with the technology that constituted the data.

Approaches to analysis of talk

There is well documented evidence of strongly opposing views as to how talk should be treated as evidence of learning and of thought (Edwards & Westgate, 1994). Consideration of different approaches to data analysis was a necessary stage in the research process, and an evaluation of various studies of classroom talk was an important aspect of the research process.

Among the approaches to talk-analysis which have contributed to our understanding of classrooms there are several: sociolinguistic, ethnographic, conversation analysis, systematic observation, and interaction analysis, each with a distinctive array of analytic procedures and conventions for setting out transcripts of data, drawing inferences and analysing cognitive processes.

Originating with Flanders (1970), interaction analysis describes and categorises various forms of instructional practice that take place between teachers and students where there is a teaching-learning speech transaction. Such categories tend to be prescriptive and narrowly defined, reflecting static rather than dynamic patterns of interaction. All categories are *a priori*, and assigned to the talk by observers who systematically record occurrences. As the categories are predetermined, this seriously restricts observation of behaviours, as only those categories defined in the observation schedule are recorded. A related approach to data analysis is content analysis (Henri, 1992), which highlights critical dimensions of the learning process and conducts an analysis on a multilevel basis, assigning behaviours to different features of the learning process.

There are several recent modifications of systematic observation approaches to talk analysis reflected in empirical studies of higher order cognition. Nastasi & Clements (1993; 1992) investigated how peer interaction in educational computing environments mediate higher order thinking processes. This approach relied on a statistical relationship being established between socio-cognitive processes and problem solving scores as an indicator of higher level thinking.

Other studies have used variations of the coding process. A recent study of peer interaction during collaborative writing with computers (Kumpulainen, 1996) used a system of analysis which classified children's linguistic utterances according to the functions displayed. In a study of the development of scientific reasoning, Azmitia & Montgomery (1993) used a coding scheme to quantify features of scientific reasoning which included justifying solutions, evaluating, clarifying, questioning and explaining. This research, like that of Nastasi & Clements (1992; 1993) was based on the Piagetian concept of cognitive conflict, which related success in problem solving to the degree of conflict or verbal disagreement that arises among peers. While the design of the study did not include consideration of naturalistic settings or longer stretches of discourse, the data analysis procedures were nevertheless of interest to the present study as they highlighted the role that dialogue and transaction played in supporting reasoning, which was central to the definition of higher order thinking developed in this study.

Advantages and disadvantages of coding schemes

Many studies have adopted systematic coding schemes in order to reduce the data to manageable and identifiable categories. While coding schemes are convenient for a researcher who is seeking to classify large amounts of data, the approach is of limited value is some respects. Firstly, the categories once defined, may become absolute, and often obscure the actual context of the talk (Edwards & Mercer, 1987). In addition, Draper & Anderson (1991) claim that:

- many utterances are ambiguous and have multiple functions;
- categories tend to be based on mutually exclusive criteria;
- discourse, conversation and classroom interaction is progressive and cumulative and so taking talk out of context can make it sound ambiguous; and
- the selection of single utterances as the unit of analysis may not capture the interactive nature of dialogue.

While most studies utilise inter-rater reliability when assigning utterances to categories, there is still an issue of how the choice of the initial categorisations was made. Although provision by the researcher of examples of the categories in their original contexts may help to restore confidence in the coding scheme, there must also be strong links between the theory adopted and the methodology. A further criticism of coding schemes is voiced by Crook (1994), particularly with respect to collaborative learning. He argues that coding schemes may fail to capture the essential temporal dimensions of talk and the cooperation between learners that develops over time. To avoid the same criticisms applying to thinking skills, which are cumulative and developmental, an approach was adopted where changes in quality of talk were documented and monitored at each stage of the study,

Several studies of classroom talk have used categorisation schemes for handling large amounts of data, and this is a notable advantage of coding schemes. Bennett & Dunne (1991) investigated patterns of language use in cooperative settings and used a two level coding scheme to classify the data into task related and non-task related categories. A discourse approach was taken by Emihovich & Miller (1988) combining predefined behaviours with linguistic categories generated by the researcher to identify different levels of metacognition in learners. These studies and others have produced insights into learning patterns and classroom roles and their advantage is that they allow large amounts of data to be handled, use explicit criteria for categorisation and provide the basis for comparisons to be made between the communicative behaviours of different groups of learners (Wegerif & Mercer, 1996).

In addition, systematic analysis of classroom discourse using the above techniques has revealed some of the basic inequalities of classroom talk, such as the high proportion of teacher talk, and the preponderance of open or closed questions (Dillon, 1982). For such purposes, systematic coding techniques provide a useful overview of communicative patterns. Nevertheless, the disadvantage to using such schemes is that they overlook the fact the talk is complex, and multi dimensional and multi-functional.

If we are to capture the complexities of talk as action and as cognition, in its wider social context, the choice of an appropriate method for analysis is essential. The socio-cultural framework of the study regards talk as situated action emerging from the context of social interaction, and so it would have been inappropriate to neglect the contextual setting. These issues were discussed in Chapter 8, where triangulation in methodology was suggested as a solution to the issue of achieving a multi-layered perspective of telematics classrooms. The next section will detail some advantages of the approaches which are inclusive of participants' perspectives, ie interpretivist data analysis.

Overview of interpretivist approaches to data analysis

If sensitivity to content and the development of meaning and understanding over time are part of our understanding of how learning occurs, then these dimensions must be captured through the methodology chosen for the analysis of classroom data. Inevitably, this entails examining the processes of learning as they are displayed in talk. The ethnographic approach of Barnes & Todd (1977) and Barnes (1992) are examples of an ethnographic approach to analysis of language events. By combining analysis of classroom events with insights and observation of participants, the reader is given a precise understanding of how knowledge is constructed in the classroom and the processes that are involved in teaching. Through transcribed extracts of talk and insights gained from interviewing teachers and students, we are given a realistic view of the culture of classrooms, and the roles of teachers and learners. This form of qualitative analysis adds considerably to our understanding of classroom events, particularly when accompanied by a robust theory of learning and a set of methods.

An example of a research project which fulfils these criteria is the work of the *National Oracy Project* (Norman, 1992) in the United Kingdom, influenced by Vygotskyan approaches to education. This is an account of the continuing reflective practices and recordings of teachers across a whole nation, utilising classroom recordings, observations of learners working in groups and ethnographic insights. The outcomes of the project had far reaching effects, leading to the recognition of oracy across the

curriculum as an explicitly stated and essential aspect of effective education. The methodologies employed were diverse, multi-layered, and focused on qualitative processes of interaction in classrooms combined with insights by teachers.

A further example of qualitative data analysis is a recent study by Hudson (1996), who investigated the idea of co-construction of knowledge as a mechanism for cognitive change. The study draws extensively on the work of Teasley & Roschelle (1993) and rests on the supposition that collaborative problem solving occurs through participants' engagement in a socially negotiated set of understandings called a 'joint problem space'. While the framework for analysis did not utilise predefined categories, the analysis is based on turns at talk, as well as specific discourse forms such as narration, questioning, repairs and prediction in order to show how participants use conversational turns to achieve joint problem solving. The categories are derived from turn taking patterns of everyday conversation, as used in conversation analysis (Schegloff, 1991). This approach is also consonant with socio-cultural theory (Wertsch, 1984), as it recognises that talk is essential in mediating discourse and joint construction of knowledge. Coordination of thought through language is necessary for a joint definition of task, and the cognitive product is socially negotiated (Vygotsky, 1978). This is a good example of recent research which shows how learning from a social perspective can go together with a microanalysis of the talk between students.

As socio-cultural theory has gained ascendancy, learning through interaction has become a priority on the research agenda (Elbers, 1996). The emphasis on context, largely influenced by Vygotskyan psychology "reflects a move away from attempting to explain cognition as a process located solely within the individual, towards an understanding of the interpersonal context of cognitive growth" (Light & Butterworth, 1992, p. 1). Studies conducted by Mercer (1995; 1996) Mercer & Fisher (1995) and Lyle (1993) exemplify this paradigm. In these studies, language data was recorded and transcribed and selected sequences were used to illuminate cognitive processes and social behaviours. Characteristic of these approaches to analysis of talk is the view that context is essential to an understanding of cognition. Talk must be considered in relation to the events, tasks and activities that surround it. For example, the work of Edwards & Mercer, (1987) examined the activity and talk of classrooms and shows how, through discourse features, the teacher controls turns, topics, directions and interpretation of knowledge.

This acknowledgment of social and cultural factors influencing the development of thinking in the telematics classrooms of the study necessitated an interpretivist approach to data analysis with insights provided by the researcher and selection of

units of analysis which had explanatory power within the wider context of the interaction. The basis of such a research approach combined analysis of discourse with ethnographic research.

Ethnography of classroom discourse

An example of qualitative data analysis is ethnography which, according to Hammersley (1992) can be identified by a number of approaches as follows:

- a concern with analysis of empirical data derived from real world contexts;
- data are gathered from a variety sources;
- categories for what people say and do are not preset and fixed; and
- analysis and interpretation of meanings take the form of verbal descriptions with quantification and statistical analysis playing a subordinate role.

While ethnographic methods of analysis provide insights into classroom life and make learner talk the subject of analysis, Edwards & Westgate (1994, p. 58) have criticised such interpretivist approaches for their lack of validity, rigour and objectivity.

> ... no detailed information is given about how frequent or how representative were the kinds of exchanges which are quoted. The method is therefore vulnerable to several closely related criticisms. The first of these is that talk is treated as direct evidence of instructional and pedagogical processes without sufficient reference to its organisation as discourse.

This criticism is indicative of a perspective on research methods which sees qualitative methods as insubstantial and lacking validity, because selected extracts are used to make generalisations and observations. It is argued that whole segments of talk be analysed, so that the data is not removed from context. Second, some indication must be given of how representative the selected fragments are of the entire corpus.

In analysing classroom data there must be some way of reducing the data to manageable proportions so that overall patterns become visible. This can be interpreted as an argument for combining qualitative approaches in reporting results, with provision of explicit evidence for the occurrence of such data. This can be achieved by systematic analysis of data, and by using computer based text analysis procedures to yield quantification of occurrences of behaviours and categories identified in the data.

The present study of telematics classrooms required ethnographic methods of analysis in order to capture the dynamics of interaction. As talk was the principal source of data, discourse analysis was an appropriate technique used to analyse data. In addition, quantification and reduction of data was essential, bearing in mind that the corpus of data comprised forty five hours of classroom observation. Before detailing this method of data analysis, a discourse analysis approach based on conceptual coding of data is explained.

Conceptual coding of data

In conducting research, the important issue is not whether the approach is quantitative or qualitative, but as Howe (1988, p. 15) argues, to "forge ahead with what works" and adopt a pragmatic stance rather than be tied to the dogma of a single research approach. Arguing against the tyranny of the qualitative-qualitative divide in research, Hammersley (1992) surveys a range of educational research and draws the conclusion that the preoccupation of two different research paradigms is unhelpful to the design of the research. Not only does it lead to confusion and unproductive debate, but it also obscures the real issues, such as consideration of a range of analytic tools and approaches to the conduct the research. Hammersley (1992) states that the research process has several aspects, formulating problems, selecting cases, producing data analysing data and communicating findings. Each of these stages can be approached using a variety of strategies. He proposes that methods should not be rigidly separated:

> in all research we move from ideas to data as well as from data to ideas. What is true is that one can distinguish between studies which are primarily exploratory, being concerned with generating theoretical ideas, and those which are more concerned with testing hypotheses. But these types of research are not alternatives; we need both.
> (Hammersley, 1992, p. 168.)

Through readings of various approaches to analysis it was concluded, in empathy with McCutcheon (1981, p. 9) that "the researcher is a perceptual lens through which observations are made and interpreted, so the researcher profoundly affects what can be understood." Whatever decisions are made about methodology reflect the researcher's own perceptions about how talk is defined, what counts as data, and how the pedagogical significance of talk is to be displayed. Awareness of these issues was an important aspect in the search for objectivity, and so multiple levels of analysis and triangulation of methods were used to ensure validity for the present study.

The theoretical framework of Vygotskyan theory provided the initial justification for examining teacher-pupil discourse, and also provided a source of ideas for guiding observations and analyses of the discourse. Having conceptualised the teacher's role as scaffolding learning and assisting development, it was essential to achieve consistency in data analysis in order to explore how these functions were manifest in the data. Similarly, the operational definition of HOT was informed by a socio-cultural view of thinking as participation in social activities and conversation where knowledge construction was the goal, and the analysis of data had to reflect these theoretical constructs.

Linking the theoretical framework of the study to the analysis of teacher talk led to the need for cognitive coding, ie for identifying and classifying the ways in which teachers supported students' thinking skills through the interactive functions of talk. In addition, student talk had to be examined for instances of higher order thinking. Both aspects of the research required analysis and coding of classroom talk. It was important to approach the discourse analysis task with caution, and avoid the trap of *a priori* categories and observational schemes which might narrow the interpretation of what occurred in the telematics classrooms of the study.

Coding schemes may imply a view of that discourse fragments are meaningful, stable and unambiguous, but this need not be the case. Conceptual coding can be sufficiently flexible to take account of multiple meanings. Strauss & Corbin (1990) describe the process of open coding in qualitative research as the first basic analytical step which requires " naming and categorising of phenomena through close examination of data" (p. 62). This is not merely naming and creating categories, but conceptualising data, discovering patterns of interaction and their properties and dimensions. This principle was applied in the present study. Conceptualisation of data emerged from the theoretical grounding of the research, from socio-cultural theory, and so theory and research methodology were seamless. This was the basis for analysis of task that occurred in the telematics classrooms of the study.

In fact, the real issue in data analysis is not whether to choose qualitative or quantitative methods of analysis, but to capture contextual detail, and for the context setting and participants to be included as part of the analysis. Conceptual coding, explanatory detail and contextual description can shed light on the question of how cognition is developed in social contexts, and this was the approach adopted for analysis of data. Instead of using *a priori* categories, the analysis was conducted through open coding, where categories emerged from, rather than being imposed on the data. The approach required attention to context and participants, and this was achieved through multiple levels of interpretation of the language and interactions that

occurred in the classrooms of the study. Before describing the procedure in detail, the adoption of a computer-based text analysis procedure is described as a way of combining detailed interpretative analysis with the generalisation of findings across a large corpus of data.

Computer based text analysis

As discussed previously, observational methods of analysis, based on systematic coding have been criticised for failing to handle the development of contextualised, emerging meanings which are the essence of talk as social action. What the researcher has attempted to do is find a reasonable balance between confronting the limitations and difficulties of different analytic approaches, while utilising their advantages.

It was essential to develop methods appropriate to the task at hand, to explore the data at many different levels, at different phases of the research and within individual lesson structures, and at the micro level, where utterances occurred in particular contexts. One of the problems of conducting a long-term interpretivist research, as was the case within this research, is the issue of the volume of data to be analysed. A computer based approach can achieve this with ease and so avoid the problem described by Hoyles, Healy & Pozzi (1994) that qualitative data analysis is a "labour intensive operation and data overload is a common experience".

The advantages of using computer-based text analysis are documented by Wegerif & Mercer (1996) who maintain that it can be used to perform a mediating role between quantitative and qualitative approaches to analysis of classroom talk. The main points they make in support of computer based text analysis are that it can integrate qualitative and quantitative procedures for data analysis by enabling the researcher to:

- work with full transcripts;
- offer a quantitative breakdown of turns at talk;
- show how turns at talk operate in the context of larger chunks of discourse;
- provide a means to explore the data prior to imposing categories;
- show both local and general features of the talk;
- present interactive events in context ;
- locate and compare linguistic features across whole texts with accuracy;
- compare language use in different segments of transcripts; and
- show the relationship between extracts and their context within transcripts and provide a realistic insight into the whole corpus of data.

The need for a computer-based approach to data analysis was essential to the present study, which aimed to provide multiple perspectives on the data, and to investigate student and teacher roles and the contexts in which higher order thinking was supported. Teacher talk and student talk constituted the bulk of the data, and a procedure was required which could:

- derive categories of thinking from the data;
- show participation rates in lessons by teachers and students;
- illustrate changes in the quality of student talk over time;
- investigate how teachers supported higher order thinking; and
- analyse students interactions with technology.

Analysis of data required several levels of abstraction: at the local level of turns at talk, at the contextual level of the entire lesson, and at the level of individual utterances. A computer-based approach solved the problem of multiple levels, by allowing the researcher to access both local and global levels at the same time, and across a range of transcripts. In this way, both quantification of turns and derivation of functional categories from data could be achieved.

In order to reap the benefits of qualitative and quantitative approaches to analysis, two computer based packages were selected with the capacity to analyse transcripts at multiple levels. The software program QSR NUD.IST, (1995) allowed the researcher to handle non-numerical and unstructured data such as that presented in transcripts of lessons. The computer based text analysis system also allowed the researcher to move between full transcripts of lessons and smaller units of analysis, and so combine investigations of micro episodes with holistic views of the data. This approach proved consistent with the socially-based, situated, theoretical framework of the study. In addition, key word searches for the linguistic features of higher order thinking were done electronically, using Concordancing software to conduct text searches, allowing the iterative cycle of exploration, testing and quantification of occurrences of higher order thinking.

Use of this computer-based approach to the analysis of data enabled the researcher to combine qualitative analysis of interactions with quantification of instances of thinking episodes, and therefore gain an overview of the data and the emerging features of lessons at various stages of the research. The software NUD.IST enabled text-based analysis and allowed a quantitative breakdown of turns at talk which were later analysed in depth by combining insights gained from classroom observations.

Insights into patterns of social interaction leading to higher order thinking within selected transcripts of talk was possible, as each utterance was analysed and saved in a systematic way. In this way both micro and macro levels of analysis were achieved, giving the researcher a fine grained picture of telematics classrooms. The analysis was a cycle of exploration of thinking behaviours combined with refinement and in depth investigation of patterns of talk, and student-teacher interaction at several different levels.

The next section looks more closely at how the data was approached in order to focus on the research questions concerning the interaction patterns which led to the development of higher order thinking in telematics classrooms.

Levels of analysis

Analysis of data involved looking at talk from different perspectives. The study extended research conducted on interaction in telematics classrooms (Oliver & McLoughlin 1995a; McLoughlin & Oliver, 1995) in which transcripts were analysed at different, but complementary levels.

The basis for the framework for analysis was the research questions, which focused on certain main themes at each stage of the research Phases 1, 2 and 3. The research themes were clustered as follows:

- patterns of teacher-student talk;
- elements of teacher pedagogy that supported higher level thinking;
- evidence of higher order thinking in student talk; and
- interactions with the computer that supported thinking.

To a provide an in depth analysis of the dynamics of telematics classrooms, a multi-level approach was developed to explore the linguistic, social and cognitive aspects of interaction. A similar approach is advocated by Mercer, 1996. Table 9.1 shows the different levels of analysis adopted. The first level, *linguistic*, looked at two dimensions of talk, participation rates of teacher and students and functional categories within the entire corpus of the data. Firstly, the participation rates of teachers and learners were quantified based on turns taken at talk. This would provide answers to the exploratory phase of the research and show:

- how talk was distributed across the classroom; and
- how participation rates by teachers and students varied over time.

Table 9.1 : Levels of analysis of data

Level of analysis	Focus	Unit of analysis
Linguistic	• participation rates & turns	turns at talk, units per turn;
	• global pattern of discourse	major functional categories of talk
Pedagogical/social	• teacher roles and practices	functional categories of teacher talk
	• cognitive support given to learners	Interactive sequences of teacher talk
Cognitive	• epistemic character of talk (higher levels of thinking)	cognitive categories of student talk related to higher order thinking
	• Changes in patterns of language over time	language indicators of higher order thinking

Quantitative findings on distribution of turns and participation rates of students were used to amplify the qualitative analysis of interaction patterns and opportunities students had for discussion of ideas and exchange of views.

In addition, an overview of the functional nature of these exchanges was required in order to analyse the teacher's role and the levels of decision making and control that was exercised. The researcher explored the major functional categories demonstrated in the classroom by teachers and students. The utterances were coded according to their apparent function in the immediate context.

At the second level, the pedagogical orientation of the talk used by teachers which guided and scaffolded learners in higher order thinking was analysed. While discrete utterances were categorised according to how they offered cognitive support to learners, longer extracts served to establish the different social roles adopted by teachers.

At the third level of analysis, aspects of higher order thinking were identified at the linguistic level. The operational definition suggested four major indicators of language related activity indicative of higher order thinking, consistent with the curriculum outcomes for the telematics program as:

- interpretation;

- critical inquiry;
- reflection; and
- cognitive accountability.

The instances of higher order thinking which might occur were identified according to their function in context. So for example, a student who challenged another student, or cited evidence in support of a position, was found to employ particular communicative functions recognisable in discourse. Secondly, each category of higher level thinking was identified according to language indicators and structures. (Examples of language indicators of reasoning are provided in Chapter 10). Computer-based analysis led to an exhaustive search for all examples of higher order thinking, and established consistency with the categories assigned to utterances. The advantage of a computer-based approach was that it was possible to mark the changes that occurred in language use by students and teachers from each phase of the study to the next. Computer-based analysis also facilitated quantification of findings from one phase to the next, and so comparisons between phases were more readily achieved.

Reliability of the categories assigned to the data

The conceptual coding of teacher talk and student talk was carried out with due consideration given to other sources of data, such as lesson plans, curriculum documents and texts used by the teachers. This form of triangulation ensured that the functional categories assigned were consistent with the context of each lesson.
Two researchers independently coded sections of the transcripts which included a range of functional categories. At the initial comparability stage, the agreement was approximately 80%. This level of agreement was improved by discussing examples, and by conducting further analyses of transcripts in order to establish agreement. When there was 95% agreement between the researchers, the remaining transcripts were coded. Where there was an instance of uncertainly about coding of teacher data, the teacher was asked about her pedagogical intention for that segment. In this way, the categories used were meaningful to all participants in the study.

Summary and conclusions

A multilevel approach to the analysis of data was developed, in keeping with the socio-cultural orientation of the study. Having reviewed a range of approaches to analysis of talk, it was found that systematic coding schemes were often narrowly focused and lacked contextual detail. On the other hand, purely ethnographic accounts rely on small samples of evidence that might not be representative of the

entire corpus of data. The approach most suited to answering the research questions was to combine ethnographic observation with multi-level, conceptually based analysis of all talk occurring in the telematics classrooms of the study. Each of the levels of analysis, linguistic, pedagogical and cognitive contributed to an understanding of the how higher order thinking was fostered and scaffolded in telematics classrooms.

The procedures for analysis of data were described as functional and communicative, and were intended to analyse teacher talk and roles adopted in the classrooms, and as linguistic, in the case of higher order thinking, where key words and usages served to identify instances.

At all stages in the analytic procedure, the theoretical framework of socio-cultural theory informed the analysis and provided the conceptual grounds for the analysis of data. This concept of scaffolding informed the analysis of teacher-pupil discourse, and guided observations of how teachers offered cognitive support and scaffolding to learners. Table 9.2 shows how computer based tools assisted in analysing data at different levels.

Table 9.2: Use of computer based text analysis tools for integrated analysis of data

Data	level of analysis	Approach
Student talk	participation rates	quantify % of talk
	communicative functions	Use NUD.IST software for open coding
	cognitive level ie evidence of HOT	Use of concordancing software search text for reasoning indicators
Teacher talk	participation rates	quantify % of talk
	communicative functions	Use NUD.IST when assigning open coding
	instructional functions	Use NUD.IST when assigning conceptual coding

The analysis of the discourse of higher level thinking was informed by other studies using Vygotskyan theory (Mercer, 1995; 1996) where there was analysis of language behaviours indicative of higher order thinking. Through the social and verbal interaction between students and teachers information was shared, explanations were

offered, questions were raised and alternative perspectives were considered. Secondly, student reasoning had to be articulated in language, and become visible through talk, as these forms of discourse were pragmatic functions of the social context, and also served communicative needs. The larger context of these interactions was provided by the actual lessons in which teacher support for HOT was analysed.

The establishment of a relationship between the overall patterns of discourse, the social context, and opportunities for higher order thinking was explored in the analysis of each of the classrooms in the study which were Maths, Science, English, Social Studies and Italian.

Having outlined the need for a multi-level discourse-analysis approach to the language data of the study, and the benefits of a computer-based text analysis approach to achieve in depth analysis while maintaining a global view of the findings, Chapter 10 focuses on how the conceptual categories for coding of data were built up through investigation of the communicative and functional categories of discourse and applied to teacher talk and student talk in the telematics classrooms of the study.

CHAPTER 10

Functional categories of talk and interaction

Introduction

The analytic approach developed for data analysis was intended to investigate teaching-learning processes and structures in telematics classrooms. Socio-cultural theory places great emphasis on language through which higher order thinking is fostered, and on the teacher as a supportive agent in learners' development.

The adoption of a socio-cultural approach permeated all aspects of the research methodology adopted for the study of telematics classrooms. In describing the focus of Vygotskyan psychology as socially shared cognition, Pintrich (1994), p. 143 summarises the implications of the approach:

> In essence, this perspective replaces the Piagetian image of the lone epistemic subject best represented by Piaget's story about the little boy, all alone on the beach, counting pebbles and discovering that no matter how he arranges them, he has the same number, thereby coming to his own understanding of conservation of number, with an image of groups of children selling candy on a street corner in Brazil, thereby coming to understand arithmetic principles through interacting with others and using the cultural tools and symbols of their semantically rich and interpretative world.

Consistency between the socio-cultural framework of the study and the methodology was essential. The Vygotskyan approach is unique in taking into account the link between cognitive development and instruction which takes place in school (Pontecorvo, 1990). Vygotskyan theory characterises language as a psychological tool for thinking, and talk as engagement in social forms of thinking (Chapter 5). This means that talk, occurring through social interaction is the means by which understandings are developed between teachers and students, and when peers are interacting. The analytic focus was therefore at the level of interactive systems in the classroom, and included individuals as participants, interacting with each other and with the technology. The coding and analysis of teacher and student talk was based on this conception.

The purpose of this chapter is to:

- discuss the units of analysis for the data;
- explain the conceptual basis of the coding and analytic framework applied to teacher talk and student talk;
- present the analytic approach for identification of higher order thinking; and
- present the framework for analysis of technology use.

Categories used for coding the data are related to the theoretical framework of the study and to the preceding chapter describing how computer-based tools were used to explore the data at different levels.

Analysing teacher and student roles

Socio-cultural theory is not just a theoretical issue of the relationship of thought to language, but a fundamental one of how to approach classroom research. The focus is not on individual achievement or development, but on social, cultural and collaborative forces which lead to cognitive development.

In addition, socio-cultural theory is concerned not just with learning, but also with teaching, and so teacher-student and student-student interaction through verbal discourse constitute the core of teaching process. Fundamental to this perspective is an emphasis on processes of teaching and learning, where there is regulation and support by a more competent other through scaffolding until such time as the learner becomes self-regulating. An important aspect of this is that knowledge is built on shared understandings between participants, and that individuals working in isolation have limited resources and means of constructing knowledge (Crooks, 1994; Edwards & Mercer, 1987). When we look at teacher roles in telematics classrooms, the explanatory concepts developed are built on socio-cognitive theory and relate to distribution of authority, control, decision making and how teachers scaffold or assist higher order thinking.

For analysis of student roles and talk, socio-cultural theory meant looking at how learners participated in social practices, such as collaboration, discussion or conflict, and how they achieved thinking outcomes. Discourse analysis was the analytic tool used to reveal what forms of activity and discursive practice were productive in fostering higher order thinking. Student discourse was analysed for the manner in which it reflected reasoning, inquiry, mindfulness and cognitive accountability.

For both students and teachers in the present study, the teaching and learning events in the telematics classroom were socially organised activities, and how each participant

contributed to the learning transaction was the subject of inquiry. In these interactions both teacher and student roles were revealed and the operational definition of higher order thinking developed was tested against actual student discourse.

A final point about the analysis of data relates to theory and research methodology. As described in Chapter 8, the research design was based on naturalistic observation of teachers and students as they operated in their everyday contexts, in the environment of the school. This approach emphasised the importance of the immediate social context in which learning occurred, and there was no attempt to manipulate or control the environment in any way.

Units of analysis

Functional categories of teacher talk and student talk were induced from the data and informed by the theoretical framework of the study. The basic unit of analysis was the communication unit, defined as an utterance on a single subject, usually a sentence (Smagorinsky & Fly, 1993). Communication units occurred in turns at talk (Sacks, Schegloff & Jefferson, 1974) and a turn consisted of one speaker's uninterrupted sequence of units. Use of the communication unit was essential to show the distribution of talk. This led to account of the number of communication units occurring in teacher talk and in student talk, and showed the actual participation rates of teachers and students as a proportion of all talk. Teachers did not necessarily have more turns that students, but their turns usually contained several units each serving a different function.

Beyond the communication unit, larger units of teacher student interaction were identified. Consideration had to be given to units of analysis which recognised the social dimension of learning. In order to incorporate context and social interaction into the analysis of classroom learning Crook, (1991, p. 83) states: "Our unit of analysis becomes activity in a context, and the study of cognitive change, therefore, must dwell on the settings in which understandings are acquired and the circumstances that specify transfer of learning between these settings". Thus, in studying higher order thinking, it was also necessary to study the contexts in which thinking occurred. The findings of the study therefore specify certain conditions in telematics classrooms which are conducive to higher order thinking (Chapter 16).

The other unit of analysis larger than the communication unit was the three part exchange of Teacher Initiation, Student Response and Teacher Evaluation (I-R-E)

which was prevalent throughout the lessons. An example of an IRE interchange is as follows:

Teacher: What is the Italian word for ice-cream?
Student: *Gelato*
Teacher: Well done, brava. And how do we say "tea" in Italian?

Here the teacher's turn was longer than the student's and served multiple functions. It had a feedback component, and a questioning component. In comparison, the student's response was minimal and served only to respond to the teacher's question. This pattern has been found across many classrooms and characterises the asymmetry of roles that occur in most classrooms and criticised by many educationists (eg., Schratz & Mehan 1993; Lemke, 1990). The IRE interchange has been associated with its controlling function, as the teacher usually initiates by asking a question.

The second was the actual lesson which consisted of any number of IRE sequences. These lessons were considered as natural talk cycles have been recognised in a number of research studies (Elbers, 1995; Hobsbaum, Peters & Sylva, 1996), but each study has particular boundaries defined by the parameters of the dialogue. Within each lesson, the teachers planned various activities and experiences for students, and each lesson was taken as a whole language event. It was anticipated that there would a progressive change in quality of teacher talk from the initial phase of the study through to the final phase, as a result of the interventions and that this would be characterised by gradual change in teacher control and questioning of students to other, more supportive features of teacher talk. The expectation that students would gain in autonomy and self-direction was anticipated to become evident through longer turns, greater student participation in classrooms talk, and to provide additional evidence of students' development of higher order thinking.

The next sections describes how teacher talk and student talk was analysed into categories which reflected the functional and communicative activities that occurred in telematics classrooms.

Analysing the role of the teacher through talk categories

Functional categories were not assigned on *a priori* basis to transcripts, but emerged from the data as it was analysed. The objective was to give a global overview of the telematics classrooms and how teachers and students used talk to achieve social and educational objectives.

The initial analytic framework developed for telematics classrooms consisted of a limited number of categories used to give an overall view of talk based on content analysis. In this study (Oliver & McLoughlin, 1997), the framework was also applied to an investigation of interactions in live interactive television (LIT). Five types of communicative interactions were found in audiographics teaching environments. Table 10.1 describes each of these interactions and provides an examples and descriptions of each.

Table 10.1: A Framework for investigating interactions in telematics lessons

Type of Interaction	Description	Example
social	teacher/student talk establishing and developing rapport	T: Hello Mandy, how are you? S: Very well thank you. T: Great to hear from you, what are you going to do for us?
procedural	teacher/student dialogue involving information exchange on course requirements and procedures	S: Mr Gray, can you tell me how many pages you want us to write? T: I'm looking for about 2 pages in total. S: Can we use a topic of our own choice?
expository	student or teacher demonstrating knowledge or skill in response to a direct request from another.	T: Can any one tell me the correct name for this animal? S: Is it raptorus maximus? T: No, but it is from the raptorus family.
explanatory	teacher using student responses to explain knowledge and develop content.	T: This is how we place our fingers to play the note A. Can you play an A for me Mandy? S: Mandy plays an A. T: That was good but you have to blow a bit harder and make sure your fingers are covering the holes completely.
cognitive	teacher providing constructive feedback to a student response causing the student to reflect and to consider an alternative perspective/reality.	T: Can you tell me what you think was the main reason for his actions? S: He was angry and wanted to get even. T: But was that all? What about his wish to improve his position and standing? S: I suppose but he did but I though that he would done it differently.

Oliver & McLoughlin (1997) found that although audiographics and LIT learning environments differed significantly in terms of their physical and interactive capabilities, they supported similar forms of communicative dialogue and discourse.

The main objective of this framework of analysis was to give an overall picture of the quality of interactions that occurred, so that it was possible to determine in any given lesson:

- the proportion of talk that was socially oriented;
- the amount of lesson time given to expository talk and procedural talk; and
- the proportion of cognitive talk that occurred.

What the framework did not explain however, was how teacher's verbal behaviour correlated with student learning or quality of talk. It did not address the issue of what interactive mechanisms were at work in the dialogue, or raise questions as to who initiated a social or cognitive interaction, and to what purpose. Another limitation was that it assumed that all talk by students and by teachers fitted into several generic categories.

Because of these limitations, the coding scheme was extended for the present study. The new scheme for analysis of talk had to address the research questions of what instructional functions were carried out in teacher talk, and what interactive mechanisms enabled students to engage in higher order thinking. The socio-cultural framework of the study demanded consideration of learning as assisted performance, where teachers intervened and scaffolded students' learning. Therefore teacher roles had to be reconceptualised and the framework for analysis changed to incorporate the dimension of scaffolding. Furthermore, the link between discourse and learning has been emphasised in the socio-cultural framework where higher order thinking is regarded as an internalisation of social actions scaffolded through language and other cultural tools. This hypothesis required that discourse be analysed at a micro level in order to see how teacher-student interactions supported dialogue, which in turn led to occasions of higher order thinking. Analysis of this depth required that the sequential ordering of talk be considered, in order to determine the relationship of the learners' verbal behaviour to the actions performed by teachers or peers. This approach was in agreement with the statement of Orsolini & Pontecorvo (1992, p. 117) who stated that "the discourse practices of instructional contexts have an inherent interactional nature".

Functional categories in teacher talk

The socio-cultural framework required close inspection of the climate of the classroom and this was achieved by examining the reciprocal roles of teachers and students. By combining multiple levels of analysis of teacher talk it was possible to capture both surface features of dialogue and also its communicative, functional and social dimensions.

Functional analysis of teacher dialogue served to illustrate important aspects of the teacher's role, for example, the scaffolding aspect whereby the teacher assisted learning and the controlling or expert role established by the teacher's status and the rules and expectations that were specified in the classroom. Consideration of all aspects of the teacher's role was necessary in order to understand the entire context of how higher order thinking was fostered, assisted and valued in the classroom.

Teacher turns were analysed according to the functional roles that teachers normally perform when they try to assist learning:

- they control talk and elicit relevant information from students; (Edwards & Mercer, 1995);
- they respond to things students say; (Wood, 1992);
- they give feedback on student learning; (Cole & Chan, 1987);
- they manage resources and time; (Cohen, 1994); and
- they offer cognitive support and promote student learning (Maybin, Mercer & Stierer, 1992; Cazden 1988).

Each of these functions was investigated and teacher-student interchanges were analysed and coded. The three part dialogic interchange (I-R-E) was recognised as the basic structural component of a lesson, with the teacher usually initiating, controlling the topic and allocating speaking turns (Sinclair & Coulthard, Cazden 1988; Mehan, 1979). In telematics lessons during Phase 1, this was found to be the basic exchange unit, and other patterns of talk, such as student-to-student dialogue were also recorded. Within the basic dialogic interchange, the social and cognitive functions that teacher talk performed were described and quantified. As Griffin & Mehan (1981) have remarked, "the academic and interactive aspects of schooling seem to be involved in each other to such a degree that is impossible to separate them".

It was considered essential to document and record the entire range of functional behaviours in telematics classrooms, because an important element of the research was to uncover teacher roles which were supportive, or otherwise, of higher order thinking.

The functional categories that merged from teacher talk data are depicted in the Figure 10.1. Each of the functional categories ascribed to teacher talk are described through examples drawn from the actual transcripts to support these categories. The approach to analysis was informed by the work of (Henri, 1992) and other studies of classroom discourse (Bennett & Dunne, 1991; Wild, 1995). An overview of the major categories of teacher talk are depicted in Figure 10.1

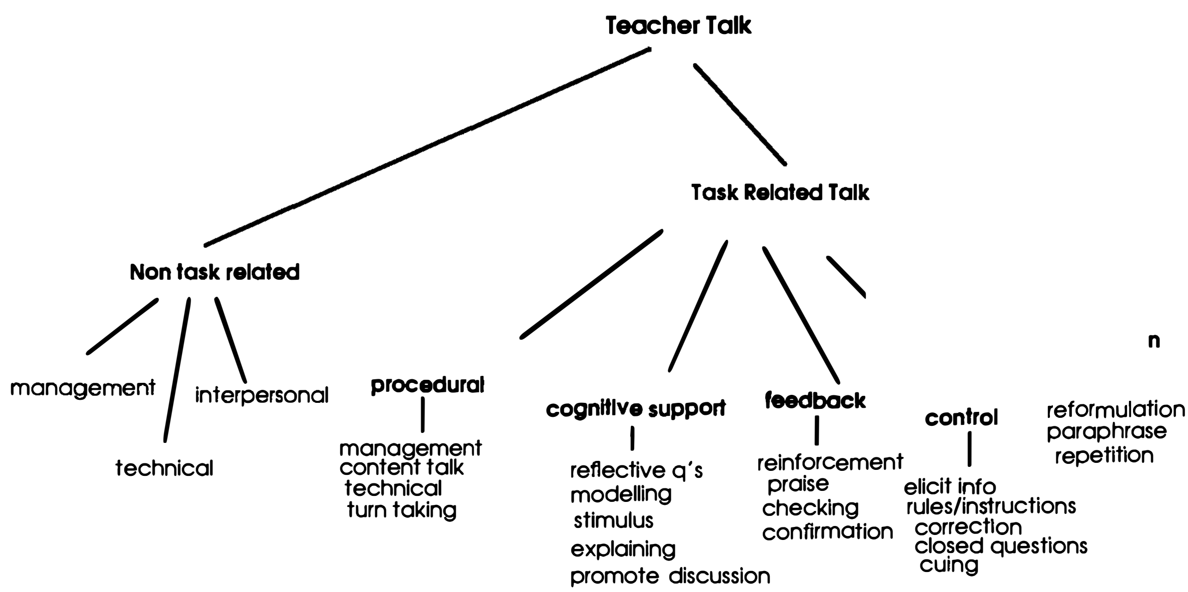


Figure 10.1: Functional categories and subcategories of teacher talk

Through the available data, the transcripts of talk and observations of lessons, teacher pedagogies were inferred from talk and practices in the recorded sessions. Moreover, the reciprocal nature of talk in classrooms meant that teacher utterances were considered and evaluated in the light of how students responded and participated in the lesson. This form of analysis recognised the interdependence of teacher talk and learner talk.

Task related talk

Preliminary analysis of data indicated that talk occurring at the start of a lesson was aimed at achieving social and technical goals which was defined as 'non-task related talk'. At the initial stages of the lesson, for example, a lot of talk was concerned with setting up the computer and audiolink, ensuring attendance and checking homework. Non-task related talk at the beginning of the lessons usually reflected three functions, management, technical and interpersonal. The interpersonal exchanges served the purpose of greetings, introductions and friendship building, while the management function was the teacher role of checking attendance ensuring materials had arrived

and assessments were understood and in progress. The technical category related to all the dialogue surrounding use of the equipment for setting up the lesson.

'Task related procedural talk' occurred throughout the lesson, as sometimes the computer links failed and students had to be directed to use the equipment in particular ways. The categories of management and content talk were included in this category, as teachers spent some time talking about the subject matter in a non-interactive way at the outset of a lesson. In addition, instances where teachers allocated turns for students to talk were also procedural functions.

'Task specific talk' formed the core of the lesson, although occasional procedural and management functions permeated the discourse. Throughout the lesson, talk was jointly accomplished by teachers and students and the basic Initiation (by teacher) Response (by student), Evaluation (by teacher) (I-R-E) pattern occurred for most lessons.

This triadic exchange reflected the way in which telematics classes were organised by teachers, though the pattern was found to change at later phases when student-student discussion occurred. Nevertheless, each lesson was analysed separately, and each lesson reflected variations on this pattern, with varying amounts of talk dedicated to task related as opposed to task specific talk.

The separation of task specific from task-related procedural talk served a pragmatic function, besides reflecting language usage in telematics classrooms. After the non-task related talk at the beginning of each lesson, there were some occasions during a lesson when technical hitches arose while tasks were being completed. This category of talk was assigned to 'procedural'. Procedural talk occurred throughout most lessons, and the proportion of this talk was accounted for in the analysis of individual transcripts.

The division of talk into non-task related, procedural and task related proved to be an effective way to estimate how much of the lesson time was given to on-task talk, relating to the achievement of specific cognitive goals. The reality was that teachers had many diverse responsibilities and these were reflected in the patterns of talk. Management of time, resources and student learning emerged as important features of the teaching role in telematics classrooms, and the development of higher order thinking was embedded in the wider context of teacher objectives.

Procedural talk

Much of the talk that occurred in telematics classrooms at the commencement of lessons related to setting up resources and technology. Throughout the lesson, teachers also had to manage the interactions that took place and control the pace and sequence of events and clarify procedures and assessment tasks for students. For example:

T:	Our next topic is culture and I'd like you all to write it down on a piece of paper.	**procedural**
S:	Just the title teacher?	
T:	OK, go on.	**procedural**

Towards the end of lesson, procedural talk was once again used to set up homework assignments and clarify tasks set for homework. Apart from openings and closings, procedural talk occurred during lessons when teachers changed tasks or topics, or when the technology was used to transmit a visual related to the lesson objectives.

Turn allocation was a management function that most teachers employed, partly to ensure that all students participated in the lesson. Students were usually called by name to respond to a question or request. For example:

T:	Right, Kim and Ryan do you have a calculator?	**management**
S:	No	
T:	Ryan, do you have a calculator?	**management**
S:	No	
T:	and Nick?	**management**
S:	Yes	

Where the teacher's communication unit consisted of both turn allocation and another function, turn allocation was considered a subsidiary function and the other function of the utterance was counted. Where teachers did not allocate turns but invited responses or suggestions from the group, this was categorised as cognitive support, as it fostered inquiry and initiative.

Content talk occurred usually at the beginning of the lesson, where teachers sometimes expounded on the subject matter without any stated aim, or sometimes during a lesson where they extended student responses, but without ascertaining whether students

needed the information given. In a sense, content talk was the opposite of cognitive support as the aim was not to support student understanding, but to get through preliminary descriptions of subject matter.

The following extract from Science illustrates procedural talk and management of turns, with some cognitive support.

T:	All right Ryan, what is your interpretation of number one?	**cognitive support**
S:	Like football or soccer, you know	
T:	Yes it is supposedly the international symbol for soccer. Now number two, go through that for us.	**procedural**
S:	Slippery when wet, like on a road sign.	
T:	ok slippery when wet, yes that one is fairly common, isn't it, you see it one the roadside all the time, and number 13?	**procedural/ management**

Procedural talk was essential to keep the lesson moving, and to ensure that all students had an opportunity to participate in the lesson.

Control

In education, the role of the teacher is closely bound up with controlling the behaviour and responses of students (Lemke, 1990; Edwards & Mercer, 1994). Several researchers have provided insight into how interactive moves controlled by the teacher inhibit or promote opportunities for learning. Teacher roles are often linked to issues of management and control in the classroom, and by virtue of the asymmetry of roles, students often are deprived of initiative and the opportunity to contribute (Mehan 1979; Cazden, 1988a; Wood, 1992).

Teacher behaviours categorised as control were closed questions which served to establish rules of behaviour, dictate ways of interpreting content or give specific directions. For example, in the following extract from Social Studies Phase 1, the teacher is eliciting students' ideas on defining features of culture. Students have suggested lifestyle, beliefs, housing, values and religion. The teacher suggested that they write up 'appearance', and then proceeded to elicit information from students to justify her decision to include this. Eventually, she praised a student who suggested clothing, as she regarded this as relevant, and reaffirmed that appearance should be listed. This dialogue had the effect of controlling or limiting student's interpretation of

the topic, although the extract does contain one instance of scaffolding or 'cognitive support'.

T:	Are you going to write up appearance then?	**closed question**
S:	Yes	
T:	With regards to what then? Their appearance could mean anything, Does that mean that all the ugly people belong to one culture?	**cognitive support**
S:	No, I mean like (.)in some cultures where they are not allowed to show their hair or their head and stuff so they have to cover it up.	
T:	So what's that got do with it? that's got to do with religion though. You better put religion up there -But it's got to do with something else too.	**procedural control**
S;	What they wear?	
T:	Yes, what's that called?	**closed question**
S:	Clothing	
T:	Aha - yes wonderful. Write up clothing, appearance..	**praise**

Here, it was clear that the main objective of the teacher was to engage the students in producing the response that she desired, which was clothing as an indicator of culture. The student had wanted to write up 'appearance' to suggest that hairstyle and clothing were aspects influenced by culture, but this did not occur as the teacher thought that clothing was a more appropriate term, and controlled student responses until they produced the answers she wanted.

In addition, explicit direction of activity such as "I'll send the stuff via computer and you can copy it down" was also considered as control. On the other hand, selecting a student to respond is a normal part of classroom management in telematics classrooms, and is not a feature of control. Questions which were designed to produce short factual responses or information known to the teacher were classified as control, as the pedagogic intent of such questions was to limit the range of options available to students.

Cuing of student responses was also considered a strategy of control, as the result was not usually productive of higher order thinking or elaborated answers. Usually cued

responses promoted shallow thinking, and constrained student initiative by prompting a particular response. The following example illustrates teacher cuing.

T:	What sort of element do you think carbon might react with to form a compound?	**reflective question**
S:	Chlorofluorocarbon	
T:	Well that is true, but I was thinking also of another gas that we breathe out after we breathe in	**cuing**
S:	Carbon dioxide?	
T:	Yes good show.	**praise**

The control functions of teacher talk were found to be easily identifiable from the data, as they were usually directive in nature, and tended to elicit either no response from students, indicating acceptance, or short answers, indicating compliance.

Reconstruction

According to socio-cultural theory, talk is a medium for sharing ideas and knowledge and teachers strive to create a common understanding of events in the classroom in a variety of ways. Mercer's (1995) extensive research on teacher discourse revealed that when teachers participated in the three part exchange (I-R-E), the third part (evaluation) may illustrate a variety of moves, using what students say as the basis for what they say next. In this way, teachers use student contributions to establish 'common ground' or mutual understandings. Mercer (1995) claims that this can be achieved through:

- *confirmation* ("yes, that's right");
- *repetition* (drawing attention to a contribution deemed to be important);
- *reformulation* (offering a tidied up version of a students' contribution); and
- *elaboration* (extending or explaining the significance of a student contribution).

All of these moves and interchanges are voiced and executed through language and are indications of the teacher's supportive role. In analysing the transcripts, consideration was given to these strategic moves and their occurrence in telematics classrooms. The computer based analysis procedure enabled the researcher to generate other functional categories related to reconstruction, in which teachers

responded to student ideas. The overall category of reconstruction included the categories of reformulation, paraphrase and repetition. Such teacher moves were found in the data and fulfilled the following functions:

reformulation:	The teacher takes the learner's contribution and reworks and extends it, then repeats it to the group as an example of what has been established as understood about the topic.
paraphrase:	The teacher repeats the student's contribution or paraphrases it.
repetition:	The teacher simply repeats what has been said by a student, the pedagogical intent being to demonstrate that the student response is correct and acceptable.

Reconstructions and reformulations were only counted when they acted as separate utterances to rephrase a student's contribution, rather than being part of a question or to elicit further information.

In the following extract, the teacher is trying to conduct a graphic outline of culture by questioning the students. The extract provides examples both reformulation and repetition. The teacher indicates acceptance of the student's response, and then extends it by reformulation.

T:	Clothing and what was the last one? Sorry	**procedural**
S:	Um, I said it was eh - values.	
T:	Oh clothing and values Ok.	**repetition**
	What about values?	
	What do you associate with values, Melissa?	**elicit information**
S:	beliefs	
T:	Yes, beliefs again, and religion.	**reformulation**

In the next extract, the Science teacher questions and accepts the student's answer, but paraphrases it so that it is more correct, and couched in appropriate language, thereby extending the student's response.

T:	Any other type of difference that you would expect to find among those two groups of plants Mike?	**cognitive**

S: Yea- algae and fungi are not like um- - the ferns and flowering plants- trees and plants like stand above the ground
But the algae and fungi don't -its like- cos they don't stand, they rest like-(.)

T: Yes you're right.
You're saying that the non-tracheae like plants tend to be more aquatic and the tracheae tend to be more terrestrial plants. Is that what you mean? **reformulation**

S: yea

The intention of the teacher was to extend the student's contribution and make it more explicit, although there was no evidence that the student used this information in his own explanation or that he might have internalised it. The benefits to other students were that the teacher took the opportunity to establish common understandings, to introduce the language of Science and to ensure that all students heard the idea expressed in the language of science. However, to contribute to understanding, learners must be encouraged to use language for themselves because as Barnes (1976, p. 115) maintains, by formulating knowledge for themselves, they gain access to the principles upon which concepts are based.

The teacher role of reconstructing students' contributions was examined to see whether it had a visible effect on students' ability to reason and use the elaborated style effectively, and therefore it was an important part of the teacher's role.

The prevalence of this kind of talk has been attributed by some researchers to the teachers' need to maintain control of the content and to ensure that students have the 'right version' and receive the syllabus content (Edwards & Mercer, 1987). However, it was decided not to include the category of reformulation as control, as it was found in the transcripts that the pedagogical intent was to control students' thinking.

Cognitive support

The Vygotskyan view of teaching and learning is that these are reciprocal activities and that learners benefit from the support and guidance of a more competent 'other'. The concept of scaffolding learning has a great deal of appeal to teachers as it confirms their roles and perceptions of how they see themselves intervening successfully in children's learning. Research on teachers assisting students in computer assisted

learning environments has used the concept of scaffolding to describe successful teaching interventions (Mercer & Fisher, 1992; Emihovich, 1988). The importance of the concept in the analysis of teacher talk is that helps clarify effective teaching from other kinds of 'help' offered to students by teachers. For example, there must be evidence that the teacher intends to teach or impart a new skill or concept, and is not merely just talking or explaining without a particular purpose.

From turn to turn teachers can be seen to offer support to learners in various ways, and the analysis tried to capture these strategies and cluster them as cognitive support. The data revealed that teachers used several ways to support students to express ideas and engage them in the lesson, for example, through questioning, cuing, offering stimuli, explaining ideas and promoting discussion.

The scaffolding role was conceived as the teacher offering support or assisting students throughout the lesson. The subcategories of explaining, asking reflective questions, cuing, modelling and promoting discussion were clustered under cognitive support, as these discourse strategies reflected the pedagogical intent of the teacher to assist learners in the comprehension of new material. Instances of cognitive support fitted into the pattern of Initiation, Response, and Feedback (marked 'cognitive')

T:	I think that was really good. You have really got the characterisation there. Michael what would you like to say about Anita's' story?	**feedback** **cognitive**
S:	It is better than Babylon	
T:	Can you say a little bit more than that?	**cognitive**
S:	Well I I it is quite detailed what she thought about her life and she sort of described in a little bit of detail about the revolution and stuff	

Cognitive support was expected to be manifest in a variety of verbal patterns, and there was confirmatory evidence in the literature that a range of scaffolding strategies are common in classrooms. For example, many researchers have found that the most prevalent way of eliciting information is by questioning (Wood, 1986, 1991; Edwards & Westgate, 1994). There is some debate however, about types of questions and their usefulness in enabling students to construct knowledge for themselves, and in generating higher order thinking (Dillon, 1988; Carlsen, 1991). Indeed Wood (1986, p. 209) goes so far as to say: "The extent to which a child reveals his or her own ideas is

inversely proportional to the frequency of teacher questions". Nevertheless, initial analysis of data showed that teachers used questions to instigate reflection or to extend students' explanation of events. These questions were intended to stimulate thought and to probe students into justifying their answers. An example is taken from a Maths lesson in Phase 1 of the study.

S:	fifty eight	
T:	How was that- were they easy for any particular reason?	**cognitive support**
S:	Well when you said ten or twelve or something, it was pretty easy and then you kept on adding (.) like numbers or so that you would make it up to ten.	**higher order thinking**

Research suggests that apart from questioning, teachers sometimes utilise a number of strategies which induce student contributions and lead them to initiate and inquire, rather than merely respond to questions. The following cognitive supports are suggested by Wood(1986):

- speculation;
- suggesting an alternative;
- illustrating with an example;
- giving a personal view; and
- being informative.

Edwards (1992) is somewhat disparaging of teacher questioning and believes that teachers who use a variety of strategies are likely to succeed in promoting exchange of ideas. For instance, he recommends that teachers try the following techniques if they want to extend or initiate discussion:

- make an open ended statement;
- invite elaboration;
- admit perplexity;
- encourage questions;
- maintain silence; or
- promote disagreement.

The data revealed that teachers used several strategies to provide a stimulus for discussion to students, including introducing a topic or setting a problem, or illustrating a solution with an example. The following example illustrates how a teacher modelled the solution to an equation and then followed with reflective

questions. In the interchange, the teacher first modelled the solution, using mathematical language, thinking aloud as she approached the problem. In doing so she demonstrated that the processes of thinking *through* the problem were just as important as finding the solution. Following the teacher's modelling of a solution path, a second problem was presented for students to solve and a stimulus was provided. One student initiated and solved the equation, showing that the scaffolding was effective, while also displaying higher order thinking (HOT) in her response

T:	So I have got two piles of sweets, the second pile is double the first, the total number of sweets is 112, how many sweets are in each pile?	**reflective question**
	So my first step in a wordy question .. I think well what variable am I going to represent. In this case Oh, I thought the important thing is the number of sweets,	**modelling**
	so I will let N be the number of sweets in the first pile. Then I think- how does that compare with the second pile- the second pile is going to have double the sweets in it , so its 2N. *(Uses drawing tool)* Then I think, I consider, I have got to write an equation, so I read it again, I have got the first pile plus double that pile equals twelve.. So looking at that writing framework first of all we choose which variable we are going to represent	**modelling**
	(Teacher sends down another screen depicting a problem to be solved.)	
	Now the second one I have put up there is a little bit harder.. The second pile has five times as many as the first pile, and the second pile has also has sixty more than first pile.	**modelling**
S:	Teacher, this is Ryan I know how to solve it	
T:	good go ahead and do it so that you are explaining it to everyone else as well please.	**procedural**
S:	Would it be say N pile of sweets should be m as 6o equals 5 M? *(Student uses the computer to display an equation.)*	**HOT**

The transcripts showed that there were several other strategies used to support learning. Because of the absence of the teacher, telematics classrooms presented many opportunities for teachers to promote independent student discussion and collaboration. At each phase of the study, transcripts were analysed in order to find where student discussion and exchange of ideas was promoted and whether this led to higher order thinking.

Feedback

Teachers frequently reinforced what students said and praised contributions from time to time. Positive feedback in the form of praise constituted a large part of the lessons. In Italian for example, students were studying the language for the first time, they had to struggle with pronunciation, but every attempt received a warm response of 'Bravo' or 'Brava' with encouragement to speak out.

Occasionally, teachers would reinforce a point that had occurred earlier, or check that students had understood an important concept. For example, in one Maths lesson, the following exchange shows that the teacher checked on students' understanding by asking another student if the explanation made sense.

T:	So how did you get five hundred and forty degrees?	**cognitive**
S:	Well, there three triangles, there is three triangle in a pentagon, so they um, ( ) make five hundred and forty.	**HOT**
T:	Ryan does that make sense to you?	**feedback**

The category of feedback was taken as a separate category with three separate functions, checking, praise and reinforcement, and examples of these functions were found in most transcripts.

Despite the asymmetric roles of teachers and students that is witnessed in many classrooms, there is scope for the student to learn, and to participate in knowledge construction, if the quality of the communication allows scope for expansion of ideas, elaboration, questioning and expression of views (Mercer, 1995). Opportunities can be provided to students to engage in dialogue and discussion, but teachers have to apply particular pedagogic strategies to achieve this construction of knowledge, and teachers must achieve 'handover of control' so that learners have the opportunity to self-direct their own efforts, and to plan, initiate and discuss classroom experiences without direct guidance from the teacher (Edwards & Mercer, 1987).

Some recent research on teaching and learning confirms that the scaffolding role adapted by the teacher can occur within the pattern of interactions that occurred within the IRE structure, and that although these asymmetric roles prevail, students can in fact learn, contribute and develop higher order thinking (Wood & Wood, 1996;

Cazden 1988; Hobsbaum, Peters & Sylvia, 1996). Teachers can intervene successfully to support learning, and lead students to develop higher order thinking through appropriate strategies. Forms of scaffolding have been investigated by several researchers (Fisher, 1993; Coles, 1995; Wegerif, 1996), and these studies focus on how the teachers assist students to verbalise their thoughts in order to promote higher order cognition.

In summary, teacher talk was analysed according to its functional and communicative role in supporting learning. Five major functional categories were identified as procedural, cognitive support, feedback, control and reconstruction. These higher level categories each had a number of subcategories relating to specific communicative and pedagogical functions. The categories adopted were informed by the socio-cultural theoretical perspective that teachers scaffold or assist learning. Analysis of the data therefore required a close scrutiny of the interactive features of talk, and it was essential that teacher talk and student talk be analysed simultaneously. All forms of teacher talk were accounted for in this analysis, and the categories depicted in Figure 10.1 were those reflected in the data. In some cases, there were ambiguous instances of teacher talk. These were resolved by reference to the pedagogic intent of the teacher, if the context did not supply an immediate interpretation of the talk. Teachers were shown a copy of the transcript and asked what the purpose of the utterance was. This procedure resolved any difficulties that occurred between the two analysts who coded the data.

Analysis of student talk

So far this chapter has looked at the forms of discourse used by the teacher in the classroom. This section focuses on the functional categories of student talk and the communicative roles that learners played in the telematics classrooms. All the talk was analysed and so that an overview could be obtained of how much talk was spent on non-task talk, as opposed to task related talk and higher order thinking.

Initially, student talk was analysed according to patterns of talk in classrooms (Edwards & Westgate, 1994; Mercer, 1995; Edwards, 1990; Barnes, 1992; Wood, 1991), and in conjunction with the categories observed in teacher talk. Much of this research indicates that students are disempowered in the classroom because:

- the teacher controls much of what is said, done and understood;
- teacher talk occupies a significant portion of class time;

- the curriculum, or content coverage means that teachers have prepared lessons where they expect to impart a particular portion of that content;
- students are expected to learn for themselves what has been planned for them in advance though syllabi; and
- much of classroom discourse remains implicit, with teachers rarely expressing what is expected of students, beyond obedience.

The passive and dependent role that students have to assume in many classrooms does not match well with the active demands of higher order thinking. Previous research has shown that learners find it hard to break out of the traditional passive roles assigned to them in the classroom, where the teacher directs discussion, controls turns at talk and validates students' contributions (Lemke 1990).

For students the impact on their role and participation in the classroom is significant. As described by Mercer, (1995) to be a competent pupil you have to:

- speak only when you are spoken to, or invited to speak;
- listen when the teacher talks, even when you already know the answer;
- answer questions, not because the teacher wants to know, but because the teacher wants to know if you know;
- accept that what you already know about the subject will never be asked for;
- look for clues about what the teacher wants you to say and do during the lesson; and
- keep up with the lesson, and try not to fall behind even if you are struggling.

Indeed, previous research conducted in telematics classrooms (Oliver & Reeves, 1994a) confirms the passive role of students, and their engagement in routine tasks and drill-like interactions. This research provided a background against which to compare the findings of the present study, but it did not provide a detailed analysis of interaction patterns. Later studies such as McLoughin & Oliver (1995) and Oliver & McLoughlin (1997) provided insight into approaches that would be appropriate in analysing data in telematics classrooms, and the present analytic framework for analysis of student and teacher talk extended these frameworks.

Major functions of student talk

Student talk was analysed according to the functional categories that it displayed. There were two major aspects to this analysis. Firstly, the research questions required that student talk be analysed in terms of whether higher order thinking was evident in

the data. The first consideration was therefore to utilise the operational definition as a point of reference, and to identify language behaviours that would satisfy the criteria of higher order thinking. In addition, as the research focus was on the pattern of teacher-student dialogue, and how this changed over time, all student talk had to be analysed to reveal its form and function so as to provide a holistic interpretation of the student-teacher relationship. The researcher's interpretation was based on students' cognitive and communicative activity, actions, and verbal and non-verbal utterances as well as gestures. In addition, student dialogue was analysed as part of a dialogic interchange, or IRE structure, as explained for teacher talk. This pattern was pervasive throughout telematics lessons, with students responding, rather than initiating exchanges. Analysis of student talk to identify higher order thinking was conducted alongside identification of communicative functions of talk.

The reciprocity of teacher and student dialogue was recognised in determining the functional categories of student talk. As teachers were the main initiators of dialogue, student talk tended to display similar patterns. For example, where teachers talked about technology at the start of a lesson, students responded in a similar vein. Likewise, interpersonal exchanges opened by the teacher were reciprocated. This led to a pattern of functions in student talk which could be matched with parallel functions in teacher talk. Both task related and non-task related functions were found in the transcripts of student talk, and this was further analysed to reveal particular functions such as procedural and expository talk.

The third major category in task related student talk was higher order thinking (HOT), and as the focal point of the research questions related to the identification of HOT, it was necessary to identify instances of thinking across all phases of the data. Figure 10.2 shows the three broad categories of student talk as non-task related, task related and higher order thinking.

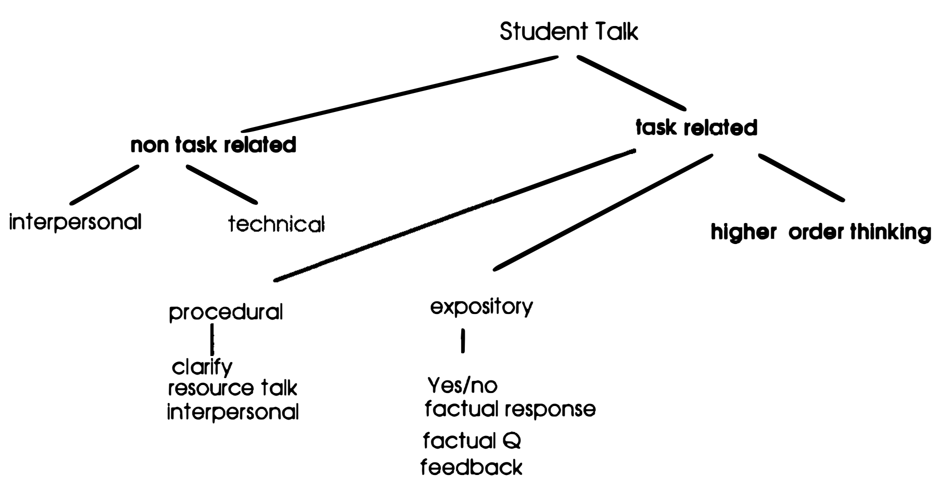


Figure 10.2: Major categories of student talk

A range of communicative functions were clustered under non-task talk and task-related talk. Before elaborating on the approach to analysis of HOT, the interpersonal, technical, procedural and expository functions of student talk are explained and examples provided from the data.

Interpersonal talk

Non-task related talk served two major functions for students, one interpersonal and the other relating to technology. At the commencement of lessons before engagement on the lesson tasks, exchange of greetings and pleasantries was customary, and served to establish rapport between teacher and students. These openings to lessons were essentially social and interpersonal, and the orientation of the conversation was not the content of the lesson, but on establishing a friendly relationship. A fairly typical exchange which illustrates the interpersonal function of talk is the following extract:

T:	Ok we are still waiting for Paul, so stand by guys. Ok, so how is the weather down there in Brookton?	**procedural**
S:	Nice and sunny.	**procedural**
T:	Sunny is it?	**interpersonal**
S:	It is sunny but it is not really warm or hot.	**interpersonal**
T:	So it in not as cold as it usually is down there ?	**interpersonal**

Lesson closings too often contained exchange of greetings and personal comments, and these exchanges were considered important by teachers in the maintenance of a friendly atmosphere in the classroom. Occasionally, non-task talk occurred during a lesson, when for example, participants joked or broke off the activity because of some distraction, or when the technology failed.

Technical

The second major category of non-task talk was occasioned by the technology, and was frequent at the opening or closing of a lesson, when teachers required the assistance of students in trouble shooting or operating the computers and modem. Most frequently, technical talk occurred at the start of a lesson, when the link was made between the teacher's computer and those at the remote sites. From time to time lessons were interrupted when the modem link failed, and the teacher was unable to send down graphics.

At the early stage of the project, when teachers were new to teaching via telematics, technological problems were common. In addition, students had little experience with the technology and were unable to resolve problems without specific guidance. However, as the term progressed they became more confident and competent in overcoming technical hitches. The following extract is an example of communication coded as non-task technical talk.

T:	(Asking about a graphic that has been sent.) Does it look all right on your screen ?	**technical**
S:	No, I haven't got anything but a flashing little dot.	**technical**
S:	Oh, I haven't got one of those.	**technical**
T:	Can we try again? (Teacher tries to resend graphic) Then I will pass control back to you.	**technical**

Most technical talk occurred in relation to the computer technology. On the other hand, the two-way audio link was fairly reliable, and in many instances where the visual link failed, the lesson continued on with audio channel only.

Procedural talk

As the teacher initiated many of the exchanges that occurred during lessons, it was found that student talk mirrored the functions that were found in teacher talk. Data showed that in many transcripts where teachers engaged in non-task related and procedural talk, student talk mirrored this pattern. Much procedural talk by students related to either resources (texts or computer transmitted material), clarification of tasks set or in response to the teacher. The following example illustrates procedural talk between students and teachers.

T:	Who haven't I asked?	
S:	Anita, you haven't asked Diana or Judy.	**procedural**
T:	Mel, give me another one please.	**procedural**
S:	Ok I've finished that one.	**procedural**
T:	Ok, let Tony do the next one.	

Procedural talk occurred throughout most lessons, but mostly at the beginning and end when homework was set and assignments and other administrative details were being discussed.

Expository talk

Several other categories of student talk were dependent on, or in response to teacher talk, and when teachers engaged in talk about subject content or information, they tended to set up the expectation that student talk would follow in a similar vein.

The category of expository talk was prevalent in a great deal of student talk, and a major part of this category comprised short answers or yes/no responses to teacher questions. Occasional questions from students about content punctuated the question-answer pattern that was evident across all lessons. This extract from one of the Science lessons in Phase 1 illustrates some expository talk, where the dialogue is a series of short answers to teacher questions.

T:	Yes Number eight?	
S:	No cars.	**expository**
T:	Yes cars prohibited.. You see that sign in some cities particularly Europe or Singapore areas in the central city district where they have those signs up where cars or private cars aren't allowed to go. Aright Gareth number nine to twelve.	
S:	Car wash.	**expository**
T:	Yes that is pretty easy that one isn't it? and next one	
s:	Fencing.	**factual response**
T:	Fencing in the Olympics or something like that, yes.	
S:	Mountain range.	**expository**
T:	You think that is a mountain range?	
S:	Wildness.. oh wilderness?	**expository**

Occasionally a student ventured to ask a factual question, relating to a text or the explanation of a term, but most of these questions were not indicative of searching inquiry or reflection.

Analysing higher order thinking

The interdependence of thought and language has widespread theoretical and empirical support (Vygotsky, 1986; King, 1994; 1990; 1992). Language is the essential

partner of thought and the social interaction which generates and provokes language is therefore critical in the development of cognition (Chapter 5).

The operational definition of higher order thinking developed for the study was based on reasoning through language, involving four related verbal reasoning behaviours:

- cognitive accountability;
- critical inquiry;
- interpretation; and
- reflection.

Each of these was subdivided into categories and each subcategory involved using language to reason, question, infer, conclude, generalise, interpret, or think through language.

Support for higher order thinking as a form of socially based communicative action comes from many contexts and perspectives.

- Language is a form of interpersonal and social action; individuals talk and exchange ideas constantly. This verbal give-and-take is not only a form of social interaction, but also a catalyst for changing thinking (Rogoff, 1991).

- When people use the language of thinking to communicate views, opinions and intentions in settings such as school an university, it is important to make clear whether the ideas expressed are speculation, inferences, conclusions and so on. This can be achieved by using language and evidence to signal that what is being said is based on evidence, rather than being pure speculation (Tishman & Perkins, 1997).

- Explicit reasoning through language occurs in many contexts, and is part of what constitutes competence in discourse communities, such as scientists, where reasoning and argumentation rely on evidence (Swales, 1990; Lemke, 1990; Kuhn, 1993).

- The literature on critical thinking (Ennis, 1993; Weinstein 1993; Lipman, 1991; Paul, 1993) emphasises that reasoning based on evidence and justifiable claims is a fundamental part of learning to think.

- From the socio-cultural perspective, reasoning is not decontextualised or abstract, and the learner does not learn to reason by contemplating the objective world in

isolation. Instead, reasoning is a form of social action and meaning making- an 'epistemic game' (Tishman & Perkins, 1997) where the rules are made explicit by the teacher. Children can learn to engage in the thinking discourse through contextualised activity.

- Students can learn new frames of reference and language forms and ways of expressing meaning, through social interaction and by guided participation in discussion, by teacher scaffolding and modelling of reasoned discourse (Emihovich, 1988).

- In the classroom, there has to be scope for students to express their own understanding of subject matter, and to have opportunity to express their ideas through talk. If they do not have the scope to interpret events or to express their own understanding, then they will not have the sense of personal agency needed to master new forms of discourse (Greeno, 1997; O'Loughlin, 1992).

- A number of research studies have used terms to describe the ideal language environment of the classroom. The community of inquiry approach (Coles, 1995; Brown, 1997) is one where students have shared input, full participation rights, time to think and question and time to discuss and listen. In these classroom language use is 'dialogical' (O'Loughlin, 1992) 'transactive' (Azmitia & Montgomery, 1993) which means that it is used to express and share meanings. Unlike classrooms where the authoritative voice of the teacher is heard, students have opportunities to act on each others' reasoning and reconcile differences between their own and other's views. This is one form of pedagogic practice which helps learners develop communicative rationality.

- Empirical studies of learners working in various environments support the view that explicit verbalisation of plans, ideas and intentions through language, promotes cognitive development and conceptual change (Chang-Wells & Wells Tudge, 1990). By observing and participating in problem solving approaches that have been the product of joint effort, students increase their own repertoire of skills (Webb, Troper & Fall, 1995; King, 1992). In addition, exchanging ideas through verbal interaction promotes higher levels of thinking, such as question generation, explanation and elaboration (King, 1994; Webb & Farivar, 1994; Chi, Leeuw et al. 1994). Interpersonal discussion of ideas to resolve conflict and reach agreement is a further benefit of collaborative work with peers and computers (De Corte, 1992; Pea, 1992; 1993).

In summary, both theoretical and empirical research on higher order thinking links it with language use in social contexts, and higher order thinking is concerned with offering justifications, reasons and evidence to support views held.

The language of reasoning and educated discourse

When talking of language use and reasoning there are two misconceptions that are found, both of which tend to minimise or trivialise the importance of spoken language in the classroom, and overlook its potential for developing reasoning and argumentation. The first is that spoken language may be regarded as secondary to written language as people mistakenly believe that "spoken language is formless, confined to short bursts, full of false starts, and lacking in logical structure" (Halliday, 1988, p.100). This view may also be supported by school based practices of assessment which emphasise the importance of the written word, often regarded as the only product of thought. There is a lot of compelling evidence to dispel this view. Much recent research in the UK, the *National Oracy Project* (Norman, 1992) and the *Spoken Language and New Technology* (SLANT) Project (Mercer, 1994), have emphasised the communicative nature of learning and the quality of talk that is conducive to thinking and learning.

The type of talk most productive of learning and thinking is described as *exploratory talk* (Wegerif, 1996). In this interactive speech mode, hypotheses are formed and proposed, ideas are presented and information is offered when learners share views and discuss ideas. Learners engage critically with each others' views, and "knowledge is made publicly accountable and reasoning is more visible in the talk" (Wegerif, 1996, p. 51).

The second misconception is that some theorists and linguists have emphasised that educated discourse is unlike everyday discourse because it is more formal, constrained and decontextualised. This may lead to a devaluation of informal reasoning, as is found in the language used in classrooms. However, research suggests that in everyday talk, the informal structures of argument are essential forms of rationality and are the structures through which people present their views, and justify the beliefs they hold. In classrooms, such informal reasoning is the bridge to the more formal reasoning of disciplinary understanding (eg, Kuhn, 1993; Means & Voss, 1996), as it is through engaging with multiple perspectives that learners can progress to more advanced levels of understanding, by discussing and revising their own ideas.

Linguistic indicators of higher order thinking

In keeping with the discourse analysis approach adopted for investigation of the telematics classrooms of the study, the entire corpus of student talk was analysed for instances of higher order thinking. The four dimensions of higher order thinking identified in the operational definition served to guide the process. Each of these dimensions was linked to surface linguistic features, or modes of expression, and their functional impact within the context of the whole lesson.

The identification of the higher order thinking components of reasoning, judgement and use of evidence in the transcripts of talk, was through the language used to express these functions. The transcripts were searched for evidence of thinking and reasoning.

For cognitive accountability or reasoning, the definition accepted was taken from Thomas (1981, p. 10): "To accept some claim as true on the basis of supporting reasons, or to offer or consider reasons in support or explanation of some claim or fact, is to engage in reasoning". Throughout the lessons, instances were sought where students accepted, offered, considered and evaluated evidence and expressed views verbally.

The English language has a number of words which signal that a statement is serving the function of reasoning. Examples of inference indicators include 'as', 'for', 'because', 'whereas', to signal that what follows is a reason being given for the statement (Thomas , 1981). Each of the indicators of higher order thinking-cognitive accountability, interpretation, reflection and critical inquiry- were identifiable in the transcripts through linguistic features and functional analysis. The usual manifestation of cognitive accountability was for example, use of explicit reasons and evidence for claims made and views expressed. This was evident when a student used the words 'because', 'cos', 'so 'or 'therefore' to link a reason to a claim. These words were called keyword indicators of higher order thinking, and for each sub-category of thinking distinct linguistic forms were found to occur. These are displayed in Table 10.2.

Linking surface features of language to actual instances of higher order thinking proved to be an effective approach through which the researcher could:

- substantiate the occurrence of HOT;
- identify usages across all transcripts; and
- identify word usages in context, so that a functions could be ascribed systematically.

Table 10.2 : Categories of higher order thinking with keyword indicators

HOT category	subcategories	Key word indicator of HOT
Cognitive accountability	explain; justify; infer; conclude;	*because, cos:* used to link a reason to a claim *so, then, therefore,* to signal a conclusion drawn from preceding evidence
Critical inquiry	Challenge; inquire; clarify; investigate; question; hypothesise;	Questions *what if? why:* *you mean?* used to challenge and inquiry *if; .. then, would, maybe, perhaps;* to link conditions to inferences
Interpretation	express opinion: suggest ideas; make rules, generalise; compare/contrast; give examples;	*it means, that means,* *it says, I think* *always, never,* *in comparison,* *for example/whereas* to express understanding or interpretation of text, activity or concept
Reflection	evaluate ideas self evaluate;* show awareness of learning	I think : comment or observation; metacognitive statement *no fixed linguistic form for self-evaluation and metacognition

The occurrences of HOT were counted for each subject in each lesson, so that for each phase, a count of key word usages could be made. The analysis was also used to demonstrate how student language changed over time, and it was possible to cross-reference results to show that increased occurrence of higher order thinking (HOT) matched the increased use of inference indicators which were the verbal signals of higher order thinking.

Support for a discourse analysis approach to investigation of reasoning is found in a number of studies. Thomas (1981) uses a number of inference indicators for higher order thinking, while Means & Voss (1996) and Tishman & Perkins (1997) suggest that informal reasoning can be assessed in data by analysing how the discourse is structured and by searching for argumentation structures. However, the particular approach adopted for the present study is unique not only in its identification of particular modes of thinking, but also by identifying combinations of linguistic forms which supported these forms of thinking.

Using a computer based text analysis approach, the researcher was able to show all selected key usages and the context in which they were used. To analyse the data, the transcripts were searched for argument structures, instances of questioning, inference, rule generation and reasoning. Examples of student talk are given in the following sections as exemplars of higher order thinking in each of the categories, cognitive accountability, critical inquiry, interpretation and reflection.

Cognitive accountability

In the school context, a particular form of argument-based reasoning is essential to conceptualising evidence in subject matter domains. Some examples of reasoning as higher level thinking are :

- the use of reasons to support conclusions;
- the use of evidence to test conclusions; and
- the weighing of alternative perspectives in decision making tasks.

This view of reasoning, or critical thinking is supported by Lipman (1991) Voss (1990) Means and Voss, (1996), who claim that sound reasoning can be judged according to :

- the acceptability of the supporting reason:
- the relevance of the supporting reason; and
- the extent to which counter arguments are considered.

For the present research this form of reasoning has been called cognitive accountability, as it requires students to justify their beliefs, reasons and views by using evidence to support their claims. This term was based on the emerging consensus from the literature that effective educational talk requires reasoning to be made explicit and that views be supported by valid evidence (Fisher, 1996). In the following extract the teacher is asking a student how his mousetrap car design might avoid certain problems. The student shows evidence of higher order thinking in his response.

T:	What sort of problem would this design, especially the initial application of energy to the wheels, what sort of phenomena do you think your idea might avoid?	**reflective question**
S:	S: Friction, <u>because</u> it would go flying through the air.	**HOT: explain**

Here the student uses the word 'because' to signal that he is giving a reason for his answer, and explains that friction would be avoided through the catapult design.

Another example of reasoning applies to conclusions drawn from preceding statements, and these are signalled by the words *consequently, therefore, which shows that, so, you see that, then.*

In the following example, students are evaluating historical evidence as to whether King Arthur existed, and they are considering evidence from different sources to make hypotheses.

S:	if it was true and there was evidence about it <u>then</u> there wouldn't be so many tales bout how he died, there <u>would</u> be one or two, but nor four or five like there is there <u>would</u> be clear evidence on how he died, not where he died, not all these fictional tales.	**HOT: critical inquiry**

Here the student is stating reasons for her belief. Other examples of reasoning in the above extract was students' ability to infer, or speculate using conditionals. This was recognised as inference and was signalled by the use of the words *if, then,* with a conditional tense.

In the following example, the student attempts to summarise the evidence for King Arthur's existence:

S:	<u>if</u> it was true and there was evidence about it <u>then</u> there wouldn't be so many tales about how he died, there <u>would</u> be one or two, but nor four or five like there is there <u>would be clear evidence on how he died</u>, not where he died, not all these fictional tales.	**cognitive accountability**

In this extended answer, the student shows high levels of reasoning, by using the preceding premise signalled by 'if', to justify her conclusion and proposing her conclusion that "there would be clear evidence on how he died".

This analysis is supported in the work of Fisher (1996) and Tishman & Perkins (1997) who claim that effective educational talk must display evidence of reasoning, and this

reasoning must not only be verbally explicit, but also be substantiated by valid evidence.

Critical Inquiry

Questions posed by students to each other to request clarification, explanation, or demand justification for claims made were indicative of inquiry. In the following extract students weigh up the evidence from various sources and question and challenge each other. Not only is the talk argumentative and reciprocal, it also shows that students are questioning and challenging each other.

S1:	Because there is not really enough descriptive evidence or information to actually ever say that he was ever around.	**cognitive support**
S2 :	to support this theory	**HOT: explain**
S3:	But he still, he must have been-there must have been something there because..	
S1:	Where did they get their stories from then?	
S:2	yes how could they get such descriptive stories just from nothing?	
S1:	It might have been just rumours you can't tell.	

In the above extract, students are engaged in a form of exploratory talk (Fisher, 1996; Mercer, 1995), where they challenge each other and justify their responses, while taking into account the contributions of other students. They attempt to support their interpretation of historical evidence with reasons and logic. The reasoning is marked by use of reasons to support claims, and challenges which take the grammatical form of questions.

The hypothetical mode of talk is marked by frequent use of the conditional tenses, and by expressions such as *might, maybe, perhaps, what if,* indicating that students are exploring, speculating and hypothesising, searching for plausible solutions and engaging in critical inquiry.

S1:	If it was real and there was true evidence about it then there wouldn't be so many tales of how he died there would be maybe one or two, but not four or five like there is there would be clear evidence on how he died and where he died	**HOT:** critical inquiry

S2 : ok Tricia your turn **procedural**

S3: If someone was killed in a car accident, say yesterday, no, you have to take this as a metaphor, OK?
No SHHH, you haven't heard me out
If someone was killed in a car accident the day after tomorrow, the day after the car accident there would be hundreds of stories out. **HOT: interpretation**

When students were talking together in this manner, they provided examples and justifications for their claims, and became very explicit in their reasoning, showing higher order thinking.

Reflection

When learners demonstrated awareness of their own knowledge or thinking processes or engaged in self criticism, it was an indication of metacognition. In telematics classrooms teachers could encourage students to consider their own approaches and to become self-critical and self aware. Student reflection could be recognised in a number of ways. In some instances, these self oriented statements were signalled by the phrase *I think*, and sometimes the same phase often signalled that an idea was to be evaluated, as in the following extract.

T: We have got 2 piles of sweets, the second pile has got twice as many as the first pile and the second pile also has sixty more than the first pile. **cognitive support**

S2 : Teacher, this is Ryan, I think I know how to write it.
I think It's an equation like this (*draws on screen*) **HOT: reflection**

In the next example, the teacher asked a student to explain how they arrived at the answer, and discussed approaches used to solve equations.

T: you could put brackets around there. You didn't have to because we were only dealing with add and subtract, the order of operations doesn't matter. **cognitive support**

S2 :	Teacher, I didn't use that. I was doing trial and error cos that is quicker	**HOT: reflection**

In evaluating ideas, either those in texts or those presented by other students, a number of examples occurred in student talk. During a Social Studies lesson, students were asked to write down and consider all the views presented, and use them as the basis for an argument. One student questioned this:

S:	Excuse me, teacher, do we just write our ideas down in the arguments for?	**procedural**
T:	Oh not, you can write down both lots of arguments.	**procedural**
S:	Well that is going to be a bit hard, because we don't even agree with them.	**reflection/self evaluation**

In some classes teachers invited students to share ideas and to offer constructive comments to each other on their work. This occasioned some reflection on the part of students.

T:	So Michael what can you say to Melissa to make it a little better?	**reflective question**
S:	Ok well expand her thesis a little bit and that so that maybe if she added a little bit about the Middle ages like whether they worked and stuff..(interruption)	**HOT: refection and interpretation**
S:	I've done that	**procedural**

Here the student offers a suggestion after being invited to do so by the teacher. The suggestion shows evidence that he has evaluated the ideas of the other students and suggests that she *expand her ideas* but is interrupted. Throughout the transcripts, reflection arose when opportunities were presented to students' through tasks. Some of the evaluative statements were preceded by the phrase 'I think', signalling that students were expressing their own ideas.

Interpretation

In the category of interpretation, there were three subcategories ie, rule making, suggesting an interpretation and generalising. These categories reflected instances where students expressed their own ideas, understandings and interpretation of

material and subject matter. Interpretation of ideas was sometimes signalled by words such as 'it means that' or 'that means' or 'it seems or like'.

In the following extract, the student is commenting on another students' draft essay.

T:	What is different about Michael's approach Melissa?	**reflective question**
S:	it seems, it appears to be actually doing speech or actually talking in a normal conversation	**HOT: reflection**
	And I reckon that is good because other times we talk we are like reading a book or something	**interpretation**
T:	yes he sort of got a little less formal approach and that does sound good.	**reflection**
S:	he was sort of like, you know. sort of saying like telling someone?	**HOT: interpretation**
T:	Oh you mean he was addressing his audience directly?	**reconstruction**

Where students were suggesting ideas, or alternative approaches they sometimes used the word 'why ' or 'why not' to indicate that other ideas were being considered.

In the following extract, students are commenting on each other's work and offering constructive criticism. They were talking about the middle ages, and student 1 (S1) was giving advice to student 2, (S2).

S1:	oh, so you can have a great description of what it was like, and then in the second paragraph like saying all about the details.	**HOT: evaluate ideas**
S2:	oh so you mean, so maybe I should put the second paragraph before, like my thesis second and then put that.	**HOT: refection and interpretation**
S1:	and another thing, like when you were reading it out kind of it didn't really sound like two paragraphs to me because it was all on the same topic and all at the same time.	**HOT: evaluate ideas**

In this extract, students show different forms of higher order thinking, including interpretation, cognitive accountability and reflection. These occasions for HOT occurred during student-student dialogue when the task required students to work collaboratively.

Overview of student talk

To conclude this section on student talk, a brief recapitulation in the form of a diagram shows the entire range of categories used for analysis of student discourse. These are displayed in Figure 10.3.

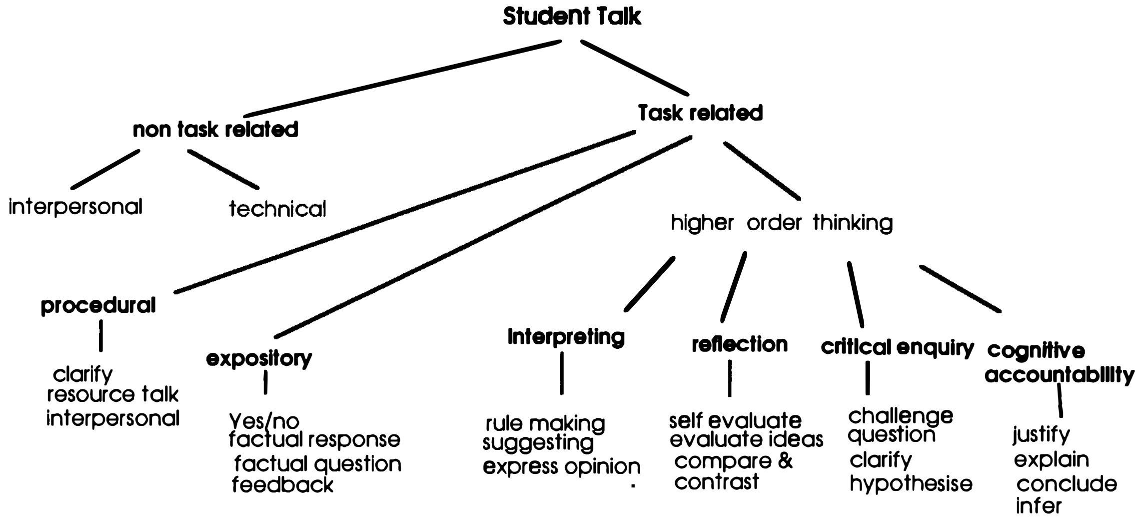


Figure 10.3: Functional categories of student talk

Investigating the role of the computer

In telematics classrooms, there has been no systematic inquiry into how computers can be used to directly scaffold higher order thinking. In a major study of telematics classrooms in Western Australia, Oliver & Reeves (1994a) suggested that teachers are not discerning users of the technology. The major use of the computer was found to be:

- a device to mediate the teacher's message; and a
- a screen to which students refer in the same way that they would a blackboard.

Rather than enhancing the interactivity and involvement of students, the technology constrained the range of pedagogic strategies that teachers used. Very often, visual stimuli were transmitted via the computer screen but these were not interactive, nor were they conducive to higher order learning. These conditions lead to teaching practices where "a high proportion of the instructional activity was guided more by the capabilities and features of the technology than the learning outcomes being sought" (Oliver & Reeves 1994a, p. 86). Much of this can perhaps be explained by the

limited training that teachers received using the technology, and the emphasis placed on incorporating visual screens into the lesson, regardless of their pedagogical purpose.

In later research on telematics classrooms, (Oliver & McLoughlin, 1997) observed several main applications of the computer:

- as a display tool for visuals;
- to teach vocabulary;
- to present new information; and
- to engage in interactive games.

None of these activities were regarded as conducive to higher level cognition, and through procedural usage of the computer, the teacher managed to control students' activities to progress through a planned agenda of activities. The dearth of cognitive activity related to computer use emerged very clearly from this research which concluded that teachers used the computer only to present, consolidate and rehearse the lesson content. This was explained to some extent by the fact that teachers found computer use difficult, as it required lengthy preparation and prior creation of computer screens.

The potential cognitive and collaborative usage of computers in telematics classrooms was explored in Chapter 8, which concluded that using the computer as a cognitive support rather than as a piece of hardware can transform its usage in supporting learning. This would require adoption of a pedagogy consistent with Vygotskyan theory which has less to do with exploiting the technical features of the computer to illustrate content and focuses more on the potential of the technology to:

- provide an effective environment which fosters social interactive learning between students (Light, Littleton et al, 1994);
- facilitate collaboration, interaction and discussion; (Mercer, 1994);
- support the kind of talk that is conducive to higher level cognition; (Teasley & Roschelle, 1993); and
- create a forum for joint activity for both teachers and students (Crook, 1994).

For this research on telematics classrooms the socio-cultural perspective offered the best means of analysing computer use in telematics classrooms, as computers were conceptualised as part of the social fabric of the classroom. Crook (1994) sees computers as mediational means, which support the communicative processes of teaching and learning. Mercer, (1993) emphasises the joint co-construction of meaning

that computers can facilitate, for example: the physical outputs of the computer, the screen displays, print-outs, as physical representation of decisions, visible products of problem solving and other activity that can be used to develop shared experience between teacher and learner. Therefore, adoption of a socio-cultural view of computers in telematics classrooms suggests scaffolded interactions where computers can fulfil an array of functions:

- provide platforms for discussion and negotiation of ideas;
- support collaboration;
- enable expression of novel ideas and constructive inquiry;
- provide visual stimuli for reflection though presentation of multiple ideas;
- enable students to represent choices; and
- give students tools to display and summarise ideas.

These are examples derived from research on computer-based learning environments and illustrate how the computer can support learning in a social context, where the emphasis is not the interface with individual students, but how computers can support the social dialogue and communicative processes that lead to higher order thinking (Wild, 1995; Wertsch & Toma, 1995; Scardamalia & Bereiter, 1992).

Mercer (1994) has remarked that teacher scaffolding of a student's learning with computers must be evaluated not only in terms of whether or not children acquire certain procedural rules for operating the equipment, but also by the quality of talk they engaged in while using it. This dimension of computer technology use was acknowledged and incorporated into the framework for analysis of computer use in the telematics classrooms of the study.

The teachers in the study were not introduced to advanced level graphics and were not provided with 'technology-driven' solutions to supporting HOT. Instead, during the first intervention they all had opportunities to discuss how higher level thinking could be developed in the classroom through sharing of information, discussion and negotiation by students, with the computer supporting and enabling expression of ideas.

Previous approaches to analysing the role of the technology in telematics classrooms were based on its capacity to support interaction. For example, Oliver & McLoughlin, (1997) set out to quantify and how and where computer interactions were used in teaching and learning. This was achieved by identifying the initiator and the respondent for each interaction. This analysis resulted in a finite set of categories as follows:

T- C : Teacher initiated and directed to the whole class.
T-S: Teacher initiated and directed to a specific subject.
S-T: Student initiated and directed to the teacher.
S-S: Student initiated and directed to other students.

Each of the interactions was categorised further as *social, procedural, expository, explanatory* or *cognitive.* It was found that procedural and expository interactions predominated, that the majority of interactions were teacher initiated, and that verbal interactions greatly outnumbered visual interactions utilising the computer.

Several limitations of this approach to analysis of computer use compelled a revision and a now analytic focus. First, the analysis attempted to separate verbal and computer based interactions, and this proved quite difficult and artificial. In most cases verbal interaction accompanied technology based interactions. Second, the coding and analysis of interactions was limited by the narrow range of categories, comprising only social, expository, explanatory and cognitive. Third, these particular categories did not provide a strong insight into the quality of interactions that occurred: the mere use of the computer in a classroom and the frequency of interactions did not provide convincing evidence of learning, or engagement in higher order thinking.

There is very limited research on telematics environments on the role of technology in fostering thinking and other major studies conducted have not given attention to how technology can contribute to higher order thinking (eg., Oliver & Reeves, 1994a; Lowe & Pietsch, 1993).

Laurillard (1995; 1993a) emphasises the social aspects of cognition and the role that language plays in mediating the interaction between teachers and students (Chapter 5). The conceptualisation of learning as conversation is essentially interactive, and when technology enters the environment it creates new possibilities for learning, but must meet the social demands of education. These demands or requirements are that the technology should offer scope for learners to engage in dialogue through:

Interaction: Interaction between student and teacher is the fundamental aspect of the learning conversation. This requires negotiation and discussion of goals, activities and purposes of the lesson. Interaction via technology entails joint decision making and negotiation, which cannot occur if the teacher has sole control.

Adaptation: Students should be able to adapt or modify the teachers conception of the subject matter in some way, so as to project their own ideas and conceptions of the subject matter. The students should have control of the computer in order to modify the teacher's conception of the subject matter.

Discussion: Throughout the activity, there should be discussion and verbal interaction between teacher and students in an attempt to present and discuss all angles and aspects of the subject. The technology could support this kind of interaction and the visuals created or co-created could become the subject of discussion.

Reflection: Throughout the learning activity, students should be given an opportunity to act on feedback and to reflect on the learning experience so that they come to a realisation of how and what they learn best. Computer technology can assist this by enabling students to display ideas visually, in order to make internal thoughts visible and open to challenge, modification and revision, thus leading to higher order thinking.

It was therefore considered appropriate to apply Laurillard's (1993) conversational framework to computer technology use in telematics classrooms and to investigate whether it supported the development of higher order thinking by enabling interaction, reflection, adaptation and reflection. The conversation model is one of the few theoretical accounts of learning with technology that is consistent with socio-cultural theory, with a focus on dialogue to promote higher order thinking.

The analysis of all computer interactions involved the isolation and comparison of aspects of computer use in the interactive sequences of dialogue. Computer visuals were analysed according to the four dimensions of the learning conversation reflection, interaction, discussion and adaptation (Laurillard, 1995). Figure 10.4 provides an example of the aspects of computer use that were analysed in the lessons. In addition, individual screens produced by teachers and students were analysed and related to the discourse forms that emerged while they were being created.

A matrix was used to compare computer use across classrooms according to several criteria, which were later collated and analysed to provide a complete and comparative analysis of computer use across all lessons.

Computer Graphics	Lesson/Phase
No. of visuals	
Locus of control	
purpose of graphic	
student activity	
interaction	
discussion by students	
adaptation by students	
reflection by students	

Figure 10.4: Matrix for analysis of computer technology use

Features of computer use analysed as supporting higher order thinking were as follows:

Visuals: The number of visuals that teachers use and whether they were prepared in advance, provided an indication of the level of teacher preparation, teaching preference and pedagogy. In cases where visuals were prepared in advance, teachers sometimes did not build student activity into visuals, but used them solely to motivate students or to present lesson content.

Student Activity: Whether students used the computer to respond to teacher questions or to depict their own understanding of a topic was indicative of the degree of autonomy and control in the classroom. The type of activity surrounding computer use was considered likely to influence the nature of dialogue that occurred. In problem solving students may not be able to explore alternative solutions if the problem is set by the teacher. On the other hand narrowly defined activities such as vocabulary practice may not afford opportunities for dialogue.

Pedagogic purpose: The use of visuals is also indicative of the pedagogic purpose of the teacher. When sending visual material to students, teachers usually made their objectives clear. Where the pedagogic goal was unrelated to HOT and was simply illustrative or motivational, the visual was also likely to have no interactive features. A further point was that the pedagogic purpose ideally should have matched the lesson objectives and engage students as active participants in learning.

Locus of control: This is one of the most debated and controversial issues in computer assisted learning (McLoughlin & Oliver, 1995) and can be the key to the development of successful self-regulation in learners (Kinzie, 1990). The software *Electronic classroom* (Crago, 1995) ensures that control automatically resides with the teacher unless it is

passed to students by selecting a control feature which allows them to operate the screen. Students cannot therefore assume control or initiate a visual interaction unless empowered to do so by the teacher. If teachers retain control of the screen throughout an entire lesson, it may be indicative of a didactic style of teaching and an unwillingness to allow students opportunities to express their ideas. This may constrain students' initiation of ideas, expression of views or participation in the lesson.

Cognitive level of student interaction with the computer: Another aspect of the analysis of computer use was to monitor and compare technology use in lessons which achieved higher level thinking by using the four dimensions proposed, ie levels of *interaction, adaptation, discussion* and *reflection.* All visuals were analysed in conjunction with the dialogue that accompanied their use. In this way, occurrences of higher order thinking could be linked to technology use and so help to identify which aspects of computer activity were supportive of higher order thinking processes. In addition to the categories of interaction, reflection, adaptation and reflection, other usage of the computer to display content, structure the lesson or motivate students without engaging them in dialogue and interaction was categorised as 'other'.

Applying these categories to the videotaped lessons and transcripts entailed focussing on instances where students used the computer to communicate, draw, share ideas and solve problems. The analytic task was conducted by saving and investigating the visual products of lessons, both the teacher graphics and the students' productions. Graphics produced by students were saved for subsequent analysis.

Summary

In this chapter the analytic framework for analysis of student talk, teacher talk and computer use was presented. Each of the research foci was addressed and an appropriate method for analysis of data was proposed which was consistent with the socio-cultural framework of the study. An analytic approach for investigating both student talk and teacher talk was presented which was consistent with socio-cultural theory. For teacher talk, most important dimensions for the researcher to determine were:

- the supportive/scaffolding quality of teacher talk;
- strategies adopted for scaffolding of higher order thinking skills; and
- the overall communicative and functional patterns demonstrated in talk.

For student talk, conceptual coding technique and a computer based tool was used to search for patterns across transcripts. The data was broken down into turns, units and IRE exchanges. Each of these categories became the focus for analysis.

Table 10.3 provides an overview of the research questions, data analysis procedures and units of analysis for each question. In student talk, the cognitive or epistemic quality of talk was the main object for analysis, and this was achieved by considering how student talk displayed reasoning and argument structures through the linguistic form of utterances. The operational definition of the study provided the starting point for analysis, but ultimately the linguistic form and communicative context of utterances determined how talk categories were coded as instances of higher order thinking.

The third major aspect of the learning context to be analysed were the interactions and quality of talk occurred around the technology. Using the conversational framework proposed by Laurillard (1993a; 1995) it was proposed that by investigating the extent to which computer activity supported the activities of interaction, discussion, reflection and adaptation, it would be feasible to assess the contribution of technology to the development of higher order thinking.

Part 3 of the study moves on to the main study and to the first observation of telematics classrooms. This was the preliminary investigation of the telematics classrooms of the study from which base-line data was collected in order to plan further interventions in support of higher order thinking.

Table 10.3: Overview of research questions and analytic procedures

Research Questions	Data	Analysis procedure	Unit of analysis
Phase 1			
1. What were teachers' perceptions of HOT?	• interviews • questionnaire	interview teachers	teacher responses
2. What patterns of participation and discourse was evident in teacher and student talk?	• transcripts of lessons	a) investigate IRE pattern; b) investigate teacher role	a) sequences of turns at talk b) functional categories of teacher talk
3. What evidence of higher order thinking was there?	• transcripts of lessons • videotapes	investigate student dialogue for HOT according to operational definition and language indicators	a) turns at talk b) language indicators of HOT
4. What was the ratio of student talk to teacher talk?	• observation of lessons • transcripts of lessons	quantify participation rates in talk	a) turns at talk b) communication units
5. How was the technology used to support HOT?	• computer visuals	Do visuals support interaction, discussion, adaptation and reflection?	use of matrix for each computer visual
Phase 2			
6. What changes occurred in the ratio of student talk to teacher talk ?	• transcripts of lessons	quantify participation in talk	a) turns at talk b) communication units
7. What evidence was there of HOT in learner dialogue?	• transcripts of lessons	investigate student dialogue for HOT according to operational definition	language indicators of HOT
8. What changes occurred in teacher strategies to scaffold HOT?	• transcripts of lessons	investigate cognitive support offered by teachers	a) teacher talk b) scaffolding functions
9. How was the technology used to support HOT?	• videotapes • screen print outs	Relate instances of HOT to technology use & apply conversational framework	use of matrix for each computer visual
Phase 3			
10. How did the ratio of student talk to teacher talk change?	• transcripts of lessons	quantify participation in talk	a) turns at talk b) communication unit
11. What evidence of HOT was there in student dialogue?	• transcripts of lessons	investigate student dialogue for HOT according keyword indicators	language indicators of HOT
12. What changes occurred in teacher strategies to scaffold HOT?	• transcripts	Analyse functional categories of talk and teacher-student interchanges	a) teacher talk b) scaffolding functions
13. How did the technology scaffold HOT?	• videotapes • screen print outs	Relate instances of HOT to technology use & apply conversational framework	use of matrix for each computer visual
14. What similarities and differences were observed in occurrences of HOT across different classrooms ?	• overview and analysis of results for all 3 phases	Analyse results for HOT in each subject area & compare patterns	overall classroom patterns

Part IV

Interventions and observations of Phase 1, 2 and 3

CHAPTER 11

Phase 1: The exploratory study

Introduction

This chapter reports on the initial phase of the study of the telematics classrooms in which the research was conducted. The observations took place in metropolitan and rural schools in Western Australia where telematics was used to deliver and receive curriculum subjects. Research described in this chapter utilises the conceptual framework of socio-cultural theory to investigate the occurrence of higher order thinking in telematics classrooms, and addresses the research aims of the investigation.

The purpose of the exploratory stage, referred to as Phase 1, was to investigate teacher practices in relation to fostering of higher order thinking so that interventions could be planned for subsequent lessons to achieve this outcome. The explanations and descriptions presented here fit into the larger explanatory structure of the thesis, with an emphasis on development of thinking through social interaction, and the primacy of talk to effective student participation and engagement in classroom practices where thinking processes were demonstrated.

Through participant observation and a research partnership approach, the researcher worked closely with teachers as they delivered lessons via telematics and also visited remote schools where students were receiving lessons. These encounters with teachers and students enabled the researcher to refine and develop the functional categories which were ascribed to teacher talk and to student talk, while situating both types of discourse within the teaching-learning partnership of socio-cultural theory (Chapter 10). As explained in Chapter 5, the teaching-learning relationship was perceived as one where teachers scaffold learning and students learn through guided participation in the social activities, dialogue and interaction. Nevertheless, the researcher approached the analytic task with an awareness that teachers often have to combine the pressures of teaching the prescribed syllabus content, and at the same time develop autonomy and higher order thinking in students.

The research aims for Phase 1 of the study were to:

- investigate teachers' perceptions of higher order thinking;

- establish the ratio of student talk to teacher talk in the telematics classrooms observed;
- observe the frequency of higher level thinking episodes;
- define the role of the teacher in supporting higher order thinking; and
- establish how the technology was used to support higher order thinking.

The chapter is set out so that each of the following aspects contributes to an understanding of the dynamics of the classrooms and provides data in response to the research aims:

- background to Phase 1;
- teacher views on the meaning of higher order thinking;
- quantification of communication units to illustrate participation rates of teachers and students;
- overall findings on categories of teacher talk and student talk; and
- microanalysis of Phase 1 lessons.

Setting out the overall participation rates and types of talk provides a backdrop against which the more detailed findings and microstructures of each classroom are examined. Descriptive statistics are shown for types of talk in each class, and these are later interpreted through qualitative analysis of the microstructures of the classroom, including teacher pedagogies and student activities.

Prior to the observation of the classrooms in Phase 1, each of the teachers participating in the study was asked for their views on higher order thinking, and a questionnaire was distributed to teachers asking for their responses to these questions:

1. What is your understanding of the term 'higher order thinking' in the classroom context?

2. Why is higher order thinking important to your students?

3. What strategies do you presently use to develop higher order thinking ?

4. How do you assess whether students have demonstrated higher level thinking?

5. What aspects of teaching for higher order thinking are you concerned about?

Responses provided the researcher with insights into values and attitudes of each teacher and also their teaching strategies for fostering thinking in telematics classrooms.

Background to Phase 1

As described in Chapter 10, the research was a long term, intensive observation of teachers and students that took place throughout a natural cycle of classroom events, thereby making it an ethnographic study (Patton, 1990). The study was conducted over one year and the subjects were the students and teachers who participated in the telematics program. When the Academic Talent Program via telematics commenced in February 1996, none of the teachers who commenced teaching had any prior experience with distance teaching or with using audiographic conferencing. The telematics delivery was intended as a pilot for the Academic Talent Program for rural schools, as this was the first time that Mathematics, Languages other than English (LOTEs), Science and Humanities were offered to selected students in Western Australia via telematics. For teachers, the objectives of achieving higher order thinking had to be integrated into a syllabus which aimed to enrich, extend and accelerate students while covering the syllabus content.

The first task for the researcher was therefore to observe the classrooms, monitor interaction patterns and establish what practices were in place to support higher order thinking, while investigating the degree to which this outcome was being achieved via telematics delivery. At first the researcher worked closely with teachers, assisting with setting up of the technology, trouble shooting, observing classes, visiting rural schools and discussing the curriculum and teaching materials. This observational stage led to a deeper understanding of the culture of telematics classrooms and the interactions that occurred between teachers and students. For example, all teachers were initially apprehensive about using the technology and believed that a successful lesson required use of the technology, particularly the computer screen. To varying degrees they planned multi-modal lessons which incorporated graphics and visual presentations. The researcher observed and noted these procedures, attempting to gain an understanding of how teachers set up a classroom environment conducive to thinking, the roles they adopted and how they employed the technology.

The socio-cultural framework, with its emphasis on social context and talk for learning, provided an interpretive lens through which teacher action was viewed and also provided the explanatory framework to develop the pedagogic practices that could lead to higher order thinking in the classrooms. Participation rates, teacher pedagogy,

technology use, tasks and activities planned, all constituted the micro elements of the investigation into telematics classrooms. The results of this microanalysis also provided answers to the research questions related to explaining :

- the occurrence or non-occurrence of higher order thinking, and
- how technology was used to support learning and higher order thinking.

Figure 11.1 shows the possible social and contextual influences on higher order thinking that were investigated, in the light of the socio-cultural framework of the study and the centrality of communicative and social processes in the classrooms. (Chapter 7).

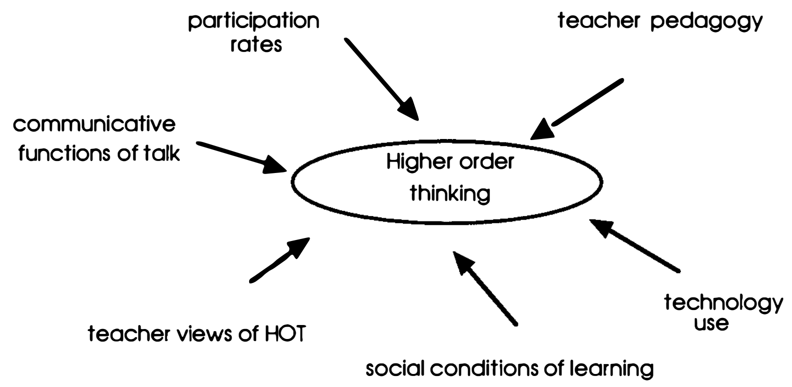


Figure 11.1: Social and contextual influences on higher order thinking

The classes and patterns of talk were observed and evaluated from several different angles, to reveal the dynamics operating in each classroom, and whether higher order thinking was demonstrated by students. Each of these influences on thinking was revealed through talk, and were essential to understanding the context in which learners and teachers interacted. In particular, the interplay of these factors in the classrooms was regarded as a possible way of opening up or closing opportunities for higher order thinking.

Participation rates of learners and teacher was calculated by a breakdown of turns and communication units according to speaker turns. In traditional teacher-centred classrooms, the fact that there are unequal communicative rights may limit opportunities for students to contribute to lessons. It was important to observe whether that the teacher in the telematics classroom would take up more time talking than would students, as this was the case in other classroom research (Edwards & Westgate, 1994).

Communicative functions of talk revealed how teacher and students interacted and communicated in the lesson. Teacher talk and student talk was analysed into functional categories which showed the main communicative functions of the lesson, and how much talk was dedicated to task related learning.

Teacher views of higher order thinking were considered as a possible influence on how the teacher promoted or supported activities related to higher order thinking. Teacher beliefs were also likely to influence the strategies they used in the classroom and whether the development of thinking was explicitly stated as an aim of their lessons.

Teacher pedagogy was made visible in talk patterns and in the quality of feedback and support given to students. By analysing teacher pedagogy through talk, the dynamics of classroom conversation came into focus and the teaching strategies which led to inquiry, reflection and thinking were then located and explored.

Teacher and learner roles reflected the social conditions of learning and were apparent in patterns of talk, stated expectations and goals of the teachers as they interacted with the learners. Within classrooms, both teachers and students contributed to the learning experience. In every classroom there were explicit and implicit rules and expectations that applied, and these expectations influenced what was said by students, how it was said and how it was evaluated. Thus, by investigating talk in the classrooms it was possible to look more closely at teacher strategies and how they changed over time.

Technology use was considered to be an important aspect of teacher pedagogy and student learning. If technology was intended to support learning and thinking there would have to be a degree of learner control in its use and application, otherwise learners might not have opportunities to express their own ideas and perceptions. In telematics classrooms, the learners had both audio and visual technology at their disposal, but they were dependent on the teacher to assign control over the use of the technology.

The various ways in which technology can support learning and social interaction were discussed in Chapter 6. For the telematics classrooms of the study, all usage of the computer was evaluated in terms of whether it enabled interaction, discussion, adaptation, and reflection, which are elements of the conversational framework proposed by Laurillard (1995). All visuals used during classes were analysed in terms of whether they supported Laurillard's conversational acts, or whether they were used only for display or motivational purposes, without engaging students in dialogue. This framework was consistent with the socio-cultural framework, because it

recognised that technology use must be integrated with social interaction, teacher-student dialogue and language use.

Each of these dimensions, social, communicative and interactive, was applied to data analysis in order to investigate conditions appropriate for supporting higher order thinking. Table 10.3 in Chapter 10 provides an overview of the questions, types of data, analytic approaches and units of analysis for the study, and Figure 11.1 depicts the essential elements of the socio-cultural influences on higher order thinking which contributed to the microanalysis carried out in Phase 1. Through fine grained analysis and rich, thick descriptions of the classrooms, the aim was to bring about explicit understanding of the contexts and preconditions for higher order thinking. In order to collect data, the researcher visited each school to observe and videotape lessons. Field notes were made of student actions, behaviour and the atmosphere in the classroom. Other lessons were observed from the delivery school, and during this lesson the researcher observed the teacher, listened to the ongoing talk and followed the teacher's progress while the lesson was recorded at the remote school.

The next section will present the results of Phase 1, following the observation of lessons, interviews with teachers, and the videotaping and analysis of lessons. Five teachers and their classrooms participated and these were identified by subject area, ie Science, Maths, English, Social Studies and Italian. In this chapter, each of the distributed classrooms is presented, described and analysed in order to reveal participation rates, teacher pedagogies, occurrences of higher order thinking and technology use.

The Science classroom

Students and school profile

Students receiving the Science program were distributed across three schools, several hundred kilometres apart. There were a total of five students in the class, three at one school, and one at each of the other schools.

All students were in the first year at secondary school, and all were aged between 12 and 13 years. All students followed the same Science course, intended for first year secondary school students in Western Australia.

At each site receiving the telematics lesson, students were in a separate room, designated for this purpose. While the lessons were in session, students were not supervised, but they usually received printed materials in advance of the lesson. The

equipment at each school was that required for participation in the telematics program: a Macintosh computer with the appropriate software, a hands free telephone, and a microphone which was used to communicate with the teacher. Typically, students sat facing the computer, with the microphone about 20 cm to the right or left. In addition to this equipment students usually had printed materials set by the teacher, and the standard text book for the course.

Telematics lessons in Science did not include any laboratory work or scientific experiments. Students carried out these in their other classes under the supervision of the Science teacher responsible for their grade, and the telematics lesson was usually devoted to extension of content, discussing and clarifying concepts, terms and application of principles.

Teacher profile

When interviewed about her views of higher order thinking, the Science teacher believed that understanding of the scientific process was important for students studying her subject. The skills she thought most important were problem solving, observation, and techniques of investigation. She believed that students should develop new ways of looking at things, and be confident in developing new pathways to express ideas. When asked about strategies used to achieve these objectives, the Science teacher mentioned encouraging students to ask open-ended questions, not accepting explanation at face value and promoting discussion. She believed that students should be open minded and inquiring.

While the teacher had a clear perception of what she wanted to achieve, she believed that telematics constrained her teaching style, eliminated body language and removed visual cues, thereby making communication more difficult. Nevertheless, she believed these obstacles could be overcome and that the technology could be used creatively 'to observe how students think'. She was comfortable and skilled with the technology and was not anxious when establishing modem links and using graphics in her class. She also maintained that technology could be used creatively to allow students to map their own understanding of scientific concepts.

The teacher did not consider that she was currently achieving her goals, and believed that professional development which focused on communicative strategies to foster thinking in the classroom would be useful.

This profile of the Science teacher provides a relevant contextual background when discussing the results of Phase 1 observations and what it revealed about her pedagogy. The next sections will look at participation rates in the Science class.

Science Lessons 1 and 2: Participation rates

In the first Science lesson observed, the subject of the lesson was physical and chemical change, including combustion. As a preliminary exercise, the students did an exercise where they identified different international chemical symbols, as a warm up activity prior to identifying atoms, compounds and elements. After identifying the symbols, students defined each of terms and gave examples. Finally, students discussed the differences between physical and chemical change.

In Science 2, the subject was force and load, and students had to calculate the mechanical advantage of some model cars they had designed out of mousetraps. Several formulae were presented to students during the lesson and they had to calculate the mechanical advantage in various problems set by the teacher.

Participation rates for each lesson were calculated by counting the turns, communication units and overall participation rates of teachers and students in each lesson.

Table 11.1: Units, turns and teacher/student ratio of talk in Science Lessons 1 & 2

Talk	Science 1	Science 2	Mean
Teacher turns*	213	162	187.5
Student turns	116	152	134
Teacher units**	361	413	387
Students units	166	229	197.5
Teacher Ratio	61%	71%	66%
Student Ratio	39%	29%	34%

*Turn= one speaker's uninterrupted conversational turn

**Unit = a unit of communication within a turn, usually a phrase that carried meaning

Table 11.1 shows that in both lessons, the teacher talked a great deal more than students, and teacher turns were usually longer than student turns, as they contained a higher number of communication units. For example, in Science Lesson 2, the teacher had 162 turns consisting of 413 units. This meant that every turn had, on average, two to three units. In comparison, student turns were shorter, consisting usually of one unit. In the entire lesson, all five students had only 152 turns between them. The

imbalance in communicative rights in the classrooms was clearly illustrated by the ratio of student to teacher talk.

Tasks and activities

Science Lesson 1 covered a number of topics and activities. The first of these was the identification of symbols for elements. Students were presented with a number of symbols on the screen and asked to identify them. Most of the symbols were easily recognisable and widely used, such as the symbols for slippery roads, wildlife crossing and Olympic events. This activity engaged the students in a question answer pattern, and though they responded to all questions correctly, their answers were evaluated, reiterated and to a large extent rephrased by the teacher. The next activity was similarly an identification activity, and students were asked to look at the screen and give chemical names for elements. While the technology was used successfully and no hitches occurred, the interactions supported by the visuals were typically low level expository exchanges, with the teacher pointing out formulae or reformulating students' answers so that they sounded neater. The activities did not appear to increase levels of verbal participation among students, and the teacher retained control of the screen for the entire lesson. This was evident from the transcripts, as the teacher did ask students to, take control, a procedure that was necessary when using the graphics feature.

In Science Lesson 1, the tasks and activities were largely taken from the textbook, and were not problem solving tasks which required planning and reasoning. Instead, they required short factual descriptions and it appeared that students knew a lot of the content already. This extract from Science Lesson 1 illustrates the question and answer pattern that characterised much of the conversation. The communicative functions are shown after each utterance. Most utterances related to procedural matters or explanation of content by the teacher, but did not display thinking or reasoning by students.

T:	OK. lets take a look at combustion and burning very quickly guys. Just turn to page 257 for a moment and this was well activity 12.2 and if you haven't done it you can have a go today.	**procedural**
	Ross have you had a go at 12.2?	**procedural**
S:	No not yet.	**procedural**

T:	well if you can it would be a good one to have a go at.. Combustion or burning (.) well perhaps Gary or Sean you might just read out three things that are needed for combustion to take place.	**control/directions**
S:	Oxygen , it that right?	**expository**
T:	Well if you look at page 257 it says combustion is a rapid chemical reaction. OK, producing large amounts of heat or light, well usually that is the case.	**expository**

Throughout the lesson, the textbook was at the forefront, and was consulted and adhered to by the teacher when answers were given by students. The dialogue showed that the teacher expected students to repeat what was in the text, and she modified their responses throughout the lesson so that they conformed to the textbook version. The text seemed to constrain what was an acceptable answer, and was used extensively by the teacher as a source of information to judge the accuracy of students' contributions. This approach was reflective of a transmissive pedagogy.

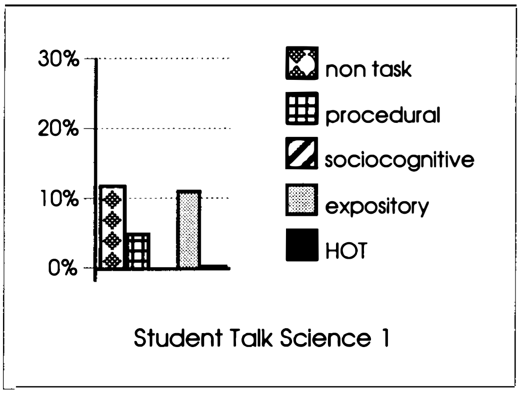
In Science Lesson 2, the topic was force and mechanical advantage, a topic which had not previously been taught to the students. The teacher presented a visual stimulus to students, a diagram of a lever and then presented the formulae that had to be applied when calculating mechanical advantage. Students had to do several calculations where they applied the formulae.

Neither of the graphics appeared to enrich the quality of talk nor did they engage the students further in higher order thinking. For example, one graphic depicted a list of terms that students had to define according to the textbook notes. The teacher did not ask students to explain what they saw, or talk about it in their own words. The transcripts indicated that students were expected to answer questions on the content that was relatively unfamiliar to them, and that they were grasping at the teachers' cues in order to answer these questions.

Functional categories of talk

Interpretation of the functional categories displayed in classroom talk was important to gain an understanding of the teacher's role and the students' activities. This section reports on the patterns and communicative functions that emerged in teacher talk and student talk for each Science lesson. The functional categories of talk that emerged were analysed, and the data consisted of all communicative exchanges in student talk and in teacher talk. (The scheme for analysis of data is described in Chapter 10.)

Figure 11.2 shows the overall patterns of teacher and student talk in Science 1, with each category expressed as a percentage of the total talk that occurred in the lesson.



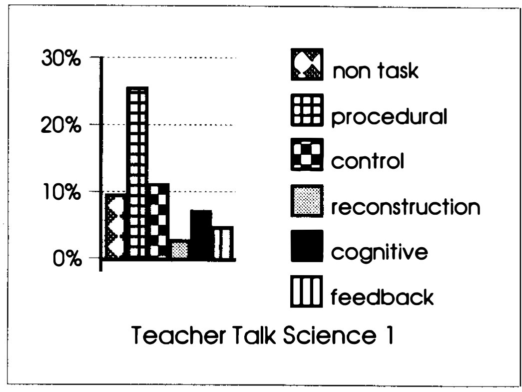


Fig. 11.2: Categories of student talk and teacher talk as a percentage of total talk in Science 1

Student talk in Science 1 was dominated by non-task talk, procedural talk and expository talk, with only one or two occurrences of higher order thinking. Non-task talk occurred at the beginning of the lesson, and was related to establishing a modem link, getting the class set up and chatting to the teacher. Procedural talk was centred around homework assignments and materials and texts to be used. Expository talk, which accounted for more than fifty percent of student talk, consisted of short answers, responses to questions and factual replies. In the entire lesson there were only two instances where students gave an extended answer explaining or justifying their response. Also absent was the category of sociocognitive talk, which essentially is talk between students where they collaborate, discuss and share ideas. This indicated that most of the interaction that occurred was initiated by the teacher.

In Science 1, the three categories of non-task, procedural and control accounted for more than 40% of teacher talk. Procedural talk occupied a great deal of the lesson, which indicated that a considerable amount of time was spent on setting up and managing the learning situation. Functions such as allocation of turns, management of resources and technology and general 'content talk' made up this category. Only 12% of the talk in the entire lesson was devoted to helping students to learn new concepts. As explained in Chapter 10, procedural and control talk were concerned mainly with instructions and with management issues rather than with conceptual content. In teacher talk, the percentage occurrence of cognitive support (8%) was low compared to procedural talk (28%) and confirms that supporting higher order thinking was not a major element in teacher pedagogy.

Science Lesson 2 proceeded much as the first had done, with procedural and management functions consuming most of the teacher's time. There were some differences however. Lesson 2 was concerned with teaching students about force and load, the relationship between these concepts and the mousetrap cars that students had constructed prior to the lesson. Conceptually, this lesson demanded a great deal of students, unlike Science Lesson 1, and presented some interesting points of comparison. Science Lesson 1 appeared to be quite easy for students as they answered all the low level questions set by the teacher, but in Science Lesson 2 they could not do so as the concepts of force, load and mechanical advantage were introduced, all of which were new to the students. The proportion of cognitive support to students increased in this lesson, as Figure 11.3 shows.

Fig. 11.3 also shows that student talk consisted almost entirely of non-task talk, procedural talk and expository talk. Despite the conceptual nature of the content, only a small percentage of student talk showed evidence of higher order thinking and throughout the lesson students either responded to factual questions asked by the teacher or gave yes/no responses.

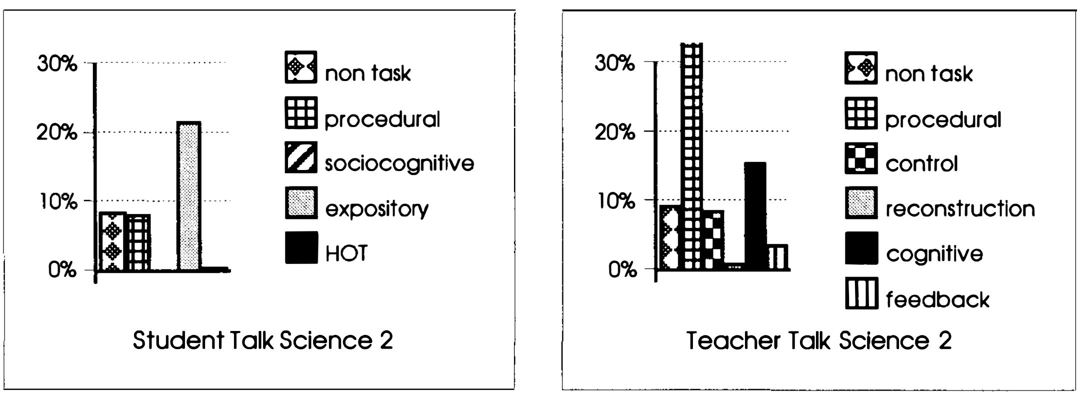


Fig. 11.3: Categories of student talk and teacher talk in Science 2

The non-task talk occurred mainly at the commencement of this lesson and continued throughout when students had problems receiving the graphics for the lesson. There was no evidence of collaboration or talk among students, and the interactions that occurred were initiated by the teacher. Table 11.2 shows the percentages of student talk in each category.

Table 11.2 : Percentages of student talk in Science lessons of Phase 1

Lesson	non task talk %	procedural talk %	socio-cognitive talk%	expository talk %	HOT %	Total %
Science 1	42	17	0	39	2	100
Science 2	22	22	0	55	1	100

A clearer view of the quality of student talk can be gained by looking at the transcripts in more detail and by presenting higher order thinking as a percentage of actual student talk rather than as percentage of all classroom talk.

Table 11.3 illustrates the main categories of HOT that occurred during this lesson, showing the keyword indicators used to identify instances of HOT. Neither lesson showed any reflection by students in the form of self-evaluation or metacognitive statements, largely because the focus of the lesson was on presentation and display of factual content from the textbook. There was a small percentage of interpretation, critical inquiry and cognitive accountability across Lessons 1 and 2, in particular instances where the teacher asked a question that demanded explanation or elaboration. These examples are illustrated in the section on teacher pedagogy.

Table 11.3 : Keyword indicators of higher order thinking in Science Phases 1-2

HOT Category	Keyword Indicators	Mean % of keywords in Science lessons
Cognitive Accountability	because, cos, so, then, therefore	1%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	.5%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	
Reflection	meta statement	0%
	Total percentage of HOT	1.5%

In terms of participation in talk, Table 11.1 shows that the teacher talk accounted for 60%-70% of the total talk that occurred in the lesson. Of this only a small percentage was devoted to explaining the subject and helping students with conceptual understanding. The remainder was given to procedural talk, such as turn allocation, management functions and content talk, where long and detailed explanations were

given, but without much involvement by students. The teacher engaged in a lot of procedural talk, as she had to transmit several visuals, check the model cars that students had produced and also set tasks for homework. In addition, there were technical problems throughout the lesson at all three sites which were connected.

The characteristic three part exchange (I-R-E) was in evidence, with the teachers once again initiating the dialogue. Like the first Science lesson, Science Lesson 2 displayed a good deal of non-task talk while procedural talk accounted for more than 30% of total talk, making it the largest overall functional category (Fig. 11.3).

Teacher pedagogy

In both lessons, dialogue was characterised by short verbal interchanges where the teacher elicited information from students and either repeated or reformulated it as a bridge to the new conceptual chunk. Table 11.4 shows the breakdown in categories of talk for teachers. More than 50% of talk in both lessons was made up of control and procedural functions, indicating a directive role for the teacher.

Table 11.4: Percentages of teacher talk by category for Science Lessons in Phase 1

Lesson	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	total %
Science 1	16	41	19	4	12	8	100
Science 2	13	47	12	1	22	5	100

Both lessons had a proportion of talk devoted to cognitive support, signalling that the teacher did attend to the conceptual content of the lesson, and also scaffolded students' understanding. However, in most lessons it seemed that higher level thinking was constrained by teacher control of turns and feeding of information through the three part structure of initiation by the teacher, student response, and feedback by the teacher. Students did not have the opportunity to ask questions, seek information or discuss what they were learning. The teacher questioned students directly, and elicited facts, information and details. Expository responses to questions were therefore frequent in student talk, and the questioning style of the teacher limited students by focusing on production of the correct answer. This extract illustrates the point quite clearly.

T:	Give an example of a combustible material.	**control**
S:	Wood	**expository**

T:	OK wood.	**repetition**
	Anything else?	**control**
S:	Plastic	**expository**
T:	plastic?	**repetition**
S:	plastic and paper and you know..	**expository**
T:	Oh, I see, OK.	**feedback**
S:	and things like that, and oh, gases:	**expository**
T:	OK some gases are certainly combustible. OK .	**reconstruction**

Interchanges like this were common throughout the lesson, and it appeared that the teacher and students were locked into a repetitive pattern of question and answer which was not progressive, nor leading to deeper understanding. Students were not called upon to expand or explain their answers, or to provide evidence or examples from real events or from their own experience. They simply recalled information when required to do so. The lesson came to an abrupt end when the computer link failed and the students suggested that they play a game. The teacher assigned some homework and engaged in some off-task conversation until the students departed.

The topic appeared to be quite difficult for students and the teacher asked many questions about it, as this snapshot sequence shows. The extract contains one example of HOT, where a student explains following the teacher's use of the phase and that is because, signalling that a short answer was not sufficient.

T:	Ross, or perhaps Kim what class lever is that?	**cognitive**
S:	a first class	**expository response**
T:	a first class, and that is because Kim?	**reflective question**
S:	uh, first class because.. (pause)	**hesitation**
T:	OK staying with you Ross what advantage type lever is a first class, Kim identified that correctly, what advantage does it have?	**cognitive**
S:	a force advantage	**expository**
T:	right a force advantage and that is because?	**cognitive**
S:	because the fulcrum is closer to the load.	**HOT: cognitive accountability**
T:	OK, well if we put it in other terms, the effort arm is longer than the load arm. OK that is true. yes	**reconstruction**

	Gary, mechanical advantage, what was the formula we said to use for mechanical advantage and then perhaps did you calculate it?	**procedural**
S:	beg your pardon? I didn't quite hear what you said.	**interpersonal**
T:	Question 3, the mechanical advantage first; what is the formula we use and then how did you work it out?	**cognitive**
S:	I don't know how you work it out. How would you work it out?	**feedback**

There were not many opportunities available for students to demonstrate higher order thinking, as both lessons were controlled and paced by the teacher. On two separate occasions in Science Lesson 1, students made contributions to the lesson that were categorised as higher order thinking. In the first instance below this was not prompted by a teacher question, while the second instance was in response to a prompt.

T:	.. in fact Ross, just under that heading if you still have control of mixtures, just write there that they are not chemically combined because that is an important thing to put down	**control/ instructions**
S:	teacher, when you have got compounds and stuff like that is chemically combined because it has been melted and you can't just separate them easily, so you have to heat them up.	**HOT: cognitive accountability**

There were only five occurrences of HOT in the second lesson, and these were all in the context of a teacher giving students the opportunity to offer extended and reasoned responses, as opposed to short factual answers. For example:

T:	right, a force advantage, and that is because Ryan?	**reflective question**
S:	well, because the fulcrum is closer to the load..	**HOT: cognitive accountability**

The transcripts showed that the students were confused by Science Lesson 2, possibly because they found it difficult. They sometimes did not respond to questions and remained silent when asked questions. One student asked to leave the lesson. From time to time the teacher attempted to scaffold students through the concepts of force and mechanical advantage, and gave detailed explanations. But students remained passive and were not encouraged to ask questions about details that they had misunderstood. Instead the teacher elicited information and when they failed to respond she filled in the gaps in their understanding with relevant facts. However, there was little evidence that the students were able to grasp the concept or explain it

in their own words, and the pedagogy involved the students to only a small extent in constructing their own understandings of concepts.

Despite the didactic nature of much of the teaching that occurred, a proportion of teacher talk, averaging 17% over both lessons, was coded as supportive or cognitive talk, as it was apparent that the teacher's intention was to enable students to "work out and quantify the mechanical advantage of simple machines". This was her stated objective to students at the start of the lesson. However, the pedagogic approach of talking and explaining to students without involving them in discussion or application of concepts made it unlikely that they would take risks or venture ideas. As a result of this, higher order thinking was not fostered or encouraged. Even when contributions were made by students, little positive feedback was offered as the following extract shows.

T:	How do you think we can measure the performance of the mousetrap car? What sort of things might we do to measure its performance?	**cognitive support**
S:	see how fast it goes or how far it goes.	**factual response**
T:	OK see how far it goes, that's easy, just measure it with a tape measure don't you?	**repetition**
	What about how fast it goes? how are you going to measure that?	**elicit information**
S:	Say, (.) set a distance, say one metre, and get a stop watch and time it and make it into kilometres per hour.	**expository**
T:	That sounds pretty good, though you have got one performance measure of how fast it goes and another one how far it goes so you have durability versus sheer velocity or speed. Do you think that perhaps increasing its performance for one might not increase its performance for the other or would they be related?	**cognitive support**
S:	Don't know	**short answer**

This extract was selected as it fairly typical of the exchanges that occurred in the lesson. The teacher accepted the student's responses, and reformulated each one. In the second response, she used terms that were unfamiliar to a student who admitted that he could not answer. Here an obvious opportunity for scaffolding was presented, but the teacher missed it. In the end the teacher answered her own question.

Included in the procedural category was a quantity of 'content talk' where the teacher, rather than engage the class in discussion of key concepts, explained ideas in the form

of a lecture, without any apparent attempt to involve students in initiating explanations. Content talk was talk about the lesson or topic in general, but not directed to any student in particular, or in response to a question, or to assist in the resolution of a problem or completion of a task. As it did not appear to directly assist learning or interaction, it often consisted of a monologue at the start or at the end of a lesson. Neither was content talk marked by any pedagogical intention to summarise or focus student attention to conceptual detail. For the teacher it appeared to be a part of the procedure of conducting a lesson, or managing the transition from one activity to another. For example:

T:	number two, go through that one for us	**procedural**
S:	Slippery when wet like road signs.	**expository**
T:	Yes slippery when wet	**repetition**
	that is a fairly common one isn't it?	
	you see on the roadside all the time.	**procedural**
	And number 13?	**procedural**
S:	Bright lights	**expository**

This extract reveals several aspects of the teacher's role. Firstly, teacher turns were longer than students', sometimes consisting of four units of communication, each serving a different function. The initial question to the student was merely to elicit information and the response was reiterated. The transition to the next point on the teacher's agenda was made through another direct question. It was clear from the dialogue that the teacher had a lesson plan, and was progressing through it without giving much opportunity to students to question or explain their answers in greater depth.

Overall, the Science teacher's approach to teaching could be summarised as 'get it right'- as her main concern was with students responding with the text book version of events. When students responded correctly she usually reformulated their answers so as to conform to her version. When students could not answer she did not scaffold their understanding but engaged in a monologue or lengthy explanation, without establishing the extent of their knowledge.

The social conditions of learning

As explained in the theoretical framework in Chapter 5, the social context of learning has relevance for how and why students develop thinking skills. For example, a

pattern of dialogue that allows collaboration and exchange of ideas has been found to encourage higher levels of reflection and justification of ideas (Kruger, 1993; Azmitia & Montgomery, 1993). In contrast to student initiated dialogue and collaborative talk, both Science lessons displayed teacher-centred dialogue patterns. Overall, the Initiation, Response, Evaluation pattern of interchange prevailed, with the teacher initiating and questioning and the students responding with minimal replies. The students did not ask questions, nor were they asked for any feedback in either lesson on whether they understood the concepts presented. The teacher asked questions throughout the lesson and evaluated each answer received, giving feedback, or reconstructing students' answers.

These interactions reflected the teacher as an authority figure. In addition, the large amount of talk dedicated to eliciting information, cuing, and issuing instructions to student affirmed the controlling role of the teacher. While this might be the expected pattern in a large class where discipline and management issues are at the forefront, the telematics class consisted of only five students and therefore management problems were considerably reduced. All through the lesson, the teacher directed the activity and flow of discourse, questioned students and evaluated their answers.

In discussing learning, Newman, Griffin & Cole, (1989, p. 64) emphasised the importance of eliciting students' prior knowledge when they wrote: "for a lesson to be needed in say, division, it must be presumed that the children cannot do division". Another way of planning the teaching experience would be to establish students' prior knowledge of the tasks and concepts, and to use this knowledge as a bridge to other unfamiliar contexts. The teacher of Science did not appear to realise that the students were already familiar with much of the content in the first lesson, and that the subject matter did not challenge students. The following example is an illustration of how the teacher confined students to short answers through close questioning, but did not facilitate deeper explanations or give students scope to display the depth of their understanding.

T:	for example, hydrogen peroxide, H202 why has it got those two little twos there?	**elicit information**
S:	because it means to every particle, like for every particle, of oxygen there is two particles of hydrogen.	**factual response**
T:	Right, so the formula in fact for compounds tell you two things doesn't it? It tells you firstly the types of atoms that are composing that particular kind of compound and it tells us what Sean?	**cuing**

S:	Yes	**interpersonal**
T:	and what else does it tell us?	**elicit information**
S:	It also tells us that there are three particles.	**factual response**

The fixed pattern of question and answer created a particular 'culture' in the Science classroom: one where the teacher asked the questions and students answered, and the teacher then validated students' knowledge. There was no negotiation of responsibility, and the teacher did not create opportunities for students to present their own ideas. Participants in this classroom did not have equal status: the teacher asked all the questions. On only one occasion during the second lesson, when the teacher was explaining chemical change, did a student volunteer a question, though this may have occurred through boredom with the lesson. The teacher then decided to ignore the questions and directed her attention to another student.

T:	physical change is one where no new substance is formed, it is just a physical change.	**cognitive support**
S:	like if I hit Gary	**expository/question**
T:	Sorry Sean?	**interpersonal**
S:	If I went up to Gary and punch him, would that be a physical change?	**question**
T:	it might be, but it might also be a chemical one, how could I change that matchstick chemically Ryan?	**elicit information**
S:	you could burn it.	**factual response**

The teacher by-passed the student's response, which would probably have acted as a distracter to her lesson plan. Even in her supporting role, the teacher continued to control, initiate and direct student talk through questioning, cuing and adherence to set exercises. Explanations were conducted in the form of question and answer, and the feedback given was not praise, but a rewording and extension of what students said so that they conformed to the text book version.

In neither of the Science lessons observed were the students given a participatory role in the classroom. The teacher expected them simply to answer her questions, follow instructions and apply the formulae given without question. There was very little opportunity for them to contribute ideas from their own everyday observations of the environment around them.

In Science Lesson 2 , students appeared to be confused and uncertain about the concepts of force and load, and some struggled to keep up with the pace of the class. On several occasions the teacher asked students to jot down notes from the screen, or write down facts that she presented. The students were spoonfed with information and given no opportunity to construct knowledge for themselves. This pedagogy, combined with the imbalance of talk and turns resulted in a class where students:

- displayed little interaction with peers;
- gave short answers;
- sometimes showed frustration or boredom; and
- seldom elaborated on their answers.

Overall, this produced a learning environment which did not appear conducive to the emergence of higher order thinking.

Use of computer technology

In both lessons, the teacher used the visual elements of the technology quite effectively but achieved limited success in terms of enabling students to participate actively in the lesson. Table 11.5 presents a summary of aspects of computer use in the two Science lessons.

Table 11.5: Computer technology use in Science Lessons 1 & 2

Computer Graphics	Lesson 1	Lesson 2
No. of visuals	3	2
Prepared by teacher	yes	yes
student activity	identification	observation
purpose	display symbols	display formulae
locus of control	teacher	teacher
interaction by student	no	no
discussion by student	yes	no
adaptation by students	no	no
reflection by students	no	no

For both lessons, all screens were prepared in advance and were designed to match lesson objectives. In Science Lesson 1, the first of these was a set of international symbols which the students had to talk about and identify.

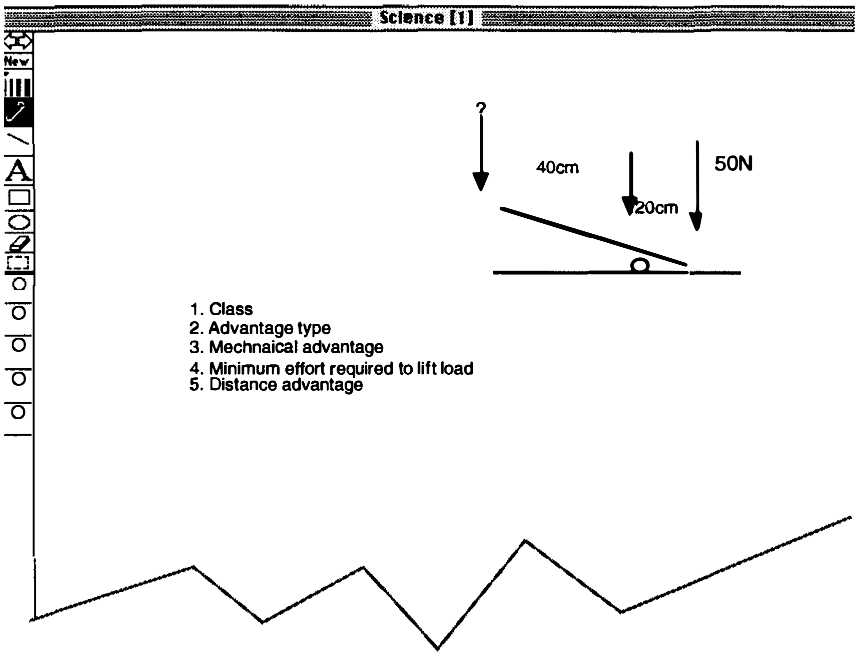


Figure 11.4: Computer visual for Science Lesson 2

In this part of the lesson, the computer visuals simply tied the students to the teachers' agenda of identifying symbols. In fact, the transcripts of talk showed that students already knew these symbols, and the teacher did most of the talking about their location and international significance. Locus of control remained with the teacher for both lessons, and students did not have an opportunity to use the computer tools except for a brief interlude at the end of the lesson when students started to create a mind map, but this ended before the activity was completed. In Lesson 2 the screen display was of a lever, and students had to label the diagram (Figure 11.4).

However, the complexity of the concepts and the unfamiliarity of students with the notion of mechanical advantage meant that the teacher talked at length throughout the lesson just to explain the concept.

The visual assistance provided by the screen provided some scaffolding to students, who at least had a common reference point and access to the teacher's plan. The next visual sent to students showed the formula that the teacher expected the students to apply. This is displayed in Fig. 11.5.

By looking at the screen, students worked out the mechanical advantage for the first problem. The students later worked on different problems assigned by the teacher, and they were given control of the screen in order to display their diagrams and calculations. However, there was little in the way of explanation or discussion and students appeared to be simply applying formulae learnt without any discussion of the processes involved in solving them.

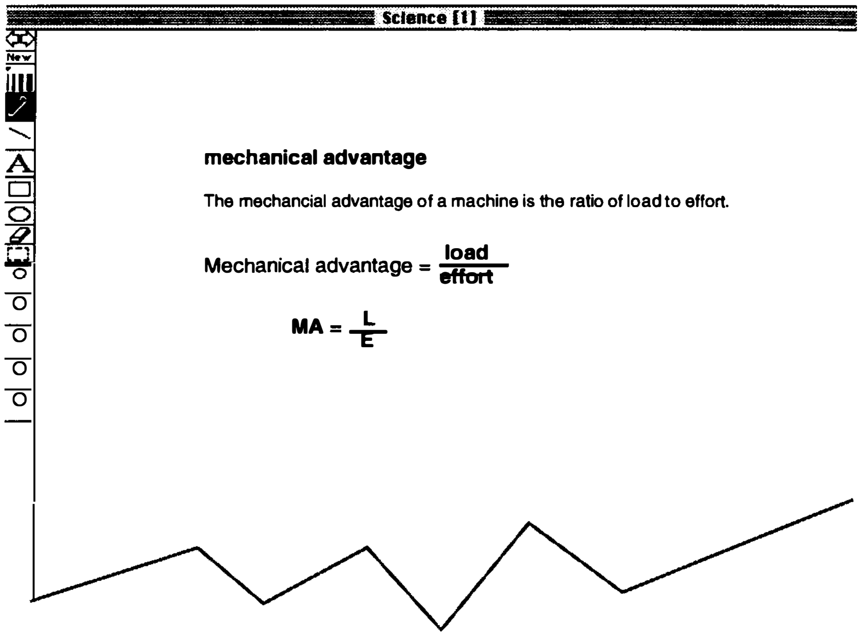


Figure 11.5: Computer visual for Science Lesson 2

In fact, students were using calculators to work out the calculations, and this required only procedural knowledge, rather than principled understanding of the concept of effort and load.

As an illustration of the previous point, the following sequence shows that students had very little understanding of how to carry out the operation, and of what numbers to enter, even though the teacher had spent the previous 30 minutes explaining this in great detail.

S:	Teacher, with the mechanical advantage isn't that just type in the number and press that button?	**expository**
T:	It is yes. If your mechanical advantage is four then you press the reciprocal button and that gives you your distance advantage.	**cognitive support**
S:	what number do you type in?	**expository**

Although control of the computer was given to students and they produced examples of problems set by the teacher, the dialogue showed little engagement in reasoning, inquiry or reflection throughout the course of the lesson. So although the technology appeared to be used quite appropriately to provide a visual dimension to the concepts being taught, on closer examination it served only a narrow set of goals:

- to display a visual stimulus;
- to explain a formula;
- to set tasks; and
- to allow students to apply the formula.

There was little scope for interaction or for students to question, or display their understanding of the subject matter, or to adapt the visual as they could barely grasp the complexity of the concepts of effort, load and force. The screen did however serve to focus attention on an area of new knowledge, and engage students in interaction and discussion with the teacher. It did not however, fulfil the adaptive and reflective dimensions of the learning conversation, as students neither modified nor added to the visuals. The dialogue that ensued was reflective neither of higher order thinking nor of principled understanding of the concepts of force and load.

Conclusion

In conclusion, it can be said that the transcripts provided evidence that procedural and control categories dominated both Science lessons in Phase 1. The teacher remained in control throughout, and the social environment was not conducive to discussion and exchange of ideas. There appeared to be a lot of procedural talk, and little cognitive or principled talk in either of the lessons. Higher order thinking in student talk was a rare occurrence.

Use of the technology can be accounted for within the broader context of the teacher's pedagogy. The practice of questioning students, the controlling of turns and definition of topics were all aspects of an authoritarian and controlling teaching style. The teacher's style emphasised that students should 'get it right', ie produce the textbook answer to the problem set. As a result, interaction patterns tended not to show much variation, and the overall effect was to create a classroom where transmission of information, rather than active investigation and problem solving were the established pattern.

The Mathematics classroom

Students and schools profile

Students who participated in the Science program were also studying Mathematics via telematics. There were five students in this distributed classroom, in three

geographically separated classrooms. There were three students at one site, and one at each of the others.

The syllabus that was used was created specially for these students, and while it covered the core components of the curriculum, the main objective was to extend and enrich students. The mathematics teacher focused on investigative tasks and problem solving, and her objective was to make the students self-reliant and independent learners.

In the two lessons observed during Phase 1, two separate mathematical topics were covered. Maths Lesson 1 was concerned with solving equations. Problems were presented and students had to change them into mathematical equations and then solve the equation.

In Maths Lesson 2, the subject was polygons and the calculation of interior angles. Students first constructed a concept map of the kinds of polygons they had been learning about. The remainder of Lesson 2 was concerned with finding the size of the interior angles of a polygon and finding a rule to express the sum of the interior angles. The conceptual content of the lessons therefore had a lot of potential for students to engage in higher order thinking. For both lessons, students had printed materials in the form of booklets with tasks and exercises.

Teacher profile

From the interview conducted with the teacher to ascertain her views on higher order thinking, the Maths teacher considered thinking as essential to understanding and learning. In her view, students needed to be able to investigate problems, find solutions, make inferences and generate rules. Students needed to take risks, explore ideas and apply rules to new problems and this was her conception of Maths education.

The strategies that she reported using in her classes to develop higher order thinking were setting open-ended tasks, developing investigative skills and encouraging conjecture and prediction in students through problem solving.

To be successful in Mathematics, she believed that students needed to be able to ask questions, engage in reasoning and justifying solutions and have the ability to visualise mathematics equations and pathways to a solution. Her objective was to design activities to develop these skills.

She believed that teaching via telematics inhibited her natural style of teaching, as it constrained her normal teaching style. Firstly, she felt that there was a lack of spontaneity that was characteristic of face-to face classrooms, and the absence of visual clues and body language made it difficult to 'read' students. She felt that silences were sometimes difficult to interpret and she was never quite sure whether to intervene or to allow the students more time to think.

In response to the question asking about concerns and the kind of help that would resolve these problems, she replied that she needed specific assistance in the form of:

- different ways to develop students' higher order thinking;
- a clearer working definition of HOT;
- a better understanding of the subskills of HOT; and
- strategies to monitor and assess these skills informally, in class through the processes of dialogue and conversation that were the usual means of communicating with students.

The teacher also believed that she was not currently meeting the stated goals of the academic talent program, in terms of achieving higher order thinking.

Participation rates of teachers and students

The distribution of talk in the mathematics classes is displayed in Table 11.6. Teachers and students had almost the same number of turns, but teacher communication units exceeded those of students. In Maths Lesson 1, teacher talk accounted for 66% of the lesson, while in Maths Lesson 2 it accounted for 60%.

Table 11.6: Units, turns and teacher/student ratio of talk in Maths Lessons 1 & 2

Talk	Maths 1	Maths 2	Mean
Teacher turns	210	270	240
Student turns	213	274	243
Teacher units	445	495	470
Students units	233	328	280.5
Teacher Ratio	66%	60%	63%
Student Ratio	34%	40%	37%

As in the Science lessons, teacher turns were longer that student turns, and this gave a measure of the proportion of the lesson spent on teacher talk. In both the Maths and Science lessons, teacher talk was in excess of 60% of total lesson talk. The disproportionate amount of time taken up by teachers was once again in evidence.

Further analysis of the communicative functions of teacher talk showed how much active teaching was happening in the class, and how much of the time was spent on non-task talk.

Task and activities

Maths Lesson 1 was organised around activities relating to solving mathematical equations. For each problem, the teacher started with a screen display, in cartoon format, depicting the problem and then passed control to students who used the writing tools on the computer to display their solutions. There were several tasks and activities in the lesson during which the teacher reminded students that they had to think aloud and explain how they arrived at the equation, and how they solved it.

The students worked through three problems successfully with the teacher guiding, eliciting and supporting them as they talked. After 40 minutes the computer failed and the teacher made the decision to abandon the computer and change the activity to a mental activity, or in the teacher's words, mathematical imagery. Students were told to close their eyes and 'imagine a box which could store numbers'. The video tapes of lessons showed that students remained on task through the exercise and were able to follow detailed descriptions and problems, and solve then without recourse to other tools, such as pens and paper. Apart from exemplifying the range of the teacher's strategies, the activity also provided a good example of how the audio technology was used effectively to develop students' thinking and listening skills.

In Maths Lesson 2 tasks and activities covered were varied and offered student opportunities for collaborative talk. The first task was to complete a mind map on polygons, and students shared ideas and contributed to the map from their geographically separate schools. The second task was to calculate the sum of the interior angles of a polygon which was displayed on screen. The teacher made various demands on the students, and she involved them from the start by attempting to elicit their expectations and prior knowledge about the subject. The following extract shows how the teacher evoked students' prior knowledge of polygons and prepared them for the task of measuring the interior angles of a polygon. This focusing on the task was achieved by combining questions to elicit information with questions which pushed students to reflect.

T:	what do I often ask you to do in mental tests, to do with polygons?	**cognitive**
S:	angles and stuff	**expository response**
T:	Right, we are going to be looking at angles today. Anything else?	**elicit information**

S:	surface area and things.	**response**
T:	Yes, anything else?	**reflective question**
S:	Volume	**expository response**
T:	Well would a polygon have volume, how many dimensions has a polygon got?	**reflective question**
S:	two	**expository**
T:	so would polygons have volume?	**elicit information**
S:	No	**short response**
T:	What would they have?	
	We would be looking at what if were measuring them?	**reflective question**

The tasks set for students appeared to be demanding, and throughout both lessons they were fully engaged. Although the students were on task, a lot of expository talk was centred around the actual questions and explanations of the tasks to the teacher. In addition, the teacher had to explain new concepts and approaches throughout the lesson to promote understanding of the measurement of angles, thereby increasing the amount of teacher talk that occurred.

Overall there was evidence that the tasks gave students opportunities to show understanding, to share ideas and to create and display their understanding of the subject using the technology.

Functional categories of teacher and student talk

The students contributed approximately 40% of the total talk in Maths Lesson 1. The categories of talk for the students and teacher are displayed in Figure 11.6.

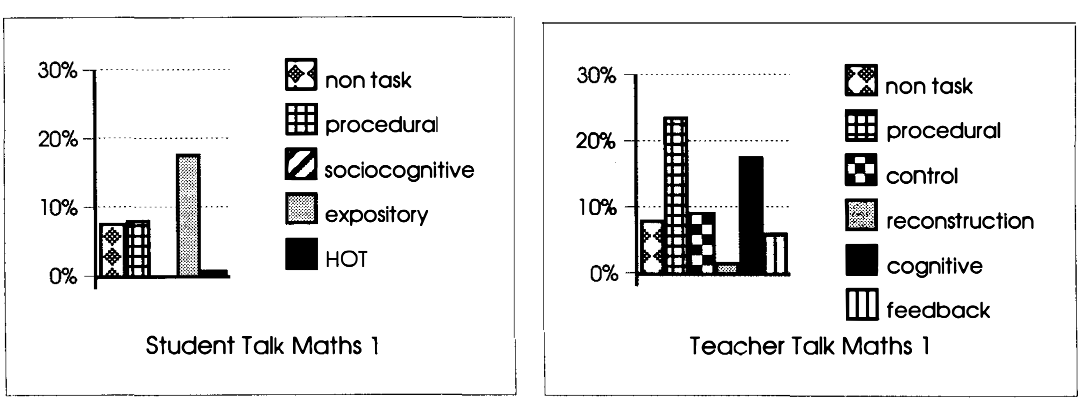


Fig. 11.6: Categories of student & teacher talk as a percentage of total talk in Maths Lesson 1

Student talk was characterised by high levels of non-task, procedural and expository talk. These three categories taken together, accounted for 97% of student talk in the lesson. In expository talk, which was the highest category of student discourse, the students explained the working out of equations step by step, and were focused on the tasks set by the teacher throughout the lesson. Responses tended to be short answers, and the teacher directed and managed the responses by careful questioning and guided elicitation. Students had opportunities to venture ideas and make suggestions and there were several instances of higher order thinking, though these accounted for less than 3% of all talk.

As illustrated in Figure 11.6, teacher talk displayed a great many procedural functions and this accounted for approximately 25% of the talk for the entire lesson. Much of this talk centred on homework and ensuring that students had assignments completed. In addition, several technical problems occurred in this lesson, and at one point the modem link failed and the teacher had to proceed using the audio link alone. Nevertheless, throughout the lesson, the teacher displayed a range of teaching strategies to support students, and these are clustered as 'cognitive' in Figure 11.6. An explanation of the functions of teacher talk are given in the section on teacher pedagogy.

There were several instances of higher order thinking in Maths Lesson 1, where students explained and justified their strategies for solving the algebraic equations in the lesson. The cognitive support provided by the teacher gave students scope to participate and express their own representation of the problem, thereby giving them the space to think. Percentages of all categories of student talk for both lessons are shown in Table 11.7.

Maths Lesson 2 showed similar patterns to Lesson 1, and the main functional categories are displayed in Figure 11.7. Student talk showed three main categories, non-task, procedural and expository. As explained in Chapter 10, non-task talk was talk where technical details and procedural matters were the main focus. Procedural talk was centred on tasks set for homework, clarifying objectives and setting up the lesson. Expository talk, which was the largest category of student talk at 52%, occurred throughout the lesson in response to teacher questions about size of angles, number of triangles and types of polygons, where short factual answers often occurred.

In Maths Lesson 2 the teacher talked again dominated the lesson. At the outset of the lesson, there were some problems establishing the computer link, and then it was

found that the audio equipment was not working efficiently, and this accounted for the non-task talk.

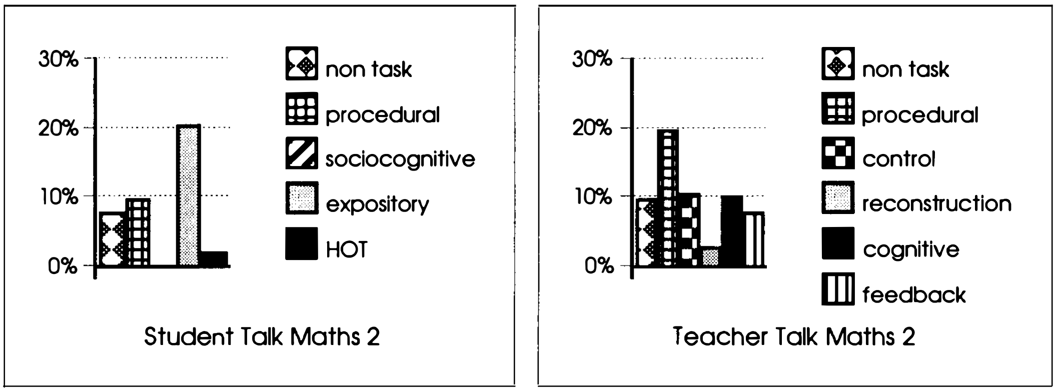


Fig. 11.7: Categories of student & teacher talk as a percentage of total talk in Maths Lesson 2

Homework had to be checked, and material for independent study which was not received was noted by the teacher. Much of this talk was in the procedural category, as the teacher was issuing directives to students. For the mathematics course, a lot of additional independent study had to be completed by students and the teacher ensured that this was understood so that she could proceed with the lesson.

Table 11.7: Percentages of student talk in Maths lessons of Phase 1

Lesson	non task talk %	procedural talk %	socio-cognitive talk %	expository talk%	HOT %	total
Maths 1	22.5	24	0	50.5	3	100
Maths 2	19	24	0	52	5	100

There was a considerable amount of time spent during the lesson ensuring that students had completed the requirements for tasks set, and this accounted for the large amount of procedural talk. Table 11.7 shows the percentages for each category of student talk in Phase 1, with expository talk being the largest category.

In both lessons there was a small percentage of higher order thinking and Table 11. 8 displays the various components of HOT in student talk as revealed by the mean percentage of language indicators found in the transcripts for both lessons. Both lessons showed only a small percentage of higher order thinking with 3% in Lesson 1 and 5% in Lesson 2.

Table 11.8 : Keyword indicators of higher order thinking in Maths Phase 1

HOT Category	Keyword Indicators	Mean %Indicators in Maths lessons
Cognitive Accountability	because, cos, so, then, therefore	2%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	1%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	1%
Reflection	meta statement	0%
	Total percentage of HOT	4%

The occurrences of HOT in student talk were fostered by the teacher's pedagogic strategy of enabling the students to think aloud as they solved problems and explained the processes by which they arrived at solutions. For example, this extract shows that the teacher was explicit in her instructions that students 'think aloud'.

T:	so just think aloud again so Ross knows what you are doing because she can't see the screen.	**cognitive support**
S:	OK, um each piece of pipe is three metres and you have got four of them	**HOT: cognitive accountability**
	so that is four time s three plus seven time eight	

In both lessons there cognitive accountability was shown by students, indicating that reasoned responses were part of their conversation. Students also showed the ability to interpret Mathematical concepts when supported by the teacher. In Maths Lesson 1, the teacher used some mathematical imagery towards the end of the lesson, where she asked students to imagine a large box where numbers are stored. At the end of one such exercise the following interchange occurred:

S:	fifty eight	**expository**
T:	Who said that? Gary?	**management**
S:	Yea-they were real easy.	**feedback**
T:	How was that? were they real easy for any particular reason?	**cognitive support**

S: Well when you said something like ten and twelve or something, it was pretty easy and then you kept on adding like numbers so that would make it up to ten, so that was really easy. **HOT: Interpretation**

Other short statements by students indicated their involvement in the lesson, and that they showing their understanding verbally.

"Teacher, I have got it now. I understand."

""I tried to do it in my head, but I got one hundred and five and so one angle is one hundred and five, but I forgot it is not twenty five, it is forty. "

These examples showed that in the Maths lessons students engaged in reasoning processes. However, there were only a small number of higher order thinking episodes in both lessons.

Teacher pedagogy

The teacher's pedagogy was characterised by a number of strategies which supported learning. In order to describe their strategies, it is necessary to reconstruct, as far as possible, the interchanges that occurred during the lesson. Percentages of teacher talk categories are shown in Table 11.9. Cognitive support was offered to students in both the Maths lessons indicating that the teacher had well defined strategies to assist students.

Table 11.9: Percentages of teacher talk by category for Maths Lessons of Phase 1

Lesson	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	total %
Maths 1	12	36	14	2	27	9	100
Maths 2	16	32	17	5	17	13	100

The topic of Maths Lesson 1 was algebra. The teacher defined the task for students as involving the stages of looking at a problem, changing it into a mathematical equation and then solving the problem. The following example shows how a range of cognitive support strategies such as modelling and reflective questions scaffolded learning.

T:	Sally has got four books of tickets and two loose tickets. Nick has got six book of tickets and two loose tickets. Now Nick and Sally have got the same number of tickets so when they each have the same we know we are dealing with an equation.	**cognitive support**
	So first we let S stand for the number of tickets in a book	**modelling**
	Ryan, I am going to start with you and pass control.	**procedural**
	Would you write an equation that represents that equation in that situation and while you are writing it tell us what you are thinking.	**cognitive support: (reflective question)**
S:	well you add all the booklets together, um I think so	**expository**
T:	So you have got 2	**checking**
S:	equals (student writes on screen)	**expository**
T:	say it aloud	**management**
S:	question mark plus question mark plus question mark plus question mark plus twelve	**expository response**

During the dialogue the students produced an equation on screen as shown in Figure 11.8. When the equation was solved, the teacher did not merely go on to a new problem, but gave the students an opportunity to reflect and evaluate how they arrived at the solution.

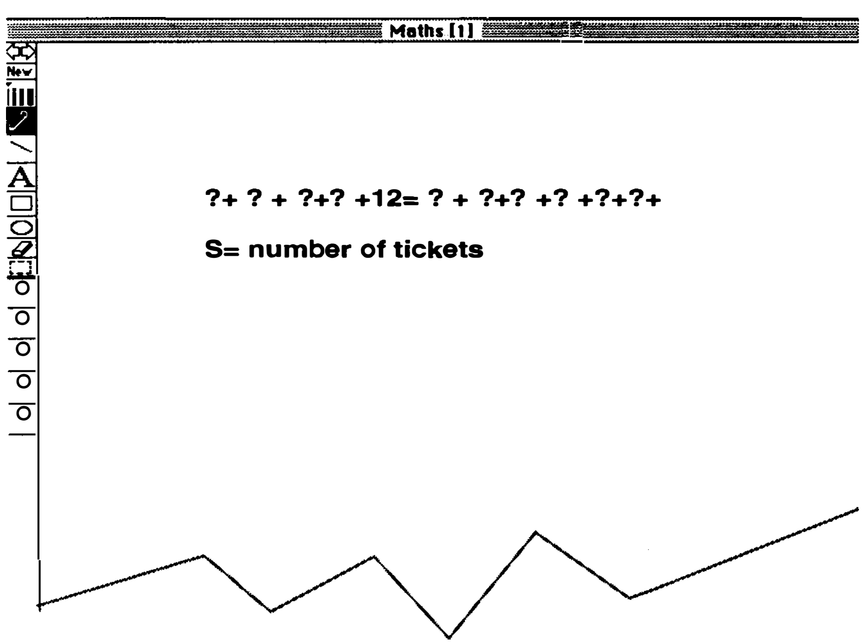


Figure 11.8 : Visual produced by students in Maths Lesson 1

The following extract shows that the teacher combined questioning with praise and then used reflective questioning to give the students scope to explain and display higher order thinking.

T:	What is the last thing we need to do, does anyone remember?	**elicit information**
S:	Write in the sentence answer?	**expository**
T:	right. You could write in that there are five tickets in each book, excellent.	**feedback/praise**
S:	check it.	**feedback**
T:	yes check it, who said that?	**management**
S:	Gary	**procedural**
T:	Gary, would you, don't write it on the screen, but would you explain how ?	**cognitive /reflective question**
S:	Well if there is six question marks or six unknown things on the left side and you work out that it was five so you go five plus five plus five plus five plus five plus five, so the are six fives, plus them together and then you add the two that is in there and then you work it out	**HOT: cognitive accountability**

The strategy of asking students to explain their ideas gave them an opportunity to reflect, elaborate and expand on the processes involved in solving the equation and thereby demonstrate thinking processes. Here the computer technology scaffolded higher order thinking by enabling the students to represent and modify the solution to the equation.

In Maths Lesson 1 students were given an active verbal role and were expected to participate, explain and justify answers. Several instances of extended explanations occurred when students explained their thinking aloud as they solved problems. However, these incidents accounted for less than five percent of student talk. The large amount of time given to controlling and directing students can be explained by the fact that these students (who were the same students as those doing Science) were clearly unfamiliar with the process of explaining and justifying ideas and needed specific support to make their thinking clear.

Comparing the Maths and Science teachers in terms of their pedagogies brings their classroom practices into sharper focus. Whereas the Science teacher relied on questioning and explaining to foster new skills the Maths teacher engaged the students in *doing* mathematics, and in talking about it. The focus was on *thinking processes*, not answers, and all students had an opportunity to display their solutions and justify them.

This approach combined with the teacher strategy of emphasising new ways of using language and explaining ideas produced instances of higher order thinking in both Maths lessons.

Social conditions of learning

The teacher tried to establish an open and non-threatening environment for the students where they could ask and answer questions and challenge each others' solutions. This was evident in the transcripts of lessons and in the extracts cited below.

Each of the students took turns to explain and think aloud and the teacher reassured the students by saying "if there is anyone who doesn't understand the steps would you please say so straight away and don't be embarrassed". This was an attempt to create a trusting environment in class and students were willing to venture ideas in explaining the equations.

In the same lessons the Maths teacher also took the initiative to ask students to explain their answers, rather than just provide a solution. As a result, students tended to give extended responses and this led to instances of higher level thinking. The following extract illustrates the point quite well.

T:	Just do it in your head and talk about it.	**management**
S:	Then you have 3c's so nineteen plus nineteen is thirty eight plus	**HOT: cognitive**
	nineteen is fifty seven so they equal fifty seven each (pause)	**accountability**
	and so that is right.	**HOT: interpretation**
T:	That is perfect, excellent.	**praise**

Here the teacher set the expectations for the student, as she had done throughout the lesson: you must explain the answer, or talk about it. The student did so, and produced not only a longer turn with three communication units, but also displayed interpretation and cognitive accountability which were examples of higher order thinking. By working through the mathematical equation the student was able to justify the answer and produce data in the process of doing so.

The student's extended turn also displayed a different grammatical form to the short answers typical of many lessons in other subjects. Several clauses were used to present evidence and then the conclusion was drawn from the evidence presented, signalled by the word 'so' repeated several times. Higher order thinking in this student's talk was in evidence and can be supported by other studies on the discourse of reasoning,

emphasising that reasoning processes are signalled by discourse and pragmatic functions in talk (eg, Fisher, 1996). (See Chapter 11 for examples of how HOT is signalled in verbal expression.)

The teacher usually responded warmly to students' efforts and praised them, rather than reformulating their answers to match her own agenda. Through insistence on talking through problems and solutions, the students were guided towards mathematical thinking and language use. This contrasts with the content-based emphasis of the Science lessons. The students ventured to ask questions on a number of occasions and Maths Lesson 2 made several inquiries such as:

"Why can't you do it the other way?	**challenging**
" I will have a go"	**initiating and risk taking**
" know what it is. I have got an idea".	**suggesting ideas**

These examples of student talk show that the classroom environment was one where the learners were encouraged to ask questions, think for themselves and put forward ideas.

Use of computer technology

In both Mathematics lessons, extensive use was made of the computer technology to display problems, create visual stimuli and engage students in finding solutions to problems. Table 11.10 shows the main aspects of computer technology use for Maths Lessons 1 and 2. For both lessons, screens were prepared in advance by the teacher, except in Maths 2 where students worked to create a graphic overview of the concepts covered. Both lessons used the computer screen for problem solving.

Control was passed from teacher to students during the lesson, and students were expected to use the screen to display their solutions and provide evidence for their explanations. In the second lesson, students had to create a mind map showing different types of polygons and their shapes, sizes and numbers of sides. Use of the computer screen throughout each lesson ensured that students at different sites had a similar visual representation to work from. The computer technology enabled students at each location to share ideas and have a common reference point for their talk, and also supported dialogue. This fulfilled some of the elements of the 'conversation model' (Laurillard, 1995) by enabling interaction, discussion and adaptation of the teacher's ideas and concepts.

Table 11.10: Computer technology use in Maths Lessons 1 & 2

Computer Graphics	Lesson 1	Lesson 2
No. of visuals	3	3
Prepared by teacher	yes	yes/partly
student activity	problem solving	problem solving
pedagogic purpose	problem solving	mind mapping
locus of control	shared	shared
technical problems	yes	yes
interaction by students	yes	yes
discussion by students	yes	yes
adaptation by students	yes	yes
reflection by students	no	no

In Mathematics Lesson 2, the computer was used by students to create a mind map. This was created jointly by the teacher and students in order to summarise types of polygons and their properties. Students made a number of suggestions about types of polygons, but did not elaborate extensively on their responses. The objective was to summarise properties of polygons and while the teacher gave control to the students, she elicited information and directed the activity in order to complete it with the minimum amount of fuss. Later in the lesson, the teacher presented a problem concerning the interior angles of a hexagon and polygon. The following conversation ensued:

T:	Good, supposing you had forgotten that a quadrilateral added up to three hundred and sixty, but you remembered that a triangle added up to 180 who could work it out?	**cognitive support**
S:	Sean could.	**feedback**
T:	Right go on then.	**feedback**
S:	Well if you add two triangles together you can <u>always</u> make a quadrilateral.	**HOT: rule making**
T:	Good and then what, how does that help you?	**cognitive support**
S:	Well you know that one triangle is 180 <u>so</u> two triangles have to be 360.	**HOT: reasoning**
T:	You have got it.	**Praise**
	So extending that a bit further what about for a pentagon?	**cognitive support**
S:	Well I can do an octagon.	**suggest idea**
T:	OK go for an octagon.	**reinforcement**

S:	Seven hundred and twenty.	**expository**
T:	Seven hundred and twenty how do you know it is 720 degrees?.	**reflective question**
S:	I went two times er square, three hundred and sixty which is seven hundred and twenty.	**explain**
T:	Oh excellent OK.	**praise**

While the computer visual depicted key information which gave students an understanding of the whole question of angles in a polygon, it was the teacher's scaffolding and use of reflective questioning that led to the instance of higher order thinking observed in the episode above. In the same extract the teacher also scaffolded learning by providing cognitive support, feedback and reflective questions at strategic times during the interchange which allowed the student to express her thinking.

In summary, the Maths teacher used the technology to:

- provide a visual representation of the problem;
- allow students to map their ideas;
- foster sharing of ideas; and
- enable interactive problem solving.

Throughout Maths Lessons 1 and 2 there were instances where the technology was used to support thinking, but at other times it created delays and problems for the teacher, particularly at the opening of the lesson.

Conclusion

In conclusion, the Maths teacher's pedagogy could be summarised as 'Say what you think', reflecting an approach of asking students to think aloud and explain their thinking processes as they solved problems. Although there were few episodes of higher order thinking in these lessons, the teacher showed an understanding of the importance of enabling students to think for themselves and to use language to express their ideas in Mathematical concepts. The transcripts showed that the low occurrence of HOT was related to the high frequency of teacher questions which elicited questions and the preponderance of explanatory and expository talk which the teacher engaged in. There were however, some positive aspects of the teacher's approach. The encouragement to students of thinking aloud created an open and trusting atmosphere in the class, and made the objective of thinking visible and comprehensible by students. In articulating aloud their thinking, some instances of reflection, cognitive accountability and inquiry occurred. With computer technology use, control was often

shared and although most of the visuals were created by the teacher, they enabled discussion and interaction with students. Visuals which were adapted by students showed the greatest potential to foster higher order thinking.

The English classroom

Student and school profile

Two schools received the English program, and these schools were approximately fifty kilometres apart. At one school there were six students, while at the other, there was one student. The solitary student received lessons in the library where there was usually another class in session. This resulted in a great deal of background noise from this location, and effectively prevented the student from hearing what was said by other students in the extended telematics classroom. The poor audio quality made interaction between the two sites impossible, and sometimes caused delays as instructions often had to be repeated to the individual student.

The school where six students received the telematics lesson had a small room which was dedicated to telematics. Their equipment included a hands-free telephone, a tape recorder and a graphics tablet. The graphics tablet arrived at the school towards the end of the first semester, and so it was not used during Phase 1. By the second term, the students were proficient users of the technology and used it extensively in class to draw pictures, make notes and create visuals which were transmitted to the teachers and the other school. This was more efficient than students using the keyboard to type responses, as the graphics tablet could be easily passed around to each student and did not require keyboarding skills.

Teacher profile

During the interview, the English teacher said she believed that students needed higher order thinking in order to become independent thinkers and learners. In order to foster higher order thinking through English her aim was to involve students in literature and discussion and to enable students to read about, and make experiences personally meaningful. Through encounters with other cultural events and the experience of literature, she believed that with appropriate guidance, students could develop breath of understanding, and freedom of thought so as to be creative. Intellectual curiosity was for her an important aspect of developing higher order thinking.

In order to assess whether students were achieving thinking in the classroom she believed that it was best to look at the products of thinking, like essays, but wanted to find out about other ways of assessing thinking though the informal channel of conversation.

Her major concern was the fuzziness of the term higher order thinking, and she wanted to ask how it could be translated into practical classroom action, and what subskills, if any, were associated with the term. In addition, she wanted to develop strategies that would work in telematics classrooms so that she could achieve better outcomes.

Her reflections and concerns had much in common with the other teachers in the study, as she was concerned with finding a workable definition for thinking in the classroom and with application of appropriate teaching strategies.

Participation rates

Both English lessons in Phase 1 were shorter than other lessons, due to delays caused by technical problems at the start of the lesson. While Maths and Science lessons lasted for one hour, the English and Social Studies lessons lasted for 45 minutes so absolute numbers of communication units were less. Participation rates, turns and communication units for each lessons are displayed in Table 11.11.

Teacher and student turns were quite balanced in these lessons, with approximately the same number of turns taken by the teacher and individual students. However, when it is considered that there were seven students in the combined classes, the distribution of turns was still not equitable and the transcripts showed that not all students had a turn to speak. Within conversational turns, the teacher's communication units outnumbered those of the students.

Table 11.11: Units, turns and teacher/student ratio of talk in English Lessons 1 & 2

Talk	English 1	English 2	Mean
Teacher turns	48	72	60
Student turns	51	71	61
Teacher units	109	182	145.5
Students units	61	99	80
Teacher Ratio	64%	58%	61%
Student Ratio	36%	42%	39%

Participation of students in English Lesson 2 was higher than in English Lesson 1, and the interaction patterns and tasks were investigated for both lessons in order to show the roles, activities and higher order thinking reflected in the dialogue.

Activities and tasks

In English Lesson 1, the subject was mythology and the task was for students and teacher to co-construct a graphic outline of myths on the screen as part of a module on belief systems. This was the only activity in the lesson, and the creation of a graphic outline was intended for later use as the basis for creating and writing a myth of the students' own choice. This lesson was planned as the groundwork for that activity. Most ideas suggested were prompted by teacher questioning and direction. The teacher had clearly predefined ideas on the kinds of myths and legends that she expected students to talk about, and throughout the lesson she prompted and cued responses so that all suggestions from students fell neatly into predefined categories. The computer screen was used in this lesson to display the ideas that emerged as a result of teacher questioning.

In English Lesson 2, after repeated attempts to establish a computer connection, the teacher abandoned the computer link up and used the audio channel with existing printed resources to discuss sources of evidence from the past. The topic included, for example, where data on cultures, beliefs systems and past civilisations could be located. The lesson commenced with a discussion of possible sources of evidence and students took notes as the teacher explained. There was limited activity from students apart from answering questions posed by the teacher. There was no student product (for example a plan or outline) for review and integration by the teacher to consolidate what had occurred. Ideas discussed in the lesson could not be displayed due to the failure to establish a modem link. Several attempts were made to reconnect the computers but were not successful. The lesson ended with both students and teachers complaining about the unreliability of the technology.

Functional categories of teacher talk and student talk

In English Lesson 1, the teacher discussed with students the nature of myths and their origin in animism and monotheism. The purpose of the lesson was to construct a graphic overview of myths based on these three belief systems.

Figure 11.9 shows the categories of talk in English Lesson l for teachers and students. The category of HOT was almost absent from student talk, and in the entire lesson there were only occasional contributions from students that could be considered as

reasoning. The categories of non-task, procedural and expository talk accounted for the majority of student talk, and together they constituted more than 75% of student talk that occurred.

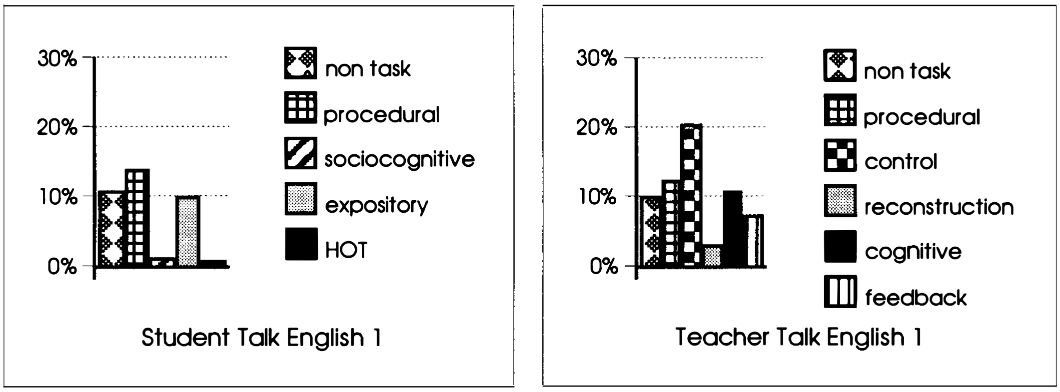


Fig 11.9: Categories of student talk and teacher talk in English lesson 1

Teacher talk displayed a large proportion of control and procedural talk, which accounted for more than 30% of the talk that occurred in the lesson. In teacher talk, the cognitive support offered to students was limited, and consisted mostly of lengthy explanations as opposed to strategies to encourage contributions from students or enable them to think for themselves. Feedback was given to students in the form of praise or encouragement for their responses, although this was only a small proportion of the talk. Teacher talk accounted for 64% of the entire lesson and much of this served the function of directing and managing contributions from students while maintaining direction in the discussion.

In English Lesson 2, which took place a week after English 1, student talk showed some minor differences. Figure 11.10 shows the functional categories for teacher talk and student talk. While the non-task, procedural and expository categories were still dominant, there was a small increase in thinking behaviours.

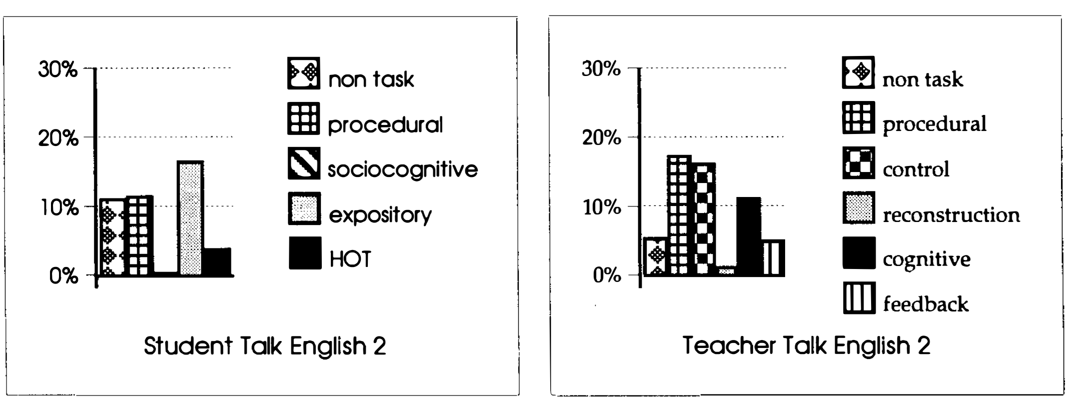


Figure 11.10: Categories of student talk and teacher talk in English Lesson 2

Analysis of the transcripts showed nevertheless that student talk was largely expository and procedural, with short responses given to teachers' questions throughout the lesson. The actual occurrence of HOT that occurred in Lesson 2 was approximately 3% of the total talk for that lesson (Fig. 11.10). As the lesson enabled students to discuss issues relating to sources of information about the past, the lesson created openings for the students to express their views. A further breakdown in student talk categories can be seen in Table 11.12. which shows talk categories as a percentage of student talk. Expository and procedural categories together constituted over 60% of student talk in the English lessons.

Table 11.12: Percentages of student talk in English lessons of Phase 1

Lesson	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total %
English 1	29	38	3	28	2	100
English 2	25	28	1	38	8	100

The instances of higher order thinking were rare, though some occurred as a result of students being encouraged to provide extended answers, or to elaborate. Students sometimes demonstrated reasoning in their responses, where they hypothesised on the sources of evidence, as the following extract illustrates.

T:	what ways have people collected data through civilisation, ancient civilisation- what different ways did they use?	**cognitive support** **reflective question**
S:	Um maybe through old- though people's old bel- belongings - like when as old person dies. They might find some old history in their belongings.	**HOT: hypothesise**

These occurrences of higher level thinking were isolated however, and most of the talk was circumscribed by the teachers' narrow range of instructional strategies which limited opportunities for students to go beyond displaying factual knowledge.

The percentage of HOT that took place can best be seen as a percentage of student talk, and Table 11.13 shows the mean percentage of language indicators for HOT in both lessons. In English Lesson 1, the total percentage of HOT was approximately 2% of student talk, while in English Lesson 2 it was slightly more, reaching 8%. Taken as a proportion of all talk, HOT can be seen to be only a minor part of the interchanges that occurred, and evidence from the transcripts showed that most of the lesson was given to expository talk, display of facts and knowledge, and procedural talk. The focus of

attention in both lessons was not on conceptual understanding but on details of the lesson, homework assignments and content talk.

Table 11.13 : Keyword indicators of higher order thinking in English Phase 1

HOT Category	Keyword Indicators	Mean % Indicators for English lessons
Cognitive Accountability	because, cos, so, then, therefore	2%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	1%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	2%
Reflection	meta statement	0%
	Total mean percentage of HOT	5%

Neither of the lessons had any reflection by students, or any display of metacognition. An explanation of the quality of student talk was achieved by analysing the exchange patterns in the lesson. As teachers initiated the dialogue, and students responded, the starting point for analysis was initially on the nature and purpose of teacher talk. For example, teacher talk in both lessons showed a large proportion of control talk, with instructions, directions and questions throughout the lesson. The percentage of control talk for English Lessons 1 and 2 was 32% and 28.5% respectively (Table 11.14).

Though the teacher did not reformulate students' answers or rephrase them as the teacher of Science did, the controlling features of teacher discourse were in evidence in the closed questions and elicitation's of student answers. Only 17%-20% of teacher talk was given to cognitive support, where the teacher fostered understanding and development of thinking. In this category, there were instances of reflective questions and explanations intended to scaffold students' understanding. But the overwhelming emphasis in the lessons was on the production of factual information and content.

Teacher pedagogy

At the outset of the English Lesson 1, the teacher stated that the aim of the lesson was to create a graphic overview of types of myths. She said

T:	I'm going to write the word myths and then I am going to write three subheadings, one is going to be creation, one is going to be good and evil and the other's going to be people and what I'd like you to do is think about what you are going to put under each of these subheadings because I'm going to pick on each of you and ask 'what are your lists...?'	**procedural/ management**

From the commencement of the lesson, the teacher managed turns, directed the conversation and its interpretation while students responded to questions and made suggestions. Table 11.14 shows that the procedural and control categories of the both lessons accounted for 60% of teacher talk.

Table 11.14: Percentages of teacher talk by category for English lessons Phase 1

Lesson	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	total %
English 1	15.5	19.5	32	5	17	11	100
English 2	10	30.5	28.5	2	20	9	100

Some of the teacher-student exchanges that occurred in both lessons showed that the teacher was keen to hear students' ideas and encouraged them to offer suggestions. In English Lesson 1, suggestions were welcomed and responded to in a non-evaluative way and the teacher gave students the impression that the whole venture was one of teamwork and participation. She invited students to work along with her in completing a graphic outline of the topic, as the following extract shows:

T:	So if you know a little about ancient religions, a little about Greek mythology, the Greeks and Romans, a little Christian mythology, I want you to help me fill out this chart with ideas...	**stimulus**

Despite this invitation to participate, the lesson did not show any features of creative or searching inquiry by students. The teacher prompted and cued most of the responses that occurred, and the graphic outline that emerged was more a reflection of the teacher's views than of students'. Besides direct questioning of students and invitations to respond, the teacher did not create any other motivating conditions for the emergence of higher order thinking, nor did she make it clear to students that they were expected to think about their ideas or justify them.

The responses of students were not defended or discussed and the ideas that emerged seemed more like a random collection of 'spur-of the-moment thoughts' than deeply considered views. The teacher suggested the framework of ideas and through coaxing and persuasion managed to get students to add some details to the graphic outline. The ideas were shaped and elicited by the teacher throughout the lesson, as the following extract shows.

T:	OK, first of all, under creation, I'd like you to write down the first thing that creation myths might be concerned with.	**procedural**
	One thing that we might be concerned with is the creation of the earth.	**control**
	(Student types in 'earth')	
	What other things might we put up there?	**elicit information**
S:	(Students whisper in the background)	
	(The word 'people' is added to the computer screen by a student in one of the schools.)	
T:	OK lets get these kids working a bit harder.	**management**
	OK Aaron, would you like to write something?	**management**
S:	under creation of the earth?	**procedural**
	we got creation, the people in it..(.) well	**expository**
	(Student stands up to use the keyboard and types in some words.)	
T:	OK. Aaron, trees and flowers, that's very important.	**praise**
	What other things do we have creation myths about?	**elicit information**
	OK, I'll ask Anita.	**procedural**

While the teacher tried to get students to give their views of the topic, she actually directed the students to put *her* ideas into the graphic outline rather than their own. This pattern occurred throughout the lesson, and there was very little discussion of the contributions made by students to the topic. The main objective to the lesson appeared to be completion of the graphic outline on the screen rather than achievement of cognitive outcomes.

In English Lesson 2, the subject of the lesson was a discussion of how to find and use evidence in history and other areas and how to look for sources of data about past events. The lesson commenced with a discussion of how people working on the past, for example historians and archaeologists, relied on data to support their work. Students had done some prior reading on the subject, and so the context was set for a

class discussion. The teacher invited students to give their ideas on the topic. Questioning was the pedagogical approach adopted, as the following extract shows.

T:	What other ways can you get data from people's stories?	**elicit information**
S:	You can ask them	**cognitive support**
T:	Yes, you can ask them - there might be some other ways. Come on, think about it.	**cognitive support**
T:	How do you get to know the history of England or Europe?	

In this extract, the teacher asked an open or reflective question, which encouraged the student to provide a reasoned explanation. Occurrences of HOT were due to the fact that the teacher, on one or two occasions, created an opportunity for the learners to express and elaborate on ideas, and to display reasoning. The following extract provides an example where cognitive support is given through a question designed to encourage an elaborated answer.

T:	How else might we collect information about or data about past societies?	**cognitive /question**
S:	Diana her . I've got an idea bout how we might do it.	**procedural**
T:	OK, go on.	**management**
S:	You could ask people, like Aboriginal people about their culture, <u>because</u> they'd know a lot about their culture before, <u>so</u> you'd ask people who know a lot about the past, or you know, their heritage.	**HOT: Justify**

In English Lesson 2, when the technology failed, there was less preoccupation with using the computer to create graphics and more of a focus on dialogue to explain ideas. Nevertheless, the controlling aspects of the teacher's pedagogy were always present, and this limited students' scope to express their own ideas. These controlling features, as found in the analysis of transcripts were asking closed questions, limiting the topic and constraining the students to produce the teacher's ideas rather than their own.

Social conditions for learning

For both lessons, the dialogue indicated that the social conditions of the classroom were not conducive to discussion and exchange of ideas. In English Lesson 1, the teacher tried to create an atmosphere where students would contribute to the lesson, and through visual representation of ideas on screen she tried to create opportunities

for discussion. However, there appeared to be little understanding among students that thinking *through* issues was important, as they rarely expanded or elaborated on their ideas. The teacher did not make her objectives very clear at the outset of the lesson, and so students did not appear to be motivated to make contributions, or go beyond expository answers. This may have happened because the teacher's style tended to be directive, and her ideas were usually incorporated into the suggestions of students. The transcripts show that it was unlikely that they had any real sense of joint construction of knowledge, as they appeared to wait for questions and prompts before offering ideas.

In Lesson 2, when asking students to cite sources of evidence about the past, the teacher gave some cognitive support in the sense of explaining and asking reflective questions, and occasional occurrences of HOT resulted. But overall, the activity and tasks were not conducive to students' discussing issues or taking a position from which to reflect on the views expressed.

This extract from the second lesson illustrates the point about the directive style of the teacher. The students and teacher were discussing where our records of the past come from and who produced them.

T:	who do you think wrote those journals, about the history of England and Europe?	**elicit information**
	(students whisper to each other)	
S:	Maybe, like the people who were there and saw everything like...	**expository**
T:	Do you think they were written by a particular group of people?	**reflective question**
S:	maybe just, like farmers and um	**expository**
T:	No I don't think it was the farmers doing the writing in those days- they couldn't read or write.	**feedback/correction**
	In fact most of these English people, European people, a hundred years ago were illiterate.	
S:	So maybe it was the explorers or people- like the rich people who had the education and all?	**suggest idea**
T:	Again, the rich people had a higher education- and they only learned- they didn't do a lot of writing they were dedicated in those days they were.. .	**cognitive support**
	(*student interrupts*)	
S:	Historians *(words inaudible)*	**expository response**

T:	What Sam? *(teacher cannot hear the reply)*	**procedural**
S:	Historians	**expository reply**
T:	No not really historians-	
	do you know what the education of the rich was like a hundred years ago?	**closed question**
S:	The kings and queens, like they got educated.	**factual response**
T:	No I'll tell you who did the educating. It was the church.	**control**

In this extract, the teacher took a diversion from the main topic of how we find out about the past and began to direct students to thinking about who produced historical records. The students suggested several ideas but these were rejected by the teacher. The exchanges that occurred were like a guessing game, with the teacher probing, and students making attempts to come up with the right answer. Finally, the teacher steered the topic to her interpretation, and gave the students her own version of events: "I'll tell you who did the educating. It was the church."

The social conditions as reflected in the interaction patterns placed the teacher centre stage, with her views being imposed on the learners' throughout the lesson. Nowhere in either lesson was there any evidence of the teacher inviting a challenge or seeking opposing views from students, or creating an environment where students could evaluate the ideas that emerged from the lesson. This kind of pedagogy could not be described as scaffolding, as the teacher was not attempting to develop in students a particular skill, but seemed intent on promoting a particular view of historical events.

Use of computer technology

Table 11.15 shows use of the computer technology for English Lessons 1 and 2. In the English Lesson 1, a computer visual was used by the teacher to create a graphic outline of the topic, myths. Control of the screen was shared, with students taking turns to write in an idea.

Students used the keyboard to type in words associated with the theme, and the keyboard had to be passed around the classroom and shared among six students. The teacher gave control to the students at appropriate points in the lesson where they were able to make a contribution.

Table 11.15 : Computer technology use in English Lessons 1 & 2

Computer Graphics	Lesson I	Lesson 2
No. of screens	3	
Prepared by teacher	yes	
locus of control	shared	
student activity	mind map	
purpose	create a structure	
Interaction by students	yes	
discussion by students	yes	
adaptation by students	no	
reflection by students	no	

In Lesson 2, the computer link failed and so there was no visual dimension to the class. In both classes there were delays and difficulties associated with the technology and this occasioned talk about technical problems and created distractions.

In English Lesson 1, the use of the computer and passing of control to students did lead to sharing of ideas across different locations, but this was hampered to some extent because the teacher framed the discussion and controlled contributions. By the end of the lesson, the computer screen depicted the ideas that had emerged from the interchanges that occurred. This is shown in Fig. 11.11.

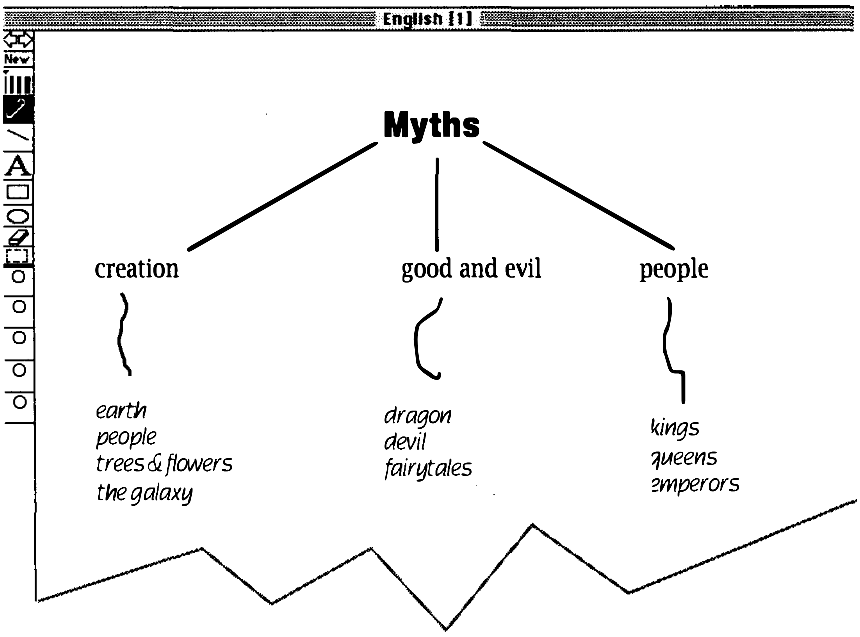


Figure 11.11: Computer visual for English Lesson 1

This particular use of the computer did not directly lead to higher order thinking, but was used by the teacher to show an organisational structure for the lesson and may

have helped students to focus on the ideas begin presented. Although some students had a turn at writing an idea in the graphic outline, most of what went into the graphic outline was the teacher's own ideas. Instead of using the screen as a resource to build social interaction and discussion of ideas, it was used by the teacher only to structure the activity and give a semblance of input by students.

Conclusion

In conclusion, this teacher's approach could be described as 'Let's talk about our ideas', as she attempted to involve students in discussion of issues related to her subject. However, the objective of fostering higher order thinking was hampered by overuse of directives and controlling questions which limited students' explanatory powers and constrained conversation to the teachers' agenda. Computer technology use caused some delays in Lesson 2, and was used by the teacher to display a structure for the lesson that was not negotiated with students, and therefore did not engage students in reflection on ideas or adaptation of the teacher's presentation of the lesson content.

The Social Studies classroom

School and student profile

Two schools participated in the Social Studies program, with the same students studying both English and Social Studies. The total class comprised eight students, with six at one site and two at another. The classroom setting and equipment was the same as for the English program.

The curriculum offered in both English and Social Studies was intended to be integrated, with themes and research topics covering areas of common ground. The generic skills of researching a topic, essay writing and use of evidence were emphasised in the curriculum documents, and students had to complete several written projects during the school year.

Teacher profile

The Social Studies teacher believed that the best reason for teaching students to think at higher levels was because it was required in the curriculum that students be exposed to these skills. She therefore planned her course to meet these requirements. In order to meet the stated aims of the curriculum, the teacher used debate, discussion and hypothesis testing to provide opportunities for higher level thinking. She considered

that the most important skills for students were synthesis, analysis and interpretation and these skills were, for her, the hallmarks of thinking.

She believed that teaching via telematics made it more difficult for her to achieve her objectives in terms of higher order thinking as it was difficult to see students' work immediately and give feedback. She also maintained that the best way to monitor the development of higher order thinking was through assessment of essay writing, extended answers and other products of students' efforts. She did not consider that thinking could be well assessed through verbal expression and talk.

She was interested in learning about strategies to teach students of high ability and in particular, strategies that would work in the telematics classroom.

Interpreting this teacher's responses through further questioning revealed that she did not see possibilities to develop thinking through oral and discursive practices in the classroom, and that she had quite a narrow view of higher order thinking and saw it as emerging only in the written products created by students. Nevertheless, she stated that she would like to hear about other teachers' views of how to foster thinking in the classroom, as this area of teaching was new to her.

Participation rates

For Social Studies Lessons 1 and 2 the participation rates in classroom talk are shown in Table 11.16. Both lessons were short as a result of delays in the initial stages connecting the computers, and lasted only thirty minutes.

The overall verbal participation rates for students in the lesson was 36%, reflecting the number of communication units contributed by all eight students who participated in the lesson. This is comparable to other lessons in Phase 1 and showed a disparity in the amount of student talk as compared with teacher talk that occurred in the lessons.

Table 11.16: Units, turns and teacher/student ratio of talk in Social Studies Lessons 1 & 2

Talk	Social Studies 1	Social Studies 2	Mean
Teacher turns	46	70	58
Student turns	53	69	61
Teacher units	108	155	131.5
Students units	60	81	70.5
Teacher Ratio	64%	66%	65%
Student Ratio	36%	34%	35%

Tasks and activities

The topic of Social Studies Lesson 1 was the construction of contour lines, and the teacher intended to do a cross section on a map. The students had been sent some preliminary reading about the subject, but this was a new subject for them. Most had difficulty with the concept, and throughout the lesson they struggled to understand why or how contour lines were put on maps. The teacher commenced the lesson by saying:

T:	We're looking at contour lines and your notes should explain some details.	**procedural**
	If you actually read through this you'll see that a contour line is very important, especially on a topographic map because they help us identify landforms.	**cognitive support**
S:	Teacher, it's Diana here. Most of us have read about two pages and well, none of use really understand it.	**feedback**

From the outset students expressed their lack of understanding regarding the concept of contour lines, and the teacher attempted to explain the idea to them. This took the form of lengthy explanations during which students simply looked at their maps and listened. They were not involved in any activity apart from listening during most of the lesson.

Most of the time in class was spent with further teacher explanations about contours, but the students were not participants to this, and the transcripts indicated that they were not given any role apart from listening, or responding to closed questions.

Social Studies Lesson 2 was dedicated to the construction of a graphic outline of culture. At the outset of the lesson the teacher said:

T:	I'd like you all to do a quick outline of culture showing what you mean by that term.	**management**

This activity initially gave students an opportunity to discuss and compare views, and the teacher encouraged them to do so. After a couple of minutes, students were asked for their ideas on culture and these were entered on a graphic outline. The teacher passed control of the computer screen to students and questioned them about their views. However, participation by the students was limited and the teacher and did not give them an opportunity to evaluate, plan or draw conclusions about the ideas that

were circulated. The routine task of filling up the graphic outline with ideas became the focus of attention. The activity led to a display of key words relating to culture, such as 'attitudes', 'values', 'religion ' clothing' and 'food', but there was no involvement by students in explaining and criticising the ideas that emerged, and so the quality of talk by students was largely expository and descriptive, with short answers given to teachers questions. Functional categories of talk are detailed in the next section.

Functional categories of talk

Figure 11.12 shows the pattern of talk and main categories for both teachers and students in Social Studies Lessons 1 and 2.

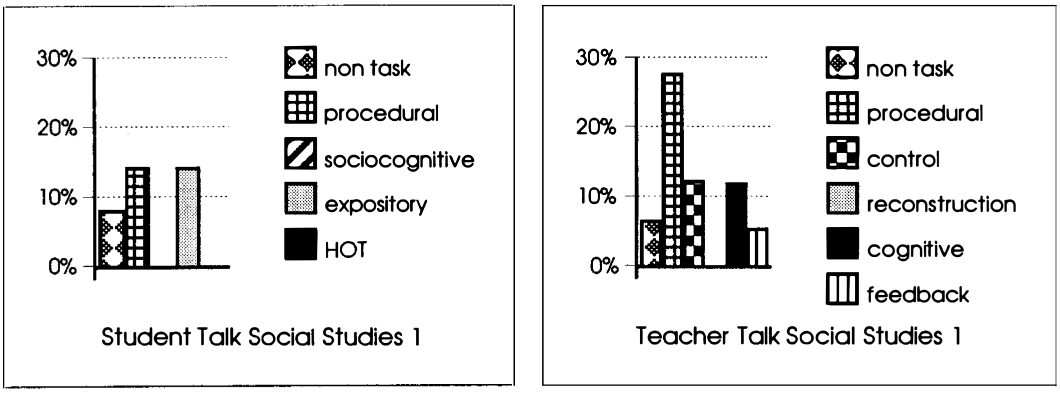


Fig. 11.12: Categories of student talk and teacher talk in Social Studies 1

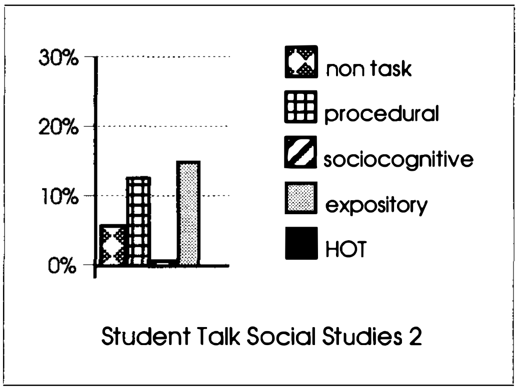
In Social Studies Lesson 1, the distribution of turns showed that teacher talk occupied 64% of the lesson, with students contributing the remainder. In terms of the quality of student talk, higher order thinking was not in evidence.

For students, procedural, expository and non-task talk consumed the bulk of the lesson, as they tried to grapple with new concepts on mapping contour lines and follow the teacher's instructions. Thirteen minutes of the lesson were spent trying to establish a connection between the computers, as the remote sites could not get a connection through the server. Despite the technical problems, the teacher continued with the lesson using the audio link and was not unduly perturbed by the inconvenience.

Of the remaining time, procedural and non-task talk accounted for approximately 35% of teacher talk, leaving only a small proportion of talk which could be devoted to helping students understand and apply new concepts. The small amount of

cognitively-oriented talk by the teacher was directed to explaining at length the concept of contour lines on maps, giving examples and questioning students. But the transcripts showed that this did not prove effective in scaffolding understanding, as the concept seemed far too difficult for students to grasp.

Social Studies Lesson 2 was concerned with the topic of culture. Students had to decide on a definition and then construct a graphic overview on the computer showing their ideas. The patterns of talk showed a strong similarity to the first lesson (Figure 11.13). Expository talk and procedural talk took up most of the students' contribution to the lesson, accounting for 73% of their talk. The only small change that occurred was that the category of socio-cognitive talk was in evidence, showing that students discussed ideas and collaborated on a few occasions during the lesson.



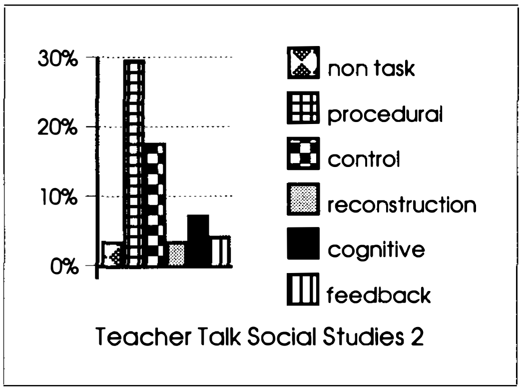


Figure 11.13: Categories of student talk and teacher talk as a percentage of total talk in Social Studies 2

Analysis of the talk that occurred in the lesson showed that teacher talk displayed a large proportion of procedural talk, which included talk about technology, allocation of turns and classroom management functions. Though the class commenced with the teacher promoting discussion among students, opportunities to contribute freely to the lesson and discuss issues was lost, as the teacher circumscribed student talk by directing, controlling, cuing and reformulating ideas that emerged. Only a small proportion of teacher talk offered cognitive support to students, or provided a stimulus for discussion.

Table 11.17: Percentages of student talk in Social Studies lessons of Phase 1

Lesson	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total%
S. Studies 1	23	38	0	39	0	100
S. Studies 2	17	37.5	2	43.5	0	100

Overall, student talk showed no evidence of higher order thinking, and the lessons showed a preponderance of expository talk and procedural talk (Table 11.17).

Teacher pedagogy

In both lessons, much of teacher talk could be described as 'content talk' as the orientation of the teacher was towards lengthy explanations and monitoring learners' contributions as opposed to scaffolding thinking by inviting discussion and exchange of ideas. Content talk was a sub-category of procedural talk, and the intention of this was merely to present the syllabus content efficiently rather than to assist students to think independently. Teacher pedagogy can be identified from the functional categories of teacher talk for Social Studies lessons as presented in Table 11.18.

Table 11.18: Percentages of teacher talk by category for Social Studies lessons in Phase 1

Lesson	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	Total %
S. Studies 1	10	44	19	0	19	8	100
S. Studies 2	6	45	27	5	11	6	100

The teacher also exerted a good deal of control over lesson development and student talk, with both lessons showing controlling discourse in the form of elicitation of responses and directives. Social Studies Lesson 1 did not manage to engage students in questioning or enable them to go beyond expository or short answers to the teacher's questions about how contour lines are used in mapping. Given that the topic of contour lines was new to the students, it had the potential to offer possibilities for students to inquire, investigate and wonder about this new concept. However, the exchanges that occurred had a didactic pattern with the teacher 'telling' rather than 'explaining' to students. Students found the concept of contour lines difficult to grasp and the teacher spent a long time talking about sea level and how to mark altitude on a map with dots. Finally, having explained as much as she considered necessary, the teacher asked:

T: Now turn to page 21. Are there any more questions about this, that you don't understand? **checking**

To which one student responded:

S: Teacher, this is Traits here. I don't understand what you were talking about right from the first. **feedback**

It appeared that very little of what the teacher had said was understood by the students, so in fact the teacher had not succeeded in scaffolding understanding. In Vygotskyan terms, the concept of contour lines was outside their zone of understanding. Much of the talk that had taken place was 'content talk', where the teacher talked *about* the subject, rather than assist the students to understand by engaging them in active discussion about the concept. This distinction is a crucial one to make, and it is one way in which the quality of teacher talk was judged as 'cognitive support' which scaffolded understanding, as opposed 'content talk' which was merely a teacher monologue about the topic.

In Social Studies Lesson 2, the teacher was intent upon filling in the graphic outline of culture and but instead of creating opportunities for students to give their views, she presented her own and told the students to copy them down. The following extract shows how the teacher controlled the topic by adding 'laws' to the graphic outline on culture, even though a the start of the lesson she had called for students to give their own ideas. She also cued them to write 'customs' into the outline.

T: Now if we go back to the diagram, there's another value that we can add in there.

If we go to the right we can add 'laws' - **control**

OK laws are identified by- laws are important cultural things.

So we mentioned language, dress, food, laws- what about customs? **control**

These extracts show that there was little inquiry, or reasons given for ideas proposed, and the lesson appeared to be limited by the directive approach taken by the teacher. In the following extract one student suggests that 'appearance' should be considered as part of the graphic outline of culture, but she is challenged by the teacher. The extract shows a directive teaching style, where the learner is asked to put 'religion and clothing' into the graphic outline on culture, with a minimum of explanation.

T: Are you going to write up appearance then? **elicit information**

S: yes **expository**

T: with regards to what then?

	Their appearance could mean anything, does that mean that all the ugly people belong to one culture?	**cognitive support**
S:	No, I mean like in some cultures where they are not allowed to show their hair and stuff (um) they have to like, cover it up	**expository**
T:	So what's that's got to do with it?	**checking**
S:	That's got to do with religion though.	**factual response**
T:	You'd better put religion up there.	**control**
	But its got to do with something else too.	**cuing**
S:	What they wear?	**factual question**
T:	Yes, what's that called?	**elicit information**
S:	clothing.	**factual response**
T:	Aha, yes wonderful.	**praise/**
	Write up clothing- appearance.	**control**

Here the teacher played a guessing game and brought the student around to thinking about clothing, rather than appearance as an indicator of culture. In the course of the conversation, the student was directed to put in two additional points, which were obviously part of the teacher's agenda, the topics of religion and clothing. Instead of arriving at these conclusions through presentation of student views and discussion, the teacher issued direct instructions to students in order to create an outline that corresponded with her own ideas. This was further evidence of a didactic mode of teaching, and could explain the total absence of higher order thinking in the Social Studies lessons.

Social conditions of learning

Much of the dialogue in the Social Studies lessons showed elements of control and a didactic approach to learning. The teacher quite clearly regarded the coverage of content as important, as this took precedence over discussion and exchange of ideas. In each lesson, very little time was spent orienting students to the tasks they were expected to undertake or the outcomes they were expected to achieve.

In Lesson 1, the learners were expected to understand and draw contour lines and cross sections on maps, but they failed to achieve this because they were unfamiliar with the concepts. As none of the students appeared to understand content of the lesson, there were no shared resources for students to call on, nor did the teacher encourage them to help each other.

In Lesson 2, they contributed ideas to a graphic organiser which the teacher had drawn up on the computer screen, but were not given opportunities to argue their own ideas or explain what culture meant to them. None of the ideas that emerged were the product of joint discussion by students, and no questioning of ideas took place. Individuals responded to questions, and if the teacher liked the answer, the word was put into the graphic outline. The only cognitive resources available to students were their own individual ideas, as no attempt was made by the teacher to get them to collaborate, share ideas or discuss and evaluate. Most of the ideas that emerged were the teacher's, the students were expected to accept and not question. The transcripts showed that the quality of their responses was minimal, and mostly expository in nature leading to a complete absence in HOT in the lessons. (See Table 11.17). On only one occasion did the teacher give an indication that she wanted students to discuss the ideas they had been working on with regard to culture.

T:	... and while you are talking among yourselves I want you to discuss in your group the idea of culture and tell me.	**cognitive**
	(Students write notes and talk among themselves. One minute passes.)	
T:	OK, have you got any ideas yet?	**elicit information**
S:	yes, we've got beliefs and lifestyles.	**factual response**

After a couple of minutes this social collaboration ended and students were called upon to propose ideas and type them on the computer screen. There was no suggestion by the teacher that students should justify or explain their proposals. Here, an opportunity for scaffolding thinking was lost. Consequently, the talk that resulted was mostly in the form of short answers.

During the lesson, the teacher gave no indication of the kinds of skills or concepts that were important, and she continued to question students and to elicit information which was put on the computer screen to represent the common knowledge of the group. Students were not free to question each other or to discuss their own ideas and reach a consensus. Individual ideas were taken on board and students were directed to add them to their graphic organiser uncritically.

In the following extract, the teacher solicited a response from a student and then required everybody else to copy it, without explaining why. Transmission of facts seemed to be valued rather than exploration of ideas.

T:	Well how about you Dana, can you add something?	**turn allocation**
S:	Dana has already done the last circle- she said speech *(referring to the computer graphic)*	**factual response**
T:	What was that?	**procedural**
S:	speech.	**factual response**
T:	OK, speech, everybody write speech.	**control: instruction**

Throughout these lesson, students appeared to be more focused on the teacher's instructions rather than on generating their own ideas on culture. The social context created by the instructional dialogue was not conducive to principled understandings or reflection by students. Neither was there a sense of collaboration in the classroom, or an atmosphere where students could help each other. Every contribution was filtered by the authoritative language of the teacher.

Use of computer technology

The were technical problems in both Social Studies lessons. In the first lesson, the modem link failed and there was no computer link between the teacher and the participating schools. Fifteen minutes of class time were lost in an attempt to make the connections but finally the lesson commenced. The first lesson proceeded using the audio link, and students made use of the materials and maps that the teacher had sent to them the previous week. Table 11.19 summarises the main aspects of computer technology use for Lessons 1 and 2 in Social Studies.

Table 11.19: Computer technology use in Social Studies Lessons 1 & 2

Computer Graphics	Lesson I	Lesson 2
No. of screens	-	1
Prepared by teacher	-	no
student activity	-	graphic outline
purpose of graphic	-	defining terms
locus of control	-	shared
interaction by student	-	yes
discussion by student	-	yes
adaptation by students	-	no
reflection by students	-	no

In Lesson 2, the link was successfully made and the teacher and students used the computer extensively throughout the lesson to display ideas in the form of a graphic outline on the topic of culture (Figure 11.14). The teacher created the structure and then gave control to the students from time to time so that they could put their ideas on the screen. In this way, students at one remote school could see and hear the ideas of other students and contribute to the discussion.

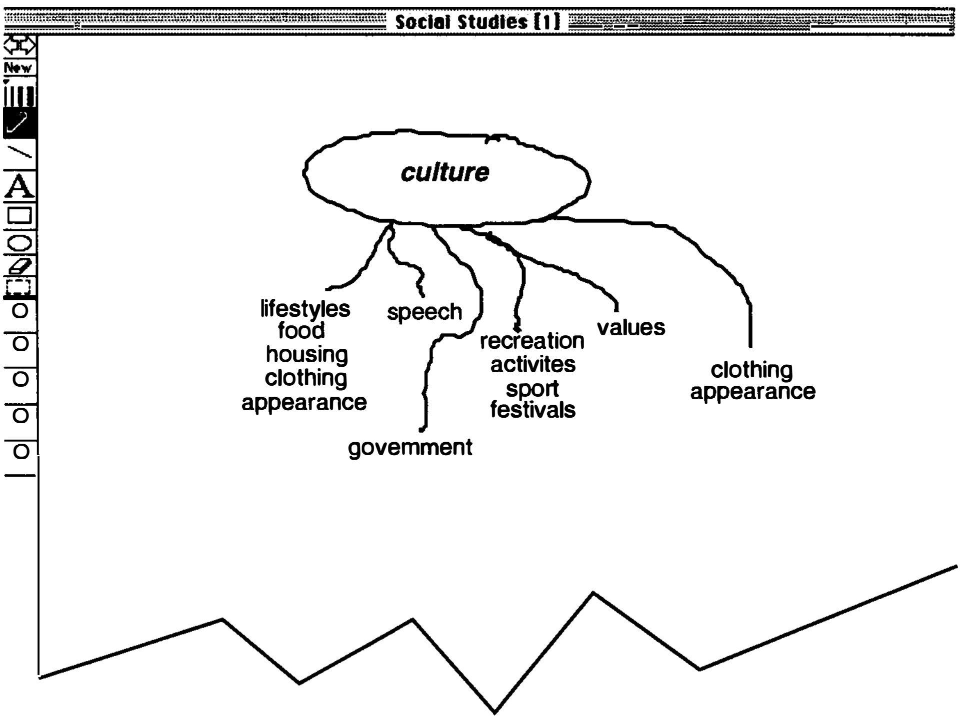


Fig. 11. 14: Computer visual for Social Studies Lesson 2

While the technology worked quite efficiently in conveying images and words, none of the interactions around the computer led to higher order thinking or language indicative of reasoning. The creation of a graphic outline on the topic of culture could have acted as a platform for further discussion, but this did not materialise as opportunities for discursive collaboration were not opened up for students. The focus on details and facts as opposed to discussion of ideas was attributed to the pedagogic style of the teacher, which was overly controlling and didactic.

The quality of the audio link was poor, and this interfered with the success of both lessons. Students at remote schools could not hear each other clearly and therefore could not converse or discuss ideas. In addition, there was also a good deal of interference and noise coming from one classroom and it was carried to the other remote school. From time to time the teacher was unable to hear what students were saying, and this slowed the lesson down and decreased interactivity.

Overall, technology problems in the Social Studies lessons limited the time that was spent on instructional talk and task related activities. The failure of the modem link in the first lesson led to repeated attempts by the teacher to establish a connection and wasted more time. In the second lesson, the computers were linked up, but the quality of talk did not show engagement in higher level thinking. The combined limitations of a teacher centred pedagogy and the authoritarian climate of the classroom served to restrict the learners' participation in meaningful and reflective dialogue.

Conclusion

Overall this teacher's approach could be summarised as 'See it my way', because the learners were not given opportunities to contribute in meaningful ways to the lesson, and the teacher's views were the ones that were voiced and proposed to the learners without much discussion. There was an absence of higher order thinking in both lessons, and when the transcripts were analysed and coded what emerged was a preponderance of procedural talk and expository indicating that the teacher did not have a clear focus on developing higher order thinking. In technology use, the didactic and controlling elements of the teacher's pedagogy were revealed, and students were not supported in any activities that could have enabled them to understand the subject matter.

The Italian classroom

Student and school profile

In the Italian program there were two participating schools. There were seven students in total in the class, with six at one site and one at another. The students had not studied Italian before, so this was their first exposure to the language. The equipment at the schools was the same as for other lessons, as the students taking Italian were also studying English and Social Studies. The 'telematics room', as it was called, was for the exclusive use of the students in the Academic Talent Program.

Students were very enthusiastic from the start about the prospect of studying a foreign language via telematics. Many of them invited their parents into the class to observe the lesson. Students studying Italian via telematics enjoyed a unique status in the school, as other students were studying whatever foreign language was offered by their own school. No textbooks were used for the course. Instead the teacher sent

materials by post to the students, and they had to complete homework assignments for each lesson.

Such was the enthusiasm for Italian, that the six students studying together took turns for a parent of each to attend the lesson. This was also partly out of a sense of duty to the school, which wanted students to be supervised during lessons. So in the classes that were observed in Phase 1, there was usually a parent present. The students sat around a large table on which the computer sat, and passed the keyboard around the table as the activities required.

Teacher profile

The Italian teacher was very enthusiastic about her subject, as this was the first time that Italian was offered via telematics in Western Australia. Previously, students studied either French or Japanese at their own school, depending on which language was offered.

The Italian teacher had a very positive outlook and was convinced from the outset that telematics would be an exceptionally good medium through which to teach the language. It required students to develop good listening skills and enabled verbal practice, both of which could be effectively fostered via telematics. With these optimistic views she approached the task of teaching Italian at a distance with confidence that higher order thinking could be supported.

When asked about the kinds of higher order thinking skills that her students needed to develop, she had well defined ideas. For her, higher order thinking in Italian would be manifested in students' ability to:

- use the language to express what they knew;
- apply the language known in different contexts;
- extend themselves by looking for rules in the language; and
- take risks and attempt more difficult tasks.

She believed that at the beginning, when learning Italian for the first time, students would have to work at low levels such as vocabulary acquisition and pronunciation practice, but achievement at higher levels would depend on their ability to listen attentively, extend themselves and practise skills learnt.

In order to assess whether students were acquiring higher level thinking objectives, she intended to emphasise these skills to students, monitor their progress and look at their

approaches to study and how they solved problems. She believed that higher order thinking would be manifested in students' approaches to study and their attitudes to tasks. For example, students who were unmotivated and dependent when learning a language seldom reached higher levels of cognition, as they remained reliant on the teacher. Nevertheless, she believed that it was her job to foster these skills and to encourage students to take them aboard as part of their study of Italian.

When asked about how higher order thinking could be fostered, she asked for examples of how to use telematics effectively to support and extend students' learning and thinking processes. She was concerned that her classes were quite short, and with only two forty five minute lessons and a lot of content to cover, she wanted to learn about strategies that might optimise opportunities for thinking.

Participation rates

Results of the analysis of turns and communication units in the Italian lessons is shown in Table 11.20. The overall participation rates showed a great disparity in the amount of talk contributed by teachers and students in the lessons. In Lesson 1, student talk was quite limited, as students had to listen quite a lot at the initial stage of the course in order to learn the sounds of the language. They contributed only 20% of the talk, and it was clear that their responses were short as the number of communication units (80) corresponded to the number of turns.

Table 11.20: Units, turns and teacher/student ratio of talk in Italian Lessons 1 & 2

Talk	Italian 1	Italian 2	Mean
Teacher turns*	39	78	58.5
Student turns	31	80	55.5
Teacher units	124	155	139.5
Students units	31	82	56.5
Teacher Ratio	80%	65%	72.5%
Student Ratio	20%	35%	27.5%

In Lesson 2, student participation increased to 35%, but the number of communication units per turn remained similar. Overall, the disproportionate amount of teacher talk was not surprising, given that the students were at the early stages of learning the language and needed a great deal of listening practice.

Tasks and activities

In Italian Lesson 1, it was observed that students first listened to new vocabulary items as the teacher read these from a computer visual, then wrote the words down and practised them orally. The vocabulary items were related to food and drink, and students took turns explaining and translating the words. Listening and oral practice were the main activities of the lesson. The activities were highly structured, as students were in the early stages of learning Italian and would have been unable to achieve a great deal without teacher support. These activities were mediated by the teacher's talk and directions and were forms of teacher scaffolding.

In Lesson 2, the students completed a worksheet that required them to ask and answer questions about where they were going (plans), how they would get there (transport) and what time they expected to leave and arrive. This task gave students an opportunity to initiate questions and make combinations of words that were meaningful to them. The activity was quite interactive, and students volunteered examples and practised using the computer screen to write their own suggestions.

In both lessons, there was high level of task engagement and students were interested and motivated by the tasks, and keen to practice oral skills. Evidence for this was found in the transcripts where students volunteered for turns, and responded enthusiastically to questions.

Functional categories of teacher and student talk

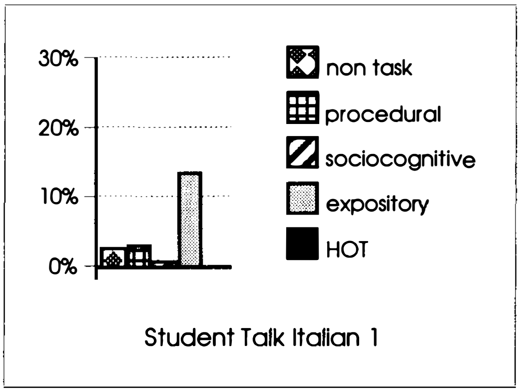
Observation of lessons did not commence until the end of the second term, when students had already become familiar with the technology and the teacher had developed greater confidence with the technology. In the first lesson observed, students were learning vocabulary items related to foods, and putting these into sentences such as:

Mi piace il pesce (I like fish), or
No mi piace il carne (I don't like meat).

The point of the exercise was to enable students to combine vocabulary items learnt with Italian expression for 'I like' or ' I don't like' in the grammatical form:

Mi piace, or *No mi piace*

Because the lesson had a great deal of modelling and explanation by the teacher, participation rates for students were low. Student talk accounted for only 30% of the total talk in the lesson. Analysis of the dialogue between teacher and students showed that in this lesson there were no exchanges that could be identified as higher order thinking (Figure 11.15). Student talk consisted mostly of expository talk with students repeating and practicing phrases in Italian.



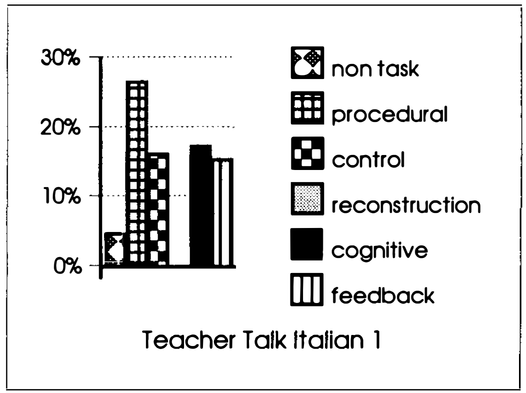


Figure 11.15: Categories of student talk and teacher talk in Italian 1

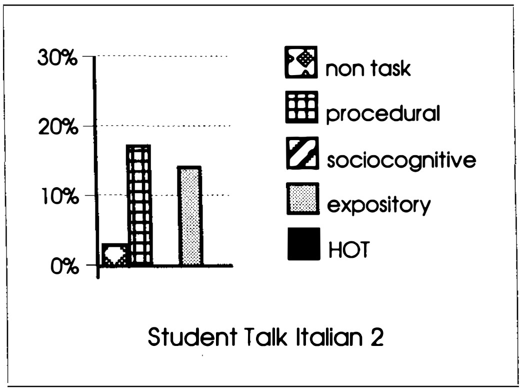
The teacher modelled and explained new vocabulary throughout the lesson, referring to the computer screen (Fig. 11. 17) as in the following example:

T:	OK the next one *cebolle*, is the word for onions- its plural. So you put *le* before that it that's *le* (spells word)	**explaining**
	Le cebolle	**modelling**
S:	*le cebolle*	**expository**
T:	OK the next one - *pizza*- what do you think comes before that?	**elicit information**
S:	*la? la pizza?*	**factual response**

In Lesson 2 (Fig. 11.16), the patterns of talk were somewhat similar, with the teacher explaining that the purpose of the lesson was to compose a set of questions and answers around the themes of travel, time and place. The screen illustrated phrases such as *Dove vai*? (Where are you going?*)* and *A che ora vai?* (What time are you going?)

A good deal of procedural talk occurred in this lesson due to:

- problems starting up the computers;
- checking homework assignments; and
- encouraging students to use the graphics tablet to display their work.



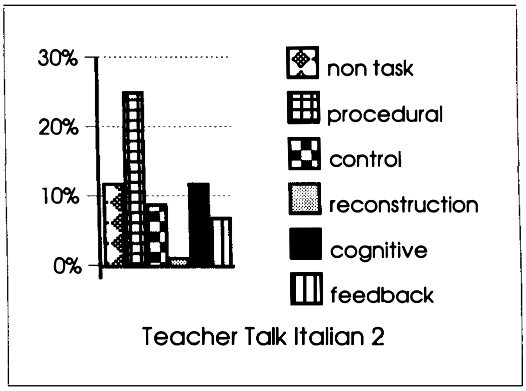


Fig. 11.16: Categories of student talk and teacher talk in Italian 2

The percentages of student talk categories in Italian Lesson 1 and Italian Lesson 2 are displayed in Table 11.21, and no higher order thinking was recorded in student talk. There was a great deal of expository talk in both lessons, showing that students were actively involved in language and vocabulary practice, and in responding to questions. On a few occasions, there was some discussion or sociocognitive talk among students (3%) when they were writing down new items of vocabulary and checking the meaning of these with each other.

Table 11.21: Percentages of student talk by category in Italian lessons of Phase 1

Lesson	non task talk %	procedural %	socio-cognitive %	expository %	HOT %	Total %
Italian 1	13	16	3	68	0	100
Italian 2	9	50	0	41	0	100

With regard to teacher talk, some of the cognitive support in these lessons came from teacher explaining content, concepts or skills, and the structured drill and practice activities showed that it was her intention was to increase students' vocabulary and basic knowledge of the language. However, this strategy often resulted in lengthy explanations by teachers and increased the imbalance of talk as students had to listen for extended periods of time. Nevertheless, the teacher attempted to integrate explanations with practice and students were invited to provide examples of grammatical points covered. This extract provides an illustration of a teacher explaining the grammar in Italian Lesson 2.

T:	The next word is peperoni, and peperoni is the word for capsicum- and in front of that you put 'i', just 'I' you say 'i peperoni' Good. Now bisteca ends in 'a'.	**explaining**
	What do we put there?	**elicit information**
S:	la- la bisteca	**response**
T:	la- exactly right, la bisteca.	**praise**

Though student talk showed no exchanges that could be described as higher order thinking, students were, throughout the lesson, engaged in intensive listening, practicing vocabulary and pronunciation skills.

Teacher pedagogy

As students were at an elementary stage in learning the language they did not have sufficient confidence to practice independently of the teacher, and so a structured learning environment was important to support their learning. This was provided by the teacher, who also allowed scope for students to put their new vocabulary to communicative use in dialogue with her. The percentage of control talk and procedural talk in Table 11.22 are indicative of this structural approach.

Table 11.22: Percentages of teacher talk by category for Italian lesson in phase 1

Lesson	non task %	procedural %	control %	reconstructio n%	cognitive %	feedback %	total %
Italian 1	6	33	20	0	22	19	100
Italian 2	6.5	32	16.5	3	29	13	100

One aspect of the teacher's approach that was striking was the amount of positive feedback and praise given to students who responded to questions or volunteered examples (Table 11.22). No corrective or negative feedback was given to students, and if a mispronunciation or error occurred, the teacher rephrased or repeated the word correctly in Italian, thereby modelling correct language use for students. The following extract provides an example.

T:	*la pizza.* OK the next one - *le lasagne*, I think I talked about this one before.	**modelling**
	Do your remember what it is?	**elicit information**

S:	yes lasagne- le lasagne	**response**
T:	All right, the next one, *mellanzane* has *il* in front of it too	**modelling**
S:	*il mellanzane,* what's that?	**question**
T:	*mellanzane,* that's the word for egg-plant or aubergine	**explaining**

The activities provided valuable listening and speaking practice for students, and were usually combined with visual reinforcement of vocabulary items on the computer screen.

Given the elementary level of the students, ie the fact that they were novices in the language, the teacher's supportive and structured style of teaching was appropriate and motivating for students.

Social conditions for learning

The Italian lessons were obviously a source of great enjoyment for students, and this was evident in viewing the video tapes of lessons. They always greeted the teacher cheerfully in Italian and each individual student responded to her question *Come vai? (How are you?)* and said *Good bye* to her in the target language. The students were unselfconscious in their use of the language and they put great effort in pronouncing the words correctly.

Several factors contributed to making the classroom conducive to interactive learning. Firstly, there were often parents in the classroom who had volunteered to be with the students during the lessons, and these parents were also interested in learning Italian expressions. Perhaps their presence motivated the students to work harder. In addition, students in the class helped each other considerably, although this interaction was not part of the formal lesson planned by the teacher. They explained vocabulary to each other and helped each other when they had turns writing examples of the computer screen. The teacher's warm, friendly and supportive style interaction was evidenced in her continual praise and support of all efforts made, and she always responded to students with *'Bravo'* or *Bravissima'* or *'fantastico'* (Great! Fantastic!). Feedback was never negative. This created a supportive and non evaluative atmosphere where through intensive listening and verbal practice and students learnt Italian.

Although there was no higher order thinking demonstrated in the Italian lessons of Phase 1, there were examples where students worked consistently to achieve a better

understanding of the task, and applied intensive listening skills. From time to time students demonstrated supportive behaviour, such as helping each other with vocabulary items, and this cooperation was encouraged by the teacher.

Use of computer technology

In both lessons, the technology was used to support the main teaching activities, but did not scaffold higher order thinking. Table 11. 23 displays the main aspects of technology use for Italian Lessons 1 and 2.

Table 11.23 : Computer technology use in Italian lessons 1 & 2

Computer Graphics	Lesson 1	Lesson 2
No. of screens	1	1
Prepared by teacher	yes	yes
student activity	write example of words learnt	improve vocabulary
purpose of graphic	display vocabulary	improve grammar
locus on control	teacher	teacher
interaction by students	yes	yes
discussion by students	no	no
adaptation by students	no	no
reflection	no	no

In Italian Lesson 1, the computer screen displayed the main vocabulary items so that students could both see the examples and then generate sentences from these examples. Later the screen was used interactively for students to put in the definite or indefinite article before words. The shared facility of the graphics tablet enabled students to generate their own examples of words learnt and to project these on to the computer screen. In the first lesson, the teacher used two visuals to show vocabulary items and to pose questions. An example is illustrated in Figure 11.17. Students then produced their own examples from the screen by combining different items of vocabulary.

Lesson 2 focused on the communicative functions of asking about destinations, time and plans. Students used their own notes to practise question and answer forms. In this lesson, students used the graphics tablet to generate their own examples of new structures learnt during the lesson. For example, students drew a clock and practised questions and answers relating to time.

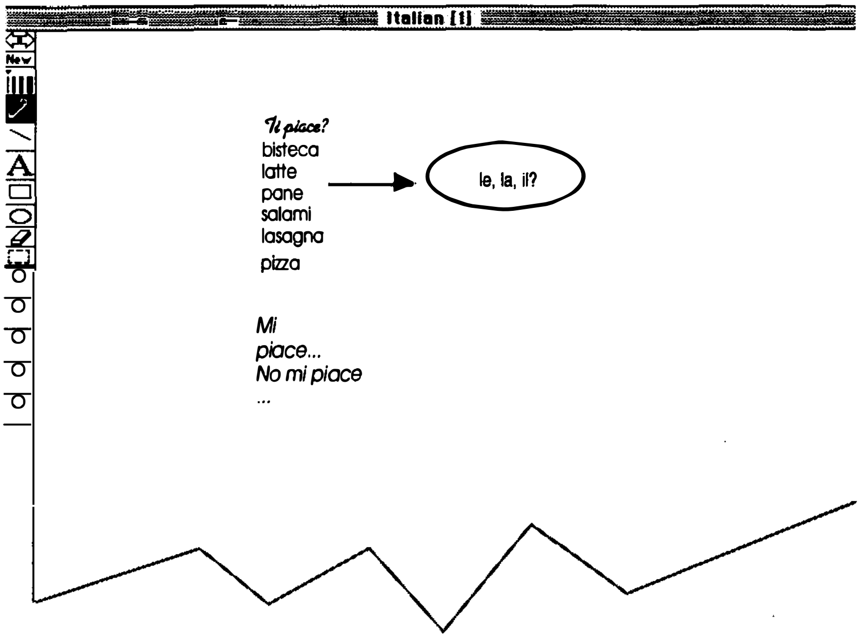


Figure 11.17: Computer visual for Italian 2

In both lessons, uses of the technology were interactive, and the teacher passed control of the technology to students where they could create their own questions and answers. The quality of sound in the second lesson was poor and there was a lot of static on the line, but the lesson proceeded successfully. Overall, the computer was used successfully to support interaction and involve students in active learning, but did not enable adaptation and reflection by students.

Conclusion

In the Italian lessons, there was no higher order thinking found in the transcripts of lessons, and analysis of the talk showed the main emphasis in lessons was the acquisition by students of vocabulary and basic communicative functions of the language. The teacher's pedagogic style could be summarised as 'listen, practise and learn' as these activities were part of her approach and were reinforced to students throughout the lesson. Computer technology was used as a visual display device to show vocabulary items, and encourage grammatical practice, but did not engage students in adaptation reflection on their own learning.

Overview and summary of findings from Phase 1

This section summarises the findings of Phase 1 and the responses to the research questions relating to the occurrence of higher order thinking and contributes to an

understanding of the social context of telematics classrooms through an investigation of:

- teacher beliefs about higher order thinking;
- participation rates in classroom talk;
- functional categories of classroom talk;
- teacher pedagogy;
- learner tasks and activities; and
- the use of computer technology.

The profiles of each classroom, ie Science, Maths, English, Social Studies and Italian provide an insight into the views of each teacher on HOT, the occurrence or non-occurrence of higher order thinking and the factors that contributed to this. The theoretical framework of socio-cultural theory required that the cluster of social and contextual influences be considered in relation to classroom learning and these were described in Figure 11.1 as teacher pedagogy, social conditions of learning, technology use, communicative patterns of talk and classroom tasks and activities. The social, interactive and communicative nature of learning was considered primary in responding to the research questions for Phase 1 of the study (See Table 10.3).

1. What were teachers perceptions of higher order thinking?
2. What pattern of teacher-student discourse was evident in lessons?
3. What evidence of higher level thinking was there?
4. What was the ratio of student talk to teacher talk?
5. How was the technology used to support HOT?

Each lesson was discussed in relation to the above influences and each displayed different circumstances and patterns of talk that would impact on the quality of student thinking. Nevertheless, there were some common points in participation rates, interaction patterns, teacher pedagogies and technology use. In the sections that follow the findings of Phase 1 are summarised so that each of the research questions is addressed.

Teacher views on higher order thinking

Observation of lessons and the low incidence of higher order thinking indicated that there was a lack of congruence between the teachers' professed views on higher order thinking and their classroom practice. All of the teachers interviewed had expressed the view that they wanted to achieve higher order thinking and many believed that

they might not achieve their goal of enabling students to investigate, probe new ideas or develop new pathways to express ideas.

This finding showed a gap between teacher practices and higher order thinking outcomes and underscores the fact that some teachers had well defined ideas about HOT which were not evident in their teaching. The disparity between teacher values and teacher practice was evident in several of the teachers interviewed, and while all valued higher order thinking, not all managed to put these ideals into operation into the classroom. Some teachers had a limited understanding of the term higher order thinking and were uncertain as to how it could be recognised and fostered.

The apparent gap between the stated views of teachers on higher order thinking and classroom practice is not surprising, as there is often a gap between theory and practice. Freeman (1996) has explored teacher views and claims that they are a reflection of the values teachers hold. As such they are representations of the ideals of the teaching profession rather than an indication of how teachers teach. To illustrate the point, the words of Hargreaves (1977) are cited:

> When teachers are asked to display their values (to researchers, parents, colleagues etc.) they doubtless feel constrained by that situation to express their ideals and to assert a strong degree of coherence, consistency, and integration among those values. Practice will not be a simple reflection of those values because practice arises in every different situation which has quite a different structure and set of constraints.
>
> (Hargreaves 1977, cited in Freeman (1997, p. 746).

The finding that teachers had unclear notions about what higher order thinking meant and how it could be realised in the classroom may have contributed to the low level of HOT in Phase 1 classrooms. This prompted the first intervention in the study, an attempt to bring teachers to a common understanding of the communicative, language based nature of thinking, and of their role in scaffolding the process.

Participation rates of students and teachers

Participation rates of teachers and students was measured in terms of communication rates and turns at talk, and this approach yielded quantitative data on the ratio of teacher talk and student talk in each lesson. As students' ability to display higher order thinking was observed through verbal and communicative reasoning, it was essential to establish how much they contributed to each lesson. A count of

communicative units and turns also gave some insight into the level of activity among students, and the roles and pedagogies of teachers.

Quantitative data on participation rates were used to support the qualitative analyses of interaction patterns and teacher pedagogies. The unit of analysis was the communication unit, which was a phrase or sentence expressing a single idea. This was preferable to using a turn at talk, because teacher turns were much longer that student turns, and therefore teachers talked for a greater proportion of the lesson than did students. Descriptive statistics were used to present the distribution of talk in the classroom and the findings were analysed to the discourse patterns for each classroom. The ratio of student to teacher talk was calculated for each class taught and percentages of talk recorded. There was a marked asymmetry in the proportion of talk by teachers in the lessons of Phase 1 (Figure 11.18).

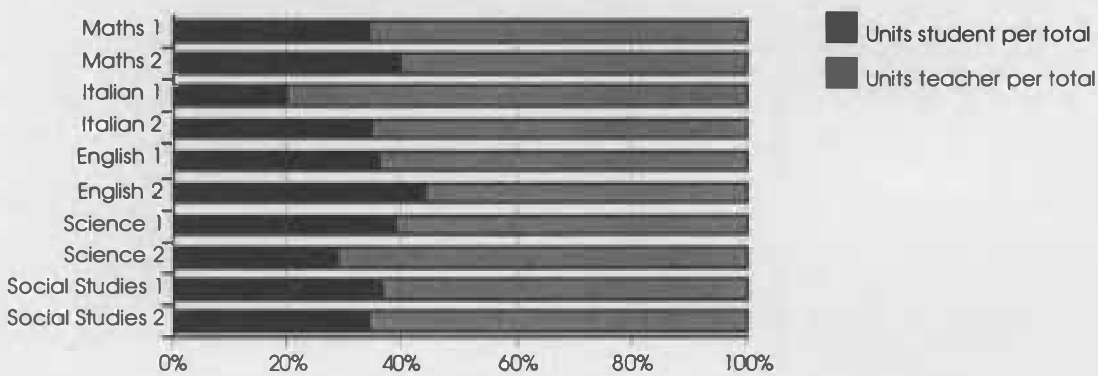


Figure 11.18: Participation rates of teachers and students in classroom talk

Figure 11.18 shows the percentage of communication units spoken by students and teachers in each of the lessons in Phase 1. The fact that there were unequal communicative rights is apparent, as student talk accounted for less than 50% of all of the lessons observed.

Patterns of teacher-student discourse

Figure 11.18 also indicates that teacher talk took up more than 60% of all talk that occurred in Phase 1, as measured in communication units. Relating this to the absence of HOT in most of the lessons, it could be concluded that students had limited opportunities to produce extended responses or to initiate talk. This limitation is confirmed by the overall patterns of interaction that emerged in the lessons, where

only teachers initiated while students responded. The three part exchange characterised all the lessons in Phase 1, with the teacher taking two turns to every student turn as follows:

T:	What's the Italian for steak Aaron?	**Initiation**
S:	bisteca	**Response**
T:	bravo,	**Feedback**
	and now Michael how do you say 'onions' in Italian?	**Turn allocation**

In Italian, teacher talk far exceeded student talk, possibly due to the fact that students were studying Italian for the first time and needed extensive listening practice. These results are not uncommon in classrooms, and a great deal of previous research has established that teachers talk for up to 60% of a lesson (Mehan, 1979; Edwards & Westgate, 1994). In telematics classrooms, the same phenomenon has been found to occur (Oliver & Reeves, 1994a). Microanalysis of each class provided the explanations for this imbalance of talk, and illustrated the constraints imposed on student dialogue by teacher pedagogy and a learning environment which did not support student initiative and higher order thinking.

Overview of teacher talk

Teacher talk was analysed in a manner which would enable the researcher to interpret the major functional categories of talk and also investigate the pedagogic strategies that teachers employed in the classroom. Analysis of each communication unit meant that particular strategies and teaching functions could be related to instances of higher order thinking and generalisations made across different classrooms. Through analysis of the functional categories in talk and a count of each category as a percentage of talk for each lesson, it was possible to display the overall results for each and gain a global impression of which functions were most common in teacher talk.

Across all lessons, results showed that non-task talk, procedural talk and control talk were used extensively by teachers. Table 11.24 shows the mean percentages for each category of teacher talk across all lessons in Phase 1. In most classes, as Table 11.24 shows, non-task, control and procedural talk accounted for over 60% of all talk. Translated into teaching practice, this meant that preparation for tasks, management and direction of student activity accounted for the overwhelming majority of teacher talk.

Table 11.24: Mean percentages of teacher talk by category in Phase 1 lessons

Lesson	non task%	procedural %	control %	reconstruction %	cognitive %	feedback %	Total%
Maths 1& 2	14	34	15.5	3.5	22	11	100
Italian 1& 2	6	32.5	18	1.5	26	16	100
English 1 & 2	12.5	25	30.5	3.5	18.5	10	100
Science 1 & 2	14.5	44	15.5	2.5	17	6.5	100
S. Studies 1& 2	8	44.5	23	2.5	15	7	100

Some of the non-task talk can be accounted for by the technical problems encountered during lessons, when modem links failed, or when audio quality was poor. Nevertheless all lessons had a proportion of cognitive support, where teachers assisted students with understanding concepts and with acquiring new skills, and the focus was on understanding. Within the category of cognitive support, most talk was related to explaining content to students, as opposed to asking reflective questions or promoting discussion and collaboration. Furthermore, most of this cognitive talk did not bring about higher order thinking in students, but resulted in expository talk, where students merely repeated drills or answered questions. The isolated occurrences of higher order thinking that occurred in Phase 1 were associated with direct cognitive support by teachers, which required students to explain or justify their answer.

Moving beyond these surface regularities to an interpretation of pedagogic practice was a necessary step which was carried out through a microanalysis of each lesson. The category of control was prevalent throughout lessons with teachers cuing responses, giving explicit directions and asking closed questions, to which students could only respond 'yes' or 'no'. Talk identified as control contained a cluster of teacher activities which constrained student activity. These were issuing rules and instructions, cuing responses, asking closed questions and eliciting information. These functions served to reinforce the authority figure of the teacher, and the procedural roles of turn allocation and management and pacing of the lesson reinforced this authoritarian role.

The dominance of these functions in Phase 1, across all lessons indicated that teachers either believed that this was the best way to achieve their objectives or that there were

constraints which led them to teach in this particular way. A further constraint might have been teachers' lack of clarity concerning HOT. In addition, problems with technology contributed to the amount of non-task talk that occurred during classes, but this was only one element in the complex issue of teacher practice in telematics classrooms.

Student talk and the absence of HOT

By looking at the overall patterns of student talk in relation to teacher talk, certain clear patterns of talk emerged which were investigated and related to teacher pedagogy. What was striking about the pattern of student talk (Figure 11.19) was the large proportion of talk taken up by non-task and procedural talk. This mirrored the patterns of talk by teachers (Table 11 24). Figure 11.19 shows the proportion of talk in each category for all lessons in Phase 1, and the low levels of HOT are apparent.

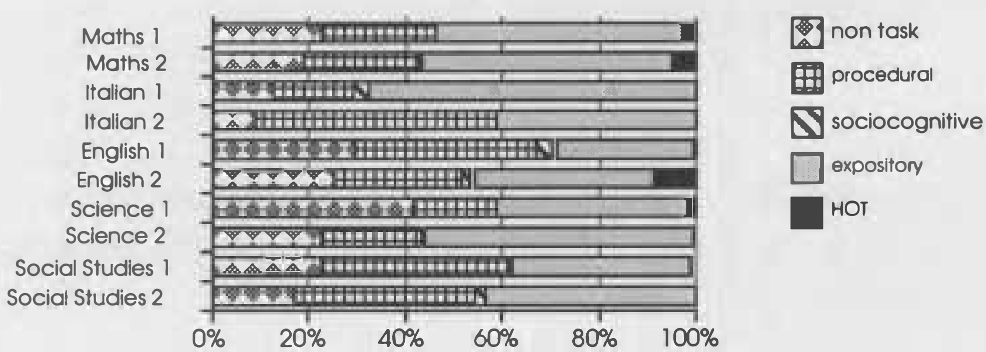


Figure 11.19: Categories of student talk for all Phase 1 lessons

The interdependency between the teacher talk and student talk is not surprising, as the dialogic form of conversation tied student responses closely to teacher initiated talk. When a teacher engaged in non-task talk, the student did likewise. When a teacher asked a closed question, the student gave an expository or yes/no answer. The low levels of talk indicating reasoning and higher order thinking was uniform across all classes, with the exception of Maths and English lessons where it accounted for 4% and 5% of student talk. The Science lessons also had a small proportion of HOT, but only 1.5%. To reinforce this point, the mean percentages of all categories of student talk are displayed in Table 11.25 with percentages of higher order thinking being noticeably lower than other categories of talk.

Table 11.25: Mean percentages of student talk in each lesson of Phase 1 by category

Lesson	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total %
Maths 1& 2	20.5	24	0	51.5	4	100
Italian 1& 2	11	33	1.5	54.5	0	100
English 1 & 2	27	33	2	33	5	100
Science 1 & 2	32	19.5	0	47	1.5	100
S. Studies 1& 2	20	38	1	41	0	100

Student talk, and in particular the question of what conditions and circumstances led to the occurrence of higher order thinking, was part of a wider explanatory purpose of the study, where several factors may have influenced the quality of talk. These included interaction patterns, teacher pedagogy, social environment, use of technology and teacher perceptions on higher order thinking. In these particular classrooms, higher order thinking was the expressly stated goal and curriculum outcome, and while there were some technical problems for teachers to overcome, the low levels of higher order thinking were a concern for the teachers in the study.

Overall, higher order thinking was almost absent from Phase 1 of the study, and this was attributed to a combination of factors, the most important being the quality of instructional dialogue and the controlling environment created by the teacher's pedagogy. In Maths and English lessons there were several instances of higher level thinking where students were called upon to justify their answers, provide an explanation or make a generalisation. These occurrences of HOT were isolated episodes, and were usually in response to a reflective question posed by the teacher.

Use of computer technology

In the telematics lessons of Phase 1, both audio and video technology were used with varying degrees of success by teachers and students. Almost all lessons observed had technical problems, the most common being delays in making a connection between modems while the other was the poor quality of sound on the telephone lines. Both problems caused delays and interruptions to lessons.

Computer technology use for Phase 1 was analysed along several dimensions, including number of screens, preparation by teacher, locus of control and purpose of the computer visual used and applied the four dimensions of Laurillard's (1995)

framework. Each visual was analysed in terms of whether it enabled the following functions:

- discussion on the subject matter;
- interaction between students and teacher where the ideas were discussed;
- adaptation by students of the information/concepts/ ideas presented; and
- reflection by students on the ideas represented.

Apart from these four categories which served to support the learning process, other uses of computer visuals, such as simply displaying facts, illustrating a point without discussion of the visual or other visuals which served to structure the class or present content, but did not engage the learners in any form of talk, discussion or negotiation were classified as 'other'. Each of the graphics was analysed and aggregated to provide a summary of the different uses of the computer in the learning process.

The analysis revealed several important issues concerning use of computers in telematics classrooms including adaptability and interactive quality of lessons, scope for discussion and reflection and locus of control. The results of the analysis are displayed in Figure 11.20, which provides the mean results of the analysis across both lessons.

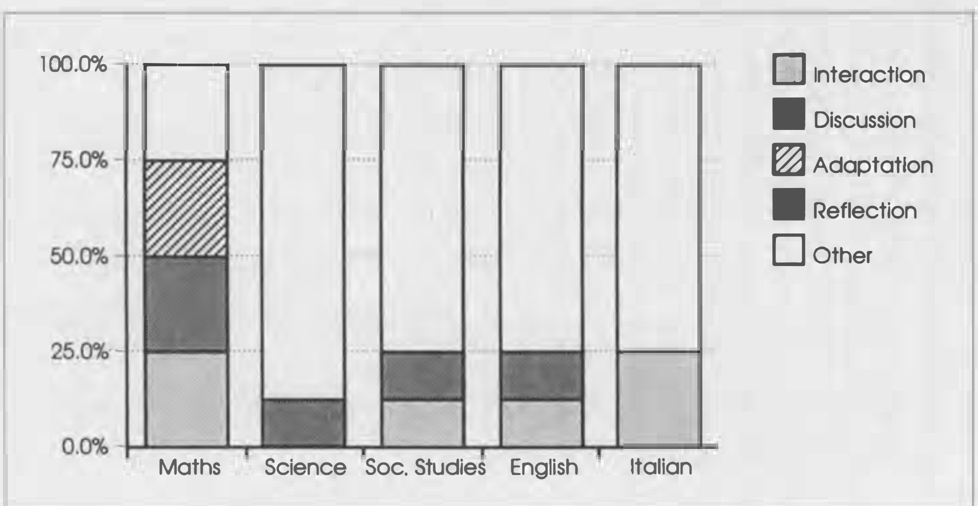


Figure 11.20: Computer technology use to support HOT in all classrooms of Phase 1

Overall, Phase 1 showed that teachers used the technology for various purposes and to varying levels of success. The Maths lessons showed that technology was used to support the interactive, discursive and adaptive aspects of a learning conversation, and both lessons had a small percentage of higher order thinking. The English lessons too displayed some higher order thinking, but in one lesson, no computer link up was

used and so Figure 11.20 shows that only interaction and discussion were supported. The Maths teacher alone used interactive screens where students could write ideas and activities, and display their own contribution to the lesson. Furthermore, control of the computer for those lessons was shared, and students therefore had more freedom to use the screen for their own purposes. However, the isolated occurrences of HOT in Phase 1 made it difficult to draw any definite conclusions concerning the role of the computer in supporting higher order thinking.

What is evident from Fig. 11.20 is that most uses of the technology were in the category 'other'. In most classrooms the purpose of the computer was to display or illustrate information or symbols, attract attention, and structure the lessons rather than engage students in reflective dialogue or construction of arguments. In Italian, this was the case for both lessons, and in Science likewise. While the Social Studies lessons did not have pre-prepared visuals, the students did not have opportunities to display their own ideas due to the controlling influence of the teacher. In all lessons, with the exception of the Maths lesson, there were no products of student thinking on the computer screen, or evidence of higher order thinking supported by computer use. Teachers used the computer largely to depict their own agenda for the lesson, which concurred with the controlling aspects of their pedagogies.

Conclusion

In Phase 1, the pattern of talk in many telematics lessons portrayed teachers as controlling and concerned with content matter rather than with student learning and understanding. The directive role was established and maintained through strict control of turns at talk, questions that served to elicit information, or elicitation of responses through cuing and prompting.

Relating these findings to the theoretical framework of the study provides important insights into the limitations of teacher pedagogy in Phase 1. Underlying Vygotsky's theory (Chapter 5) of social learning there are two major assumptions about the respective roles of the teacher and learners as they engage in dialogue. Firstly, the adult or teacher performs two roles simultaneously: modelling the problem solution or structuring the task and teaching the novice how to handle the problem. Secondly, as the learner needs to take on more of the teacher/adult role, rather than remaining dependent, the teacher must accommodate the growing competence of the learner, or as Wood (1996) states, make the instruction contingent on the amount of support required. The analysis of talk patterns in Phase 1 did not involve students fully in the

learning interaction as most of the communicative functions of talk served to control, direct and instruct students.

The asymmetric patterns of interaction and the controlling, directive discourse of the teacher talk did not create the supportive conditions for higher order thinking to take place in Phase 1 lessons. Opportunities at scaffolding thinking were lost, as teachers did not require students to elaborate or explain their answers or provide examples to support the ideas discussed. The pattern of talk, the activities conducted in the lessons and the lack of socio-cognitive resources such as collaborative talk, discussion and negotiation limited discourse patterns to a teacher initiated, three part exchange in all lessons. In these exchanges teachers initiated and students responded.

Teacher views on higher level thinking and how it could be achieved showed that some teachers had unclear perceptions of what higher level thinking involved and many were unsure of what to look for and how to support it in the classroom. This provided some insight into the pedagogies demonstrated by teachers in Phase 1 of the study. Teacher pedagogies can be characterised according to explicit aspects of their approaches, as Table 11.26 illustrates.

Table 11.26: Descriptors of teacher pedagogies in phase one lessons

Subject	Pedagogy	Implications
Science	'Get it right'	Emphasis on right-answerism.
Maths	'Say what you think'	Thinking processes are valued.
English	'Let's get some ideas together'	Students can have their say, but so can the teacher.
Social Studies	'See it my way'	The teacher's view is what matters.
Italian	'Listen and repeat'	Students learn through listening and practise.

Only the Mathematics teacher appeared to explicitly value thinking and made clear to students that she expected them not only to think, but also to talk about their thinking.

The practices can be interpreted from dialogue in the transcripts and showed that several teachers tended to emphasise content rather than process, and that students were often compelled to take the teacher's views on board as opposed to working out their own ideas.

The social aspects of Vygotskyan theory requires that we pay attention to learners' communication strategies, goals and social interaction, and how they relate to the

development of thinking. For Vygotsky, the source of individual motivation and achievement is located in socio-cultural practice. In the classroom, the special practices that learners engage in will define their roles, either as participants or observers, as active or passive in the negotiation and definition of knowledge. The structures that emerged in Phase 1 of the study showed for example that in these classrooms:

- learners did not ask questions;
- learners did not expand on, or modify their ideas in the light discussion with peers;
- learners listened to teachers, but did not engage in higher order thinking;
- learners did not justify their answers;
- the teacher defined the activity;
- there was no negotiation of task goals; and
- solving the problem appeared to be more important than thinking about it, or expressing views.

Teacher pedagogies were not supportive of active learner participation in knowledge construction, or in learner responsibility for task negotiation. Vygotskyan theory suggests that higher order thinking arises when learners are able to direct their own cognitive activity in a voluntary and self-conscious manner (Forman & McPhail, 1993). This can happen when there is handover of control to the learner (Edwards & Mercer, 1987) or when the learner begins to assume responsibility for task initiation, definition and execution. In these telematics classrooms, learners were not given an opportunity to pursue their own ideas about the task, or even to express their views on aspects of its execution.

Research has recognised that enabling learners to have 'a say', express their own ideas, or have a voice are more likely to lead to higher level cognitive outcomes than didactic and controlling pedagogies (Inagaki & Hatano, 1991; Mercer, 1995; Wells, 1993). Nevertheless, the influence of a supportive teacher who scaffolds tasks and learning opportunities has equally been recognised in the literature (Wood, 1996; Bliss et al, 1996; Cazden, 1988b). In the telematics classrooms of Phase 1, these pedagogic practices were not extensively demonstrated by the teachers, and consequently low levels of higher order thinking occurred.

Figure 11.21 summarises the constraints on HOT in Phase 1 of the study. It can be concluded that the combination of teacher beliefs and practices, together with contextual constraints contributed to the low occurrences of higher order thinking.

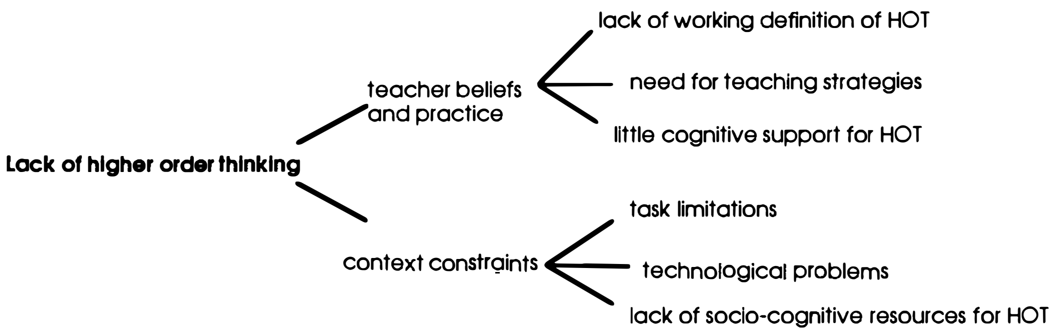


Figure 11.21: Constraints on higher order thinking in Phase 1

At the end of Phase 1, teachers were asked to what extent they had met their teaching objectives. They were unanimous in stating that:

- they had not met their teaching objectives in terms of HOT;
- the technology constrained and limited their teaching; and
- they needed clarification of how to teach for HOT in telematics environments.

Teachers were concerned about the low level of thinking demonstrated by students. When asked, teachers expressed a good deal of dissatisfaction with their teaching in Phase 1, and observed that the level of interaction and quality of thinking was poor.

These findings were carried forward to the planning of the first intervention, a workshop for teachers designed to orient them to pedagogies and classroom practices for higher order thinking.

CHAPTER 12

Planning for change: supporting HOT in the classroom

Introduction

In analysing the interactive patterns in the classrooms, two important methodological principles were recognised and maintained in all observations. Firstly, while classroom talk was analysed and found to reveal certain patterns, it was also recognised that the dialogue expressed communicative functions grounded in teachers' intentions. This meant recognising that classroom interaction "is composed of interrelated actions which are the product, not just of rule following, but also of decision making" (Hammersley, 1993, p. 100). Teachers were asked about their intentions for the lesson, and the outcomes they expected. Few had a clear idea of what thinking processes the lesson would develop (if any) and all teachers were unanimous in conveying their concerns, which were also perhaps constraints on their teaching approaches. In teaching via telematics, there were two combined pressures which teachers believed constrained their practice:

- the need to cover the syllabus content;
- technical problems and the belief that a successful lesson required utilisation of the computer technology.

These issues emerged when teachers were interviewed regarding their perceptions of higher level thinking and are reported in the teacher profiles in the Chapter 11.

If teachers decided to teach in order to cover syllabus content, rather than develop higher level thinking, then the focus of their attention would have been on content rather than process. Although teachers intended to foster higher order thinking processes, subsequent interviews showed that many had unclear ideas about what higher order thinking entailed. Therefore, in Phase 1, teachers were unable to put into action their intention to achieve higher order thinking. The rationale of the first intervention was to enable teachers to achieve the desired outcome by enabling them to develop teaching strategies to apply the operational definition of higher order thinking in their own classrooms.

Another important dimension to the analytic approach adopted was the recognition that classroom patterns of interaction were not fixed, but fluid. Research has shown

that although classroom interaction is heavily institutionalised, the patterns that occur may be expanded, modified or changed, according to teachers' intentions (Edwards & Westgate, 1994). Dialogue and discourse are part of classrooms, and are dynamic processes. Therefore, for teachers in the present study who wanted to bring about higher order thinking in their classrooms, it was essential to enable them to realise their intentions through appropriate pedagogy. The aim of the first intervention was to meet this objective and the first intervention was planned to achieve this.

The remainder of this chapter will report on :

- the aims of the first intervention to support higher order thinking;
- the orientation and pedagogical approaches discussed;
- the framework of planning for higher order thinking in the classroom; and
- practical strategies that were proposed to bring about higher order thinking.

The intervention took place after Phase 1 of the study, and at the commencement of the third term of teaching. The timing was considered to be of great importance to the study, as it was intended to help teachers to increase students' levels of HOT in the subsequent lessons.

Aims of intervention 1: Teacher development

Following the teacher interviews and the observations in Phase 1, the teachers were in agreement that they were not achieving the objectives of achieving higher order thinking in their classrooms. As reported in Chapter 11, all teachers perceived the need for this form of professional development. Specifically teachers wanted to clarify for themselves the meaning of the term higher order thinking. They also wanted to discuss and plan strategies that would be successful in telematics classrooms. Many of the teachers had viewed the videotapes of the lessons of Phase 1, and had expressed disappointment at the level of conversation and activity that took place during the lesson, and they also remarked that evidence of higher order thinking was exceedingly sparse. Some believed that this might have occurred because of the technical problems or the unfamiliarity of the students with the technology. Overall, all five teachers were unanimous in their belief that:

- enabling student thinking via telematics was a major concern;
- students had the capacity to think at higher levels; and
- teaching strategies were needed to implement and emphasise thinking.

On the basis of this feedback to the researcher, a four hour teacher development workshop was planned for teachers at the commencement of term three. The goal of the workshop was to:

- discuss with teachers with a common conceptual framework for an understanding of HOT;
- propose and elaborate on an operational definition for HOT;
- suggest strategies to support higher order thinking in telematics classrooms;
- provide an opportunity for teachers to plan how to develop HOT in their subject areas; and
- develop lesson plans to support higher order thinking.

The place of the first intervention is depicted in Figure 12.1, where it can be seen to precede observations at Phase 2, and to follow Phase 1 of the study. All stages of the research project are shown, and the workshop (interventions) can be seen to occur after the initial exploratory phase and before Phase 2 observations. By timing the workshop in this way, it was anticipated that the teaching that occurred in Phase 2 would be qualitatively different from that of Phase 1, with teachers implementing a range of teaching strategies to foster higher order thinking.

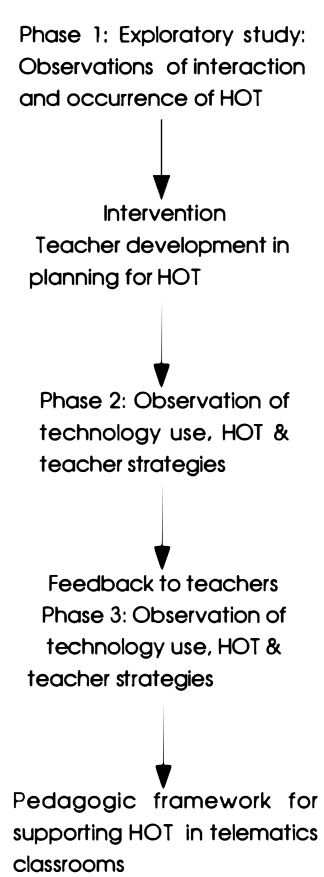


Figure 12.1: Stages in the formative experiment for supporting HOT

Each of the goals of the workshop were negotiated with teachers following a brief presentation of the theoretical and pedagogical rationale for higher order thinking skills. The workshop was planned so that teacher input was kept to a maximum, and therefore all the elements of the workshop were described as 'activities' with the workshop leaders taking a facilitative role. Each of the following sections describes the outcomes of the workshop.

Activity 1 : Understanding talk and learning

The aim of this activity was to initiate discussion on the link between talk and thinking so that teachers might begin to consider the communicative aspects of thinking and learning.

At the commencement of the workshop, after participants were given an overview of activities, the interrelationship of talk to learning was discussed as a warm-up activity. This theme was presented using an overhead projector and teachers were asked to discuss why talk was important in the classroom, particularly in relation to thinking skills. The researcher began by explaining the Vygotskyan concept that language and talk are inseparable, as social interaction creates opportunities for learners to think, and later they internalise expressions and ways of approaching problems and begin to think for themselves. Teachers agreed that thinking begins as social action but many of them saw thinking as in individual skill, and a solitary one at that. Discussion revolved around why thinking aloud, ie through talk, in the classroom was essential for teachers and for students. Teachers developed the following ideas linking talk, interaction and thinking:

- when we talk, we make visible our thoughts;
- when learners talk, it is a form of social interaction;
- when students explain and elaborate, they learn how to think;
- talk is a kind of action and verbalising action is essential to teaching;
- through observing students talk we learn more about how they think;
- communication between students helps learning;
- learners use their own language for thinking, and this is different from the teacher's;
- thinking clearly requires students to talk clearly; and
- thinking skills can be taught through action, and activities and talk.

The researcher summed up the discussion by affirming that talk was essential to teaching, learning and thinking and that through talk, learners increased their capacity to think and explore ideas. Talk also enabled the teacher to 'see' what students were thinking. In this activity, teachers began to consider how vital talk was in showing student thinking processes, and how opportunities for talk and discussion were also opportunities for students to think.

Activity 2: What is higher order thinking ?

This activity involved two related tasks. The first of these was called "Yesterday's and Tomorrow's Schools". Teachers were presented with two columns where views on expectations of students were mixed, and the task was to put the ideas into columns as they saw appropriate (Table 12.1). Discussion occurred in which the researcher participated. The outcome of the activity was that teachers agreed on the following conclusions:

Table 12.1: Yesterday's and tomorrow's schools

Schools of Yesterday	Schools of Tomorrow
Focus of development of basic skills	Focus on development of thinking skills
Students as individuals	Collaborative and cooperative learning
Elite students learn to think	All students learn to think
Hierarchically sequenced basics before higher order thinking	Higher order thinking permeates all subjects at all levels
Thinking taught as a separate subject	Thinking integrated across the curriculum
Supervision by teachers	Learner centred approaches valued

Following this activity, the teacher discussed the implications of the ideas for their own classes. The only question that was raised concerned the issue of how higher order thinking was recognised and how it differed from other forms of thinking. At this point the teachers were introduced to the operational definition of higher order thinking developed by the researcher. An overhead transparency was displayed which read:

> *Higher order thinking is not the transmission of any particular content of body of knowledge of skills, but the development in learners, through social contexts, of self-regulated reflective and critical inquiry that will enable them to exercise judgement, reasoning and problem solving skills and demonstrate as outcomes cognitive accountability in the form of hypotheses, conclusions, decisions and inferences based on sound evidence and sensitivity to context.*

The definition was explained with reference to the curriculum that the teachers were following as part of their teaching in the Academic Talent Program. By drawing parallels with the kinds of thinking outcomes required in the Curriculum Documents (EDWA, 1996), it became clear from the requirements that students needed to reflect, apply and analyse information, collaborate and integrate sources of knowledge, and that these competencies assumed high level communicative skills, reasoning and judgement. The difference between the operational definition and the curriculum statements was that the latter was more abstract and did not relate HOT to specific language skills and behaviour that could be fostered in the classrooms. Teachers found the operational definition to be more accessible and relevant to their everyday teaching.

Some discussion ensued about what the term 'higher order' meant in the classroom context, and teachers stated that knowledge or display of facts alone, would not be sufficient to qualify as HOT. One teacher suggested that it would involve students in 'going beyond superficial or rote learning, to interpreting information'. In a subsequent brainstorming task, teachers listed the following abilities as forms of thinking at a higher, reflective level (Figure 12.2).

evaluate ideas
hypothesise
interpret
analyse
relate & connect ideas
synthesise
reflect
create new ideas
question
summarise
justify
reason
predict
compare and contrast
being critical

Figure 12.2: Teacher views of higher order thinking

Subsequently, teachers were asked to reflect individually on the question: *Which of the skills listed are not applicable or not relevant in your own subject area?* All teachers agreed that the skills listed were generic thinking skills, common to all subject areas, but that they might occur in different contexts in each subject area. Several examples were offered by teachers.

The Mathematics teacher gave an example of how prediction was central to mathematical thinking, and linked to inference and rule generation. Prediction was important as it enabled students to extend their thinking and suggest whether mathematical rules could be applied to other cases or problems. The teacher of Italian said that prediction in language areas would allow students to test whether grammatical rules applied to different examples of language use. In English, prediction was a fundamental reading skill that enabled the reader to anticipate the meaning and content of text from textual cues and headings prior to actually engaging in the act of reading. Other examples were offered and discussed by the teachers.

Two unplanned events occurred as a result of the list of thinking skills being drawn up. While teachers were in strong agreement that these skills were important and indicative of deeper levels of thinking, they were unclear about how to achieve them. They asked two questions about reflection, as this was part of the operational definition:

What is reflection?
How can these skills be recognised in the classroom, in the products of students' work?

On the issue of reflection, teachers also had different ideas, and most of them believed that reflection was something that occurred after the event, and could not be observed or assessed in the classroom. In order to provoke thought and discussion on this question, the following question was asked:

If you want students to think about (reflect on) what and how they are learning, what do you do as a teacher?

Teachers spent some time talking together and then they offered a number of suggestions. To assist teachers to achieve focus and direction in their discussion, the stem *To assist students to reflect, teacher should...* was written on an overhead transparency, and teachers added a number of suggestions which were acceptable to all the teachers present (Figure 12.23). They agreed that reflection was important to all tasks and that it was often overlooked in the classroom, because teachers only expected to see evidence for it in the written products of students' work. In the course of a lesson, they believed that it might be difficult to ascertain whether students were

reflecting, but they were in agreement that if the conditions were right, and students were engaged in an appropriate activity, then reflection would occur.

To assist students to reflect, teachers should:

- ask students what they think;
- give students scope to express personal experiences;
- invite reflections at the end of an activity;
- give students tasks that help them reflect;
- show how reflection can help to solve a problem (in mathematics)
- encourage students to evaluate others;
- foster self criticism in the classroom.

Figure 12.3: How teachers saw themselves assisting reflection

When asked to provide examples of reflective activity or talk that they had observed learners display, the English teacher replied:

When a student begins with "I think" then I know that what they are about to say is either an opinion or a reflection, or maybe both.

The Maths teacher added:

I usually ask students what they are thinking about and how they arrived at solutions, so this pushes the student to reflect on what exact thought processes were going on while they were solving the problem. For some students, this is demanding, as they are not aware of what or how they are thinking.

Other comments on the question of reflection was how to plan for this in the course of a telematics lesson, where time was scarce and a lot of content was to be covered. It was suggested that it was best to embed opportunities for reflection in the tasks set for students, in assessment techniques and in ways of talking to students, so that they learnt how to reflect and express their own thoughts. Another suggestion was to make students aware of their own thinking and alert to the expectation that in the telematics classroom they were expected to think and not just remember facts. Some teachers had already received an induction into developing thinking across the curriculum through the literacy *Stepping Out* (EDWA 1994) program, and were familiar with tasks which

required students to reflect on the kinds of thinking skills they engaged in during class. This was regarded as a good starting point by the teachers, and as an encouragement to students to develop awareness and metacognitive skills. An adapted version of the self-assessment reflection task was used at the commencement of Phase 3.

The outcome of the second activity was that teachers refined their ideas on higher order thinking and its relevance to their own subject areas. They also considered the notion of reflection and how it was integrated into thinking.

Activity 3: Supporting HOT through teaching

Assisting teachers to develop strategies to support and foster higher order thinking in students was one of the most important objectives of the workshop, as this was the goal that teachers believed would give them most support in their own classrooms.

Once the operational definition of thinking was discussed and teachers perceived the link to language and communication, they were able to generate more ideas and step outside their own experiences to venture ideas on how HOT could be promoted. An initial brainstorming activity took place in which teachers offered and elaborated on approaches that they would recommend. Some of these were:

- getting students to talk about their ideas;
- making students aware of what was expected of them;
- changing the focus from learning content to displaying understanding of content; and
- setting challenging tasks.

While teachers were in agreement that fostering thinking in telematics classrooms meant demanding more of students, they were asked to nominate specific pedagogies that would create conditions appropriate for thinking skills. Only very general suggestions ensued such as to:

- set problem solving tasks;
- enable students to collaborate; and
- assess thinking skills, not content.

Many of the teachers believed that student-centred approaches such as collaborative learning were feasible in the face-to-face classroom, but were not realistic in the telematics classroom. When asked about this they mentioned a number of constraints:

- lack of time;
- the need to ensure that students were on task;
- the need to maintain a rapport with students;
- as students were unsupervised at the remote site they could not be expected to engage solely in collaborative learning; and
- teacher input and direction were needed so that students could do their independent study tasks more easily.

Class time in the telematics classrooms was valued by teachers, particularly as distance students received only 50% of the contact time given to face to face students. For the remaining 50% of time, students had to study independently on tasks and written assignments. Because of this teachers wanted to make maximum use of their class time and they also wanted to maintain a high level of interaction with their students. Student-centred teaching required high levels of organisation and a teacher presence in the classroom, where students could be observed and that this was more difficult to achieve when teachers and students were separated by several hundred kilometres.

What was required was a form of pedagogy where teachers could adapt a central and supportive role in students' learning, and at the same time develop in students higher order thinking, independence and responsibility. At this point in the discussion, the researcher proposed the concept of the teacher scaffolding students' understandings, "challenging the learners to go beyond their current thinking, continually increasing their capacities" (Bradley, 1996, vi). It was agreed that successful scaffolding was not only giving students the kind of help they needed, when they needed it, but also giving the kind of help that enabled them to achieve independent mastery. To be effective, scaffolding had to promote learner self sufficiency, rather than greater dependence on the teacher.

Through discussion with teachers, a number of scaffolding roles were suggested and described. These were informed by the researcher's theoretical perspectives and by the observations made in Phase 1 of the study. In the initial stages of teaching (Chapter 11) it was observed that teachers relied on one form of cognitive support ie, extensive explanation of concepts or questioning students. It was explained that few scaffolding episodes were observed in Phase 1, as teachers did not orient the students towards the achievement of independent thinking. Instead, the support offered was likely to increase the reliance on teachers, as opposed to leading to self-regulation by students. It was explained that to qualify as scaffolding, the assistance offered by the teacher had to extend over one or more exchanges and show that :

- structure and definition were being provided for the task (as opposed to spoon feeding information or 'telling');
- the learner was being helped towards independent performance; *and*
- learners were active in discussing, resolving and accomplishing the task.

Having explained and discussed the nature of scaffolding, teachers were asked to nominate ways that they could effectively scaffold thinking and reasoning for their students. The following suggestions emerged from group discussion, with some input by the researcher:

- task induction, such as making intentions and thinking objectives clear to students;
- ensuring that students keep a sense of the whole task and the goal;
- providing verbal demonstrations of the problem ie modelling the thinking process;
- developing in students the capacity to accept increasingly more responsibility for their own learning.

To assist teachers further, reference was made to one of the resources used in Western Australian schools. This was a collection of teacher strategies that were recognised as representative of best teaching and learning practices, *Stepping Out: Literacy and Learning Strategies* (Bradley, 1996). Teachers had heard of the publication, but few had put into practice the teaching strategies suggested. In fact, the elements of scaffolding described above as task induction, task orientation, goal direction, modelling and learner responsibility were some of the key principles of teaching and learning advocated, and were consistent with approaches being advocated for secondary teachers in Western Australia.

As teachers were unfamiliar with putting into operation some of the teaching strategies proposed, the presenter demonstrated how to model the thinking involved in a problem solving task, by articulating aloud the actual thinking processes. The emphasis on *modelling* and *coaching* of skills for students was a strategy that many teachers had not used before. Observing the modelling of thinking gave teachers an opportunity to see the knowledge, skills and values in operation by another person. Another strategy that was demonstrated was metacognition and reflection. The presenter demonstrated how to make explicit the thinking processes involved in a task, that of writing a coherent paragraph.

The presenter commenced by saying *When I write a paragraph I think about how to communicate a single idea in the clearest possible way.. Then I go on to next stage where I plan a topic sentence to convey to the reader what the paragraph is all about.*

The emphasis on thinking *through* the problem and verbalising the actual processes was unfamiliar to most of the teachers, but they agreed to try it as a strategy which would foster higher level thinking. Teachers were given an opportunity to practise this skill in pairs, and they agreed that it was not always spontaneous, and required considerable thought.

In addition to modelling coaching and metacognition, discussion took place about the other aspects of creating an environment where thinking could flourish. The two further dimensions of a pedagogy designed to support HOT were *context* and *guided support*. In telematics contexts, where students are distributed over a wide geographic area, the context of learning is not only the physical setting and the technology, but also the expectation conveyed by the teacher. In order to support thinking, the learning environment should not be technology driven, but be a communicative experience for teachers and students, with the participatory rights of students acknowledged and valued. In terms of technology use, the teachers were encouraged to think in terms of activities that would actively engage the learners instead of just displaying content and facts. Teachers spoke of the need to use the technology to support or scaffold learners and give them 'ownership of the lesson', by allowing them control of the technology and scope to show what they understood about the concepts in the lessons.

Teacher were encouraged to think about how learning occurs in the **context of guidance** by another person, be it a teacher, parent or more competent peer. All the teachers felt comfortable with the notion of guided participation, as it confirmed their own role in the learning process.

Increasing participation by students

Teachers were challenged by the notion of how to enable students to participate even when the subject matter was new, or unfamiliar. Some teachers believed that with unfamiliar materials and concepts, students would need to listen, observe and question the teacher rather than engage in dialogue. The degree to which students could be given participatory rights when they were encountering new material was debated. As a way out of the difficulty, the mathematics teacher suggested drawing on students' existing knowledge, and facilitating questioning by students themselves as a means of bridging the gap between old concepts and new concepts. Other suggestions were that students be given opportunities to question and that teachers provide a stimulus and evoke interest in progressing to new skills, by providing guidance to students. For the teachers, this meant reassessing the participatory rights of students' in the classroom. Most acknowledged that too much teacher talk sometimes occurred, and that not

enough was demanded of students. To create a sense of participation in the classroom, students and teachers have to act together to create a thinking environment. The teachers suggested that this meant:

- a non evaluative learning environment;
- encouragement of risk taking; and
- an atmosphere of trust.

Elaborating on teacher input, the researcher emphasised the quality of social interaction that would foster intellectual collaboration among students, such as sharing ideas, and promoting discussion and give and take of ideas. Teachers agreed that this would mean a change in methodology from direct teaching of concepts, to facilitating discussion and dialogue among students, giving them the 'intellectual space' to speak their own ideas, to admit to gaps in their own knowledge and to look for support and cooperation in dealing with the task.

In the discussion on supporting higher order thinking, teachers agreed that the goal of *independent reflective thought* should be made explicit. Teachers would have to make their intentions clear to students, through explicit statement of lesson objectives and tasks that the product (answer or solution) was secondary to the *thinking through* and *justifying of ideas.*

Two immediate barriers to implementing this pedagogy were the durability of teachers' own roles and their students' expectation about their roles as learners. Teachers were aware that these patterns would have to change, perhaps gradually, over a series of lessons until students were convinced that the communicative processes they engaged in would be valued above individual display of an end product, or a correct answer.

In conjunction with a change of emphasis in the classroom towards independent reflective thought, the question of how to set up these expectations was raised. Practical strategies were needed by teachers if they were to convince students that dialogue and thinking were valued. In telematics classrooms, all the teachers had established procedures and protocols to enable students to participate in the lesson. This was necessary in order to avoid simultaneous speech, or students not responding at all. Usually, teachers allocated turns at speaking by addressing individual students, and speakers would usually identify themselves before they commenced speaking. It was observed that in Phase 1, only a few students initiated questions, comments or made any contribution to the lesson unless spoken to by the teacher. This left the teacher in full control, and as teachers agreed, contributed to teacher-centred

pedagogy. Teachers wanted to break down this pattern and to open up opportunities for students to contribute more freely to lessons. This would involve creating certain understandings with students so that students engaged in higher order thinking. The pedagogic approach adopted was to create conditions for *cognitive accountability*, or reasoning. Teachers would encourage students to consider other views by:

- listening to others, and considering different ideas;
- giving everybody an opportunity to say what they think; and
- justifying what was said ie., giving reasons or evidence for ideas.

By making these expectations explicit, students would have a greater sense of what was expected, and thinking would no longer be the hidden agenda of the classroom, but become the main concern. Some of the teachers believed that this process could only be achieved gradually, and over the duration of a term, but all accepted that it was a strategy that would help to foster HOT in the telematics classroom.

At the conclusion of the discussion on how to support thinking, a diagram (Figure 12.4) was created and displayed for the teachers.

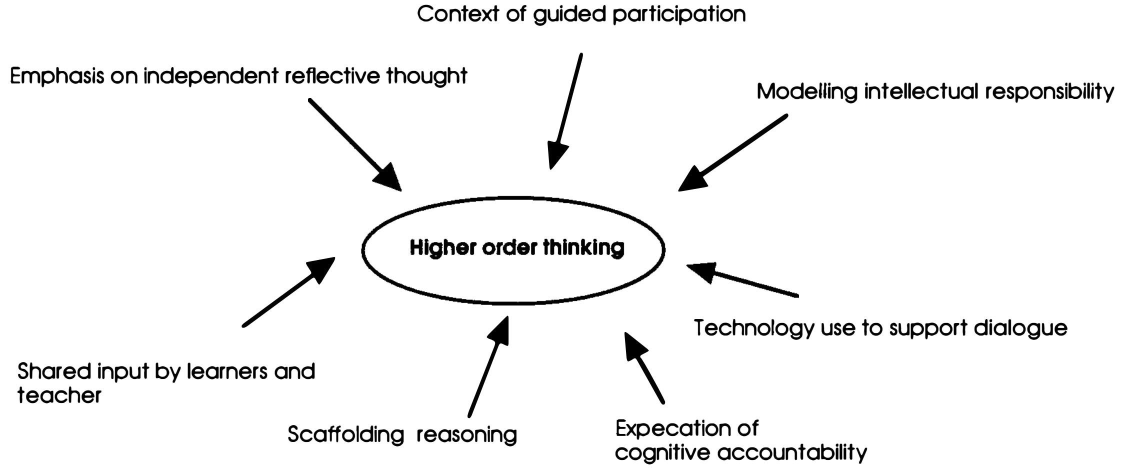


Figure 12.4: Pedagogic strategies for supporting HOT

Figure 12. 14 was a summary of the pedagogical strategies that had been proposed, depicting the strategies that teachers accepted as relevant to creating supportive environments for HOT in telematics classrooms:

- shared input by teachers and learners, rather than didactic teaching;
- an environment where cognitive accountability was valued;
- awareness of language use as part of the socialisation into practices of communities of mathematicians, scientists etc.

- scaffolded reasoning though tasks and interactive use of technologies.
- guided participation by the teacher; and
- modelling of intellectual responsibility by teachers.

Activity 4: Lesson planning for HOT

Having discussed a definition of HOT, together with teaching strategies and the elements of a supportive environment for the emergence of thinking, the next stage was to involve teachers in planning for thinking in their own classrooms. As all of the teachers had several years experience of teaching, none of them were in the habit of writing detailed lesson plans. Instead they made brief outlines of their objectives and the content to be covered, together with activities to achieve these.

Teachers were asked to consider whether planning for HOT in the classroom might be a productive and useful activity, as a way of assessing whether thinking objectives were being pursued. Having discussed the question they concluded that planning would be useful, at least at the initial stages to help them clarify what they wanted to achieve. A lesson planning outline was then presented to teachers and they were asked to comment on its suitability for telematics environments. The outline was short, and focussed on main parts of the lesson ie; thinking processes to be promoted, outcomes of the lesson, steps involved in achieving these outcomes and the higher order thinking outcomes that the lesson would promote. The lesson planning sheet is illustrated in Fig. 12.5.

The lesson outline plan appealed to teachers because of:

a) its simplicity;
b) the ease with which it could be completed; and
c) its usefulness in terms keeping a record of lessons.

The researcher at this point also suggested that it would be interesting for teachers to see the videos and transcripts of lessons (if they wished) and to discuss with the researcher the degree to which objectives for HOT were met in the lessons planned. It was agreed that this kind of feedback would be useful to further planning.

At this point in the workshop, teachers worked individually to draw up a sample lesson plan for their subject area. These were subsequently discussed and compared. Teachers found that the planning for HOT was no more than they would normally do, but up until now that had not been focusing on HOT as an outcome.

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

____

____

2. Outcomes of the lesson

____

____

3. Steps involved in the lesson

____

____

4. List the HOT you expect your students will display.

____

____

Fig. 12.5: Lesson planning sheet for telematics lessons

After this activity, the workshop concluded. Teachers were asked to complete an evaluation form asking them to rate the usefulness of the session to their teaching. There was lot of positive feedback given, and the comments most frequently made were that the workshop had helped teachers to:

- develop an understanding of HOT;
- relate language use and HOT;
- recognise HOT in classroom language;
- plan for HOT; and
- utilise a range of strategies to support HOT.

Conclusion

Offering professional development to the teachers was an essential part of intervening in the learning environment in order to bring about teaching and learning conditions where HOT could be supported and encouraged by teachers in their own classrooms.

It was also the first stage in the research partnership, where teachers and researcher collaborated in discussion and planning for change.

Although the workshop lasted only half a day, (4 hours) a great deal of discussion, planning and exchange of ideas occurred among the teachers about their difficulties, strategies and successes. They merged with a clearer notion of higher order thinking, and a revised view of how language and dialogue could support HOT. There was nevertheless some apprehension among the teachers that they might not achieve the outcomes they would plan for during the subsequent term. The researcher emphasised that achieving a social context conducive to HOT in the classroom was essential and that renegotiating social conditions would also support HOT.

All teachers had agreed to use the Lesson Planning Sheet for lessons, and so during Phase 2, lessons plans would provide insight into what teachers had intended to achieve in their lessons. With these new understandings between the researcher and teachers observations for Phase 2 commenced in September 1996.

Two final points about the intervention are related to methodology. First, the workshop with teachers was very much in the nature of a research partnership, an opportunity to enable better understanding and to work towards a common goal. While some of the teachers were unclear initially as to what higher order thinking involved in telematics classrooms, they left with a much stronger sense of the communicative, language-based experience of learning in telematics classrooms. These understandings emerged through discussion, talk, and exchange of ideas. The operational definition of higher order thinking was in accord with the curriculum outcome statements, and consistent with their own expectations of what students could and should achieve in each of the subject areas.

Overall, the first intervention established not only the collaboration between the researcher and teachers, but it also initiated the formative experiment. In the first intervention, the pedagogic goal of achieving higher order thinking in the telematics classrooms of the study was conceived as a progressive change in pedagogy, teacher roles and student talk.

Chapter 13 describes Phase 2 of the study, where teachers applied what they had learnt in the classroom and worked towards achieving higher order thinking in their classrooms. The chapter provides an in depth analysis in changes that occurred in student participation, teacher talk and student talk.

CHAPTER 13

Results Phase 2: Observing changes in interaction and thinking

Introduction

In this chapter the results of the Phase 2 observations of classrooms are presented and analysed. Phase 2 of the study commenced in the second semester of the school term, immediately following the intervention to assist teachers in fostering higher order thinking in students. Two lessons were observed and video taped for each subject, and these recordings occurred in two consecutive weeks, so that lessons would show continuity. Lessons in each subject were numbered 3 and 4, in each of the subject areas Mathematics, Science, English, Italian and Social Studies. As with Phase 1 of the study, teachers were asked not to prepare a special lesson, but all the teachers agreed to use the lesson planning sheets for six weeks of the semester.

The researcher attended one teaching session at the point of delivery, that is with the teacher, and observed the lesson without participating. The other lesson was observed at the students' school. Teachers felt comfortable with this arrangement, and it gave the researcher an opportunity to observe both the teacher and the students. At the outset of Phase 2 there were two major differences noted in teachers' approaches to the telematics lessons:

(i) each lesson was planned to include higher level thinking, and teachers had prepared lesson plans for each class; and
(ii) each lesson had HOT as an explicit outcome, and strategies were specified by teachers about how to achieve this outcome.

These aspects of teachers' pedagogy were absent from Phase 1 of the study, and it was anticipated that there would be some observable differences in the quality of talk in the classrooms following the intervention, as each teacher had a clearer conception of what higher order thinking involved and how it could be realised and supported.

The research questions for Phase 2 of the study were designed to assess the impact of the intervention and the emphasis was on monitoring changes in both learners and teachers, and in particular to assess the extent to which higher order thinking was evident in the classrooms. The research aim focused on whether the intervention was

successful in bringing about a change in the social and cognitive environment of the classroom and whether higher order thinking was in evidence. For Phase 2 the research questions were as follows:

1. How did the ratio of student talk to teacher talk change?

2. What changes occurred in the major functional categories of teacher and student talk?

3. What evidence was there of changes in the level of higher order thinking among students?

4. What changes occurred in teacher pedagogies?

5. What changes occurred in the technology use to support higher order thinking?

The chapter is set out with each of the five telematics classrooms analysed separately according to subject, and data is presented in response to the research questions. In order to clarify and contextualise the learning events in each classroom, a short section describes the tasks and activities of each lesson. In addition, a sample lesson plan was provided by each teacher. Sample lesson plans are included for each subject, and others are listed in Appendix 2. This contextualised approach was essential to the integrity of the analysis, where learning and higher order thinking were situated in a particular context, and part of goal related activity. Each of the subsections responds directly to the research questions. Prior to presenting the results of the observations, the method of analysing the transcripts is reviewed.

Analytic approach

For the research question on teacher pedagogy, transcripts were analysed with a view to revealing how teachers supported higher order thinking, as this was intended to provide an analysis of teacher practice. For example, the implicit or explicit expectations about rules for talk and interaction, the goals communicated to learners about the aims of lessons, and the patterns of social interaction that occurred provided a pedagogical framework for fostering higher order thinking in the telematics classrooms of the study. (See Figure 12.4).

Social contexts for learning were created as much by the implicit and explicit plans and expectations that teachers put in place in the classroom, as well as by the activities,

tasks and use of technology that occurred during lessons. Educationists agree that the social context acts as a support system for learning, or on the other hand, it may hinder thinking and exploration of ideas, deny students the opportunity of sharing ideas, or enable learners to extend and revise their views in collaboration with others (Mercer, 1996; Schratz & Mehan, 1993).

In the Phase 1, for example, teacher talk outweighed student talk, and the transcripts showed that most instructional talk was characterised by control strategies, procedural and management talk. Cognitive support was limited as teachers explained concepts at great length to students, but did not scaffold their understanding by providing opportunities where they could extend their own thoughts through dialogue.

In analysing Phase 2 of the study, the emphasis was on applying a socio-cultural framework to the interactions observed, and to the study of higher order thinking. Some of the fundamental features of this approach (described in Chapter 5) are as follows:

- the behaviour and talk of participants is situated and goal embedded, and part of a social context (Rogoff, 1990);
- the physical and social context, the social roles and status of individuals is likely to support or constrain the participants' goals activities and actions (Forman & McPhail, 1993);
- the actions and discourse of participants, teachers and students can transform the context, belief system and mediational means available to support thinking (Mercer, 1996);
- if approaches to thinking and cognition are to be changed, then it must be recognised that patterns of social interaction are integrated with opportunities to use language, and are part of thinking and reasoning (Pontecorvo, 1990);
- to create a context for thinking in the classroom, there must also be attention paid to the reorganisation of children's attitudes, teacher goals, and the mediational means available to support thinking (Palincsar, Brown & Campione, 1993). These mediational resources include, for example, peer support, social interaction and technological tools which allow learners to present their views and learn from others.

The intervention planned for Phase 2 of the study was based on a model of guided participation and the use of language to support and develop thinking through:

- a supportive, rather than directive role for the teacher;

- active participation and sharing of ideas by students;
- awareness of language use as part of the socialisation into practices of communities of mathematicians, scientists etc. ;
- encouragement of reflective thinking and cognitive accountability; and
- scaffolded learning though tasks and interactive use of technologies.

The procedure for analysis of transcripts was to analyse all discourse using a computer based text analysis approach at two levels. The first was a functional analysis using NUD.IST (QSR, 1993) to allocate teacher and student talk to categories guided by the theoretical framework of the study, but induced from the data.

At the second level of analysis, linguistic coding of student talk for higher order thinking was conducted to abstract instances of language based reasoning from specific utterances in student talk. In all transcripts of lessons, a search was made for key indicators of reasoning, or higher order thinking. HOT was defined and recognised by number of communicative subcategories described in Chapter 10, and each category had a language indicator by which it could be identified. For example, 'cos' or 'because' followed by a statement indicated that students were able to justify and explain their idea, by providing a reason to support a claim. Transcripts of different lessons were compared for higher order thinking in order to explore changes in student thinking with Phase 1 of the study. Computer technology use was evaluated to investigate whether the visuals and graphics used by teachers mediated thinking and learning, by supporting interaction, discussion, adaptation of ideas and reflection.

This chapter is divided into sections according to the subject area and addresses the research aims of the study. The final section presents an overview and summary of findings, and concludes with an appraisal of the degree to which teachers progressed from Phase 1 to Phase 2 in their aim of promoting higher order thinking in their classrooms.

The Science classroom Phase 2

Overview of the lessons

An essential element to Phase 2 of the study was teacher planning of lessons, resources, strategies and thinking outcomes for students. (Lesson plans for Phases 2 and 3 are provided in Appendix 2). A summary of the content of each lessons is shown in order to contextualise teacher practices and discuss how teachers changed

their perspectives and practices. For each lesson in Phase 2, the Science teacher prepared a lesson plan in order to incorporate the objective of supporting HOT in students. The content of the lessons is shown in Table 13.1, and is a condensed version of the lesson plan written by the teacher. Tasks were planned in both lessons where students would discuss ideas and become involved in activities. These activities were part of the syllabus to be covered, and also showed some of the teaching components. In Lesson 3 for example, many of the activities involved students in discussing and applying scientific principles about solutions and mixtures.

Table 13.1: Content of the Science Lessons in Phase 2

Lesson	Content	Teaching components
Science 3	• review of solutions, mixtures	students discuss ideas
	• techniques of separating different types of substances	activity based - discussion and example
	• apply knowledge of solutions to a diagram	questioning and explanation
Science 4	• separating mixtures	problem based scenario
	• identify separation techniques	an analysis of visual materials with discussion
	• different separation techniques for different mixtures, solutions and liquid	discussion with examples

The planning of tasks to support higher order thinking was important as these tasks influenced how students participated in the classroom and how the teacher supported their learning.

Changes in ratio of student talk to teacher talk

Participation rates of students and teachers in class provided an indication of the roles and activities of learners and teachers. Table 13.2 shows the number of turns and units of communication for both teachers and students. In Lesson 3, student talk accounted for only 40% of total talk, while in Lesson 4 it accounted for 43% percent.

In both Science lessons, while students collectively had more turns at talk than teachers, there was still an imbalance in the amount of talk that occurred, as teacher's proportion of total classroom talk was 58.5%, taken as an average across both lessons (Table 13.2).

Table 13.2: Units, turns and teacher/student ratio of talk in Science Lessons 3 & 4

Talk	Science 3	Science 4	Mean	Mean Difference from Phase 1
Teacher turns	208	218	213	+25.5
Student turns	242	244	243	+59
Teacher units	416	413	414.5	+27.5
Students units	283	312	297.5	+29
Teacher Ratio	60%	57%	58.5%	-7.5%
Student Ratio	40%	43%	41.5%	+7.5%

The most important differences between Phase 1 and Phase 2 Science lessons were the changes in the ratio of student talk and teacher talk. In Phase 1 an asymmetric pattern of talk was noted, and the teacher was found to talk a great deal more than students during class time. The mean percentage of teacher talk decreased by 7.5% from Phase 1, while student talk increased by 7.5%. In effect this demonstrated greater participation in classroom talk by the learners, giving them more opportunities to engage in dialogue and talk. Essentially, there was more active verbal participation by students in Phase 2 compared with Phase 1.

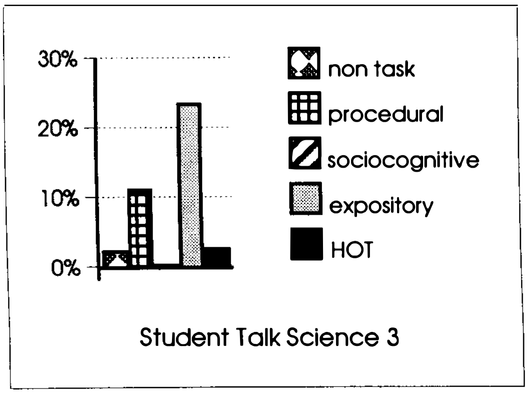
This quantitative change in participation of students in the classroom was combined with qualitative changes in interaction patterns and in the quality of teacher talk and student talk.

Functional categories of classroom talk

The major categories of student and teacher talk for each Science lesson are displayed in Figures 13.1 and 13.2. Communicative functions of student and teacher talk are displayed as a proportion of all talk within each lesson. There was some similarity between the patterns that emerged in both classes. In Lesson 3, expository talk was the predominant category for students, while in Lesson 4 the same occurred. As explained in Chapter 10, expository talk was largely to do with presentation of information, where students displayed knowledge, or recalled subject matter, but did not critically engage with it. The pedagogic concern seemed to be with the accuracy of factual detail, rather than the principled understanding of concepts. In the Science lessons, most of this expository talk occurred in the context of teacher questions, and controlling forms of discourse, such as cuing, or asking closed questions.

As Figures 13.1 and 13.2 show, procedural talk occurred in both lessons, and because of the reciprocity of communication, was evident in both teacher talk and in student talk. What is immediately obvious from these diagrams is that procedural talk was largest category for teachers, and the second largest for students. However, in both lessons, teachers demonstrated cognitive support for students, and this increased from Phase 1 of the study.

The socio-cognitive category was virtually absent from student talk in both lessons, indicating that talk was directed to the teacher and that not much discussion or collaboration occurred between students.



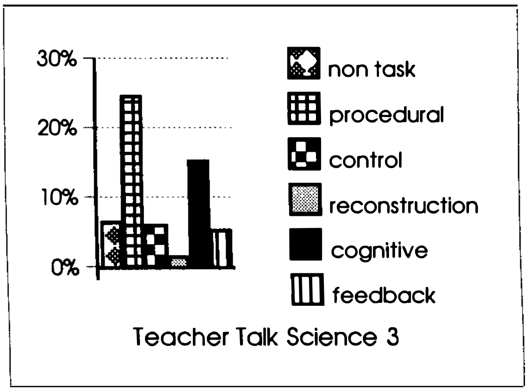
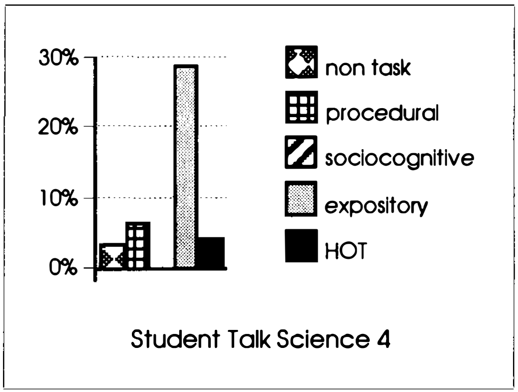


Figure 13.1: Categories of student talk and teacher talk as a percentage of total talk in Science 3

Student talk in Science 3 showed a small percentage of higher order thinking, and this accounted for only a small proportion of the total talk that occurred in the lesson. In Science 4, there was a small increase in the percentage of higher level thinking that occurred compared to Science 3. However, the occurrence of higher order thinking in these lessons was small in comparison with the amount of expository talk, and this can be seen clearly from Figures 13.1 and 13. 2. Despite the increase in HOT, the Science lessons showed a continued emphasis on expository talk where students responded with short answers which may have been informative and correct, but did not show evidence of reasoning.

In both lessons, teacher talk displayed a range of functions, with procedural talk emerging as the largest category. This prevalence of this category in both lessons showed that the management function was still visible in teacher talk, and that a great deal of time was spent organising lessons and attending to non-academic matters. Allied to this pattern, in both lessons, the category of control was apparent, suggesting that the teacher's role was still directive. However, for both lessons, there was an increase in the amount of cognitive support given to students, and there was less non-task talk than in Phase 1 of the study.



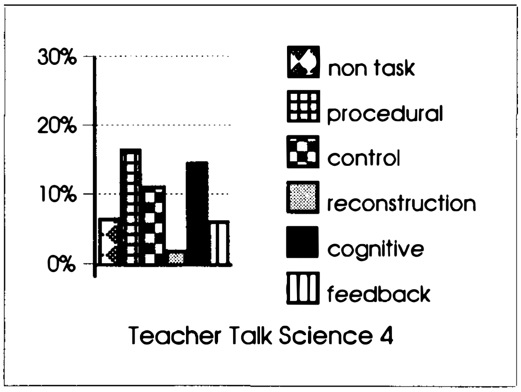


Figure 13.2: Categories of student talk and teacher talk as a percentage of total talk in Science 4

The overall changes in functional categories for both teacher talk and student talk can best be appreciated by looking more closely at the changes that occurred from Phase 1 to Phase 2.

Changes in categories displayed in student talk

The transcripts revealed some qualitative differences in student talk categories from Phase 1 to Phase 2. While Figures 13.1 and 13.2 show percentages of student talk as a proportion of all talk that occurred in each lesson, another perspective on student talk can be gained by analysing the categories within student talk, and comparing occurrences of categories across Phase 1 and 2. In Table 13.3, the mean percentages of talk for combined lessons of Phase 1 and 2 are displayed, together with the mean differences.

Table 13.3 : Changes in means and mean differences of categories of student talk in combined Science lessons from Phase 1 to Phase 2

Combined Lessons	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total %
Science 1 & 2	32	19.5	0	47	1.5	100
Science 3& 4	7	21.5	.5	63	8	100
Mean difference	-25	+2	+.5	+16	+6.5	

In Phase 2, there was 25% less non-task talk overall than in Phase 1, indicating that more of the lesson was concerned with actual concepts and academic content, as

opposed to extraneous technical problems. Expository talk still occupied a large proportion of student discourse, indicating that knowledge display and answering questions constituted a major part of the lesson. However, there was an increase in higher order thinking from 1.5% to 8% in the Phase 2. Explaining and accounting for the occurrence of HOT required two further explanatory approaches:

- investigation of evidence for higher order thinking in student talk in both lessons; and
- analysis of the teacher's pedagogy and the support given to students.

Evidence of higher order thinking

As Table 13. 3 shows, there was in increase in Phase 2 of higher order thinking among students. Evidence for this change in quality of talk was found in the transcripts. A count of the keyword indicators for thinking enabled the researcher to identify instances of HOT across both lessons. Results, as displayed in Table 13.4, showed that the quality of student talk differed from Phase 1. A count of the keyword indicators of reasoning in student talk showed that higher order thinking was in evidence in Phase 2 Science classrooms. Each category of higher order thinking is shown in Table 13.3, and a corresponding percentage for each representing the overall mean percentage for both Phases. For each of the categories cognitive accountability, critical inquiry and interpretation, there were increases in Phase 2, but no occurrences of reflection were found in the transcripts.

While this analysis provides an insight into the overall changes that occurred in student talk, it was essential to explore the pedagogical conditions that fostered these changes. Throughout the lessons, a number of instances of verbal reasoning were displayed, most of which occurred in the context of the teacher's reflective questioning and requests to students to justify their answers. Both of these forms of cognitive support scaffolded reasoning in students. Combined with the investigative tasks presented to students, the teacher's dialogue opened up opportunities for students to engage in 'talking science' (Lemke, 1990).

Table 13.4: Keyword indicators for higher order thinking in Science Phases 1-2

HOT Category	Keyword Indicators	Phase 1	Phase 2
Cognitive Accountability	because, cos, so, then, therefore	.5%	4%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	1%	3%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	0%	1%
Reflection	meta statement	0%	0%
	Total percentage of HOT	1.5%	8%

For example in Science Lesson 3, the following exchange provides an example of cognitive support, where the teacher asked a reflective question on the nature of solvents, solutes and suspensions in chemistry.

T:	why can you tell us about the nature of the relationship between the solute and solvent in the suspension?	**reflective question**
S:	the solute is um insoluble	**expository**
T	and what about the two characteristics of a suspension?	
S:	Um a suspension (pause) some characteristic er, the size of the solid particles in the suspension are very much larger than the particles of the solute.	**expository**
T:	Yes that is an important one, and the other one?	**feedback**
S:	The suspension is a heterogeneous mixture.	**expository**
T;	Which means, what is going to happen?	**reflective question**
S; I	It means that the particles of a solid do not mix uniformly with the solvent, but like settle to, at the bottom, but sometimes, like if the solid is lighter than the water it will float to the top.	**HOT: Interpretation**

In some exchanges, there were examples of students providing elaborate answers to teacher questions as in the following example, when the teacher asked about the general properties of suspension. The student replied:

S;	So like in all suspensions there are two components, and the two components will separate into two distinct layers when allowed to stand.	**HOT: rule making**
T:	OK, that is good.	**feedback**

In Lesson 4, there were also instances of higher order thinking, as the teacher had planned a number of activities to engage students in reviewing ideas and creating a mind map of separation techniques. The lesson was planned as a continuation of Lesson 3, where students had to review what they had learnt about separating substances, and apply this to the creation of a mind map. Firstly, the teacher asked them to talk about and explain their responses to the problem task set for homework. This gave students scope to demonstrate reasoning approaches and to elaborate on how they arrived at solutions. Several instances of higher order thinking resulted from the strategy of reflective questioning where the teacher requested a response to be justified.

T:	What solution or mixture do you think Judy had and why Shane?	**reflective question**
S:	Well sand, um yes, because you can just filter it out.	**HOT: justify**

During the lesson, students demonstrated skills and expertise in explaining and using cause and effect indicators to solve the problems set. The teacher provided a supportive lead in the dialogue by questioning, prompting and asking for elaboration.

In the following example, a student reads the problem and then presents a solution.

S:	Um, 20 grams of white solid are placed in one litre of water and the mixture is stirred. All the white solid dissolves. Is the mixture saturated or unsaturated?(pause)(reads question) it is unsaturated because all the um white stuff dissolved and there is none left. So it can't be saturated. (pause) Well it can but..	**HOT: reasoning**
T:	Just explain that one to us again.	**cognitive support**
S:	well if you like all the white substance dissolved, and there is none left over, so it is not saturated.	**HOT: explaining**
T:	right	**Praise**

The final activity planned for the lesson, the creation of a concept web for the topic of the lesson, gave students further opportunities to engage in reasoning through talk.

Students initiated ideas and co-constructed a map of the facts they had gathered about separating substances. Through this task students had an opportunity to summarise information, reflect on it and then present it graphically. The focus on a common product that could utilise the visual capacities of the computer created common understandings among students from each of the separate locations.

Neither of the Science lessons in Phase 2 showed any reflection by students. Table 13.4 also shows that there were small amounts of interpretation, critical inquiry and cognitive accountability in Lesson 3, and these increased in Lesson 4. It was noted from the transcripts that cognitive accountability, where students provided reasons for their ideas and statements, was fostered by teacher requests for justification and explanation. The category of interpretation, which entailed giving an opinion or interpretation of data or ideas, did not occur and few opportunities arose in the lesson where students were given an opportunity to question the text. In many of the activities, the teacher regarded the topic as given rather than constructed, and 'the facts' as reported in the text book were presented as unproblematic.

Though the actual instances of higher order thinking in Lessons 3 and 4 were infrequent, they nevertheless represented an increase compared to levels of thinking in Phase 1 of the study. This result is displayed in Figure 13.3. Overall, there was an increase in higher order thinking in the Science Lessons from 1.5% in Phase 1, to 8% in Phase 2 (Figure 13.3).

The figure of 8% represented the proportion of higher order thinking in student talk as an average of both lessons, and the percentage, while representing an increase, was quite low when it is considered that higher order thinking was the intended outcome of the lesson.

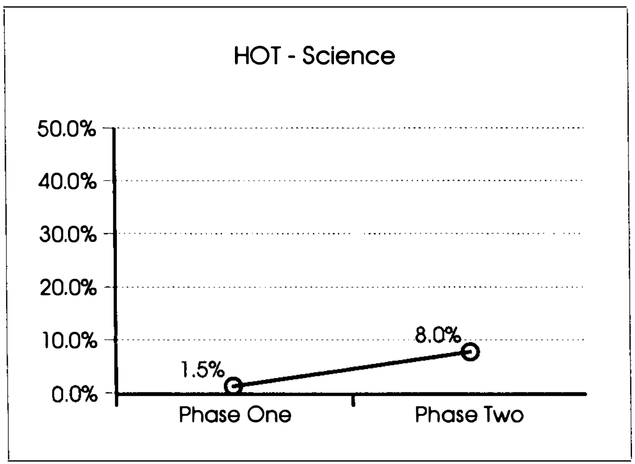


Figure 13. 3: Increase in percentage of HOT in Science from Phase 1 to Phase 2

Despite the occurrences of HOT, the dialogue in the lessons reflected what can be described as 'information mode' (Wells & Chang-Wells, 1992). Throughout the lesson, students were questioned and asked for explanations, but were rarely asked to extend their contributions to expand or organise their ideas. Language use was confined to providing answers with occasional justifications or explanation. While this use of language was an improvement over the expository mode of exchange in Phase 1 of the study, factual display of information remained an important teaching objective for the teacher, and as such she did not engage in forms of talk and discussion where language was used as a cognitive tool to enable students to reflect on their own ideas and actions.

In addition, there were few exchanges that occurred between students themselves, and all dialogue was filtered or directed through the teacher. Therefore, arguments and counterarguments where students engaged with each other's ideas were not found in Phase 2 Science lessons. It was as if the students were simply reconstructing the teacher's views on the content and principles of Science, but not engaging with these ideas or criticising them. As Laplante (1997) observed in the Science classrooms of his own study, the overall engagement was *informational* rather than epistemic.

Changes in functional categories of teacher talk

As the nature of this study required analysis of teaching and learning, teacher talk was analysed more closely by considering the functional and communicative aspects of the talk across both lessons, thereby providing a micro-analysis of each lesson. Table 13.5 displays the mean percentages of functional categories that occurred in teacher talk for the Science lessons from Phase 1 to Phase 2. For both Phases, the largest category was procedural, showing that overall management and pacing of the lesson consumed most of the teacher's talk.

Table 13.5: Mean percentages and mean percentage differences in categories of teacher talk in combined Science lessons from Phase 1 to Phase 2

Mean Talk in Lessons	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	Total %
Science 1&2	14.5	44	15.5	2.5	17	6.5	100
Science 3 & 4	11.5	35	15	2.5	26	10	100
Mean difference	-3	-9	-.5	0	+9	+3.5	

The second largest category was cognitive support, while the third major function was control. Some important changes occurred in the quality of teacher talk that could have had an impact on the opportunities for students to explain, argue and produce justification for their own ideas. As Table 13.5 shows, the percentages of non-task and procedural talk decreased by three percent and ten percent respectively, from Phase 1 to Phase 2, which effectively meant that more of the lesson was devoted to on-task talk.

Another important change that occurred was that the percentage of cognitive support given to students increased by nine percent, and feedback by four percent. The amount of control talk remained the same, indicating that closed questions and cuing remained part of the teacher's strategies. However, with the increase in cognitive support for students, other communicative functions such as asking reflective questions and scaffolding understanding were now visible in the teacher's discourse.

Changes in teacher pedagogy

While the outcomes of the lesson were related to content knowledge, such as the nature of mixtures, the specification of stages in the lesson such as 'review, discuss, apply, practice' enabled the teacher to plan activities to engage students actively in thinking about the concepts. For this lesson, the teacher anticipated that students would generate questions and apply analysis and prediction skills, and these are mentioned in the plan for the lesson. The teacher did not however list the specific strategies by which these outcomes could be reached (Figure 13.4).

The lesson commenced as planned with a discussion of the terms solutions, suspensions and separations. A visual was sent to students displaying the terminology on mixtures, solutions and solvents, and the task was to match the terms with descriptions read out by students, who were each allocated a number by the teacher. Students were required to listen attentively to one another and to describe scientific terms, without naming the term. The objective was for other students to listen and guess the answers. While the activity did bring about a good deal of student involvement and some student-to-student talk, it did not produce higher levels of thinking, as the following extract shows. In the exchange there were three students involved (S1, S2, S3).

T:	Nick, would you read out an example of one of yours and ask someone to answer it?	**management**
S:	Um it is a liquid in another liquid.	**expository**

T:	Yes and who?	**management**
S1:	Um well anybody	**procedural**
T :	Yes select Ross, Gary or Sean.	**control**
S1:	Ross.	**procedural**
S2:	What was the thing again?	**clarify**
S1:	A liquid in another liquid	**expository**
S2:	A suspension	**expository**
S1:	No	**short answer**
T :	can anyone help him out?	**management**
S3:	A miscible	**expository**
S1:	Yup.	**feedback**

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

   review of solutions, mixtures and techniques for separating ; different types of substances

2. Outcomes of the lesson

   to be able to visualise solutions in terms of the kinesics of their molecules and to apply this to separation techniques

3. Steps involved in the lesson

   (i) *review solution terminology;*
   (ii) *discuss solution terminology;*
   (iii) *apply knowledge of solutions to analysis a diagram;*
   (iv) *practice knowledge on a separation techniques puzzle.*

4. List the HOT you expect your students will display.

   students generate questions; prediction and analysis skills

Fig. 13.4 : Lesson planning sheet for Science Lesson 3

The activity involved students in defining terms and questioning each other, while clarifying their own misconceptions of the subject matter. The teacher questioned students on definitions of suspensions and separation techniques. A further screen was sent to students with the key terms, and again students were asked to explain the terms. The emphasis was on providing the correct explanation, and most of the students were able to do so.

The final activity planned was a visual puzzle of various beakers which contained substances, which were either soluble or insoluble. The teacher asked questions like: "Which of the diagrams below represents a soluble substance? " and then asked students why they thought so. These question types were quite unlike the expository type questions asked in Phase 1, and they required that students justify their responses by appealing to evidence to support their statements. These 'reflective' questions as they were called, encouraged students to elaborate, expand, and demonstrate reasoning in their talk, and marked a change from the primarily information seeking questions of Phase 1.

In Science Lesson 4, there were occurrences of higher order thinking, but there were not the prediction and analytic episodes that the teacher had planned for. Instead several instances of cognitive accountability occurred. There were qualitative changes in teacher talk, as Table 13.5 shows, and these provided evidence of a change from Phase 1 of the study, where teacher talk had little cognitive support or feedback. What was most noticeable was that the teacher asked more insightful questions, prompting students to display reasoned responses. On examining the category of cognitive support, for example, a number of changes were noted in the teacher's approach. These changes were related to:

- questioning;
- offering suggestions and stimuli; and
- asking for elaborations.

The following extract shows how the teacher supported higher order thinking through different levels of questioning:

T:	Let us say you took that test tube and put it just directly into the fridge, at a fairly cool temperature, left it there for an hour, would the test tube look the same?	**elicit information**
S:	No, um all the salt would have come out of the water	**expository**
T:	Right why?	**cognitive support**

S_1:	Because it is cold and things don't dissolve too well in cold water.	**HOT: cognitive accountability**
T :	Right, so all things being equal, solubility of most solutes is better at high temperatures than at lower temperatures and that is used to advantage in many situations too. Would you read out question 4 for me Sean?	**reconstruction**
S_1:	(Reads) it says that soft drink manufacturers dissolve carbon dioxide in their drinks at a low temperature.	**procedural**
S_2:	I know when they put it in the fridge.. like very cold	**feedback**
T:	Go on either of you if you have an explanation	**cognitive support**
S_2:	So that when it cools down it doesn't lose all the bubbles, like if they put it in while it was hot, when it cools down it would lose all the bubbles. And is just like gas	**HOT: reasoning**
T::	Right, in other words (.) yes that sounds reasonable.	**feedback**

In this extract the teacher 'scaffolded' student understanding by asking reflective questions, offering cognitive support in the form of encouragement to explain, and also by reconstructing student responses in order to provide more elaborated explanations. This marked a change from the focus on the 'getting the right answer' demonstrated in Phase 1 of the study, where students were directed, instructed and told about scientific facts in a manner that was more to do with transmission of facts that with encouraging thinking and learning. So Phase 2 Science, with more emphasis on reflective questioning, gave the teacher a different role, that of facilitator. Questions which prompted students to look for rules, or make generalisations about the examples found were evident in teacher discourse. Correlated with this were the opportunities opened for students to challenge, speculate or find exceptions to the rule. For example:

T:	Would you say that the mixtures are much easier to separate?	**cognitive support**
S:	But what if you have sand and salt?	**HOT: challenge**
T:	Then it is more of a mixture isn't it? yes you would have to perhaps separate the mixture first and how would you separate the mixtures? what are the two processes?	**cognitive support**
S1	Oh a mixture and a solution.	**factual response**
S2	But ..	
T:	Sorry Gary?	**procedural**
S2:	I don't see why it would be a mixture and a solution. It is just sand and salt.	**HOT: challenge**

These different types of questions provided cognitive support for higher order thinking to emerge, and served to establish the teacher's role as scaffolding learning. Nevertheless the management function remained part of the teacher's profile, as many of the questions asked were factual in nature. In addition, the low percentage of critical inquiry in student talk (Table 13.4) which amounted to only 3% in the lessons, showed that the students did not appropriate the teacher's questioning strategies.

Overall, in terms of teaching strategies, both lessons showed a greater range of cognitive support for thinking than Phase 1. Support for higher level thinking was linked to several patterns of teacher discourse. In Phase 1, cognitive support for students was limited to explaining ideas in depth, but this did not create opportunities for student dialogue. In Phase 2, the Science teacher introduced other strategies such as:

- asking reflective questions;
- enabling students to justify their answers; and
- giving students greater responsibility through activities which allowed students to represent their ideas via talk and technology.

One further observation on teacher-student dialogue was the preponderance of I-R-E structures, or the triadic form of exchange where the teacher initiated, students responded and the teacher gave feedback on the students' response. Very often, feedback given to students was evaluative in the sense of being labelled 'right' or 'wrong'. In Phase 2 Science classrooms, teacher feedback to students increased by 3.5%, and this included praise, encouragement and checking of responses. Nevertheless, the dominant pattern of teacher initiated discourse prevailed, and this almost certainly inhibited self-regulation and initiation by students.

Use of computer technology to support higher order thinking

Use of the computer occurred throughout both lessons, and the teacher had prepared visuals in advance. There were no technical problems during either of the lessons. Evaluation of computer use according to the conversational framework (Laurillard, 1993), provided an approach consistent with Vygotskyan theory (Chapter 5) as it emphasised learning as a social activity, where interaction and communication are essential features of learning. The four elements of the framework, interaction, adaptation, reflection and discussion provided a means of assessing the potential of the technology in supporting learning and higher order thinking.

In Science Lesson 3, one of the visuals showed a list of chemical terms which students had to identify and define, and while there was verbal interaction between teacher and students, there was no opportunity for students to adapt or change what was presented, or even to voice an opinion on whether the information was new or already known. Neither were the goals of the task negotiated with students. Lesson 3 had interactive and discursive components only, as there was verbal interaction and discussion between teachers and students based on computer visuals. However, there was no student adaptation of the teacher's input, nor was there reflection by students on how they interpreted or understood the content, ideas, or the experiences in the classroom. Most of the visuals were prepared in advance by the teachers and did not require input by students. Their function was to display scientific content.

An overview of the main components of computer technology use for Phase 2 is provided in Table 13.6. As Table 13.6 shows, the teacher gave control to the students in Lesson 4, and used the technology to present information, structure the lesson and foster interaction among students.

Table 13.6: Computer technology use in Science Lessons 3 & 4

Computer Graphics	Lesson 3	Lesson 4
No. of screens	3	3
Prepared by teacher	yes	partly
purpose of graphic	display terms/ test tubes	present problems
student activity	defining terms/ recognising differences	matching statements/ identification/ mind mapping
locus of control	teacher	shared
interaction	yes	yes
discussion by students	yes	yes
adaptation by students	no	yes
reflection by students	no	no

In Lesson 4 for example, students were required to apply and extend their knowledge of separation techniques. Having spent a good deal of time discussing separation of various substances, students were given control of the computer software and asked to display what they had learnt in the form of a concept map. With some input and questioning by the teacher, they produced a summary of what they had learnt. This is displayed in Figure 13.5.

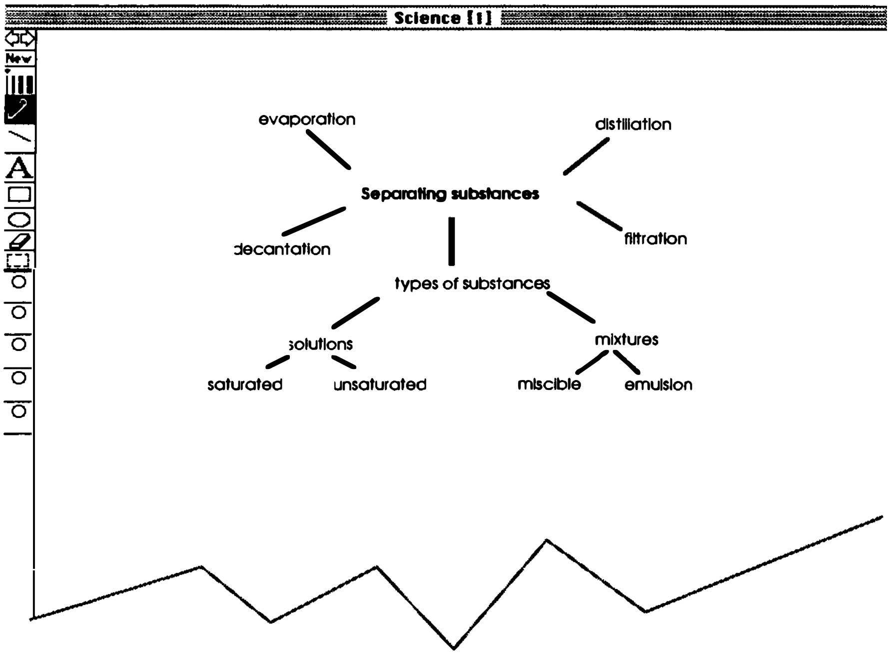


Figure 13.5: Concept map created by students in Science Lesson 4

Students produced a screen that represented their ideas, but the teacher inserted the terms 'miscible' and 'emulsion', and so did not leave the task entirely up to students. There was little scope in the lesson for reflection on the ideas presented, although the exercise enabled students to interact, discuss and present their ideas. Rather it seemed that the control exerted by the teacher pre-empted reflection at this level, and this was mirrored in the categories of HOT for the lesson.

Overall, although the computer was used to support the teachers' objectives and display content and concepts, but it allowed the students little scope to express their understandings of events.

This extract from the transcripts shows that although students had control of the technological tools, the level of discourse did not go beyond mere description and exposition of ideas.

T:	So you are obviously going to put down methods of separating substances first, aren't you? OK keep going.	**procedural**
S1:	here we are	**procedural**
S2:	evaporation	**expository**
T:	good, excellent keep going	**feedback**
S3:	My go, my go	**procedural**

T:	As we go they are all going to have to be in a logical format and we are going to have to connect them up as well with any interconnecting processes that might be relevant too.	**procedural**
S2:	Um	
T:	so what are the three you have got there?	**procedural**
S:	um eh, evaporation, decantation and filtration	**expository**

While the mind mapping exercise gave the students an opportunity to brainstorm ideas, the teacher did not ask them to evaluate the activity or to reflect on its relation to concepts already learnt. Nevertheless, technology was used more purposefully in Phase 2 than in Phase 1, to support interaction and discussion among students. This observation was supported by examples of student activity around the computer which fostered dialogue through the shared visual source of reference and the facility for representation and sharing of their own ideas through the computer. The results of analysis of computer use according to the support it gave to the dimensions of interaction, discussion, adaptation and reflection are illustrated in Figure 13.6 with Phase 1 shown for comparison. In Phase 2, there was adaptation, discussion and interaction among students, but no reflection on their own thinking or on the products they had produced on the computer to show their understanding.

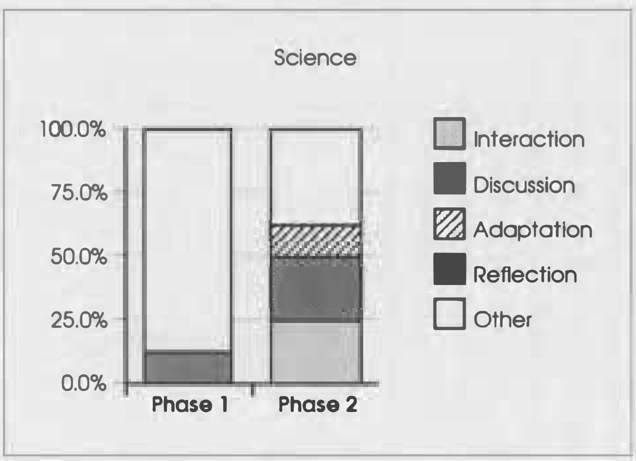


Fig. 13.6: Computer use to support thinking in Phase 1 and Phase 2 Science

In conclusion, technology use in Phase 2 incorporated more dimensions of the learning conversation than did Phase 1, as it supported dialogue, conversation and discussion among students. Reflection did not occur in the Science lessons, and this may have been because students were not given opportunities to engage in data gathering, interpreting findings and revising theories.

Conclusion

From a socio-cultural perspective, the Science classrooms changed from Phase 1 to Phase 2, and showed that more higher order thinking was achieved by the students. The dialogue that occurred between teachers and students showed a decrease in expository talk, and an increase in the amount of cognitive support provided by the teacher. The mode of teacher talk still displayed directive and control features, and the view of Science projected by the teacher was not driven by real scientific problems, but by text book knowledge. Only in teacher pedagogy was a change visible, and this was limited to engaging students in explaining and justifying their responses, so that there were instances of cognitive accountability in student discourse. There was also partial sharing of control and design of computer visuals, enabling interaction between students from different locations.

The Maths classroom in Phase 2

The activities that took place in the Maths classrooms of Phase 2 are depicted in Table 13.7. These activities were linked to different conversational acts which mediated student understanding and created opportunities for higher order thinking. The activities in both lessons involved student investigations of various forms of problem solving including investigation of 'happy numbers' and determining rules that applied to these problems and to how octagon loops could be joined.

Table 13.7: Content of Maths lessons in Phase 2

Lesson	Content	Teaching components
Maths 3	• happy and sad numbers. squaring numbers and checking solutions	students practise examples and discuss them
	• students explore different numbers, to extend their inquiry	think aloud and explaining how to get the solution
	• converting problems to equations	looking for rules; simplifying
Maths 4	• exploring octagon loops	students talk through their investigations
	• joining octagon loops	joint problem solving
	• looking for number patterns and rules to apply	teacher questioning and supporting use of mathematical language

The tasks set in both lessons were demanding and required students to think at conceptually advanced levels. The teacher's lesson plan (Figure 13.7) showed that the teacher's instructional intentions was to enable students to construct knowledge for themselves. In terms of higher order thinking, the teacher anticipated that students would make rules, generalise and show cognitive accountability.

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

   exploring octagon loops;
   explaining how problems are solved.

2. Outcomes of the lesson

   making rules for joining octagon loops;
   using mathematical language;

3. Steps involved in the lesson

   (i) *students describe how they investigated octagon loops;*
   (ii) *pool ideas and look for rules for connecting tiles;*
   (iii) *extending the investigation through brainstorming*

4. List the HOT you expect your students will display.

   making rules; generalising; explaining and justifying answers

Figure 13.7: Teacher planning sheet for Maths Lesson 4

Changes in ratio of student talk to teacher talk

In the Maths lesson of Phase 2, students' verbal contributions to the lesson increased. Participation rates of students and teachers in are displayed in Table 13.8, along with comparisons to Phase 1.

The Table 13.8 shows the number of turns and units of teachers and students in both Mathematics lessons of Phase 2. In both lessons, the ratio of teacher was consistently greater than student talk. Lessons showed that turns taken by the teacher were fewer than in Phase 1, and that the average number of turns for students was greater by 100, in lessons which were of a similar length. Thus, there was a marked increase in verbal participation rates of students in Phase 2 Mathematics.

Compared with Phase 1, the mean percentage ratio of teacher talk decreased by 4.5%, while the mean percentage ratio of student talk increased by 4.5%.

Table 13. 8: Units, turns and teacher/student ratio of talk in maths Lessons 3 & 4

Talk	Maths 3	Maths 4	Mean	Mean Difference from Phase 1
Teacher turns	145	219	182	-58
Student turns	162	224	193	-50
Teacher units	263	375	319	-150.5
Students units	180	272	385.5	+100.5
Teacher Ratio	59%	58%	58.5%	-4.5%
Student Ratio	41%	42%	41.5%	+4.5%

Nevertheless, the teacher's proportion of talk at 58%, exceeded student talk, showing that the teacher retained greater communicative rights.

Functional categories of classroom talk

An overview of the talk that occurred in the lessons can be gained by considering each lesson individually to see how talk was distributed among teachers and students. As Figure 13.8 shows, higher order thinking was evident in student talk, while the categories of cognitive support and expository talk constituted the largest proportion of teacher talk. However, in student talk, the expository category far exceeded the higher order thinking category, suggesting that explanation of facts, information exchange and display of factual knowledge were still a large part of the lesson talk.

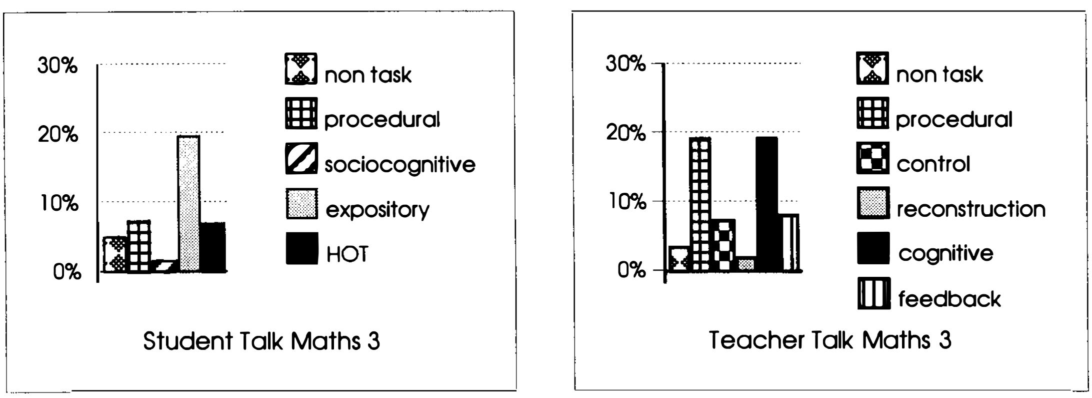


Figure 13.8: Categories of student talk and teacher talk as a percentage of total talk in Maths 3

In Lesson 4 (Figure 13.9), there was a small increase in higher order thinking, while teacher talk showed a decrease in the procedural category. In both lessons, the amount

of teacher talk devoted to cognitive support was the largest category, followed by procedural talk. These findings are discussed further in the analysis of teacher pedagogy.

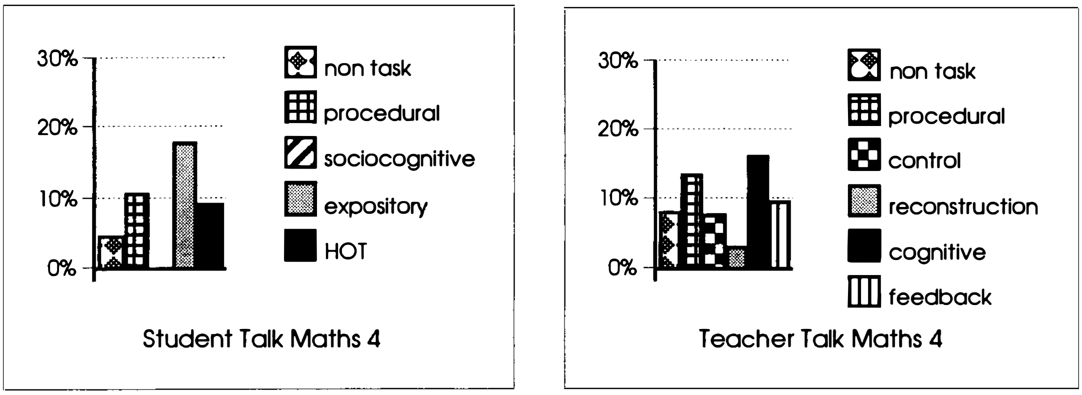


Figure 13.9: Categories of student talk and teacher talk as a percentage of total talk in Maths 4

From these observations it was possible to discuss the relationship between teacher talk and student talk, and to demonstrate that overall changes in the amount of cognitive support given to students increased following the intervention. In a later section on teacher pedagogy, the impact of cognitive support is illustrated with lesson exemplars to show how teacher-student interaction fostered students' capacities to reason. Prior to that further changes in student talk are analysed and discussed.

Changes in functional categories of student talk

There were marked differences in the quality of student talk from Phase 1 to Phase 2 of the study. The changes are presented in Table 13.9. Higher order thinking increased by 15.5%, and socio-cognitive talk, that is collaborative talk between peers increased marginally.

Table 13.9: Means and mean differences in categories of student talk in combined Maths lessons from Phase 1 to Phase 2

Combined Lessons	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total %
Maths 1 & 2	20.5	24	0	51.5	4	100
Maths 3& 4	12	22	1.5	45	19.5	100
Mean difference	-7.5	-2	+1.5	-5.5	+15.5	

All other categories of talk decreased, with the greatest differences occurring in non-task talk and expository talk. In the definitions of these categories provided in Chapter 11, non-task talk was concerned with technical or administrative matters, while expository talk was a presentational form of language where students either recalled facts, followed instructions or engaged in answering teacher questions. The biggest overall change was in the quality of student talk.

Student talk: evidence of higher order thinking

Further evidence of higher order thinking in Phase 2 Mathematics can be gathered by looking at the cluster of higher order thinking in student talk and by providing examples of student talk to support this. Table 13.10 shows the percentages of language indicators for higher order thinking in the Maths lessons from Phase 1 to Phase 2.

Language indicators of HOT in each lesson showed that students were actively engaged in constructing their own meaning for the lessons, and adept at formulating rules and expressing ideas supported by evidence. Table 13.10 also shows that reflection, interpretation cognitive accountability and critical inquiry were displayed in Lessons 3 and 4, to varying degrees. In both lessons reflection was the smallest category, and cognitive accountability the largest.

Table 13.10: Percentages of language indicators of higher order thinking in Maths Phase 1-2

HOT Category	Keyword Indicators	Phase 1	Phase 2
Cognitive Accountability	because, cos, so, then, therefore	2%	8%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	1%	7%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	1%	3.5%
Reflection	meta statement	0%	1%
	Total percentage of HOT	4%	19.5%

The combined lessons for Maths showed that only 19.5% of student talk showed evidence of keyword indicators of higher order thinking. Table 13.10 also shows that each of the four dimensions of thinking (cognitive accountability, critical inquiry,

interpretation, and reflection) increased from Phase 1 to Phase 2, with the largest increases occurring in cognitive accountability and critical inquiry. Some examples of higher order thinking from the Maths lesson of Phase 2 serve to illustrate students' engagement and reasoning processes. These occurrences are presented in the context of the lesson planned, and the content taught. The teacher planned for higher order thinking in the lesson and stated as outcomes the use of mathematical language and the making of rules to explain how to join octagon loops. In Lesson 4 for example, students had concrete examples from which to draw their observations, as they had completed a homework assignment on octagon loops. The teacher made the objective of the lesson clear at the outset when she said "I want you to focus on describing- that is, you describe how you go about things, and how you solve problems." Each student was given an opportunity to explain, describe and detail the processes engaged in during the investigation. In the following exchange, a student explains how he went about the process.

T:	OK George, can you describe what you did it, please?	**procedural**
S:	Yes, I just looked at it (pause) <u>I thought</u> about it a lot and I couldn't think of any ways to like end it.	**HOT: Reflection**
	Like we talked about how you could count on the outside ones, the inside ones and all sides of them, make shapes and that so I just looked at all the different angles	
	and like there is this one, you have four and it makes a little square in the middle, <u>but</u> you put it on its side and <u>then</u> it makes a diamond	**HOT: cognitive accountability**
T:	Right	**procedural**
S:	<u>So</u> I can make the point face down, like one of the points	**HOT: conclusion**

In this extract, not only did the student give an elaborated and extended response, he also displayed reflection and reasoning in his answer. The lesson had many other instances of higher order thinking where students initiated, showed creative thinking and formulated rules that applied to the problem. The dialogue was dynamic and fast moving with students making conjectures, hypothesising and drawing conclusions from their own work and the diagrams displayed on the computer screen. At various points in the lessons, students would venture to make their ideas heard by both peers and by the teacher, and offer suggestions prefaced by phrases like:

"Teacher, I know the rule."	**HOT: rule making**
"I have found another way of doing it."	**HOT: interpretation**

" Like it happens with every one of them."	**HOT: rule making**
" I worked out a rule."	**HOT: metacognition**

These contributions were not part of the standard three-part teacher-led exchange which characterised many of the lessons in Phase 1, where the students simply replied to questions set by the teacher. In Phase 2 there was more evidence of students showing self-regulation and independence in their thinking processes. The following extract provides an excellent example of students' ability to initiate their own thinking processes.

S:	teacher, if you want to do it a quickly to get the outside edges you times your number of octagons by four.	**HOT: rule making**
T:	OK times by four. Lets have a look at the table results and see if that works.	**cognitive support**
S:	by five	**procedural**
T:	five, why five?	**cognitive support**
S:	because there are eight sides and the outside, all the time and it is by four plus What you do is (,) see how it is a loop?... *(student refers to the computer screen)*	**HOT: cognitive accountability**
	but you have two on each end? you just take those two loops off.	**HOT: Interpretation**
T:	um, mm	**Feedback**
S:	like they are five each and all the rest are four so you just put them aside for a second so with a sixth one you have four with four sides showing. Four times four plus ten because there is five in each one. Get me?	**HOT: explain**
T:	Go bit slower for me.	**Feedback**

In this episode, the student was obviously thinking about the problem, formulating a solution and then finding evidence and examples by which to make the solution clear to the teacher. Higher order thinking was obviously displayed in this student's talk, and was facilitated by the capacity to show his formula on the computer.

In Phase 2, all four categories of thinking were in evidence in the Maths lessons, although the percentage of reflection was low. Looking at the pattern of increase in higher order thinking as depicted in Figure 13.10, there was a sharp increase in the occurrence of higher order thinking from Phase 1 to Phase 2 of the study. Analysis of the lesson plan provided evidence that the teacher achieved the stated objectives of the lesson in terms of higher order thinking.

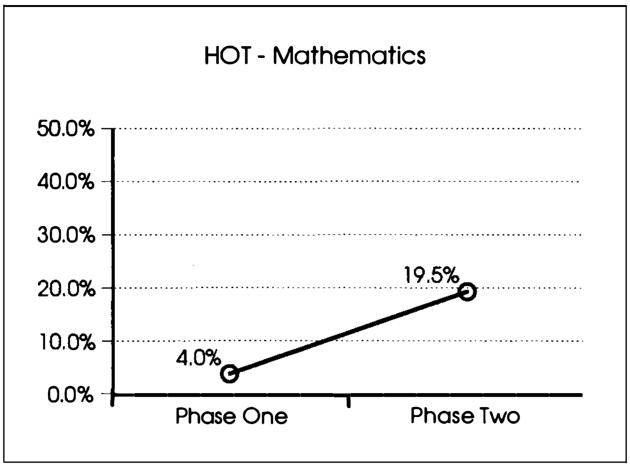


Figure 13.10: Increase in percentage of HOT from Phase 1 to 2 Mathematics

In order to understand the conditions and context conducive of higher order thinking in the Mathematics lessons, it was essential to consider patterns of teacher talk and student talk and how these created contexts for students to think and reason.

Changes in teacher pedagogy

The functional categories that occurred in teacher talk in Phase 2 are displayed in Table 13.11, alongside mean percentages of talk from Phase 1, in order to facilitate comparison. In Lessons 3 and 4 cognitive support was the largest category, followed by procedural talk. Cognitive support increased by 8.5% and feedback by 5%. These two categories were closely related to the cognitive dimensions of student learning. The category 'cognitive' was ascribed only to communicative functions which supported principled understanding and cognition, rather than learning or display of factual information. In Phase 1, transcript evidence showed a narrow range of instructional strategies by teachers, where teachers fulfilled the roles of explainer, manager, and rule giver. In Phase 2, the Maths teacher also played the role of coach and devil's advocate by prompting students to explain and justify their findings, thereby creating opportunities for reasoning and cognitive accountability.

The Maths teacher continued to emphasise the importance of language use, and of thinking through language as part of mathematical understanding. Several

interchanges that occurred in lessons showed that the teacher regarded use of mathematical language to be part of students' understanding of how to approach mathematical problems.

Table 13.11: Means and mean differences in categories of teacher talk in Maths lessons from Phase 1 to Phase 2 (as % of total teacher talk)

Mean Talk in Lessons	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	Total %
Maths 1&2	14	34	15.5	3.5	22	11	100
Maths 3& 4	10	27	12.5	4	30.5	16	100
Mean difference	-4	-7	-3	+.5	+8.5	+5	

For example, when discussing how to compare octagons, the students use the word 'things' when talking about variables, and then the teacher introduced them to the correct term.

> T: To use posh language, if Mike was looking at things to compare, there were two variables.

Throughout the lesson, the teacher made explicit the language of mathematical thinking, and modelled its usage through think aloud strategies. For example, in this extract the teacher illustrates how a conjecture is related to making a prediction about an event which has to be tested.

> T: We have got a conjecture, a conjecture is that we multiply the number of tiles by six and that will give us the number of edges. So we are going to test this conjecture by making a prediction. We are going to need to use this kind of language when you write your report up.

In Phase 1 of the study, the teacher had alluded to the importance of using language to think, and throughout Phase 2 had encouraged students to explain their thinking aloud so that other students could participate and share understanding. For example in Lesson 4, the teacher said:

> Just talk us through how you went about exploring the investigation and the kind of things that you did and the things that you discovered.

Here, the teacher took language use a step further by modelling use of new

mathematical terms and encouraging students to incorporate these in their own talk. She constantly modelled mathematical language in her explanations, and introduced it gradually throughout each lesson in order to enable students to make the transition from everyday language to Mathematical language.

A further change that occurred in Phase 2 was that the teacher made the social rules of the classrooms clear from the outset, and by making expectations explicit, created the conditions where students could share ideas and collaborate. At one stage in the lesson one student spoke of another student 'stealing' his idea, to which the teacher replied:

> OK, well we are not talking about stealing at the moment. We are pooling ideas today.

Another strategy in the teacher's pedagogy which fostered higher order thinking was her emphasis on the process of discovery and of the students' active role in creating knowledge, rather than merely absorbing it. For example, the teacher said in response to a question posed by a student about answering the assignment task:

> Well they are not really questions that you have to answer;
> <u>you are asking the questions.</u>
> *(Emphasis is taken from the teacher's recorded speech in the videotaped lesson).*

Here the teacher explained that the thinking process is not merely a matter of answering and understanding prepared problems, but of actively formulating and constructing problems and conjectures for oneself. The teacher actively sought to increase students' metacognitive and reflective processes by inviting them, throughout the lesson, to participate, share ideas and offer different perspectives on how to combine shapes to make octagon loops. The students made various suggestions about shapes and materials with which to extend their investigation on octagons by using triangles, kites and 3D shapes. Students proposed ideas but some lacked confidence in their own suggestions, saying that these ideas might be 'a bit stupid'. The teacher immediately rebutted this suggestion, and encouraged students by saying:

> None of these ideas are stupid. The thing is unless you start just being able to say any old thing you won't be able to come up with new ideas. So it could be just that you have an idea and then decide, OK, I won't; use it, but you could always jot that idea down...

The teacher wanted to create a context where students could speculate, take risks and make conjectures as she believed that students needed to see Mathematics as problem solving and idea generation, rather than simply finding solutions. This approach was

shown in her responses to the questionnaire and also in her approach to interaction in the classrooms. Following this, the teacher engaged students in a brainstorming activity to generate ideas about their investigation and also prompted student discussion of how brainstorming helped students to generate ideas. No corrective or negative feedback was given to students during the lessons observed.

The Maths teacher displayed a wide range of cognitive support strategies, scaffolding students' understanding and promoting reasoning processes and independent thinking. Apart from emphasising language use and cognitive accountability, she also created a supportive and collaborative classroom atmosphere where each student was expected to contribute ideas and to share in the construction of knowledge and solution of problems.

Use of computer technology to support higher order thinking

The teacher's use of technology mirrored her social and language based approach to thinking in the classrooms. Her objective was to enable students to combine verbal descriptions with mathematical problem solving and to use the computer screen to represent their solutions. This was hampered to some extent as both lessons had technical hitches which impeded full use of the screen. In Lesson 3, there was no computer link up as the modems did not respond. After several attempts, the teacher gave up and conducted a lesson using the audio channel alone. This was successful, and students displayed a range of verbal reasoning behaviours in their talk. In Lesson, 4, on the subject of investigating octagon loops, students were able to use the computer screen to show their own representation of the approaches they adopted.

Table 13.12. Use of computer technology in Maths Lessons 3 & 4

Computer Graphics	Lesson 3	Lesson 4
No. of screens	-	3
Prepared by teacher	-	yes
purpose of graphic	-	investigation & problem solving
locus of control	-	shared
student activity	-	explaining results
interaction by students	-	yes
discussion by students		yes
adaptation by students	-	yes
reflection by students		yes

Table 13.12 shows the parameters of computer technology use for Maths Lessons 3 and 4. All dimensions of the conversational framework were achieved through technology use, and students had opportunities to question, challenge and discuss ideas, as well as project their own representations of ideas, and manipulate the visuals on the computer screen.

Comparison of computer use in Phases 1 and 2 was facilitated by collectively examining the dimensions of conversation supported by the teacher in the Maths lessons (Figure 13.11). In Phase 1, the technology supported only interaction, collaboration and discussion.

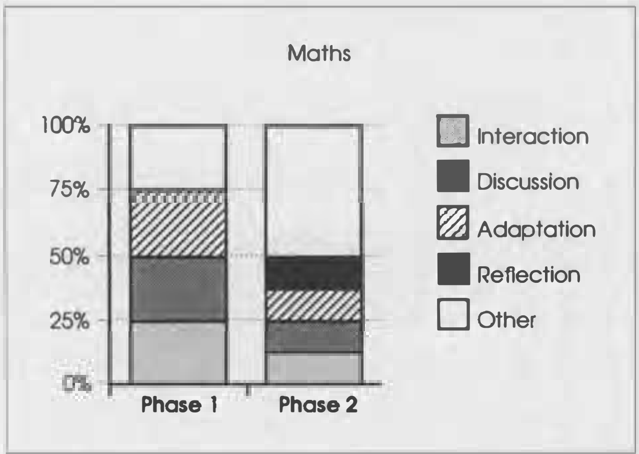


Fig. 13. 11: Computer use to support thinking in Phase 1 and Phase 2 Maths

In Phase 2, one lesson did not make use of the computer, and Figure 13. 11 shows this. Nevertheless, Lesson 4 made full use of the interactive components of the technology, and students showed higher order thinking when the teacher encouraged them to verbalise their own interpretations of mathematical concepts. This strategy ensured that ideas were shared even when the technology was not available to afford a visual dimension.

Conclusion

In summary, the teacher's pedagogy incorporated additional social dimensions in a number of respects. She created a social and collaborative context for learning by encouraging students to:

- think aloud;
- pool ideas and suggestions;
- brainstorm ideas; and

- ask questions.

Through her pedagogy she ensured that students had a clear understanding of the context in which they were learning, and of the social rules and expectations which were:

- to explain and justify ideas;
- to use mathematical language; and
- to display and explain their understandings of the tasks and investigations.

The strategies combined to create a context for student inquiry and higher order thinking. Teacher discourse in Phase 2 showed less controlling forms of talk, and a higher level of scaffolding thinking processes.

The English classroom in Phase 2

The English teacher tried to design tasks which made the topic personally meaningful to her students. In each lesson, students were given responsibility to interpret the topics by adopting a personal viewpoint or by creating a product in which they could display their own perspective. Table 13.13 shows the content and topics of each lesson.

Table 13.13: Content of English lessons in Phase 2

Lesson	Content	Teaching components
English 3	• changes that happened during the Crusades	student create a chart showing positive, negative and interesting points
	• discussion of how cultural change can occur	teacher provides stimulus for discussion
	• considering the negative aspect of the Crusades	students take on roles in order to experience the "invader" and the 'invaded"
English 4	• developing essay writing skills	students s report on their essays
	• developing an argumentative essay	students compare topic sentences and evaluate each other
	• giving examples what a good paragraph is	students provide examples from their own work

The lesson plans produced for these lessons revealed that the teacher intended that students to talk about the Crusades, to investigate ideas and to review the process of essay writing. A number of activities were planned for students (Figure 13.12).

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

   interpreting the Crusades;
   use of language to express the dominant cultural form;
   expressing ideas in an essay format.

2. Outcomes of the lesson

   essay writing skills;
   gathering information;
   developing a thesis;
   organising and expressing ideas.

3. Steps involved in the lesson

   (i) Listening skills and evaluation of writing;
   (ii)Student s read out section of essays / give and take constructive criticism;
   (iii) Review ideas and swap views with peers;
   (iv) Review the process of essay planning;
   (v) Planning for independent work;

4. List the HOT you expect your students will display.

   Active listening
   Reflection and evaluation
   Organising and categorising
   Discussion, negotiation and planning

Figure 13.12: Teacher planning sheet for English lesson 4

This lesson was part of a series of lessons on cultural change where student also learnt essay writing and research skills. Both Lesson 3 and Lesson 4 were linked, as Lesson 3 provided the ground work where students discussed ideas and then did some further homework before discussing essays based on the theme on cultural change in Lesson 4. The activities planned for this lesson included student discussion and exchange of ideas, listening to and evaluating other perspectives.

The activities in both lessons were student centred, and tasks were not imposed on students but discussed and presented so that participation and negotiation were foremost. Student contributions to the lessons therefore increased, and this affected the cognitive outcomes of the lessons.

Participation rates in talk

Participation rates for teachers and students in English Phase 2 are shown in Table 13.14. While no great difference occurred in the number of turns taken by students and teachers, teachers had considerably longer turns than students, with each turn consisting of between two and three units. The proportion of talk for teachers in comparison with student talk was also high, accounting for an average of 60% of the lessons in Phase 2.

Table 13.14 Units, turns and teacher/student ratio of talk in English lessons 3 & 4

Talk	English 3	English 4	Mean	Mean Difference from Phase 1
Teacher turns	73	79	76	+16
Student turns	72	81	76.5	+16.5
Teacher units	176	234	205	+55.5
Students units	130	146	138	+58
Teacher Ratio	58%	62%	60%	-1
Student Ratio	42%	38%	40%	+1

Nevertheless, there was an increase from Phase 2 in student turns and also in the number of communication units spoken by students. The English lessons showed no great changes in the amount of student talk that occurred in Phase 2 , and although student communication units increased by an average of 58 communication units for both lessons, the ratio of talk remained practically unchanged from Phase 1.

Table 13.14 also shows that students' participation in talk increased by 1% and that teachers still talked a good deal more than students. Nevertheless, there were changes in other aspects of student talk indicating that progress was made towards achieving higher order thinking.

Overall patterns of talk

The overview of talk shown in Figures 13.13 and 13.14 indicates that in student talk, higher order thinking increased in relation to other categories, while expository talk and procedural talk were still present. In Lesson 3, HOT accounted for approximately 15% of total talk, while expository talk took up 19% of total talk.

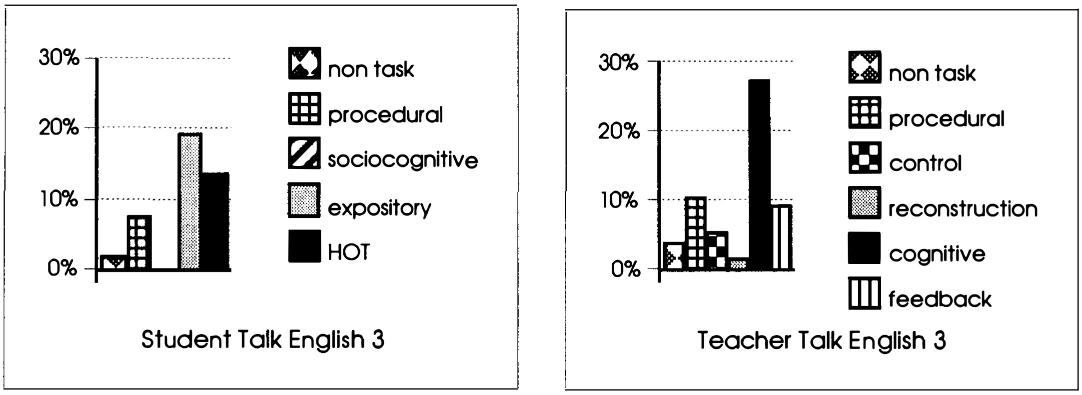


Figure 13.13: Student talk and teacher talk as a percentage of total talk in English 3

Analysis of teacher talk in English 3 showed that the single highest category was cognitive support (28% of total talk) with a similar trend in English Lesson 4. Both lessons showed that the amount of non-task and procedural talk was low (less than 10%). There were increases in both lessons in the amount of cognitive talk offered by the teacher, and a corresponding decrease in control and procedural categories.

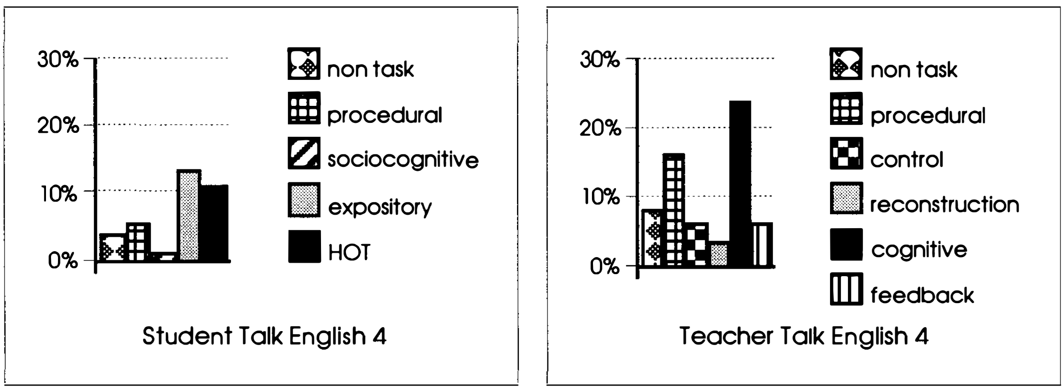


Figure 13:14 : Student talk and teacher talk as a percentage of total talk in English 4

Patterns of interaction and dialogue in each lesson were investigated further to analyse the change in quality of both teacher talk and student talk.

Changes in quality of learner talk

Throughout the study, the major issue was to bring about higher order thinking in student talk though planned interventions. In English Phase 2 this was achieved, the evidence being a marked change in the quality of student talk from Phase 1 to Phase 2 of the study as the percentages in Table 13.15 indicate.

Table 13.15: Means and mean differences in categories of student talk in combined English lessons from Phase 1 to Phase 2

Lessons	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total%
English 1 & 2	27	33	2	33	5	100
English 3& 4	8.5	17	2	42	30.5	100
Mean difference	-18.5	-16	0	+9	+25.5	

First, both non-task talk and procedural talk decreased considerably, and this meant that more of the lesson was concerned with content or cognitive understanding than with extraneous issues such as technical problems or administrative issues. Although the percentage of expository talk increased by 9%, this type of talk nevertheless was on-task, and related to subject matter.

The increase in higher order thinking from Phase 1 to Phase 2 was 25.5%, a figure that reflects a major change in the quality of student talk. The nature and context of these changes provided evidence that teacher pedagogy had changed, as had the roles adopted by students in classroom activities.

Student talk: Evidence of higher order thinking

Further analysis of the transcripts showed that in Phase 2, students displayed the language of reasoning and interpretation. Table 13.16 shows the keyword indicators for cognitive accountability, interpretation, and critical inquiry, and the increase in percentage for each category from Phase 1 of the study. There was an increase in all categories of thinking in Phase 2 of the study, and this is shown by the verbal indicators of higher order thinking in student talk. Phase 2 lessons showed occurrences of all categories of higher order thinking, with the highest increases in cognitive accountability and critical inquiry.

However, the transcripts showed that English Phase 1 had no evidence of student reflection, but English Phase 2 had 1%. The category of critical inquiry increased in Phase by 11%, indicating that students were challenging, questioning and investigating ideas throughout the lesson. Some exemplars from the lessons will serve to illustrate the nature of these higher order thinking behaviours.

Table 13.16: Keyword indicators of higher order thinking in Phase 2 English

HOT Category	Keyword Indicators	Phase 1 1	Phase 2 2
Cognitive Accountability	because, cos, so, then, therefore	2%	10%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	1%	12%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	2%	7.5%
Reflection	meta statement	0%	1%
	Total percentage of HOT	5%	30.5%

Some exemplars of higher order thinking from the lesson showed that students were not only critical of ideas, but also reflective and self-critical.

The following extract shows that students found the activity of evaluating other's ideas not only demanding but also thought provoking. In this interchange, the teacher offers cognitive support by suggesting that individuals seek help within the group and try out their ideas in order to get feedback. The exchange contains examples of metastatements, where students spontaneously reflected on their experiences with the lesson and how their understanding was improved by exposure to other students' ideas.

T	Now Tricia, if you are having any trouble doing this at the start check with the group to see if it sounds OK.	**cognitive support**
S:	Teacher, I was a bit like Tricia, I sort of couldn't really grasp the concept of what the whole thing is, like I know (.) sort of that it was an opinionative essay, and I didn't know how to set it out and how to use the information sheet (another student interrupts)	**HOT: reflection**
S:	Yes, it didn't really help much sort of you know..	**reflection**
T:	yes it is hard work, I agree that it is a form that is learned in high school but you don't come across much at lower levels, so I'm not surprised that you're having a few problems with it. Well after what we've done today, do you think you are going to find it easier to do now?	**feedback: reinforcement**

S:	Yes of course- cos we are- on - after listening to Tricias's topic sentence- her topic paragraph, and Malcolm's paragraph, and everything, we - I sort of know how to organise it a bit more. It just sort of wouldn't come to me, if you know what I mean.	**HOT : reflection**

Other examples of higher order thinking displayed in the transcripts were interpretation skills, where students expressed their own views, speculated and expressed their understandings of the Crusades. Expressions commencing 'I think' marked these interpretations.

Throughout the English lessons, the teacher created a positive and friendly climate in the classroom where ideas could be exchanged and commented on, without fear of criticism. In this atmosphere, where there was genuine reciprocity, the students offered feedback to each other and came to terms with the nature of writing and what it demanded. The following extract provides an illustration of the level of collaboration and sharing of ideas among students. The class had just finished listening to a student reading out an essay, which was in the form of a letter expressing a strong view about the injustice of the Crusades.

T	Oh, I don't know. can anybody help me out? Shall I tell Tricia to rewrite this because its not an essay shall I tell her that it does all the things that an opinionative essay should do?	**cognitive support stimulus**
S:	teacher don't want to be mean to Tricia, or anything, and its a very good essay, but - she should rewrite it again, cos it does read like an essay but she should add some things- a few things that make it more like an essay like..	**HOT: reflection**
T:	Like what?	**procedural**
T:	Like in the first paragraph she should have a topic sentence, so she could just change around the wording	**HOT: critical inquiry**
T:	Oh do you mean get rid of the "I's" and personal remarks?	**question**
S:	yes, exactly	
T:	Oh, so try to be a little more objective and perhaps include a little more fact and evidence and less emotion	**cognitive support**
S:	Ye, she's' got a lot of "I's" so that makes it sound really personal, but if you make it from general, like a group of people, not just one person, it could be better.	**HOT: critical inquiry**

The transcripts showed that in both lessons there was less teacher control over the pacing and direction of lessons, leaving more opportunities for student to engage in discussion of ideas and expression of views. Instead of questioning and directing activity the teacher listened, supported student conversation and built up resources which the students could draw on for discussion. The overall increase in higher order thinking from Phase 1 to Phase 2 is illustrated in Figure 13.15.

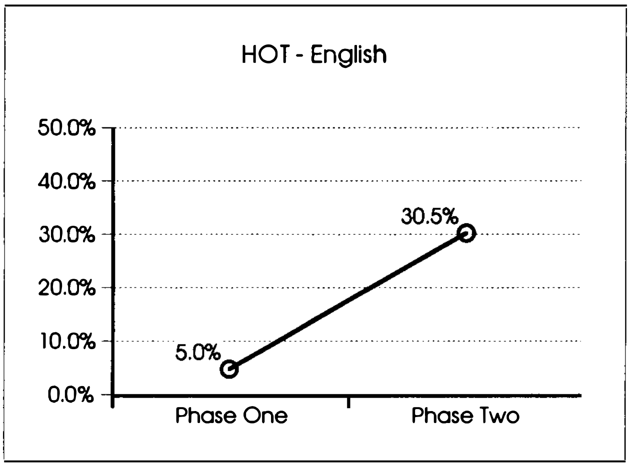


Figure 13.15: Increase in percentage of HOT from Phases 1 to Phase 2 English

Changes in teacher pedagogy

Accompanying the changes in the quality of student talk, teacher pedagogy also changed from Phase 2. The lesson plans for English 3 and 4 (Appendix 1) showed that the teacher planned for active student involvement in the lesson, with opportunities for discussion, interaction and reflection. Accompanying these trends, analysis of the transcripts showed that there was a marked decrease in the amount of control talk, where the teacher asked closed questions and set the agenda for lessons by circumscribing student talk.

Table 13.17: Means and mean differences in categories of teacher talk in English lessons from Phase 1 to Phase 2 (as % of total teacher talk)

Mean Talk in Lessons	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	total %
English 1& 2	12.5	25	30.5	3.5	18.5	10	100
English 3& 4	9	22	9	5	41	14	100
Mean difference	-3.5	-3	-21.5	+1.5	+22.5	+4	

Several major changes can be seen from Table 13.17. Overall percentages for non task talk decreased while cognitive support and feedback increased. The range of support offered by the teacher was evident across lessons, with a more open and facilitative role adopted throughout the lessons. Consideration was given to student views, and a lot of encouragement to express ideas, look at alternative view points and formulate opinions was offered to students. In this way, the teacher renegotiated classroom norms, and instead of evaluating children's contributions, she invited them to interpret the subject matter.

Apart from the teacher's change in role, there was also a greater emphasis on sharing ideas among the group, seeking feedback from other students, and on collaboration rather than competition or individual achievement. Overall, the impact of the teacher's pedagogy was to create a social setting where mutual support, reciprocal assistance and opportunities for questioning of ideas flourished.

Changes in use of computer technology

The computer technology was used to support HOT in a number of ways. The main dimensions of computer use are summarised in Table 13.18. Both lessons had minimal input by the teacher, and the screens were created by the students as explicit representations of their knowledge and ideas about the subject matter. For example in Lesson 3, the teacher provided only the initial starting points as anchors for student thinking about the Crusades, and suggested how ideas could be classified into positive, negative and interesting points about the effect of cultural clashes.

Table 13.18: Computer technology use for English Lessons 3 & 4

Computer Graphics	Lesson 3	Lesson 4
No. of screens	1	3
Prepared by teacher	headings only	created by students
student activity	write ideas on crusades	show introductory paragraphs
locus of control	shared	shared
purpose of graphic	display student ideas	brainstorm ideas
interaction by students	yes	yes
discussion by students	yes	yes
adaptation by students	yes	yes
reflection by students	yes	yes

In Lesson 3, the computer was used to present students' ideas, which were then open to revision and analysis. In Lesson 4, the visuals were created entirely by students who wrote up their own ideas, presented them to the group and then discussed them. In addition, presenting ideas in this way enabled students to revise and edit their own ideas, with input from others in the class. In this way, knowledge became socially shared and negotiable. Figure 13.16 shows computer use for Phase I and Phase 2 English.

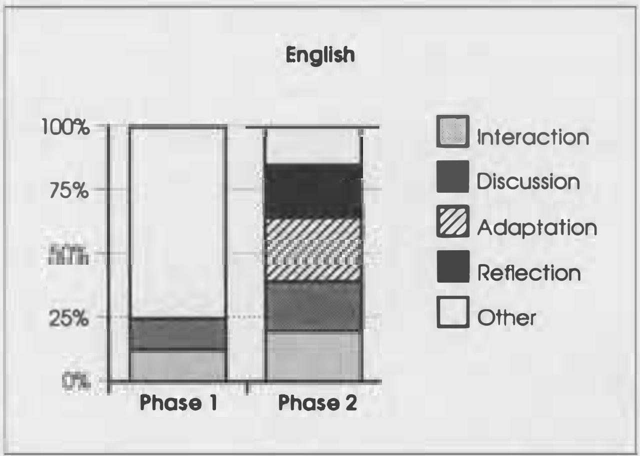


Fig. 13. 16: Computer use to support thinking in Phase 1 and Phase 2 English

In summary, usage of the computer in Phase 2 was much less controlled by the teacher and become a tool for students to represent their ideas, graphically, linguistically and pictorially. The use of the graphics tablet encouraged students in the English classes use the screen more freely, as students could depict their own ideas quite easily using the visual medium of the computer.

Conclusion

In the English lessons, higher order thinking was in evidence in student talk and interaction, as they compared ideas, discussed and elaborated their views on the ideas that were raised by the teacher. She supported student contributions, and scaffolded thinking processes by asking reflective questions, modelling thinking and providing tasks where students could show their own interpretations. The discourse pattern showed that students made more contributions to lessons than in Phase 1, and that the teacher was less directive, but more supportive. From the socio-cultural perspective of the study, the intent of scaffolding was to enable the learners to become more independent, and this was achieved by the teacher by offering opportunities for thinking in the classroom. Technology was used to encourage sharing of ideas and

collaboration among the students by allowing them to show their own views of the subject.

The Social Studies classroom in Phase 2

In the Social Studies lessons, activities were planned in order to engage students in exploring ideas about history, use of evidence and problem solving. The tasks set provided the context in which the learners interacted, talked and discussed, and found the social and cognitive resources to assist them in thinking about the ideas.

Table 13.19: Content of Social Studies lessons Phase 2

Lesson	Content	Teaching components
Social Studies 3	• understanding what history is	student speak, write and show their interpretation
	• steps in being a historian	teacher provides 4 guiding principles for discussion
	• investigation task: body at the side of the road	students take on role of detective and evaluate evidence
Social Studies 4	• continuing the role of detective in being a historian	focus on using evidence to make an interpretation: students discuss sources of evidence
	• investigating problems and finding solutions	teacher poses problems - students find solutions by asking questions

In Lesson 3, for example, the lesson centred around a discussion of history, and the teacher provided strategic direction to students by suggesting four roles, or guiding principles that would apply in using historical evidence. In Lesson 4, students were given tasks requiring them to investigate and discuss problems, in order to develop inquiring and questioning skills. Both lessons were different in kind than Phase 1, as the orientation was towards students developing independent analytic skills.

Changes in participation rates

In the Social Studies lessons there was an increase in the number of communication units in student talk and a corresponding increase in the ratio of student talk to teacher talk. In Social Studies 3, for example, student talk accounted for 51% of the lesson, while in Lesson 4 it accounted for 64% of the lesson. Thus, in both lessons, students not

only participated more, but also talked more than the teacher, in contrast to Phase 1 lessons.

Table 13.20: Units, turns and teacher/student ratio of talk in Social Studies Lessons 3 & 4

Talk	Social Studies 3	Social Studies 4	Mean	Mean Difference from Phase 1
Teacher turns	110	126.5	118	+18
Student turns	353	325	+278	+16.5
Teacher units	331	217	274	+142.5
Students units	355	388	371.5	+370.5
Teacher Ratio	49%	36%	42.5%	-22.5%
Student Ratio	51%	64%	57.5%	+22.5%

Overall, in both lessons, the mean ratio of teacher talk decreased by 22.5% while student talk had a corresponding increase. In Social Studies Lesson 4, student talk amounted to 64% of total lesson talk, a considerable difference from Phase 1 of the study.

Changes in participation rates were combined with other changes in interaction patterns and categories of talk.

Functional categories of classroom talk

The overall pattern of talk that occurred in the Social Studies class of Phase 2 is shown in Figures 13.17 and 13.18. Both lessons showed that higher order thinking occurred for approximately 15% of the total lesson time. However, in both lessons expository talk was the single highest category, varying from between 15% to 25% of total talk in the lesson.

The amount of socio-cognitive talk in both lessons remained small, showing the proportion of student talk was devoted to collaboration and interaction between peers did not increase a great deal from Phase 1.

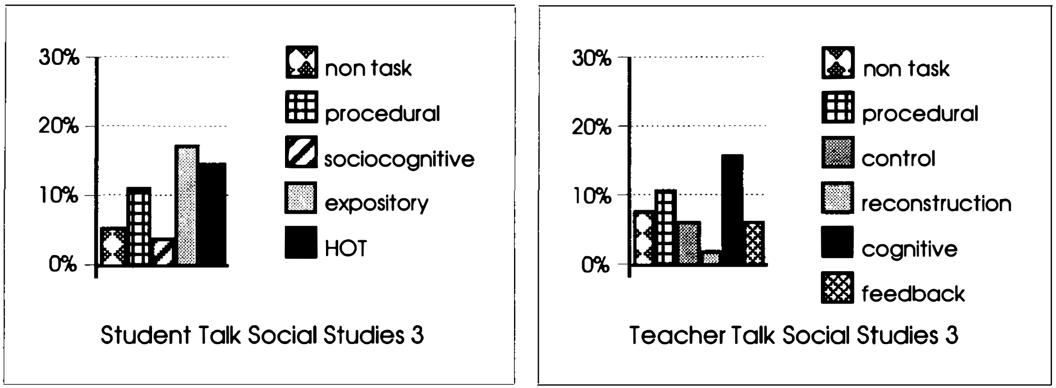


Figure 13.17: Categories of student talk and teacher talk in Social Studies 3

For teacher talk, both lessons showed cognitive support was the largest overall category, taking up approximately 15% of teacher talk in both lessons. Procedural and management functions remained prevalent in the talk, and were similar across lessons at approximately 10%.

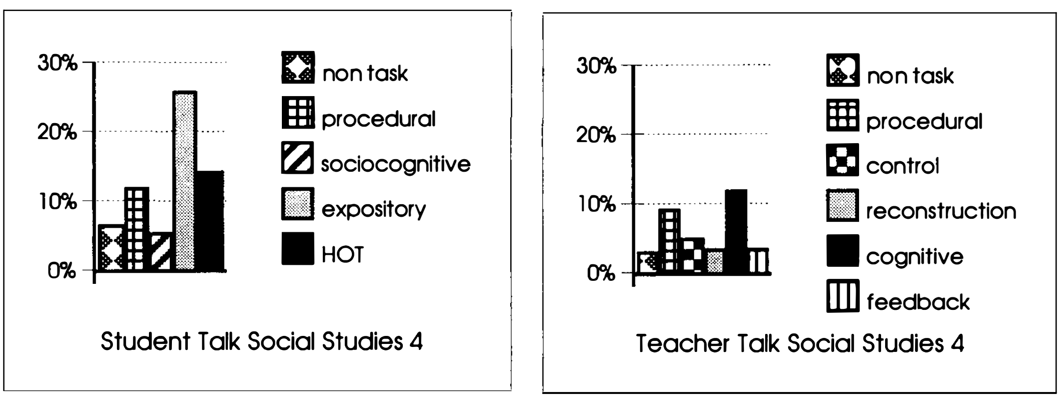


Figure 13.18: Categories of student talk and teacher talk in Social Studies 4

These patterns are confirmed in the breakdown of teacher talk into percentages according to category. Table 13.21 displays the mean percentages of all categories of teacher talk from Phase 1 to Phase 2 of the study. Cognitive talk increased by 19%, while non-task, procedural and control talk decreased. There was a small increase in reconstruction, which was the process by which the teacher rephrased or reformulated students' contributions and extended or refined them, to incorporate students' interpretations into classroom knowledge that was correct.

These changes in teacher talk can be interpreted as signalling changes in teacher pedagogy and interaction with learners, aspects which will be considered through exemplars of discourse exchanges in the classes and through analysis of the quality of student talk that occurred in the context of teacher-student interaction.

Table 13.21: Means and mean differences in categories of teacher talk in Social Studies lessons from Phase 1 to Phase 2 (as % of total teacher talk)

Mean Talk in Lessons	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	Total %
Social Studies 1&2	8	44.5	23	2.5	15	7	100
Social Studies 3& 4	12	25	14	4.5	34	10.5	100
Mean difference	+4	-19.5	-9	+2	+19	+3.5	

Changes in functional categories of student talk

Changes took place in the categories displayed in student talk, and these changes provided evidence that there was an increase in higher order thinking from Phase 1 to Phase 2 in the Social Studies lessons. Accompanying the changes in participation rates of students in these lessons, there was qualitative change in the types of talk that occurred. These results are shown in Table 13.22.

Talk that was concerned with non-task related matters decreased by 10%, while procedural talk, which related to setting up and managing the lesson and resources decreased by 19%. The increase in higher order thinking in the lesson was 25% which was a major change from Phase 1 lessons, where learner talk was mostly centred on answering factual questions set by the teacher. A small increase in socio-cognitive talk (5%), among students showed that there was greater student-student interaction, and also indicated that teacher strategies had changed.

Table 13.22 Means and mean differences in categories of student talk in combined Social Studies lessons from Phase 1 to Phase 2

Lessons	non task talk %	procedural talk%	socio-cognitive talk%	expository talk %	HOT %	Total %
Social Studies 1 & 2	20	38	1	41	0	100
Social Studies 3& 4	10	19	6	40	25	100
Mean difference	-10	-19	+5	-1	+25	

Analysis of the teacher's lesson plan and the exchanges that occurred showed that students were actively questioning and reasoning throughout the lesson. This analysis is supported by sequences of talk from the actual lessons which showed the roles and activities engaged in by students during the lessons.

The categories of higher order thinking demonstrated by students are displayed in Table 13.23. The actual occurrences of higher order thinking were established by analysing the language used by students as they engaged in reasoning processes. In Phase 2, student discourse showed that cognitive accountability, critical inquiry, and interpretation were found in student talk, and signalled the epistemic level of talk. Table 13.23 shows the keyword indicators for each of the categories cognitive accountability, reflection, critical inquiry, reflection and interpretation in Phases 1 and 2.

Table 13.23: Keyword indicators for HOT in Social Studies Phase 1 & 2

HOT Category	Keyword Indicators	Phase 1	Phase 2
Cognitive Accountability	because, cos, so, then, therefore	0%	12%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	0%	9%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	0%	4%
Reflection	meta statement	0%	0%
	Total percentage of HOT	0%	25%

All forms of reasoning were present in the lessons apart from reflection, a result which was consistent with the findings in other subject areas. Overall, the results for Social Studies show that in Phase 2, in comparison to Phase 1, there was a dramatic increase in the percentage of higher order thinking in student talk. This increase is shown in Figure 13. 19.

The activities and events of the Social Studies lessons and the structure of interactions as found in the transcripts, reflected changes in the social dynamics of the classroom and in teacher pedagogy. By investigating these elements, conditions for higher order thinking can be described for the Social Studies classroom.

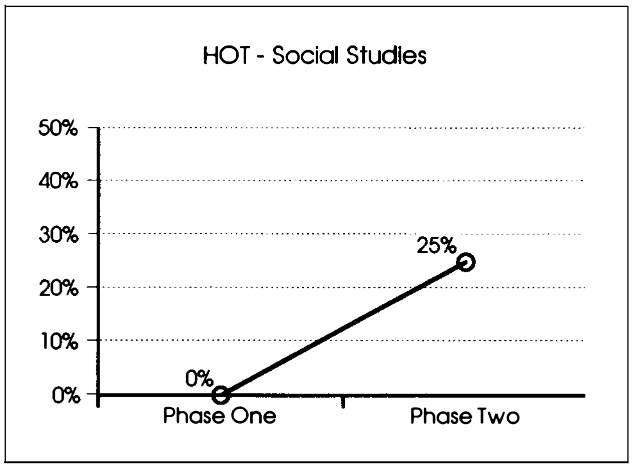


Figure 13.19: Increase in percentage of HOT from Phase 1 to Phase 2 Social Studies

The analysis of teacher pedagogy emphasised the social context of learning, the teacher's role in assisting performance, and the use of language as a social mode of thinking.

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

   Use of evidence to make an interpretation

2. Outcomes of the lesson

   Understand what is meant by evidence;
   Identify evidence relevant to given problem;
   Interpret evidence;
   Reach a conclusion based on evidence.

3. Steps involved in the lesson

   (i) Discussion of what is history?
   (ii) Discussion of historical puzzle, ways to find out information to solve a problem or puzzle;
   (iv) Present "Historical Method" on screen;
   (v) Present task "Body at side of the road" in groups, students discuss the value of evidence, the clues and information provided;
   Conclusion or interpretation must be reached.

4. List the HOT you expect your students will display.

   Analysing information;
   Interpretation;
   Discussion, debate;
   Decision making based on evidence.

Figure 13.20: Teacher planning sheet for Social Studies Lesson 3

Changes in teacher pedagogy

By looking at the teacher's approach in depth, and the strategies used to guide the construction of knowledge, it was possible to find common strands across the Social Studies lessons in Phase 2. There were some interesting differences in the teacher's style and how talk was used to support understanding across the two phases. The transcripts showed that in Phase 2 more opportunities were offered for sustained interaction among students than occurred in Phase 1. These comparisons are best considered in the light of the teacher's intention for Lesson 3, shown on a lesson plan prepared in advance. Activities, outcomes and strategies which the teacher intended to pursue are shown in the planning sheet in Figure 13.20.

The main activity of Lesson 3 was a discussion of what the term history meant to students. The teacher expected students to interpret information, discuss ideas, and make decisions based on evidence. The lesson proceeded as planned, with the students using a graphics tablet to write the question 'What is history'? on the computer screen (Figure 13.21). From the outset, the teacher emphasised that she wanted to hear students' views on events and people in history that would lead to their own personal interpretation.

The teacher's scaffolding through questions gave students scope for open-ended discussion and exploration of the topic, and no responses were evaluated, giving students possibilities to interpret the subject freely. Some of the questions asked showed a supportive and facilitating approach, as when the teacher used questions to draw out ideas on the subject and tap students' personal views.

Another strategy used by the teacher was to make a provocative statement which invited a rejoinder or disagreement. For example:

T	Some people say that history is an act of God. what do you people think they mean by that?	**cognitive support : reflective question**
S:	Teacher this is Michael. It means, <u>I think that</u> God sort of made that happen... made the history happen	**HOT: interpretation**
T:	That is right. They are saying that everything that happens, happens for a reason.	**cognitive support**
S:	like *you mean* it happens because there is some higher force, or I <u>mean</u> power?	**HOT: interpretation**

T:	Yes, that is one explanation.. but some people say that history is just the story of great men and sometimes great men.	**Cognitive support**
S:	I think that is sexist	**HOT: interpretation**
T:	Yea, right	**feedback**

This approach to scaffolding thinking did not occur in the lessons of Phase 1, and as the extract above shows, gave students the capacity to express and elaborate their views which meant that they could offer their own interpretation of events.

In the next activity of the lesson, the teacher presented the class with more evidence about a mysterious death, and students had to investigate the matter. The event was called *Body at the side of the Road*, and it gave students a sense of real inquiry as students had to sift through evidence to ascertain the cause of death. Apart from providing students with text-based information covering the background to the death, the teacher also faxed the students some pictorial material of the scene of the crime so that they could reconstruct the event for themselves. These resources created a context in which carried out the investigative task, which was put into context by the teacher who stated:

> The historian must seek out the facts, find the evidence and then weigh up the evidence to arrive at some conclusion, just like a detective.

So taking on their new role as detectives, students questioned, probed and examined the facts surrounding the fictitious death, consulting the evidence they had been given. At this point in the lesson, students collaborated, challenged and questioned each other with the common task of finding the solution. The teacher took a background role, only intervening if asked to.

S:	All we have to know about from that timetable is how many buses ran that night.	**HOT: interpretation**
S:	from two thirty to three thirty he goes to a tutorial.	**expository**
S	At nine o'clock he was supposed to be at the house. At nine o'clock in the morning wasn't it?	**expository**
S	No that could not have been the morning	**HOT: critical inquiry**
S	Yes, why not?	**HOT: questioning**

S:	Oh come on, it couldn't have been at nine o'clock at night, cos look at the diary	**HOT: cognitive accountability**
S:	In the morning?	**Feedback**
S:	That morning he had a dental appointment at nine o'clock.	**Expository**
S:	So it was at night. At nine o'clock he was going to the party and got hit.	**HOT: cognitive accountability**
S:	Yes that is what I think.	**Interpersonal**
S:	Or maybe he was coming back from the party.	**HOT interpretation**

This extract shows that for the first time, students talked to each other rather than the teacher channelling and directing all responses. In this way, the dialogue showed that the nature of the task itself influenced the interaction. At the outset of the activity, the teacher reminded students that they were in a detective role, and provided them with textual materials and resources with which to resolve the problem. In this 'situated ' context, the students participated and investigated the crime, by seeking evidence and justifying their hypotheses.

In this Social Studies class, the teacher scaffolded thinking in a number of ways. By creating a context for thinking and a social role for students, they were able to achieve a level of involvement and engagement with each other that was absent from previous lessons. This meant a transition from teacher-led discussion to student inquiry, with the teacher making only occasional interventions. The nature of these interventions showed that the teacher scaffolded thinking, by helping students to achieve their goals independently. While no direct assistance was given to students in the form of direct answers, the teacher inserted comments and verbal reminders at strategic points in the discussion to keep students on track and avoid speculation. For example she made the following comments:

"Where is there any evidence to suggest that he was on drugs? whatever you like, Mafia, mass murderer, Mafia, it doesn't really matter but you have to find evidence."

"What you have to do is decide how much of what he was doing contributed to his death. "

"What do you think the secret to being a detective is?"

"What sort of advice would you give to somebody?"

These questions signalled the transition the teacher made from the role of questioner and manager of knowledge in Phase 1, to facilitator and mediator in Phase 2. In support of this, analysis of transcripts of data showed that student talk in the lesson increased (Table 13.20). A lot of collaborative dialogue among students occurred in the course of the lesson, and students displayed autonomy and responsibility in discussing issues and presenting conclusions.

In the subsequent lesson, the teacher maintained her role as facilitator, avoiding continuous monologues and setting up contexts for exploring ideas. In addition, the teacher offered her own reflective observations and participated in the creation of understanding.

The activity of Lesson 2 was on the kind of evidence that could be used in history, where it could be obtained, and how relevant it might be. Wood (1992) proposes that when teachers display diversity in conversational strategies, and offer their own reflective observations, it can encourage longer and more animated sequences of talk from students. While Phase 1 showed that teacher talk was mostly concerned with elicitation of answers, Phase 2 displayed a range of discursive forms which helped to scaffold student thinking. The following extract provides examples of cognitive support, through explaining ideas, reinforcing and sharing in the investigation.

S:	Teacher this is Amy. You can get sort of stories from people like say my grandad's grandad told him about something, my grandad told me	**HOT: giving an example**
T:	yes stories are passed down the line.	
	stories are passed on.	**reinforcement**
S:	yes	**procedural**
S:	stories about sort of yes, what happened.	**feedback**
T:	I will tell you a story about what happened. Last Wednesday I was away from school, well I actually had an accident in the morning. I fell down the stairs and hurt my hip. OK, now a couple of students heard about that , so I heard when I came back to school that I had actually been in hospital with a broken hip, apparently!	**cognitive support: sharing ideas**
S:	(laughter) funny about stories that are passed on.	**feedback**
S:	They sort of got a bit more exaggerated as they went on.	**feedback**
T:	Yes, over time they might become exaggerated and that's one of the problems with things that are being passed on by word of mouth.	**cognitive support: explaining**

Here the main concern of the teacher was to explain and support knowledge construction by participating in the dialogue, and giving an example from her own experience. In an indirect way, this encouraged students to share their own ideas with others and to venture opinions.

Considering the transcripts and nature of student interaction throughout the lesson, it was possible to identify how the teacher' s role changed to becoming more facilitative, rather than directive. Students were engaged in tackling the real problem of sifting through evidence for the task *Body at the side of the road*, and in their roles as detectives they identified problems, found resources and facts to support their claims, resolved inconsistencies and reached conclusions. Through collaborative reciprocal dialogue they challenged each other, considered evidence and displayed reasoning in their talk. The social context and scaffolding role of the teacher made this possible, as did the supporting role of the technology.

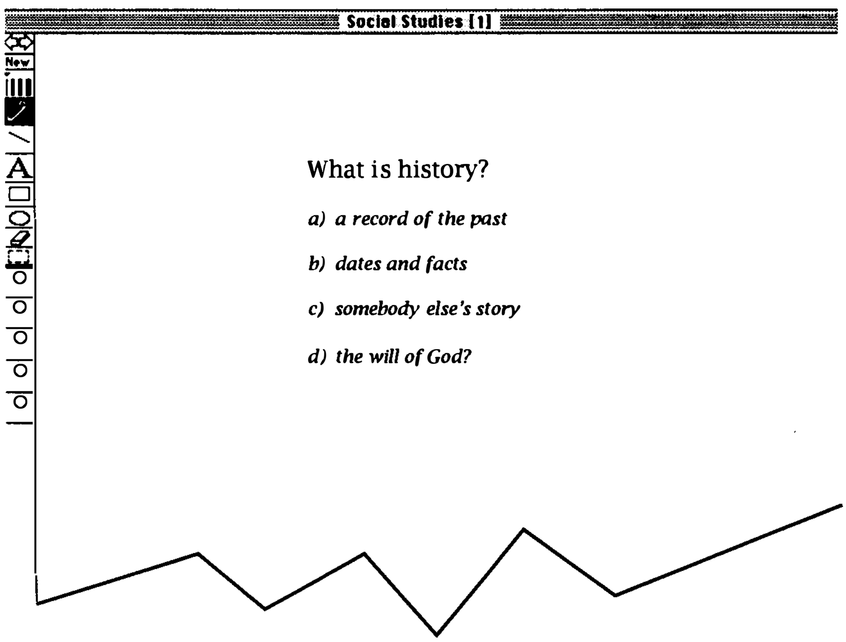


Figure 13. 21: Computer visual for Social Studies Lesson 3

Use of technology to support higher order thinking

In Social Studies 3, the teacher did not use the computer at all, but instead the students used a graphic table to jot down their ideas on 'what is history? and these ideas appeared on the computer screen where they could be modified. The graphics tablet was used throughout Phase 2 as a shared resource for writing, and each participant 'had a go' and was given an opportunity to share and display ideas with others using

this technology. This activity with the technology facilitated interaction, discussion and adaptation of ideas. Figure 13.21 shows the ideas which students produced on the computer screen, and which led to discussion and exchange of ideas.

Following this a four stage model of history was depicted on the screen displaying the steps students had to engage in to be a detective of history. This framework was then used to guide students in the activity which followed. However, this particular visual was not reflective or adaptive, and while it provided a resource or reference point for students, it did not inspire higher order cognition. The other use of the visuals in this lesson was to display facts about the activity *Body at the side of the road.*

The main dimensions of computer use for each lesson are displayed in Table 13.24 , the main difference being that in Lesson 3 the visuals were prepared by students while in Lesson 4, the teacher used visuals to stimulate discussion and to provide students with 'evidence' or resources to fuel their discussion.

Table 13.24: Computer technology use in Social Studies Lessons 3 & 4

Computer Graphics	Lesson 3	Lesson 4
No. of visuals	3	4
Prepared by teacher	no	yes
student activity	writing ideas	discussion/ investigation
purpose of graphic	generate ideas	provide visual evidence and resources
Locus of control	shared	shared
interaction by students	yes	yes
discussion by students	yes	yes
adaptation by students	yes	yes
reflection by students	no	no

Not all the visuals were supportive of all dimensions of the learning conversation, as they lacked the capacity for students to adapt and reflect on the products that were created. However, some provided a stimulus and a framework for discussion, while others merely displayed information. Table 13.24 shows the dimensions of computer technology usage in the Social Studies lessons.

In Lesson 3, students generated the ideas that appeared on the computer screen, related to the question "what is history?". Following this, another visual depicting a

four stage model of history was displayed, to how students the steps they had to engage in to be a real historian. This was used as a guide for students in carrying out the investigative task. This screen remained during most of the lesson, and while it served to structure student activity, it did not of itself inspire higher order thinking, as it was static rather than dynamic, and not adaptable by students. Furthermore, while this use of the technology achieved the purpose of giving students a resource to guide discussion, it did not help create collaboration. In fact, if the students had been given photocopies of the material this would probably have achieved the same effect. There was verbal interaction and discussion, and these resources were incorporated into the ongoing social activity of the lesson.

Figure 13.22 shows how the computer technology was used to support higher order thinking in Phase 1 and Phase 2 Social Studies. In Phase 2, there was increased use of computer visuals to support interaction, discussion and adaptation by students. In Lesson 4, the visual aspect of the computer was used only by students to record their own thoughts and ideas about the investigative process. They listened, exchanged ideas and questioned and challenged each other as part of their roles as 'detective historians'.

This discursive interaction constituted the main learning activity of the lesson, and students only used the computer to save notes on their own understandings of the lesson activities. While these notes were shared, they did not become a focus for reflective dialogue, and Figure 13.22 shows the absence of reflective use of technology.

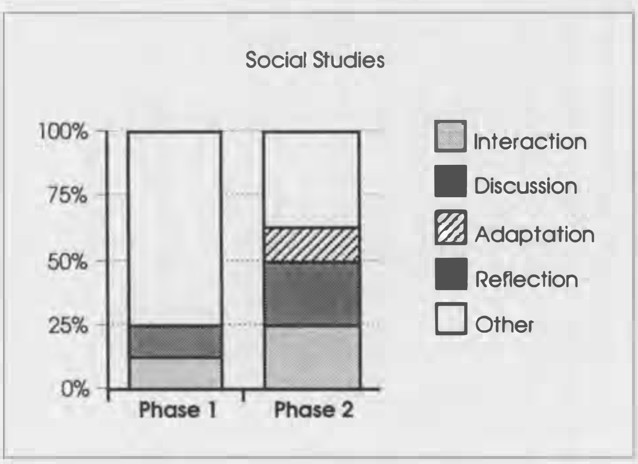


Fig. 13. 22: Computer technology use to support HOT in Phase 1 and Phase 2 Social Studies

In Phase 2 Social Studies lessons, use of technology supported higher order thinking and mirrored the discursive forms of HOT in student talk, where reflection was also absent.

Conclusion

In the Social Studies lessons, the teacher was successful in fostering higher order thinking through engaging the students in purposeful independent investigations about history and use of evidence. Both cognitive accountability and critical inquiry were demonstrated by students both lessons, but there was little reflection on the learning experiences by students. The teacher showed a range of scaffolding behaviours, including participating in the discussion with students, revealing her own thinking, and responding only to requests for assistance. The technology was used to provide a structure for discussion, but did not play a significant role in the teacher's presentation, as only one or two visuals were used to provide strategic direction for the lessons.

The Italian classroom in Phase 2

In Phase 2, the teacher adopted a communicative approach to setting tasks for students. Each lesson was planned in order to provide both new structure and grammatical knowledge, while giving students practice in using the language communicatively.

Table 13.25 shows the content of both lessons in Phase 2, and the activities around which the discourse was built. In the lessons, some changes were observed in the talk of students and in the strategies teachers used to support higher order thinking.

Table 13.25 Content of Italian Lessons 3 and 4

Lesson	Content	Teaching components
Italian 3	• vocabulary items relating to food	students give examples, teacher models
	• students practise questioning each other	teacher provides supportive help with pronunciation
	• students give examples of their own	students practise with each other and question each other
Italian 4	• asking for and giving directions in Italian	students look at a map and give directions- teacher introduces new terms
	• independent practice using the questioning forms	students practise with each other and generate new examples

The teacher planned to achieve HOT in these lessons, and introduced activities where students could demonstrate knowledge, question each other and also explore new applications for their second language.

Participation rates

Patterns of interaction and participation rates in the Italian lessons were somewhat different from other lessons. This was the students' first exposure to Italian and they had a lot of listening practice in order to pick up the sounds of the language and to learn basic expressions. For these reasons, some imbalance in the ratio of talk would be expected. Teacher talk for Lessons 3 and 4 amounted to 57.5% and 57%, which was considerably higher than for students.

Table 13.26: Units, turns and teacher/student ratio of talk in Italian Lessons 3 & 4

Talk	Italian 3	Italian 4	Mean	Mean Difference from Phase 1
Teacher turns	126	90	108	+49.5
Student turns	135	93	114	+58.5
Teacher units	157	236	196	+57
Students units	113	177	145	+72.5
Teacher ratio	58%	57%	57.5%	-15%
Student ratio	42%	43%	42.5%	+15%

Nevertheless, participation rates for students improved from Phase 1 of the study as Table 13.26 shows, with students engaging in 15% more talk. Correspondingly, teacher talk decreased by 15%. In a classroom where students were still novices in the target language, this was change of great magnitude, as students had little command of Italian and a limited vocabulary. Coupled with this change, there were other changes evident in teacher talk and in the quality of student talk.

Functional categories of classroom talk

As Figures 13.23 and 13.24 indicate, both Italian lessons had a small percentage of higher order thinking, whereas Phase 1 lessons had none. In addition, procedural talk decreased which meant that interactions were more focussed on achieving cognitive goals.

Both lessons showed similar patterns in the proportion of higher order thinking shown by students. In neither lesson did HOT exceed 5% of total talk. For teacher talk, the categories of talk showed some similarities in both lessons, with expository talk and cognitive support being the most salient features. In addition, the category of control was relatively high, reaching 14% of total talk in Lesson 4.

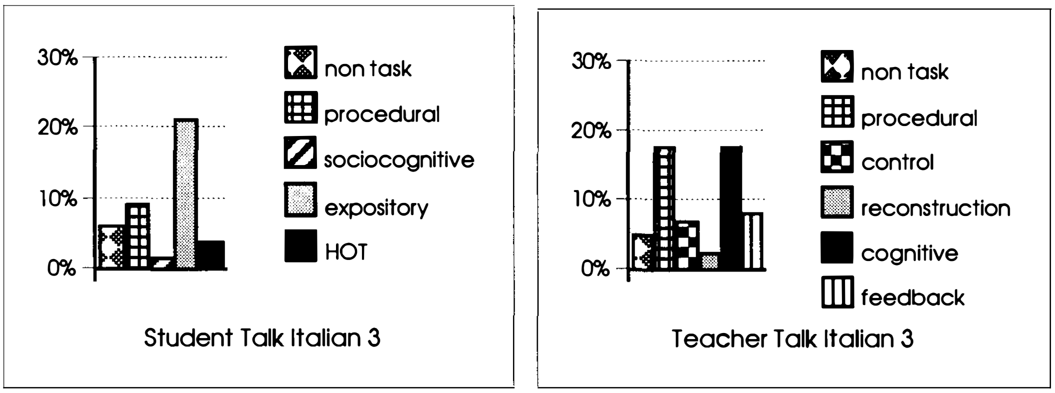


Figure 13.23: Categories of student talk and teacher talk as a percentage of total talk in Italian 3

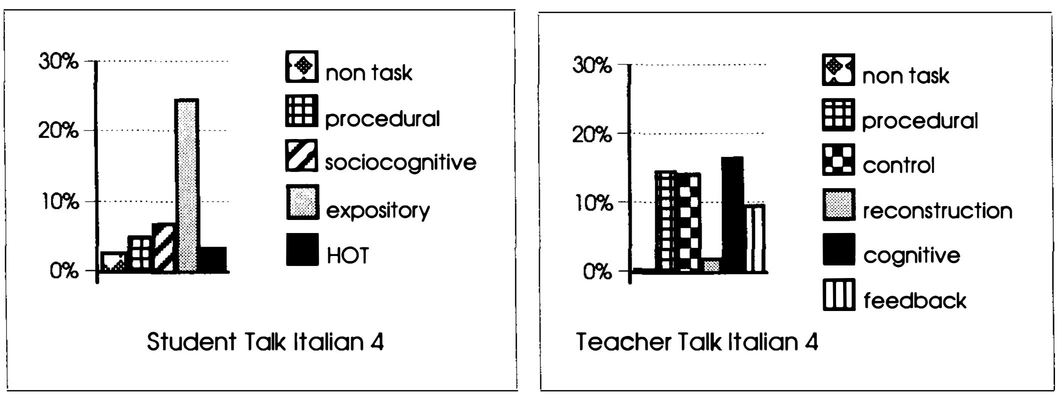


Figure 13.24: Categories of student talk and teacher talk as a percentage of total talk in Italian 4

The changes that occurred in teacher talk can be seen more precisely in Table 13.27, which shows the means and mean percentages for all categories of teacher talk. One change that occurred between Phase 1 and 2 was the decrease in procedural talk by 4.5% and an increase in cognitive support. The controlling discourse remained the same for both Phase 1 and Phase 2, but this was largely concerned with the need for the class to be structured as students practised grammatical forms in response to direct questions from the teacher.

While the amount of cognitive support offered to students was slightly smaller than in other subjects it was none the less an indicator that changes occurred in the teacher's talk. The amount of control in the lessons remained the same as in Phase 1, and observation of the videotapes of lessons showed that lessons were highly structured, and task based.

Table 13.27: Mean percentages of teacher talk by category in Italian Phase 2 combined lessons as a percentage of total teacher talk

Lesson	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	Total %
Italian 1& 2	6	32.5	18	1.5	26	16	100
Italian 3& 4	5	28	18	3.5	30	15.5	100
Italian	-1	-4.5	0	+2	+4	-1.5	

This approach may have been suited to the learners at this stage in their acquisition of a foreign language, as they had little scope to initiate dialogue and activity of their own accord. Nevertheless, there was an improvement in the quality of student talk and an increase in higher order thinking.

Student talk: evidence of higher order thinking

There was evidence from the transcripts that the quality of student talk changed considerably in Phase 2. Table 13.28 shows that procedural talk decreased by 17% and that higher order thinking increased by 8.5%. Another change was the increase in socio-cognitive talk, indicating that for a small proportion of the lesson, learners interacted and talked with each other to achieve educational outcomes, rather that with the teacher.

Table 13.28: Means and mean differences in categories of student talk in combined Italian lessons from Phase 1 to Phase 2

Lessons	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total %
Italian 1 & 2	11	33	1.5	54.5	0	100
Italian 3& 4	10.5	16.5	10.5	54	8.5	100
Mean difference	-.5	-16.5	+9	-.5	+8.5	

Further evidence of student talk can be gained from Table 13.29 which shows the types of thinking talk that occurred in the classroom, according to keyword indicators found in the transcripts.

Table 13.29: Keyword indicators for HOT in Italian Phase 1 & 2

HOT Category	Keyword Indicators	Phase 1	Phase 2
Cognitive Accountability	because, cos, so, then, therefore	0%	1%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	0%	5.5%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	0%	2%
Reflection		0%	0%
	Total percentage of HOT	0%	8.5%

Reflection was at not observed, and few metacognitive statements were found in the lessons. Interpretation of materials and texts constituted a small part of the lessons, while critical inquiry was the major part. This category was related to questioning, challenging, hypothesising and making inquiries, communicative functions which were part of the process of communication and interacting with others. The category of cognitive accountability emerged as a small proportion of student talk in Lesson 3, but not in Lesson 4.

The actual increase in higher order thinking that occurred from Phase 1 to Phase 2 is displayed in Figure 13.25, which shows that the percentage of higher order thinking in student talk in Phase 2 lessons increased to 8.5%.

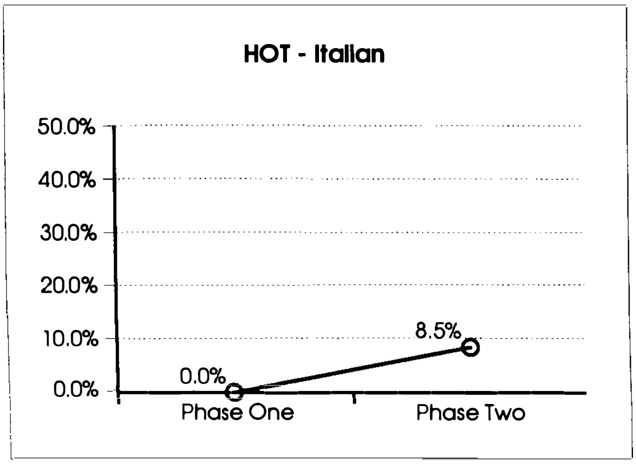


Figure 13.25: Increase in percentage of HOT from Phase 1 to 2 Italian

Most of the HOT that occurred in the lessons was related to posing questions and extending vocabulary learnt, as well as interpreting new utterances. The teacher's lesson plan for Italian 3 (Figure 13.26) showed that listening skills and questioning skills were the main objectives of the lesson and for both lesson, extending, practising and applying new vocabulary items was a pedagogic goal. Evidence from the transcripts showed that students did achieve higher order thinking outcomes by giving opinions, describing and interpreting situations and by asking questions.

Changes in teacher pedagogy

Teacher pedagogy, as discussed in the overall patterns of talk that occurred in the lesson, showed that cognitive support increased while procedural talk decreased. Apart from direct questioning of students, the teacher also required students to listen and interpret information, and match vocabulary to pictures (Figure 13.26). For example, in Lesson 4, students had a map, a set of directions and several questions they could ask. By listening carefully they were able to find their way around the map, give appropriate directions, and then apply them. For example this extract shows students engaged in a task, where they displayed evidence of higher order thinking, such as interpretation, in their talk.

T:	OK, listen carefully please. (Talks in Italian) Now Michele can you describe for me what is on your page?	**management**
S:	There is a sort of picture of a town and there is guy asking a lady where something is, I think	**HOT: Interpretation**
T:	Excellent	**praise**
S	They are trying to discuss and find out the direction to get to a certain place.	**explaining**
T:	Can you tell me please Anita where do they need to go?	**Cognitive support: Inviting response**
S:	Al museo, which is probably to the museum, cos the signposts pointing that way.	**HOT: Interpretation**
T:	Brava, excellent, it is the museum. altogether, il museo	**feedback/modelling**
S:	il museo	**expository**

The teacher used questioning and modelling strategies throughout the lesson, and scaffolded students by setting up tasks where they could engage in meaningful communicative dialogue.

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

   Asking for and giving direction in Italian.

2. Outcomes of the lesson

   Use appropriate vocabulary;
   Understand and use directions.

3. Steps involved in the lesson

   (i) Review vocabulary on directions;
   (ii) Use computer screen to show a maze, so that students can give directions;
   (iv) Writing directions;
   (v) read a map and give directions.

4. List the HOT you expect your students will display.

   Listening skills;
   Applying new vocabulary;
   Asking questions.

Figure 13.26: Lesson planning sheet for Italian 3

Overall, there was less emphasis on the teacher giving lengthy explanations and more on student participation in the dialogue. In both lessons the teaching approach could be described as guided participation, as the teacher encouraged student dialogue, questioning and interpretation.

Use of computer technology to support HOT

In both Italian lessons, the computer technology played a large part in the teaching interactions and visuals were prepared in advance by the teacher. Each lesson had a number of screens which usually displayed key vocabulary items, exercises and visual images of the target vocabulary.

Table 13.30 summarises the main aspects of computer technology use for the Italian lessons. Usage was much the same in Phase 1, with the screen being used to project vocabulary lists, and display grammatical items to remote classrooms.

At various stages the computer was used to support drill and practice forms of teaching, for example when students were asked simply to copy down long lists of vocabulary items, but this practice was limited.

Table 13.30: Computer technology use in Italian Lessons 3 & 4

Computer Graphics	Lesson 3	Lesson 4
No. of screens	3	2
Prepared by teacher	yes	yes
student activity	vocabulary practice	asking /giving directions
locus of control	shared	shared
purpose of graphic	display vocabulary	show instructions in Italian
interaction by students	yes	yes
discussion by students	yes	yes
adaptation by students	no	yes
reflection by students	no	no

In Phase 2 lessons, the teacher encouraged students to interact autonomously, and in collaboration with peers, to question, practise and apply the language communicatively. In these cases the computer was used to provide a resource for creative thinking and inquiry.

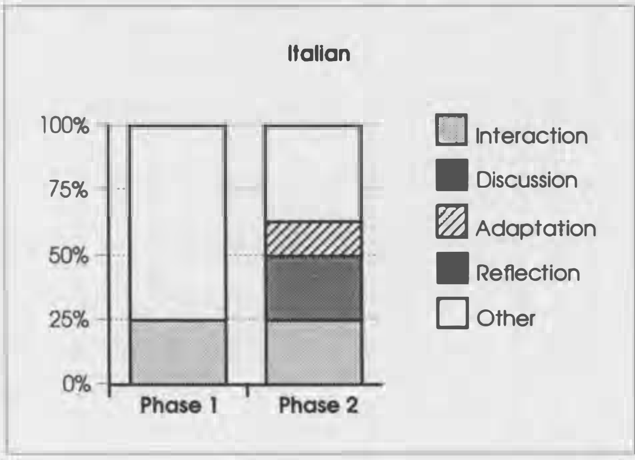


Figure 13. 27 : Computer use to support thinking in Phase 1 and Phase 2 Italian

The teacher also encouraged problem solving and language games around the computer which created opportunities for independent investigation. One such game required students to select a vocabulary item related to food or drink, and to write an initial on the computer screen. Other students then had to fill in the remaining letters of the word correctly and then pronounce it in order to win a point. The activity generated a lot of social interaction and language practice, and although students were for the most part guessing, they were nevertheless practising the target language.

There was questioning and interpretation between students during this activity. In Phase 2, therefore, the interactive and discursive components of the learning conversation were present as Figure 13.27 shows.

In one lesson, there was some adaptation by students of the teacher's notes and input, whereas in Phase 1 the computer technology was used only to display content and lesson structure, without engaging the learners in interactive discussion and adaptation of language forms to communicate with each other.

Conclusion

Analysis of the videotapes shows that the computer was used largely as a display tool in the Italian lessons, which served the purposes that a blackboard might in a face-to-face classroom. Neither of the Italian lessons engaged students in reflection on the task or on their own performance during the lesson, and although the teacher elicited expressions of students' personal experiences about for example, eating and drinking, they were engaged in critical reflection on any aspect of the lesson. Higher order thinking occurred where the teacher created opportunities for questioning and exchange of ideas, but no instances of HOT occurred without scaffolding by the teacher. Overall, while the computer technology enhanced the lesson and gave students a visual reference point, it could not be concluded that technology use directly contributed to higher order thinking.

Summary of Phase 2 outcomes

The research questions for Phase 2 of the study were largely concerned with observing and reporting on changes that occurred in:

- relative participation rates of teachers and students in classrooms talk;
- teacher talk and pedagogies to support HOT;
- student talk and the occurrence of higher order thinking;
- teaching strategies; and
- technology use.

This chapter has provided descriptive statistics for all categories of talk and compared these to results from Phase 1, to indicate that changes occurred in the quantity and in the quality of both student talk and teacher talk. In all lessons, the mean percentage decrease in teacher talk ranged from 15% in Italian, to 22.5% in Social Studies. In

Science, Maths and English the decrease was less noticeable, but in these lessons too, student talk increased as a proportion of total lesson talk.

However, the major indicator of change in the quality of student talk was the evidence found for higher order thinking.

Evidence of higher order thinking

Student talk was found to display a range of higher order thinking processes, signalled by discourse markers where students used evidence to support claims, draw conclusions, express opinions and interpret data and information. All these dimensions of reasoning were part of the definition of higher order thinking adopted for the study. However, the occurrence of reflection was quite low, and was found only in transcripts of the Maths and English lessons.

Table 13.31: Summary of mean percentage changes by subject in all categories of student talk from Phase 1 to 2

Subject	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT%
Maths	-7.5	-2	+1.5	-5.5	+15.5
Italian	-.5	-16	+9	-.5	+8.5
English	-18.5	-16	0	+9	+25.5
Science	-25	+2	+.5	+16	+6.5
S. Studies	-10	-19	+5	-1.5	+25

That the quality of student talk improved in Phase 2 can be seen in the levels of higher order thinking that occurred as compared with Phase 1. Table 13.31 shows the mean percentage changes in all categories of student talk. While all subject areas had increased occurrences of higher order thinking, English and Social Studies showed the highest percentage increases. In addition, there was an overall decrease in the amount of non-task talk and procedural talk (except for Science) indicating that more talk in lessons was related to cognitive and conceptual issues as opposed to procedural matters.

Cognitive support and teacher roles

In order to explain what elements in the classroom contributed to the increase in higher order thinking, consideration had to be given to the influence of teacher

pedagogies, social context and the role of the technology. Analysis of teacher talk categories from the transcripts showed that teachers broadened their repertoire of teaching strategies and assumed less directive roles. Evidence for this claim can be found in Table 13.32 which shows that the category of control decreased in three subject areas: Maths, English and Social Studies. The percentage of procedural talk decreased in all subjects, while cognitive support increased by varying amounts in all subject areas. Other changes that affected the dynamics of talk were the general decrease in non-task talk and an increase in feedback (except for Italian), which showed that the emphasis in lessons had changed, and that pedagogies had also changed.

Table 13.32: Summary of mean percentages changes in teacher talk by category from Phase 1 to Phase 2 in all subjects

Subject	non task %	procedural %	control %	reconstruction	cognitive	feedback
Maths	-4	-7	-3	-.5	+8.5	+5
Italian	-1	-4.5	0	+2	+3	-1.5
English	-3.5	-3	-21.5	+1.5	+22.5	+4
Science	-3	-9	-.5	0	+9	+3.5
Social Studies	-4	-19.5	-9	+2	+19.5	+3.5

One major area of change that occurred in Phase 2 lessons was the increase in cognitive support offered by teachers, which occurred in all lessons (Table 13.32). Evidence from the transcripts showed that higher order thinking occurred, or was fostered in the context of teacher scaffolding and opportunities provided by the activity and to some extent, by technology which supported dialogue and exchange of ideas. Scaffolding behaviours shown by teachers included thinking aloud, participation encouraging in discussion, questioning and offering guidance and direction.

Going beyond the surface of these changes to interpret the teacher's role was essential to understanding conditions in which HOT could flourish. Many of the lessons were characterised by a facilitative role by the teacher, where open exploration and encouragement of inquiry was made explicit. Linguistic features such as questions marked this openness and transfer of responsibility to students. Example of some of the questions asked which prompted student reflection and thinking, show that several different types were found in the transcripts:

- questions inviting collaboration and peer cooperation, as for example:

Can anyone help him out?
What others ideas can you suggest?

- questions which prompted students to interpret, and extend their thinking by offering a stimulus such as:
  Now think bigger. Think how you could change the investigation or extend it.

- 'Why' questions, or questions which elicited justifying reasons for answers. For example: *Why do suggest that?* and *Why do you think that ?*

- questions as a stimulus to discussion or elaboration. *How would you explain the solubility of sugar in relation the temperature of the solvent water?* and *What sort of things would you expect to find dissolved in sea water?* These questions were usually open, allowing students to present multiple viewpoints.

These questions encouraged students to elaborate, extend, and justify their responses. Although not all lessons showed a change to student-centred discussion, there were many appeals to learners to think for themselves. These appeals signalled a change from the authoritarian controlling role of the teacher that was evident in the Science, English, and Social Studies classrooms of Phase 1. A further dimension of the role change was that in some lessons, for example, English, Social Studies and Maths, the teacher not only facilitated discussion, but also participated in the inquiry, and became *a partner in dialogue.* This sharing, communicative role enabled teachers to participate in discussion and engage in dialogue with students, rather than constantly ask questions and elicit information. The overall effect was to create a greater sense of community in the classroom, where students and teachers participated in sharing and discussing ideas.

Technology use

With respect to technology use, teachers made more use of the interactive qualities of the computer to support dialogue and also to enabled students to represent their own ideas. Some lessons proceeded without a computer link, and yet the teacher was able to achieve higher order thinking. Overall, there was less directive teaching via the computer and more focus on enabling students to adapt or modify ideas and to create their own representations of ideas. Some of the data that emerged from application of the conversational framework to analysis of technology use showed that in Phase 1 computer visuals were mostly focussed on displaying content, but did not engage students in adaptation or discussion.

Teacher control of the computer was higher in Phase 1 of the study, but in Phase 2 this decreased as students were given the capacity to display images, and ideas which represented their understanding of lesson content. Fewer of the screens were prepared in advance by teachers in Phase 2, and so the computer was used less as a blackboard than as a forum for display of student ideas and sharing of interpretations. In the Maths classroom for example, students used the screen to work out problems, show alternative solutions and discuss results. This visual element often accompanied their reasoning strategies and enabled them to generate rules that applied to, for example, joining polygons in mathematics.

Relating the results of Phase 2 to the formative experiment

Overall, the results of Phase 2 showed that higher order thinking occurred in student talk and that other changes were observed in the telematics classrooms of the study. One immediate change that was evident was that teachers planned for higher order thinking, and made it a stated objective for their lessons. They also specified approaches they would adopt and tasks they would set to achieve this outcome. Many teachers consequently showed different teaching approaches in Phase 2 of the study both in their talk and in the activities they planned. Interaction styles were more communicative and less didactic, with less overt control of students, less elicitation of information, and a greater degree of scaffolding across all lessons, as the supportive role of the teacher emerged.

In the first intervention of the study (Chapter 12), the teachers were introduced to the operational definition of higher order thinking, and many of them could be seen to relate this to their teaching practices and lesson plans. For example, the capacity of students to show cognitive accountability was related to the teacher strategy of reflective questioning, as discussed above, where teachers actively sought to foster in students elaboration of answers and justification of responses. The adoption of a communicative approach to higher order thinking was therefore displayed in the teaching approaches of all teachers in Phase 2 of the study.

Continuing the formative experiment

While the Phase 2 classrooms showed that change was possible and that teachers were responsive to the research partnership approach, it was essential to continue with the observations and formative experiment for a further term, in order to:

- observe whether teachers were stable in the pedagogies adopted;
- observe whether students could show increased levels of higher order thinking;
- monitor changes in the social relationships and interaction patterns of teacher and students; and
- plan further interventions in order to maximise the learning environment for higher order thinking.

Chapter 14 describes the final interventions and the observational phase that followed it, Phase 3. It also reports on the changes that occurred in the levels of higher order thinking among students and the teacher practices that supported it.

CHAPTER 14

Results Phase 3: Consolidating thinking processes

Introduction

This chapter describes the Phase 3 observations of the study, prior to which a further intervention took place which was intended to foster an increase in the occurrences higher order thinking among students. The overall aim of Phase 3 was to monitor changes in student levels of higher order thinking, and observe how teachers and technology were used to support higher order thinking.

Feedback was given to teachers after Phase 2 of the study on the strategies and activities that had resulted in higher order thinking in their classrooms. This strategy was part of the researcher-teacher relationship that continued throughout the study. Teachers also had an opportunity to watch the videotapes of their own lessons and to self-evaluate their own teaching. As each teacher had different styles and approaches, it was considered inappropriate to prescribe particular strategies that teachers should adopt in fostering higher order thinking. Although no specific directives were made concerning approaches to teaching, the researcher indicated that greater student participation through discussion, peer interaction and dialogue, with less teacher control over responses was likely to achieve more student autonomy and initiation in lessons. Teachers were aware that the operational definition adopted for higher order thinking was applied in the analysis of their lessons, and that occasions where cognitive accountability, interpretation, critical inquiry and reflection occurred were documented. There was general consensus among teachers that thinking could be improved across all lessons, and that the levels of reflection were quite low.

At the commencement of Phase 3, which took place during the fourth term of teaching, teachers made use of a self evaluation form to help students perceive the relevance of higher order thinking, and to enable them to become more aware of their own thinking processes. This intervention was planned in response to the low indications in student talk of metacognitive and reflective processes. Reflection was agreed by teachers to be an essential component of higher order thinking, and in the first intervention (Chapter 12), strategies for reflective learning had been discussed with teachers as part of the overall approach to scaffolding HOT. The centrality of reflection to the conversational framework of Laurillard (1995) and to the cognitive apprenticeship model of higher

order thinking was discussed in relation to the theoretical framework of the study (See Chapter 7). This final intervention was intended to assist teachers to make thinking more visible in their classrooms, and also to enable students to become aware of their own reflective processes.

The intervention consisted of introducing students to an exercise to help them focus on higher order thinking, and to reflect on their own experience of learning. The exercise was adapted from one introduced for used in the secondary schools as part of the *Stepping Out Program* (EDWA, 1994) and is shown in Figure 14.1. Although the teachers were familiar with this strategy they had not previously made use of it. Each teacher agreed to adapt it according to their subject area and to include skills that they thought were relevant to the kinds of higher order thinking required in their subject.

How well did I use my critical thinking skills?

Name: ______________________

Topic & Task: ________________

Rate yourself by ticking the box that applies to you.

I= always
2= often
3= seldom
4= never

1. I remained focussed on the task
2. I helped clarify our aims.
3. I spoke and gave my opinion and shared my ideas.
4. I accepted responsibility and responded to questions.
5. I listened actively.
6. I explained and justified my ideas.
7. I made connections between ideas.
8. I asked questions.

Comments

My best skill is ____

I need to improve ____

Figure 14.1: Student self-evaluation form for thinking skills

The form was used by teachers and students were asked various questions about how they participated in class, whether they listened, questioned, and justified their ideas during lessons. A common strategy was adopted across all lessons for use of the thinking skills evaluation sheet. In their classes teachers were asked to:

- explain to students what each of the questions entailed;
- allow students to ask questions and clarify what kinds of thinking skills they applied in class; and
- request students to complete a self-evaluation form after each lesson for a period of six weeks.

The intention was not to use the exercise to evaluate students, but to make them aware that thinking was valued in the classroom, and also to allow them to self-evaluate their own thinking. This intervention was undertaken in order to emphasise to teachers the importance of thinking in their classrooms and to increase the occurrence of reflection in their students. In previous lessons, students did not appear to engage in reflective awareness of their own thinking, except on a few occasions during the Mathematics lessons. In addition, during Phase 3, teachers continued to write plans for their lessons, specifying the thinking they anticipated students should demonstrate as outcomes for their lessons.

The results of the observations made in Phase 3 are reported in this chapter as responses to the research aims which were:

- to monitor changes that occurred in the ratio of student talk to teacher talk as result of the intervention;

- to look for evidence was there that increased HOT in student dialogue;

- to investigate how teacher strategies changed as result of the intervention; and

- to investigate how technology was used to support higher order thinking.

This chapter is divided into several sections, according to the findings for each classroom. Each section deals with a separate classroom and examines the changes that occurred in teacher pedagogy, patterns of dialogue, teacher strategies and use of technology. Each section also focuses on changes that occurred in the quality of student thinking in all subject areas, so that the overall profile of learners and teachers is seen within the context of dialogue, interaction and participation.

Lesson plans for Phase 3 subjects are in Appendix 2 and a summary of the content and teaching components of each lesson is presented within this chapter in order to contextualise the discussion of teacher change, development of higher order thinking

and use of technology. This approach was considered to be a more concise way of surveying each lesson in terms of learner activities and teacher pedagogies.

The Science classroom in Phase 3

In the Science lessons of Phase 3, the teacher continued to teach scientific concepts and planned each lesson in order to cover the syllabus. The content of the Science lessons as shown in Table 14.1, was taken from the teacher's own lesson plans (Appendix 2), and the components show the various parts of the lesson. Higher order thinking was not explicitly mentioned to students at the commencement of the lesson, and the lesson planned showed that the teacher anticipated that HOT would occur through discussion and classroom talk that was built around the topic, the structure of the plant kingdom.

The teacher planned many of the activities so as to avoid any direct transmission of information about plants, and tried to engage students in discussion of scientific terms and principles (Table 14.1).

Table 14.1: Content of Science lessons in Phase 3

Lesson	Content	Teaching Components
Science 5	• the structure of the plant kingdom	students give examples
	• how plants are classified	students name parts and discuss their function
	• identification of why plants are important	discussion of uses of plants
Science 6	• observation, prediction and inferences as part of the scientific process.	students talk about the evidence in the visuals and make inferences
	• using visual data to produce evidence for inferences	encouragement of verbalisation and clarification
	• focus on plant structure in order to make predictions about their classification	teacher led discussion where students explain differences between plants

The teacher's lesson plan showed that the lessons were highly structured and well planned, but did not include elements where students were given opportunities to

negotiate the outcomes of the lesson. Nevertheless, the students did achieve higher order thinking during the lesson.

Changes in participation rates of teachers and students

In the Science lessons of Phase 3, there was a decrease in the amount of student talk as compared with Phase 2, as Table 14.2 shows. Teacher talk increased slightly, confirming that the teacher was still the dominant figure where talk was concerned. There was some progress in Phase 2 where the participation rates of students increased by 7.5%, but in Phase 3 this percentage dropped by 4.5%.

Table 14.2: Teacher/student ratio of talk in Science lessons 5 & 6

Talk	Science 5	Science 6	Mean	Mean Difference from Phase 2
Teacher Ratio	68%	58%	63%	+4.5%
Student Ratio	32%	42%	37%	-4.5%

Nevertheless, participation by students in Phase 3 was higher than in Phase 1. The continued asymmetry of roles in the dialogue of the Science lessons in Phase 3 was reflected in levels of student participation in the lessons, which at a mean of 37%, was considerably lower than the teacher's ratio of talk. This discrepancy also signalled the continued controlling elements in the teacher's pedagogy (Table 14.5).

Changes in quality of student talk

The lessons showed changes in various categories of talk. Table 14.3 displays the mean percentages of student talk in both Phase 2 and Phase 3 Science lessons. Higher order thinking increased by 9%. Although non-task and procedural talk increased, expository talk decreased from Phase 2. Analysis of the transcripts showed that in these lessons there was some discussion of assignments and of other events relating to the students' school activities which accounted for the increase in non-task and procedural talk. The decrease in expository talk was a positive sign, an indication that the interchanges that took place between teacher and students were less to do with information exchange, or display of knowledge and more concerned with conceptual matter.

Table 14.3: Changes in means and mean differences in categories of student talk in combined Science lessons from Phase 2 to Phase 3

Phase	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total%
Science 3& 4 Phase 1	7	21.5	.5	63	8	100
Science 5 & 6 Phase 2	12	26.5	.5	44	17	100
Mean difference	+5	+5	0	-19	+ 9	

There was an increase in higher order thinking, and as students were on-task for a greater proportion of time, they displayed more utterances where reasoning was in evidence. Although there were slight increases in non-task and procedural talk, the transcripts showed that these occurred at the commencement of lessons, and were administrative and technical matters unrelated to the teaching elements of the lesson.

Evidence for HOT in student talk

In the Science lessons, the quality of student talk improved from Phase 1 to Phase 3. Table 14.4 shows a comparison of mean percentage of language indicators of higher order thinking for each Phase of the Science lessons, and for each category of HOT, a percentage is given.

Table 14.4: Percentage of language indicators of higher order thinking in Science lessons

HOT Category	Keyword Indicators	Phases 1	2	3
Cognitive Accountability	because, cos, so, then, therefore	1%	4%	7%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	.5%	3%	7%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	0%	1%	3%
Reflection	meta statement	0%	0%	0%
	Total percentage of HOT	1.5%	8%	17%

Keyword indicators of reasoning at each stage are displayed in Table 14.4. There was a steady increase in higher order thinking from Phase 1 to 3, with Phase 3 showing that 17% of student talk displayed higher order thinking. While each component of HOT, ie cognitive accountability, critical inquiry and interpretation increased, there was no reflection displayed by students in any of the lessons. The overall increase in HOT from Phase 1 to Phase 3 is shown in Figure 14.2.

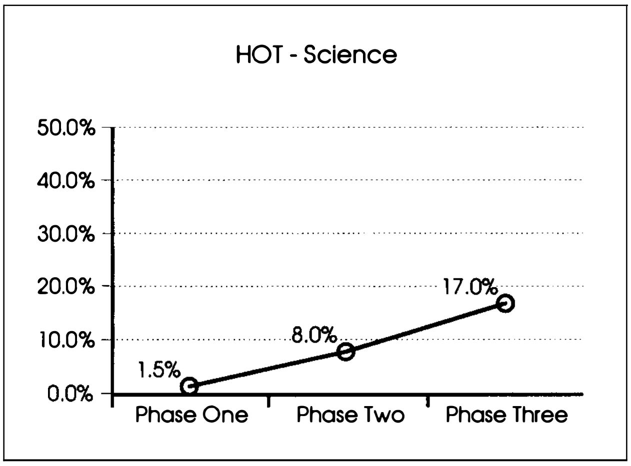


Fig. 14.2: Increase in percentage of HOT in Science lessons from Phase 1 to Phase 3

Extracts from the lesson serve to illustrate the students' and teacher's contribution to episodes of reasoning and also show how HOT was displayed in student discourse. The context of the following extract is a discussion of how and why plants are important, and students took turns giving examples, while explaining and justifying their responses. Throughout the lesson, there was an expectation of reasoning by the teacher, and students were not simply stating facts.

T:	OK Gary, what have you got so far for us? *(teacher reads from the screen)* plants, trees give homes to animals in the bush or forest and I think no trees means no animals . Ok all right fine, now lets go over to Peter, i will give control over to Peter now, you have got number 3. Just explain that one to us Peter, who wrote that?	**procedural**
S:	It was Sean	**procedural**
T:	OK can you explain that to us?	**procedural**
S:	When the trees, when they have got holes in them, so little animals live in them and possums and birds and owls and that sort of stuff and if you don't have those they won't be able to live anywhere and that is all.	**HOT: cognitive accountability**

T:	Right OK	**feedback**
S:	So if there were no trees there would be no food.	**HOT: cognitive accountability**
T:	OK, they provide a habitat or a place to live for many animals	**reconstruction**
S:	Yes	**feedback**
T:	Yes, that is quite a legitimate one. Now everyone should have the heading "why are trees important" and as we get these down we will get five. OK yours Nick, explain	**feedback/ procedural**
S:	Plants make air for us to breathe	**expository**

The extract was on the topic of the importance of trees, and each student was expected to give an example and back it up with evidence. When this was not forthcoming, the teacher asked for an explanation. The students gave many examples from their own experiences and showed initiative throughout the lesson by citing examples and justifying their responses. At one stage the students were discussing how plants purify the air and one student said:

> Teacher, someone told me that at night plants do the reverse, they breathe in oxygen and breathe out carbon dioxide, is that true?

Examples of this kind of initiative were not common in the transcripts at the early stages of the lessons, and the lesson activity did not give students scope to volunteer information. By planning lessons in Phase 3 where students discussed and debated issues, and were asked for reasons, the teacher created a more investigative atmosphere in the classroom.

In Science Lesson 6, for example, students were encouraged to make observations based on evidence presented in pictorial form, and from these observations to make inferences substantiated by evidence. This enabled students to give verbal explanations and to demonstrate accountability in their reasoning. The pattern of talk was Initiation-Response-Feedback, where the teacher initiated and the students responded. Nevertheless, student responses here did show evidence of reasoning, and were scaffolded by teacher questions.

T:	Just give me one inference about the occurrence or the observation of those footprints. Anything at all. it could be absolutely minimal or it could be an in depth inference.	**procedural**

S:	One is probably made by a human. One's made by a seagull, and...mm	**expository**
T:	OK that's fine. OK Ric, any other inference?	**procedural**
S:	Um, aah	**feedback**
T:	Anything at all?	**feedback**
S:	UM it looks like the biggest footprint is made by a man.	**HOT: interpretation**
T:	OK, why did you make that inference?	**cognitive support**
S:	Uh- it looks like a boot and its big.	**expository**
T:	Yea, OK, so one of them look quite a bit bigger than the others and you're probably suggesting it looks like a male's boot rather than a female's. Right, Paul, inference?	**feedback/ procedural**
S:	UM, all the footprints are like marching the same, and like its got one foot and the next foot is behind it instead of like, we walk with one foot and we put the other foot in front, so all the footprints there are like that.	**HOT: cognitive accountability**

Throughout the lesson, although there were instances of higher order thinking, the pattern of discourse was still initiated by the teacher, and framed by questions. This pattern of talk was prevalent in all the Science lessons, and learners were given few opportunities to talk among themselves, or to generate their own questions and offer feedback to each other. All responses were channelled through the teacher, and little scope for student-initiated inquiry was in evidence. Student reflection on aspects of their own learning, or comments on the lesson or their experience were also absent from the transcripts, and this may be attributed partly to the inhibiting effects of the Initiation-Response-Feedback pattern of talk, where the teacher initiated, students responded and the teacher gave feedback.

There were no metastatements made by students on their own learning, nor did they engage in much interpretation of what the textbook said about the subject matter. This information was taken as unproblematic, and was not integrated with the students' own interpretations and analyses of explanations in the text. The reflective component of higher order thinking was therefore low in the transcripts, and perhaps showed that the teacher regarded Science as given, rather than open to question and inquiry by students. This aspect of the teacher's pedagogy was evident in Phase 1 of the study, where the emphasis was on students getting the correct answer. Overall, the tenor of the lessons did not change substantially, and there were few discovery oriented

activities presented. However, the teacher's language strategies to foster thinking in students improved in Phase 3 lessons.

Changes in teacher talk

The mean percentage of teacher talk categories for Phase 3 are shown in Table 14.5, where means for Science Phase 3 are also displayed. In Phase 3, procedural talk accounted for 33.5% of teacher talk, and control 15%. These percentages indicate that the managerial function in talk was still prevalent. Cognitive support for students was 27%, and took the form of reflective questions, requests for extension and explanation, or invitations to question or respond to the subject matter.

Phase 3 teacher talk showed some changes from Phase 2, as Table 14.5 shows. Non-task and procedural talk decreased slightly making the lessons more focussed on conceptual content, and feedback declined slightly. The increase in cognitive support was small, at only 1%, showing that teacher scaffolding of learning did not change to any great extent.

Table 14.5: Means and mean differences in categories of teacher talk in combined Science lessons from Phase 2 to Phase 3 (as % of total teacher talk)

Mean Talk in Lessons	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	Total %
Phase 2 Science	11.5	35	15	2.5	26	10	100
Phase 3 Science	9	33.5	15	8.5	27	7	100
Mean difference	-2.5	-1.5	0	+6	+1	-3	

The increase in reconstruction was positive as it showed that student responses were being considered and rephrased or extended by the teacher, and this represented a sharing and scaffolding of knowledge. The fact that feedback declined slightly was probably a positive sign, as earlier episodes of talk showed that much feedback was evaluative in nature. In Phase 3, the teacher responded to students by reworking their contributions, sometimes rephrasing them so that they became clearer or more 'correct'. Many of these reconstructions showed the teacher offering a supportive lead in discussions.

In the following extract from Lesson 6, the teacher used a range of strategies, including scaffolding and restructuring to assist students to make inferences.

T:	OK Gary, you might have a go at this one. Anything you might say about the actual type of movement, or rate of movement of any of them?	**cognitive support: questioning**
S:	uh,. mm. well the barefoot prints were made by a person who was walking , was going a bit faster than the rest because he's like (Pause). Ross is jut annoying me , but don't worry about that.. Because the footprints are further apart.	**HOT: cognitive accountability**
T:	Yeah, that's not a bad one. because the lengths or relative distance between the prints seem to be greater, you're inferring that the person or organism with bare feet, probably human, was travelling faster relative than the others. Yea, I tend to agree with that. And what can you tell about the relative timing of those organisms or prints? Ryan?	**restructuring**
S:	Sorry, can you repeat that please?	**procedural**
T:	We are looking for something for something like a chronology here - a chronology is like a sequence of events if you like. What sequence of event would you suggest that those prints were laid down in?	**cognitive support: reflective question**
S:	The big one was made after the man and the little ones are going from the right hand were made later than the tyre track. And earlier than that the man's boot.	**HOT: interpretation**

Although the teacher still maintained control over the pace and sequence of dialogue, through the question-answer pattern students were able to extend their own reasoning and thinking. This form of scaffolding proved successful, and, as Table 14.4 shows, students did display cognitive accountability, interpretation and critical inquiry in their talk. However, higher order thinking did not exceed 17% of total student talk in the lessons, which represented a small proportion of the whole lesson.

Use of computer technology to support higher order thinking

In both lessons, the computer technology was used to involve students actively in discussion and problem solving. The teacher's influence was evident in both lessons, where screens were planned in order to illustrate syllabus content and to give students a visual stimulus for the lesson. In Lesson 5, for example, the first screen showed different types of plants in the plant kingdom and students had to classify and discuss these plants. These activities involved interaction and discussion by students (Table 14.6). In one activity in Science 6 for example, students were asked to give reasons why plants were important. Each student was given a turn at controlling the computer and writing up ideas. The initial screen displayed the question "Why are plants important"? (Figure 14. 3) and students expressed their ideas verbally and used the screen to summarise the points they had made.

Table 14.6: Computer technology use in Science Phase 3

Computer Graphics	Lesson 5	Lesson 6
No. of screens	2	2
Prepared by teacher	one prepared	yes
student activity	discussion	discuss & make inferences
Locus of control	shared	shared
purpose of graphic	stimulus	provide stimuli
interaction by students	yes	yes
discussion by students	yes	yes
adaptation by students	yes	no
reflection by students	no	no

In the same lesson, students were given control of the computer so as to depict their own ideas on the importance of plants to humanity. Each student volunteered an idea, justified it and used the computer to display the key ideas, thereby creating a focus for shared understanding. This had the effect of enabling students to adapt their own ideas, elaborate and justify them and receive feedback from other students on the ideas presented. The only aspect of the conversation framework that was missing was reflection, and this did not occur in the lesson. Students did not, for example, evaluate the points they made or self-monitor their own talk. Most responses were channelled through the teacher. Following the discussion on plants, the students simply progressed to another where they discussed plant structures.

In Lesson 6, the teacher used several prepared screens for teaching purposes, and while most generated discussion and interaction, they were not adaptive in the sense that students could take the ideas presented and change them according to their own perspectives.

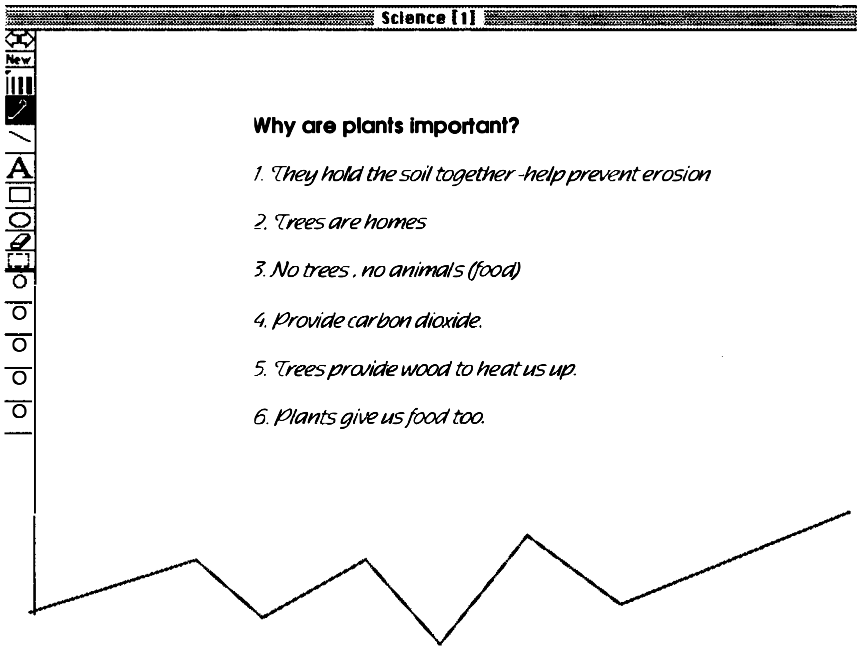


Figure 14.3: Computer visual for Science 5

The technology provided scaffolds for higher level thinking because it offered a common focus for communication, and the shared screens allowed all students to contribute to the discussion. Representing the ideas in verbal form on the screen enabled students to clarify, share and discuss their own ideas.

Overall, the technology was used to varying degrees in the Science lessons to support higher order thinking. Figure 14.4 shows the comparative uses of the computer technology to support learning from Phase 1 to Phase 3 of the study. Overall, there was progression in the use of technology to support higher order thinking, but the major change occurred in Phase 2, and remained stable for Phase 3. In Phase 1, the computer visuals afforded only discussion of the teacher's ideas, but little interaction where students could negotiate or interact with content. In Phase 2, there was progression to include interactive, discursive and adaptive elements in technology use, and students contributed to the creation of graphics such as a mind map of the lesson topic 'separating substances' (Figure 14.4).

Although Phase 3 Science incorporated interactive, discursive and adaptive dimensions of computer use, there was no reflection by students on what they had

created. In effect this meant that there was little progression from Phase 2 to Phase 3 in terms of technology use to support higher order thinking.

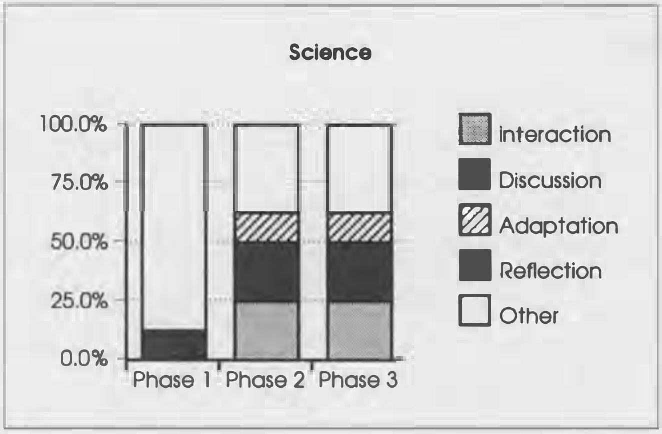


Figure 14.4 : Computer technology use to support HOT in Science lessons

Conclusions drawn from Phase 3 Science

Reflection did not occur in student talk in Phase 3 Science lessons, either in technology use or in discourse, and there were no metastatements by students showing that they were self-monitoring their own learning or commenting on their experiences. The question-answer format that prevailed throughout the lesson may have stifled opportunities for students to engage in reflection, and the transcripts showed that there was no teacher prompting of reflective inquiry. In addition, the teacher assumed a good deal of control over the problem solving strategies and did not engage in modelling practices which might have spurred students on to reflection.

While questions were used successfully to scaffold understanding, there was no recourse by the teacher to modelling of expert thinking or scientific thinking. Overall, the transcripts of Science lessons showed that students did not engage in the construction of scientific arguments which many theorists believe to be germane to the nature of Science learning (Richmond & Striley, 1996; Kuhn, 1993). This would have involved students in identifying problems, constructing testable hypotheses, designing experiments, collecting data and recognising the implications of results. While it was not possible for students to do practical laboratory work during the telematics lessons, they could nevertheless have carried out investigative tasks prior to the lesson, and then engaged in scientific argumentation.

Nevertheless, the teacher did manage to increase HOT by 9 % in Phase 3, and to scaffold learners in reasoning process. The slight increase in cognitive support in Phase 3 showed that the teacher was maintaining her effort to support higher order

thinking through reflective questioning. The lessons continued to reflect a large amount information exchange and the procedural aspects of scientific practice. Overall, the intervention to improve reflection in students was not successful in the Science classrooms.

The Maths classroom in Phase 3

The communication and thinking that occurred in Phase 3 Maths must be considered in the context of the activities that occurred during the lesson, in order to understand the opportunities provided for students to engage in reasoning activities. Table 14. 7 shows the activities and teaching components that comprised the lesson.

Table 14.7: Content of Maths lessons in Phase 3

Lesson	Content	Teaching components
Maths 5	• solving equations by doing and undoing	students do examples on the computer screen
	• construction of a flow chart to show backtracking operations	students construct their own flow charts and compare approaches
	• use of language to describe backtracking	encouragement of students to use language to describe backtracking in their own words- verbalisation & elaboration of ideas
Maths 6	• extending investigations of octagon loops	students talk about the examples they tried using different shapes
	• searching for principles, rules or patterns that can be applied	encouragement of verbalisation and reflection on findings
	• brainstorming activity to find general principles for carrying out an investigation and extending it	modelling brainstorming activity;encouragement of group cohesiveness and sharing of ideas

In Lesson 5, students were engaged in backtracking, or checking the solution to a problem by going back through the operation and stages that brought them to the answer. Students presented puzzles to other students during the lesson and checked their answers and problem solving approaches. Lesson 6 entailed students investigating and extending their own findings on octagon loops and applying their knowledge to create a written report on the exercise.

Changes in participation rates of teacher and students

In the Maths lessons, the proportion of teacher talk remained quite high throughout Phase 3, with the teacher ratio of talk at an average of 54% (Table 14.8). The mean percentage of student talk for both lessons was 46%, taken as a percentage of all talk that occurred in lessons.

Table 14. 8: Ratio of teacher and student talk in Maths Lessons 5 & 6

Talk	Maths 5	Maths 6	Mean %	Mean Difference from Phase 2
Teacher Ratio	49%	59%	54%	-4.5%
Student Ratio	51%	41%	46%	+4.5%

Nevertheless, student talk increased by 4.5% from Phase 2 of the study, showing an improvement in participation rates of students. Related to this there was a decrease of 4.5% in teacher talk.

Changes in quality of student talk

Looking more closely at the functional categories of student talk in Phase 3, some changes can be observed in the quality of discourse and in the level of higher order thinking. Table 14.9 shows the mean percentages of each category of talk in Phases 2 and 3, and enables comparisons to be made. In Phase 3, non-task talk constituted 14.5% of total talk, as did procedural talk, representing an increase on 2.5% from Phase 2. Procedural talk amounted to 15%, decreasing by 7% from Phase 2. The percentage of expository talk remained the same, at 45%. Higher order thinking also remained stable, at 19.5% for both Phases.

Table 14.9: Means and mean differences in categories of student talk in combined Maths lessons from Phase 2 to Phase 3

Combined Lessons	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total %
Maths 3& 4	12	22	1.5	45	19.5	100
Maths 5 & 6	14.5	15	6	45	19.5	100
Mean difference	+2.5	-7	+4.5	0	0	

Looking at the transcripts, these results can be accounted for by examining the context of exchanges that occurred at the start of lessons. At the early stage of Phase 3 lessons, the teacher had some difficulty with the technology and had taken a different approach which entailed sending a disk with lesson notes to students at the remote site, and using it instead of sending screens throughout the lesson. This was not a success and the teacher lost a lot of time trying it open both her own and students' disks simultaneously. The result was that non-task talk increased by 2.5% (Table 14.9). An interesting change that occurred during Phase 3 was that the level of socio-cognitive talk increased, showing that students interacted more with each other, and exchanged ideas.

Evidence of higher order thinking in student talk

Figure 14.5 shows that there was no increase in higher order thinking in the Maths lessons of Phase 3. This fact was a lot to do with the task and the need for students to check answers and correct procedures rather than to dwell on the actual processes by which they arrived at their solutions. In both Phase 2 and 3 student HOT was recorded at 19.5%. The fact that the level thinking remained static can be interpreted both as a sign of stability in teacher approach, and on the other hand, an indication that the lessons in Phase 3 did not offer greater opportunities to students to display increased thinking and reasoning.

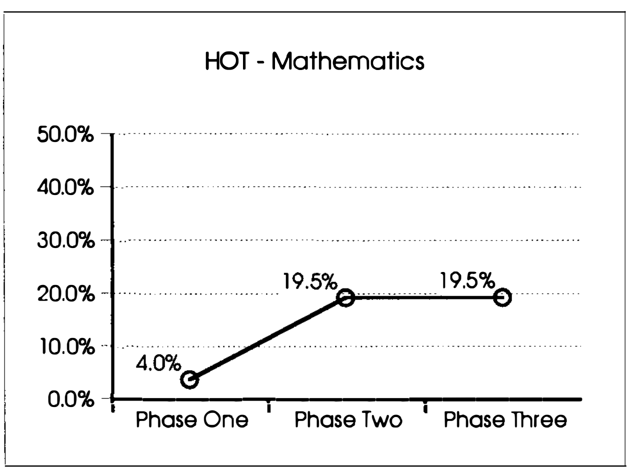


Figure 14.5: Percentage of HOT in Mathematics lessons from Phase 1 to Phase 3

Looking more closely at the discourse that occurred in the Maths lessons and the occurrence of language indicators of higher order thinking, there was a small increase in reflection in Phase 3 where students made a metacognitive statement about their

own learning or about the learning process. Keyword indicators of higher order thinking are shown in Table 14.10.

An interesting observation was that the tasks planned by the teacher for Lesson 6, showed that the teacher intended that students should work out the rules for joining octagons loops and then represent these in algebraic form.

Table 14.10: Keyword indicators for higher order thinking in Maths lesson Phase 1, 2 and 3

HOT Category	Keyword Indicators	Phases 1	2	3
Cognitive Accountability	because, cos, so, then, therefore	2%	8%	7.5%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	1%	7%	8%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	1%	3.5%	2%
Reflection	meta statement	0%	1%	2 %
	Total percentage of HOT	4%	19.5%	19.5%

The students had, earlier in the term, worked on octagons and deduced rules for joining them, and in this lesson they revisited these rules and converted them to algebraic notation. In addition, they focused on extending these rules and making predictions. The purpose of Maths Lesson 6 was to enable students to develop awareness of the process of investigation. Students were encouraged to reflect on their own thinking processes, as the following extract shows.

T:	Can anyone make a suggestion. What was the first kinds of thing that you did when you were given the investigation?	**cognitive support: questioning**
S:	The first thing I did?	**procedural**
T:	The first thing that you did.	**procedural**
S:	Did you ask the first thing that I did, that we did when we did the investigations? I just thought of how I could do them differently and how the shapes on the inside could be different.	**procedural**
T:	So you started off by drawing the shapes?	**feedback: checking**

S:	Yes I just drew the ones you had, and I thought, how could I alter them?	**HOT: reflection**

At various stages in the lesson, the students reflected on the processes they were going through and showed, in the way they talked about their investigations, that metacognitive awareness was part of their reasoning in mathematics. (The underlined utterances show reflection in student talk.)

T:	We explored outside edges or external edges, and what are you going to do now then you have fully investigated one line of inquiry, what would the next step be?	**cognitive support: questioning**
S:	make it better	**feedback**
T:	Yes you always improve	**feedback**
S:	It will get easier if you like, work on it..	**HOT: reflection**
T:	say that again	**feedback: checking**
S:	Do more work on it, like you might have it but you are not quite sure so just do some more just to make sure yourself	**HOT: reflection**

Throughout the lesson, students demonstrated the capacity to give reasons in support of their views and awareness of their own thinking processes while investigating octagon loops. In this aspect, the Mathematics lessons did demonstrate greater emphasis on reflection, as the intervention had intended.

As in other phases of the Maths lessons, the teacher actively supported thinking and reflection by scaffolding students thinking processes by reflective questioning and by modelling problem solving. Also by focussing on language use and enabling students to adopt the register of mathematics in their own explanations, the teacher fostered metacognitive awareness. In Phase 3, students also verbalised their thinking about the processes by which they inferred rules about joining octagons.

Changes in teacher talk

Teacher talk in Phase 3 Mathematics showed that non-task talk was 17%, and may have accounted for the similar increase in non-task student talk observed in the transcripts (Table 14.11). Although teacher talk did not change a great deal from Phase 2 of the study, both procedural and control categories decreased, and indication of an

increased focus of cognitive objectives in the lessons. Cognitive support, the major category where teachers assisted students, increased by only .5%.

Table 14.11: Means and mean differences in categories of teacher talk in Maths lessons from Phase 2 to Phase 3 (as % of total teacher talk)

Mean Talk in Lessons	non task %	procedural %	control	reconstruction	cognitive	feedback	Total %
Maths 3& 4	10	27	12.5	4	30.5	16	100
Maths 5 & 6	17	23	9	4.5	31	15.5	100
Mean difference	+7	-4	-2.5	-.5	+0.5	-.5	

Non task talk increased by 7%, largely on account of the teacher having initial problems with the modem connection and the students using disks at the remote sites instead of receiving visuals via the modem link. The other difference between Phase 2 and Phase 3 was that teacher control was relaxed further, enabling students to initiate, question and assume responsibility for their own learning. This approach was consistent with the 'handover of control' that is required for students to become independent learners and thinkers (Chapter 5).

The lesson showed that not only did the teacher use questioning to scaffold learning, but also she encouraged group cohesiveness, sharing and verbalisation of ideas and extending students' thinking strategies by emphasising the language of mathematical thought.

T:	So you could make predictions from your conjectures and then you could test it by drawing it. What is the next thing you would do?	**cognitive support: scaffolding**
S:1	write it up	**feedback**
S:2	Say why it works	**feedback**
T :	Yes you could it write it up or anything else as to why it works?	**cognitive support; reflective question**
S:	why it works?	**feedback**
T:	Yes you are looking and that is a very important step, you need to explain and find the rule if you can work out. Well why does the algebra work for you? Can someone explain why the formula E equals 6T works?	**cognitive support: scaffolding**

S:	Because on each octagon there are eight sheets but on- eight sides- but each of those are touching another octagon so you have the number of octagons .	**HOT: cognitive accountability**
	Take the 2 away that are touching it by the amount of octagons that you have,	**HOT: rule making**
T:	That was a wonderful explanation	**Feedback**

In this extract, we see the teacher offering various kinds of support to two students (S1 and S2) extending their thinking through reflective questioning, providing supportive feedback, and guiding thinking by regulating the difficulty of the task by taking each stage in a piecemeal approach.

Another scaffolding function that was displayed in teacher talk was to encourage team cohesiveness and collaborative thinking as the following short exchange indicates. In addition, there was an emphasis was on the use of language to express ideas clearly. In this extract, the teacher shows two forms of cognitive support: encouragement to students to share ideas and also to use mathematical language.

S:	This is Ross. I put copyright on my idea. You can't copy it.	**procedural: interpersonal**
T:	OK we are calling it pooling ideas at this stage	**cognitive support**
S:	I will buy it	**feedback**
T:	OK and the last bit is how you use mathematical language, and that is saying OK you will use the term edges instead of sides um that your verbal and written report um is clearly understood, and it is clearly understood what you do.	**cognitive support**
S:	could you use vertices?	**checking**
T:	Yes you could use vertices for the corners , excellent	**feedback**

The discourse shows that the teacher encouraged students to share ideas, to collaborate and work as a team rather than in competition. This sharing and building of knowledge is characteristic of an approach to fostering higher order thinking through a *community of inquiry* (Coles, 1995) where each participant contributes to collective discussion, is listened to and the emphasis is on the co-construction of knowledge. Unlike the interactive mechanism that operated in the Science classroom, where teacher initiated most exchanges and evaluated students' responses, the Maths teacher had strong student-centred pedagogies which involved students talking to,

and supporting each other. This form of collaborative talk was also found in the Social Studies and English lessons of the study.

Use of technology to support higher order thinking

In both lessons of Phase 3, the computer was used by students to describe and depict their own conceptions of the subject matter. For both lessons, students had control over the technology and used it to create screens, solve problems and carry out investigations. Table 14.12 displays the dimensions of computer use for Lessons 5 and 6.

Table 14.12: Computer technology use in Maths Lessons 5 & 6

Computer Graphics	Lesson 5	Lesson 6
no. of screens	2	1
Prepared by teacher	one prepared	no
student activity	discussion & mind map	create a mind map
purpose of graphic	present a problem	expression of student ideas
locus of control	shared	students
interaction by students	yes	yes
discussion by students	yes	yes
adaptation by students	yes	yes
reflection by students	yes	yes

Maths Lesson 5 concerned problem solving and showing how solutions to problems could be checked by backtracking, or reiterating the steps that had been followed to achieve the solution. In these activities students took the lead, requiring only prompts from the teacher. In Lesson 6, students created a mind map of the investigation, (Figure 14.6) showing how they would proceed from the practical work they had done in class, to abstracting this and presenting it in the form of a written report.

The different dimensions of computer technology use are shown in Table 14.12 , and both Maths lessons demonstrated all four elements of the 'learning conversation', by providing scope for discussion, adaptation, reflection and interaction by students. As an example, the computer visual created by students in Maths Lesson 5, which emerged from a brainstorming exercise was an example of shared cognitive effort, reflection and negotiation. The mind map shows how students developed a plan to set out a report based on their investigation of octagon loops.

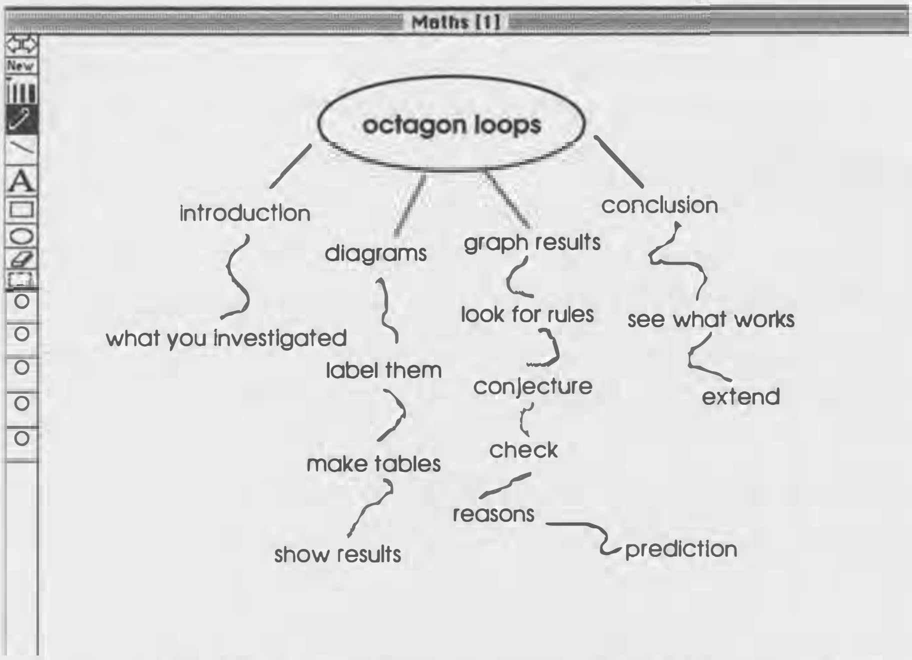


Figure 14.6: Mind map created by students in Maths lesson 5

The important aspect of this process was not the actual creation of the map itself, but the language and discussion through which the ideas emerged. The technology supported students and gave them a 'joint problem-space' (Teasley & Roschelle, 1993) by enabling reciprocal understanding between students.

Looking at the overall pattern of results from analysis of computer technology during all 3 Phases of Maths, there were some changes from Phase 1 to Phase 3, as Figure 14.7 shows.

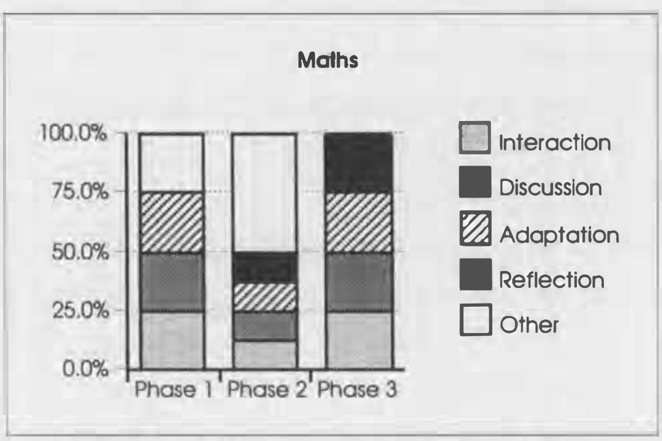


Figure 14.7: Computer technology use in Maths lessons

Phase 1 of the study displayed all interactive, discursive, adaptive and reflective dimensions, as students used the computer screen extensively for resolution of problems, display of alternate ideas and working out of solutions. From the outset,

control of the technology was shared and although the initial problem or task was set by the teacher, and students assumed control and shared the technology for the purposes of communication and to display their own representations of tasks. In Phase 2, one of the lessons had a technical failure and the teacher relied on the audio link, so no screens were used throughout the lesson. In the one lesson that did make use of computer technology, all four dimensions of the learning conversation were present. In Phase 3, as Figure 14.7 shows, there was interaction, discussion, adaptation and reflection in technology use, as students controlled the screen, presented and discussed their ideas without direct assistance from the teacher.

Overall, the technology was used in Maths Phase 3 to support discussion and provide a forum where students could present their ideas, reflect on what they had achieved and interact with each other. The major difference in technology use in Phase 3 was that all dimensions of the conversational framework were used in the visuals created (Figure 14.7), and that student thinking was supported by the displaying, sharing and revision of ideas that the computer technology afforded.

Conclusions drawn from Phase 3 Mathematics classroom

Although Phase 3 Mathematics did not show an increase in student HOT, in other respects, the results suggest that the intervention to increase reflection was successful. Student discourse showed a small increase in reflection, and this finding was supported by analysis of computer interaction, where students created screens which assisted them in reflecting on the processes of investigating octagon loops. The computer helped students to articulate their own understandings of the subject, share ideas and allowed them to apply this knowledge in constructing a model or plan to report their findings. These elements of learning encompassed the adaptive, discursive, interactive and reflective elements of the conversational framework Laurillard, (1995).

The teacher's pedagogic practices reflected the dimensions of socio-cultural learning in many ways: not only by focusing on the role of language but also by fostering the generation and extension of ideas through brainstorming and prediction. In this way, the teacher scaffolded learners, and supported them through various forms of guided support (Chapter 7). The participatory roles of the students were reflected in their membership of an extended classroom, where they contributed ideas and participated in discovery-based activities and exchange of ideas with other students in geographically remote classrooms. Furthermore, the teacher's consistent emphasis on articulating ideas through talk emphasised language as the partner of thought and

reflection. This particular cognitive strategy supported the socio-cultural thrust of the interventions in Phase 1 and Phase 2.

The English classroom in Phase 3

In the English lessons of Phase 3, a number of activities took place which enabled students to engage in argumentation and reasoning. In the context of these activities, engagement in the discourse of higher order thinking processes was analysed. Both Lesson 5 and Lesson 6 were on a related theme: the impact of historical change on society and culture. The teacher promoted an experiential approach to development of understanding: through engagement with the conceptual level of the topic at a personal level, students were able to contextualise past events and participate in constructing their versions and view of events. Table 14.13 shows the content and components of the English lessons for Phase 3.

Table 14.13: Content of English lessons in Phase 3

Lesson	Content	Components
English 5	• the industrial revolution and changes that occurred	students read out journal entries revealing their attitudes as people who experience the changes
	• aspects of religious, social and cultural change	encouragement of students to present and share ideas
	• creation of a social document or history which reflects the attitudes of the time	opportunities for students to venture ideas, reflect and also comment on each others' ideas
English 6	• life in the middle ages	students construct a concept map in order to generate ideas
	• development of a reasoned argument using data from history	students are encouraged to support statement and to challenge and argue on aspects of the topic
	• brainstorming ideas on life in the middle ages	encouragement of verbalisation, and elaboration and justification of ideas.

For example, in English 5, the topic of change during the Industrial Revolution was used to enable students to write journal entries where they assumed the role of a character living at the time. Thus, by immersing themselves in the culture of that particular period in history, students were able to enact authentic conversations based on their views. Each student produced a diary, and the written record of their

thoughts was read aloud to the group and shared, while other class members were encouraged to comment on the ideas. This collaboration led to critical evaluation and reflection by both the writer of the journal and by other the students offering different perspectives. The activities were student-centred, and the teacher fostered student-student dialogue and reflection throughout the lesson.

Changes in participation rates

In Lesson 5, the teacher had planned tasks and activities which would enable the students to become engaged on a personal and experiential level with the changes that had occurred during the Industrial Revolution. The participation rates in talk showed some changes from Phase 2, as Table 14.14 shows. Student talk increased by 17%, and students had a higher number of communication units than the teacher, and consequently a higher percentage of the total talk in the lesson.

Table 14.14: Units, turns and teacher/student ratio of talk in English Lessons 5 & 6

Talk	English 5	English 6	Mean	Mean difference from Phase 2
Teacher Ratio	45%	41%	43%	-17%
Student Ratio	55%	59%	57	+17%

This reversal of the balance of talk in favour of students occurred only in the English and Social Studies lessons in Phase 3. With it came other changes in the quality of student talk. Table 14.15 shows that socio-cognitive talk increased by 3% from Phase 2, indicating that students interacted more with peers, exchanged views and supported each other. Expository talk which was concerned with display of information or responses to questions declined, while higher order thinking increased by 10%.

Table 14:15: Means and mean differences in categories of student talk in combined English Lessons from Phase 1 to Phase 2

Lessons	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT%	Total%
English 3& 4	8.5	17	2	42	30.5	100
English 5 &6	7.5	17	5	30	40.5	100
Mean difference	-1	0	+3	-12	+10	

Expository talk decreased too, showing that the quality of student discourse changed in the lessons from a focus of information and facts to a concern with cognitive processes and higher order thinking. The transcripts showed ample evidence of a change in the quality of student talk.

Evidence for HOT in English Phase 3

In order to investigate the actual occurrence of higher order thinking in the English lessons, the transcripts were analysed for discourse features of reasoning and thinking. Table 14.16 shows the percentage of keyword indicators for each phase of the English lessons, according to the categories of higher order thinking defined in the study. The use of computer-based text analysis of transcripts to identify features of language relevant to thinking provides systematic evidence that there were differences in the quality of talk between the observation stage (Phase 1) and the post intervention stages (Phases 2 and 3). Table 14.6 shows the marked increase in the percentage of keyword indicators for critical inquiry from Phase 1 to Phase 3. This showed that students questioned, challenged and hypothesised a great deal more than they did in Phase 1.

Table 14.16: Keyword Indicators of higher order thinking in English lessons

HOT Category	Keyword Indicators	Phases 1	2	3
Cognitive Accountability	because, cos, so, then, therefore	2%	10%	12%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	1%	12%	15%
Interpretation	It means, that means, it says, I think, always, never, for example, whereas	2%	7.5%	11%
Reflection	meta statement	0%	1%	2.5%
	Total percentage of HOT	5%	30.5%	40.5%

In Phase 2, students demonstrated increased cognitive accountability, and justified their ideas and views. Each component of higher order thinking increased further in Phase 3.

The final intervention which focussed on increasing reflection was successful for the English lessons, though the increase was only 1.5%.

The overall increase in higher order thinking throughout the 3 Phases of the study is shown in Figure 14.8

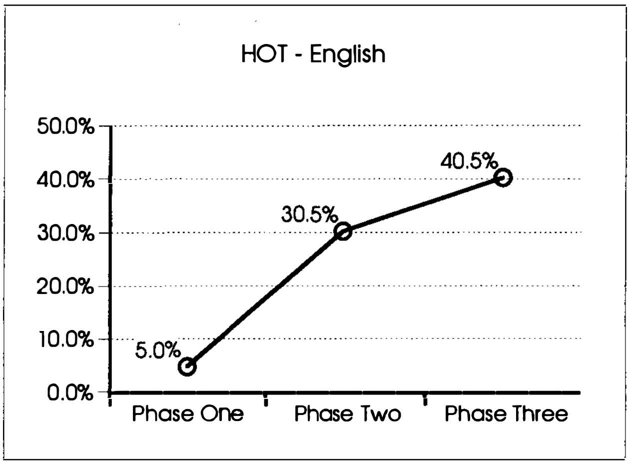


Fig. 14.8: Increase in percentage of HOT in English lessons from Phase 1 to Phase 3

Examples of higher order thinking from the transcripts provided evidence that learners were capable of reasoning both in the context of teacher scaffolding, and on occasion, engaged in self-initiated dialogue where the task was conducive to discussion and argumentation. Collaborative tasks enabled them to express ideas, to be self-directed and to reflect on their own learning. The following extracts provide examples of cognitive accountability, where claims are supported by reasons, and of critical inquiry, where learners investigated and questioned possible alternatives.

The extract is taken from English Lesson 5, where students were reading out their journal entries and listening to others' comments and responding to them in a reflective and critical manner.

S	Okay this is my first one. *(Student reads extract)*	**procedural**
T:	Okay that was very good. Melissa what do you think of that?	**cognitive support:**
S:	Anita or Melissa?	**procedural**
T:	Melissa	**procedural**
S:	Right OK I think she is like sort of realised money isn't everything in the world even there are other things and in her whole life like others and so	**HOT: Interpretation**

T:	yes in fact people often did, there were a lot of very fine reforming people, during the Industrial Revolution, a lot of people often did some very good work for others.	**modelling**
	Anita what do you think of Diana's.?	**procedural**
S:	I thought it was really good it like looked at ( ) isolation and how it really sort of changed them and now like they are realising sort of like you know how people have had near death experiences and they think they will be re-born like they have started a new life and become thankful for what they have got?	**HOT: interpretation**
T:	yes it did achieve that rather well didn't it?	**feedback: praise**
	Okay Melissa would you like to read one or 2 of yours out?	**procedural**
S:	I'll just read one. (Student reads journal entry where she assumes the role of a person living during the Industrial Revolution.)	**procedural**
T:	Very good Melissa good, Michael what do you think of that?	**feedback**
S:	I think it was pretty good except I am a bit worried because that goes completely against what I have written. so (.) yes it is good, it sounds like she is a cabin boy and what else ? its deals with others that they are sort of you know talking to each other ... I can't think of the word, oh yes, interaction that's the one.	**HOT: interpretation**

Each student in the class had the opportunity to contribute to the lesson and to give and receive feedback on their ideas. In this atmosphere of openness and intellectual curiosity, the teacher scaffolded higher order thinking and also created opportunities for reflection.

The capacity of students to argue a point of view and to consider other arguments can be seen in the transcripts and by looking closely at the nature of the discourse that occurred. In one sequence of conversation, two students engaged in discussion about the impact of the writing a journal entry on the social aspect of the Industrial revolution. Both students commented on how much more informative this process was in comparison with reading newspaper reports, which would not have reflected everybody's point of view.

Table 14.17 represents the sequence of reasoning that occurred during this conversation. The table is set out to show the basis of the argument, the claims and

evidence that students (S1 and S2) put forward and the actual words from the transcripts to support the analysis.

Table 14.17: A sequence of collaborative reasoning showing higher order thinking

Argument structure	Summary of student's argument	Transcripts extract
Claim	S1 says that journal entries are more effective than writing newspaper articles	*They wouldn't have got as much details as what each person thinks.*
Evidence	S2 says that journal entries show everybody's point of view, but newspapers only show the dominant view	*they would probably have got one or 2 people perspectives and not the lower class people*
Evidence	S2 adds that newspaper reports would only report factual aspects, not what people really felt about the changing times	*I want to say that a news paper could not have shown what they are really thinking, it would just say , but maybe things like that happened.. they would not have been able say how people talked or felt about it*
Evidence	S1 supports S2's argument by saying that newspaper only record event but don't capture people ideas and feelings	*with journal you can record what you are re thinking but newspapers they only record what you have said.*
Evidence	S2 reciprocates by supporting S1	*yes an a journal, catches that*
Conclusion	a social document that reflects the values and attitudes of the time has been created	*in a journal you can say what you like and what your think so we have achieved our outcome that is jut what we wanted to do*

In this extract we can see how students engaged in collaborative, reciprocal talk and construction of knowledge, with each student extending and building on another 's ideas. Each individual supported her own idea and those of others, and the overall effect was to create many perspectives on the same topic. The character of talk had much in common with what Mercer (1996) called exploratory talk. In this type of talk, learners engage critically, but constructively with each others' ideas. Each statement builds on the previous one and students consider each other's opinions and support each other. In the context of this investigation into discourse patterns this interactive sequence was identified as *collaborative* talk. This type of exchange between students contrasted with the I-R-E pattern where in teachers initiated and evaluated student responses. In the English Lessons 5 and 6, much of the discourse was initiated by students, thereby changing the pattern to student-student talk. This pattern of dialogue confirms that students had progressed to self-regulatory thinking.

Changes in teacher talk

Through systematic analysis of the transcripts and assignment of communicative functions to all dialogue, the teachers' changing practices were monitored from the commencement of Phase 1 through to Phase 3, a period covering one academic year. In the English Lessons 5 and 6 of Phase 3, as Table 14.18 shows, cognitive talk was the largest category, followed by procedural talk. Reconstruction or elaboration of student responses decreased by 1.5% showing that teachers did not support students and assisted them to reformulate and revise their ideas.

Table 14.18: Means and mean differences in categories of teacher talk in English lessons from Phase 1 to Phase 2 (as % of total teacher talk)

Mean Talk in Lessons	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	Total %
English 3& 4	9	22	9	5	41	14	100
English 5 & 6	9	22	6.5	3.5	44	14	100
Mean difference	0	0	-2.5	-1.5	+3	0	

The controlling aspects of teacher discourse, such as asking closed questions, limiting discussion or constraining conversation and student-to-student dialogue decreased by 2.5% from Phase 2. This change was in evidence in the videotapes and transcripts, where students were given the social resources to explore ideas, or, in other words encouraged to consider alternative ideas and also to give reasons for their own beliefs. Cognitive support increased by 3%, and the forms of support offered included scaffolding and modelling which scaffolded students' thinking. For instance in both lessons, there were instances where the teacher engaged in thinking aloud to reveal the reasoning processes she expected students to develop, and acted as a co-participant in knowledge construction.

In addition, the English teacher became more explicit about her expectations that thinking was the focus of the lesson, and made these expectations known to the students. Mercer (1995), would have called this kind of verbal behaviour 'setting the ground rules', or coopting students into the epistemic game of reasoning, explaining and justifying ideas. For example, at the outset of Lesson 6, the teacher said:

> So we are going to test our critical thinking . Our aims in writing this essay, you will remember that we are going to learn to form reasoned arguments, develop opinions from

our information and knowledge, but allow them to be challenged and questioned and be happy to justify our opinions.

Here, the teacher not only explained the student outcomes to students, she also emphasised the processes of engaging in critical thinking and cognitive accountability, using reasoned arguments, challenging and questioning. This was a more explicit statement than occurred previously in the English lessons, and is similar to the strategy used by the Maths teacher throughout her lessons, as she guided students into the practices of becoming mathematicians through her emphasis on appropriate language use. These strategies provided evidence that the intervention to make reflection and thinking more explicit in the lessons of Phase 3 was successful.

Changes in teacher pedagogy

In order to support student understanding and cognition, the teacher engaged in a variety of scaffolding roles. She became a participant in dialogue, regulated the difficulty level of concepts by providing a personal enactment task for students, and provided stimuli for discussion and made the activities discovery oriented. Students were given the freedom to explore ideas without being confined to a textbook version, and through creative and imaginary group dialogue, students created their own understandings of events.

In both lessons, there was a non-evaluative atmosphere in the classroom, and the teacher modelled thinking in her own talk, acting as a contributor to the ongoing discourse. At the conclusion of Lesson 5, the teacher created another opening for students to reflect on the activity that had taken place.

T:	Oh good, on the screen I have written the outcomes we were looking for, that is to create a social document which reflects values and attitudes at the time of the industrial revolution. Now have we achieved this outcome?	**cognitive support questioning**
S:	well yes:	**feedback**
T:	everyone has written yes. OK, let us all think about it, to what extent have we done that?	**cognitive support; reflective question**
S:	I think we have done it very well.	**HOT: reflection**

S:	We have done it very very clearly It shows what everyone thinks and it shows that over time people, everyone changes their ideas from the shipmates and crew to... everyone has changed their mind on a lot of things that happened.	**HOT: interpretation & reflection**
T:	OK is there other ways we've achieved it?	**cognitive support**
S:	I think we have achieved good.. what do you call it um because we thought that ( ) I think that each of us have portrayed a character, I'm just (.) I think we thought each of us what when we created these characters, we thought what they really think, like their attitudes and what they think	**HOT: reflection**
T:	You are right there, I agree we are getting an idea that every society is made up of multiple groups it's not just made up of one particular sort of people, poverty in the industrial revolution made us think about children in factories but forget about all the other layers of society, so we have certainly achieved that, the sense of change and the way that things were being questioned during that time, Anita what do you think?	**cognitive support: modelling** **reflective question**
S:	I think what everyone said is part of it because we sort of got into the head of what those people were thinking like and we (.). yes we got into their heads and like we really played the characters like and sort of like pooled our views and put together what the people were thinking.	**HOT: interpretation** **HOT: reflection**

From this extract it can be seen that the learners were able to reflect on their own experiences of assuming a character who lived during the industrial revolution through writing a journal to express their views on the changing society in which they supposedly lived. They completed the task with conviction and then evaluated it in terms of how it helped them achieve a deeper understanding of the social and cultural changes that occurred during the industrial revolution.

From these extracts, it was clear that the role of the teacher was important, and that at critical stages in the conversation, she made a pertinent contribution to move the discussion forward and give the students scope to show principled understanding of events, rather than superficial knowledge and facts. Certainly, the teacher's support was essential to the unfolding of students' cognition and capacity to think at higher levels.

Use of computer technology to support higher order thinking

In both lessons, the use of computer technology was secondary to student discussion and verbal interaction, and its use emerged out of discussion and activity. Ideas and arguments were displayed which were to become a focus for further student interaction. In English 5, the technology was not used extensively in the lesson, which was essentially based on verbal participation where students assumed different personae and read aloud their journal entries about life during the industrial revolution. One screen was used by the teacher towards the end of the lesson, summarising the outcome they had hoped to achieve. The teacher's use of the pronoun 'we', rather than 'you' showed that she considered herself as co-participant in the activity. To quote her own words: " I have written the outcomes we were looking for to create a social document which reflects the values and attitudes at the time of the industrial revolution. Now have we achieved these outcomes?" This use of the technology was minimal, but supported the learning objectives of the lesson, and the teacher's own strategy of helping students to reflect on their own experience. Table 14.19 shows the number of visuals used in Lessons 5 and 6, activities using the computer, and the conversational dimensions that were supported.

Table 14.19: Computer technology use in English Lessons 5 & 6

Computer Graphics	Lesson 5	Lesson 6
No. of screens	1	1
Prepared by teacher	yes	no
student activity	discussion	create concept map
purpose of graphic	show outcomes of the activity	depict student ideas
locus of control	teacher	student
interaction by students	yes	yes
discussion by students	yes	yes
adaptation by students	no	yes
reflection by students	no	yes

In the second English lesson of Phase 3, English 6, the students collaborated and discussed ideas with each other in order to generate ideas about aspects of life in the Middle ages that could be investigated. The outcome was a visual joint creation which acted as a spur to further discussion and inquiry, and reflection (Figure 14.9). The construction of a concept map arose from a brainstorming exercise that students engaged in, and having generated ideas, the teacher suggested that each point displayed could be debated. In this way, the technology became the focal point for discussion and a forum for joint activity, as the computer visual depicted what each participant had contributed.

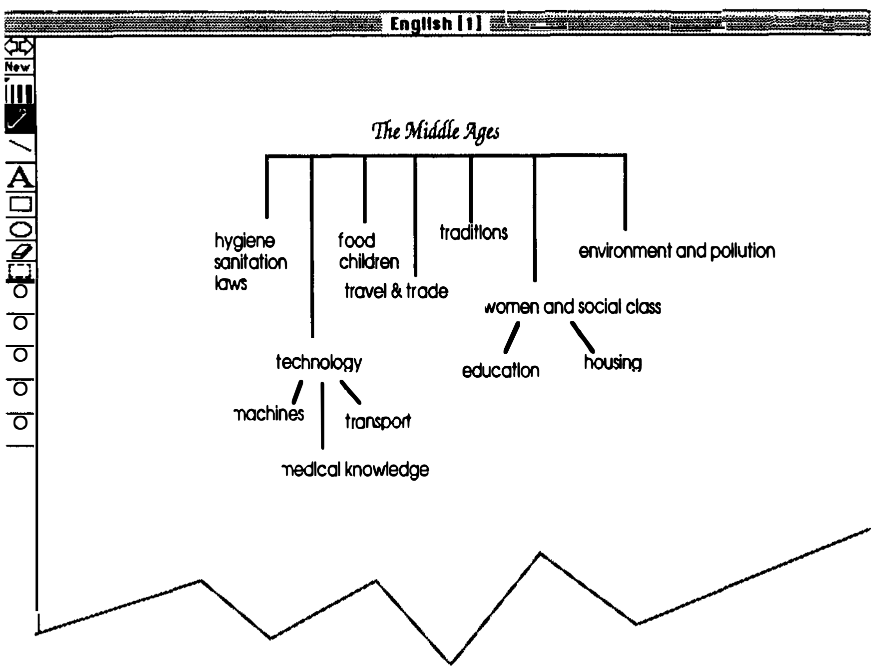


Figure 14.9: Computer screen for English 6

Throughout the activity students had control of the screen and they used a graphics tablet to project their ideas. To give the tenor of the discussion that occurred around the computer screen and the higher order thinking that emerged, this extract provides an appropriate example.

T:	Trista can you say something positive about we will start at the bottom with families. Well what about families what was good about family life in the middle ages ?	**cognitive support** **questioning**

S:	Because they had large families and had to work hard they stuck together and had a good family life, and had to rely on each other, they were rarely divorced and that sort of stuff	**HOT: interpretation**
T:	Yes Anita how would you counter that if you wanted to challenge or question what Trista has just said?	**cognitive support;**
S:	mm, because things were so hard like they probably not eaten or something, they would take it out on each other, and they would not ne nice to each other, like all the hard work would be too much for them they probably would have taken it out on each other ( ).	**HOT: interpretation and hypothesis**
T:	It is a very good point they not only took it out on each other they quite often murdered each other in the upper class families, but Trista how would you counter Anita's very good point there?	**feedback: reflective questioning**
S:	well, I don't know what I would say. (students talk to each other) well maybe that could happen, but it wouldn't normally happen very often, and I think it would be very rare for something like that to happen, or something like that.	**HOT: interpretation**
T:	So the benefits outweighed the disadvantages?	**cognitive support: questioning**

Apart from using metalanguage to encourage students to engage with each other, the teacher also tied her own discourse moves on the prior knowledge or common ground of understanding that had been achieved through use of the technology. As Figure 14.10, shows, technology use in Phase 2 and 3 English incorporated all the elements of the learning conversation, including interaction, discussion, reflection and adaptation.

In Phase 3, both lessons made limited use of the computer technology, but nevertheless HOT was evident in student talk. Both lessons employed the audio link to engage students in discussion, and the interactivity was heightened in Lesson 6 by the visual dimension of the computer through which students could debate and clarify their ideas.

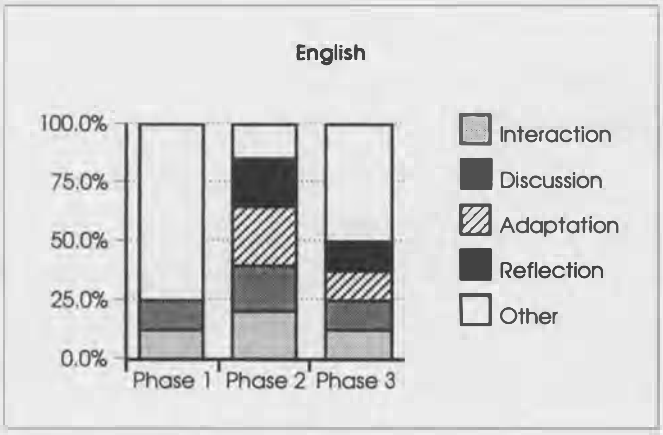


Fig. 14.10: Computer technology to support HOT in English lessons

In English 5, students listened to each others' accounts of life in the Industrial Revolution and although the computer technology was not used, their talk still showed high levels of collaborative thinking, reasoning and cognitive accountability. HOT was achieved because the students had other learning resources, ie a journal entry, and the lesson outcomes did not require use of the computer screen. In English Lesson 5 therefore, the successful achievement of higher order thinking was not dependent on the use of the computer.

Conclusions drawn from Phase 3 English

Phase 3 showed that higher order thinking increased in student discourse and that teacher strategies to support HOT also showed an increase in the proportion of cognitive talk. From this perspective, the intervention to increase reflection and student thinking was successful in the lessons. Though the actual increase in reflection was minimal (only 1%) there was other evidence from the transcripts that students were assuming greater control over their learning and achieving independent thinking. The evidence was presented in the form of a student initiated, collaborative discourse pattern, where students talked among themselves, supporting each others' arguments (Table 14.17). This was a marked contrast to the earlier phases of the English lessons where the teacher initiated all talk and questioned students extensively. This cooperative discourse showed a lot of interpretation and reflection by students.

Use of the computer to support higher order thinking took the form of a student created organisational framework for their interpretation of the Middle Ages (Lesson 6), where they assumed control and created a visual display of the ideas discussed.

Discussion was focused by the visual (Fig. 14.9) and this facilitated interaction, discussion and adaptation. Nevertheless, the teacher did not use the computer extensively in either lesson, and in Lesson 5 relied mostly on the audio channel. The teacher showed flexibility in choosing the technologies to support her learning activities, and lesson 5 showed high levels of thinking and reflection despite reliance on the audio link. It was the teacher's choice to limit use of the computer technology in this lesson, and the decision to do so did not adversely affect the quality of thinking displayed by students. The increase in HOT in the Phase 3 English classrooms was notable and reflected in part the success of the intervention to increase students' thinking processes.

The Social Studies classroom in Phase 3

In the Social Studies lessons, the teacher planned activities which would engage students in reciprocal talk and dialogue where argumentation could be sustained. The lesson activities are shown in Table 14.20. In Social Studies Lesson 5, the task was to evaluate different sources of evidence and to reach a conclusion on whether King Arthur existed. The task demanded analytic skills, summary skills and argumentative skills, as students were paired and asked to challenge each others' claims and the basis on which they were made. The lesson that resulted was an interactive and engaging debate on whether King Arthur did or did not exist. Most of the dialogue occurred between students, as the teacher assumed the role of observer and moderator of the discussion, making interventions only when asked or when she believed that students needed support.

Table 14.20: Content of Social Studies lessons Phase 3

Lesson	Content	Teaching Components
Social studies 5	the existence of King Arthur	students are provided with a number of historical sources from which they compare evidence
	use of evidence in history	student use evidence to discuss the issue
	evaluation of evidence to reach a conclusion	encouragement or discussion and exchange of ideas
Social Studies 6	the industrial revolution: benefits and costs.	students verbalise ideas and justify their ideas
	use of the ideas generated to propose an argument	fostering of student evaluation of ideas and argument
	providing examples of each aspect of social change	promotion of discussion and consideration of alternative ideas

What was apparent in this lesson was the high level of student led discussion and activity, and the change from previous Social Studies lessons which were more teacher directed. In addition, the tasks set were directly related to reasoning and thinking and required students to evaluate evidence from the resources they were provided with.

Changes in participation rates

In both lessons there was only a minor change in the ratio of student-teacher talk. The ratio of student talk was greater that the teacher's, which was a positive indication that students were assuming greater control over their learning. Overall, student talk increased by a ratio of .5%, and teacher talk decreased by .5% (Table 14.21) both of which were small changes when compared with Phase 2.

Table 14.21: Student/teacher ratio of talk in Social Studies Lessons 5 & 6

Talk	Social Studies 5	Social Studies 6	Mean	Mean Difference from Phase 2
Teacher Ratio	45%	41%	43%	-.5%
Student Ratio	55%	59%	57%	+.5%

The most important issue was however the fact that student talk in the lessons of Phase 3 was greater than teacher talk and this was accompanied by an increase in higher order thinking.

Changes in student talk

Other changes that occurred in the Social Studies lessons from Phase 2 to Phase 3 were related to the quality of student talk and can be seen in Table 14.22.

Table 14.22: Means and Mean differences in categories of student talk in combined Social Studies lessons from Phase 1 to Phase 2

Lessons	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total %
Social Studies 3& 4	10	19	6	40	25	100
Social Studies 5 & 6	7	15.5	7	30.5	40	100
Mean difference	-3	-3.5	+1	-9.5	+15	

The two major changes that emerged from analysis of the transcripts were that higher order thinking increased by 15%, while expository talk decreased by 9.5%. Other smaller changes that took place were a decrease in non-task talk and procedural talk, which meant that during the actual lessons, most of the talk that occurred was highly task focussed.

Further evidence of the occurrence of higher order thinking can be seen by an in depth analysis of the discourse that occurred in the lessons.

Evidence of higher order thinking in Social Studies

There was substantial evidence from the transcripts that student talk in these lessons showed keyword indicators of higher order thinking. Each of the categories of HOT was represented in the data, although reflection remained at a low level throughout the lessons. There was a substantial increase in higher level thinking from Phase 1 to Phase 3 of the study as Table 14.23 shows.

Table 14.23: Keyword indicators of higher order thinking in Social Studies lessons

		Stages		
HOT Category	**Keyword Indicators**	**1**	**2**	**3**
Cognitive Accountability	because, cos, so, then, therefore	0%	12%	15%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	0%	9%	16%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	0%	4%	7%
Reflection	metastatement	0%	0%	2%
	Total percentage of HOT	0%	25%	40%

As Table 14.23 shows, there was no higher order thinking in Phase 1, and an increase in cognitive accountability, critical inquiry and interpretation during Phases 2 and 3. In both lessons, the largest category was critical inquiry, where students challenged, questioned and evaluated different perspectives.

Looking at the teacher's plan for the lesson (Appendix 2) and considering the activities that occurred in these lessons provided a context in which student talk could be

evaluated and considered. In Lesson 5, for example, students were engaged in evaluating historical evidence so as to make a decision as to whether King Arthur did or did not exist. The teacher's plan showed that the higher order thinking outcomes for the lesson were for students to look at all the evidence presented and to come to a conclusion about the validity of the evidence and whether it was possible to deduce from this that King Arthur was myth or reality. The activity lent itself to a great deal of argument and discussion, and the teacher's role in this talk was non-interventionist. She simply provided input at strategic points when the students needed assistance. In this sense, her role was to scaffold students' independent thinking. The overall increases in HOT during all phases of the study are shown in Figure 14.11.

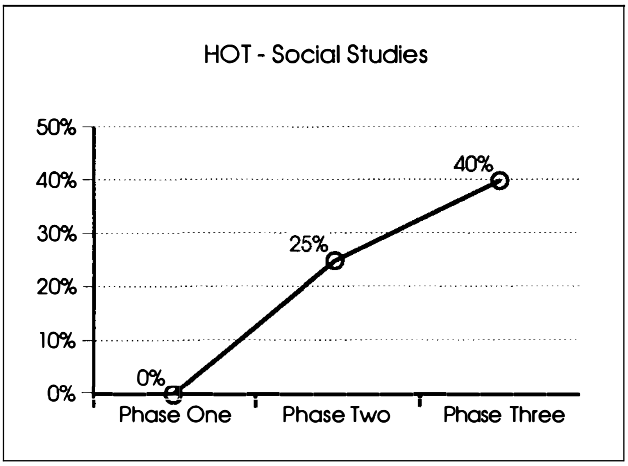


Fig. 14.11: Increase in higher order thinking in Social Studies from Phase 1 to Phase 3

Selected extracts of student talk illustrate the quality of thinking quite clearly, and show that students were capable of a high level reasoning skills. Keyword indicators of reasoning are underlined in the extracts to show where a claim is supported, an interpretation made or a challenge or question posed. Five students (S1, S2, S3, S4, and S5, participated in the exchange.

T:	What about Arthur-do you think there could be some extra data about whether King Arthur existed at all or not?	**cognitive support questioning**
	(Students discuss this question in groups for a short time)	
S:1	<u>Because </u>there is not really enough evidence or information to actually ever say that he was ever around.	**HOT: cognitive accountability**
S:: 2	To support this theory?	**feedback**

S:3	But he still, he must have been - there must have been something there because.. (interruption)	**HOT: reinterpretation**
S:4	Where did they get their stories from?	**HOT: challenge**
S:3	Yes how could they get such descriptive stories just from nothing? S: It might have been just rumours you can't tell.	**HOT: interpretation**
S4	Exaggerated.	**HOT: reflection**
S:1	yes (but) so out of hand Instead of saying a big red car you say big red car with black spots that has a blown tyre or something. Come on!	**HOT: challenge**
T:	A bit like Chinese whispers we know remember that was one of the problems with history that over a long period of time the story changes but not only that . But there is no real evidence that King Arthur existed.	**cognitive support:**
S:1	So perhaps there was like maybe there was someone called King Arthur and maybe he was these King and Queen's son and maybe he never did anything so heroic maybe he just did something cowardly or something and it got changed around.	**HOT: interpretation**

In this extract, students displayed many examples of reasoning, and they responded to each other's ideas, and explored possibilities. Apart from the communicative functions of the task itself, the tenor of the talk was collaborative, and not determined by the teacher's questions.

A further extract shows students use of evidence and their ability to argue and evaluate a point and reach a valid conclusion. Here again the teacher facilitated the discussion by scaffolding understanding and occasionally promoting controversy. At the same time, the teacher observed and monitored the ongoing talk and made relevant interventions. (Four students participated in the conversation denoted by S1, S2, S3 and S4.)

T :	more evidence, what other evidence have you got?	**cognitive support questioning**
S1	From Source B, the author of you know that book, um which is called History of Britain, he recorded a lot of the, <u>you know</u> a lot of Arthur's victories <u>so he couldn't have recorded</u> them if he didn't like research them and find out that they were really true. Like when you are writing a book you don't just sit around and get them and <u>you know</u> get them from word of mouth you actually get them.	**HOT: interpretation/ hypothesising**
T:	Okay OK lets move on, what is next up?	**feedback**
S2	A person oh well one of our ones where the wine posts have been sighted at Arthur's dwelling.	**expository**
S3	Arthur's dwellings or wherever, that was one of ours but now it has been said too so that is no good, and I can't understand the other one.	**feedback**
S4	From Source D a person collecting information about historic sites said that "at South Cadbury standeth Camelot" and so he was collecting information and writing an itinerary of historic sites for the King,	**HOT: interpretation**
	<u>so</u> he <u>would</u> have done them like really truthfully and really properly and that, not just got information like folk tales and that he <u>would</u> really have got true information and he said that you know that at South Cadbury Camlet is there.	**HOT: cognitive accountability**
T:	Okay is there any other evidence that we should bring forward before we start to have a bit of an argument about whether they existed or not?	**cognitive support: reflective questioning**
S1	Historically I would like to point out another piece of evidence. Okay, it is just Source G, <u>it says</u> no-one found scenes of battles *(another student interrupts)*	**HOT: interpretation**

S2	have ever been found and <u>so</u> to give proper evidence that was.. well, signs would be needed.	**HOT: cognitive accountability**
S1	Excuse me teacher, I am going to say something about what Judy just said, well of course none of the battle scenes have been found <u>because</u> if you were fighting with a sword <u>what kind of tracks could be left?</u>	**HOT: challenging**
S4	Bones.	**expository**
S3	They <u>would</u> have carried away the dead bodies they were not left.	**HOT: hypothesis**
S4	Not necessarily.	**feedback**

Throughout the lesson there were many instances where students evaluated the historical evidence for King Arthur's existence and discussed the issue of whether he lived or not. They offered statements for consideration and challenged and counter challenge each other. In this type of talk there was a common purpose and the reasoning was made visible and publicly accountable. Eventually, the discussion lead to an outcome or agreement and knowledge was discovered by the learners as they explored the ideas through talk. This form of interaction was neither the typical I-R-E structure, with teachers initiating and evaluating student responses, nor was it exploratory, where students collaborated and built on each others' contributions. Instead, students engaged in argument, and they challenged each other and provided evidence for their assertions.

An extract from the transcripts illustrates this pattern of interaction. Both Lesson 5 and Lesson 6 had interchanges where students engaged in argumentation, where points were raised and defended, challenges were issued and counter arguments presented. The extract from Lesson 5 (Table 14.24) concerned a debate on the existence or otherwise of King Arthur. Students had a range of evidence on which to base their arguments. The argument involved three students, S1, S2 and S3. The argument began by S1 saying that the legends could not have been fabricated and that they must have indicated the existence of a real King Arthur. This was followed by several rebuttals where counter evidence was cited. As a result of the interchange, participants in the debate had to return to the sources documents to re-examine evidence and reconsider their points of view. Table 14.24 provides a summary of the argument in order to demonstrate how cognitive accountability was achieved by students as they evaluated evidence for their statements.

Essentially, this type of talk differed from the typical asymmetric pattern of talk in other lessons where teachers initiated, students responded and then the teacher evaluated what had been said. This argumentative dialogue engaged students in the practice of thinking, by enabling them to consider alternative views and to evaluate the evidence for them. Dialogue forms the basis of argument is, according to Perkins (1997) an epistemic game, which has particular goals: the goals of knowledge building and understanding.

Table 14.24: Argumentative talk in Social Studies

Argument	**Summary of student statements**	**Transcripts extract**
Claim	King Arthur did exist	
Evidence	There are stories and legends about King Arthur, so they must prove something.	**S1:** Yes, part of the story would have to have been true because why would there be so much information? and so much of this thing is like part of it, just like a little bit wouldn't have to be true
Rebuttal	Dana counters this argument by saying that stories may have got distorted	**S2:** *There are these things but things probably did happen in the first place, people just changed it around*
Supporting argument	Tricia supports Mel by saying that the stories must point to the existence of King Arthur .	**S3:** *I was just kind of confirming what Mel said. There had to be some sort of action, what do you call it, beginning point, for the rumours to be true to begin with.*
Supporting argument	Mel continues with her original point that the stories must have substance	**S1:** *But over the years something could, might have happened. King Arthur might have say, pulled a sword out of a stone.*
Counter argument	Dana states that while the legend tell us of these events it does not prove that he existed	**S2:** *But maybe of King Arthur existed he might have pulled the sword out of the stone. But that does;t mean that he killed all those people or that he was so powerful. it doesn't mean that he existed*
Conclusion	Students have to reconsider source B, where historical facts mention that King Arthur lived, and gave some facts about him	

With argument, learners can not only verbalise their thinking, but they can also show how they support their assertions with evidence, facts and data. Argumentation therefore supports inquiry, and is essential to disciplinary knowledge in many subject areas.

Resnick, Salmon et al (1993) found that most arguments contain claims supported by evidence, challenges based on counterevidence and conclusion, based on the sum of evidence presented. These elements were present in the argument structures of the dialogue in Social Studies Lessons 3, and enabled students to show higher order thinking in their exchanges. Unlike collaborative talk, which occurred in the English lesson of Phase 3, where students built on each others' ideas and created shared understanding through dialogue, in argumentative discourse, participants built knowledge by defending and attacking other views. Both forms of discourse exhibited and supported higher order thinking, and showed instances of cognitive accountability, critical inquiry, reflection and interpretation.

Changes in teacher talk

In the Social Studies lessons the role of the teacher was non-evaluative, and only occasional interventions were made to ensure progress in the discussion. Generally, the teacher played an important, but not directive role in the discussion by encouraging exploration of different viewpoints and evaluation of multiple perspectives. The major positive change that occurred in teacher talk was an increase in the supportive role, shown by the increase in cognitive support. This category of teacher talk was 4.5% higher than in Phase 2, as Table 14.25 shows. In addition, teacher control was 3.5% less taken as the mean of both lessons. There was however, a slight increase in procedural talk in the lessons, which occurred at the commencement of lessons and was related to student assignments.

Table 14.25: Mean percentages changes in teacher talk for Social Studies from Phase 2 to Phase 3

Phase 2-3	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %
S. Studies 3& 4	12	25	14	4.5	34	10.5
S. Studies 5& 6	12.5	28.5	8.5	4	38	9
Mean difference	+.5	+3.5	-5.5	-·5	+4	-1·5

Considering teacher talk in more detail showed that teacher support for thinking used a number of social and cognitive resources. Moving beyond these surface features to interpret the role of the teacher required looking at the dialogic interchanges that occurred in the lessons.

Firstly, the teacher modelled both the language and the thinking processes that she expected students to demonstrate in the lesson. She made her expectations clear by modelling the language of thinking, and the need to consider evidence. For example, at the start of the lesson the teacher said:

> For example, there is no solid evidence to tell us if King Arthur really did, or did not exist.

Later, she asked students what they thought, and what they had heard about Excalibur, as a foundation on which to built new knowledge gained from examining evidence. The expectation expressed by her was as follows:

> you are going to look at all the evidence, and you are going to come up with some evidence on the reasons why you believe King Arthur did not exist, OK?
> Anita you are going to think of some evidence of either side, .. so you have to weigh up both sides of the argument, and you are going to work on trying to show that King Arthur did indeed exist.

Throughout the lesson, the teacher did not directly interfere or direct the discussion. Instead she gave the students the resources to work with, clear expectations about evaluating evidence and using argument and then only intervened to mediate discussion between students. Throughout the lesson, she listened and recorded the evidence that was presented so that by the end of the lesson, students could see a record of their discussion presented on the computer screen. The teacher encouraged students to consider other points of view other than their own, to reflect on them, and present a balanced argument.

By enabling students to evaluate multiple sources of evidence, the teacher assisted them to engage in reasoning and interpretation processes, and therefore scaffolded higher order thinking by fostering consideration of multiple sources of historical evidence (Rouet & Britt, 1996).

In Phase 3, the teacher's questioning strategies improved and expanded in range and quality, while her role became more participatory than in early stages of the study. For example, the category 'cognitive support' included teaching practices such as offering a stimulus (for example inviting a comment, or being provocative), modelling thinking

behaviours, asking reflective questions, and promoting discussion. Overall, the teacher was less directive and interventionist in Phase 3, and instead of offering direct support to students, provided it through activities which scaffolded their thinking.

Use of technology to support higher order thinking

While both Social Studies lessons in Phase 3 showed examples of higher order thinking, technology applications to support cognition were different for both lessons. Table 14.26 shows the usage of the computer during the Social Studies lessons of Phase 3. In Lesson 5, the computer was used to transmit pictures, data and historical sources to students in order to help them reach a decision on whether King Arthur did or did not exist.

Table 14.26: Computer technology use in Social Studies Lessons 5 & 6

Computer Graphics	Lesson 5	Lesson 6
No. of screens	3	2
Prepared by teacher	yes	no
student activity	discussion	generate ideas discussion
purpose of graphic	stimulus/ provision of reference point	provision of a shared reference for students
interactive	yes	yes
discussion by students	yes	yes
adaptation by students	yes	yes
reflection by students	yes	no

Here the technology indirectly contributed to cognition by providing a common source or reference point for students, as they considered evidence presented on the screen. While they could have read the material from a printed source just as easily, the computer gave the activity a more collaborative dimension as students used the data sources as visible support to challenge or refute views that were expressed by the group.

In addition, the teacher used the computer to display the opposing views of students as they progressed throughout the lesson, so that this could be used as a mirror for students to consider others' views, as well as their own. The teacher's intention was to engage students in reflection on their own thinking processes. In this sense, the intervention was successful in Phase 3 as it increased students' capacity to reflect on their own thinking.

In Lesson 6, the lesson required collaborative work among students as they discussed ideas relating to the industrial revolution, presenting viewpoints which were either benefits or drawbacks. Using the graphics tablet, each student wrote their own point of view and justified it, using evidence to support their views. The screen display summarised the main points of debate and allowed the students to share ideas, challenge each other and look for areas of common ground.

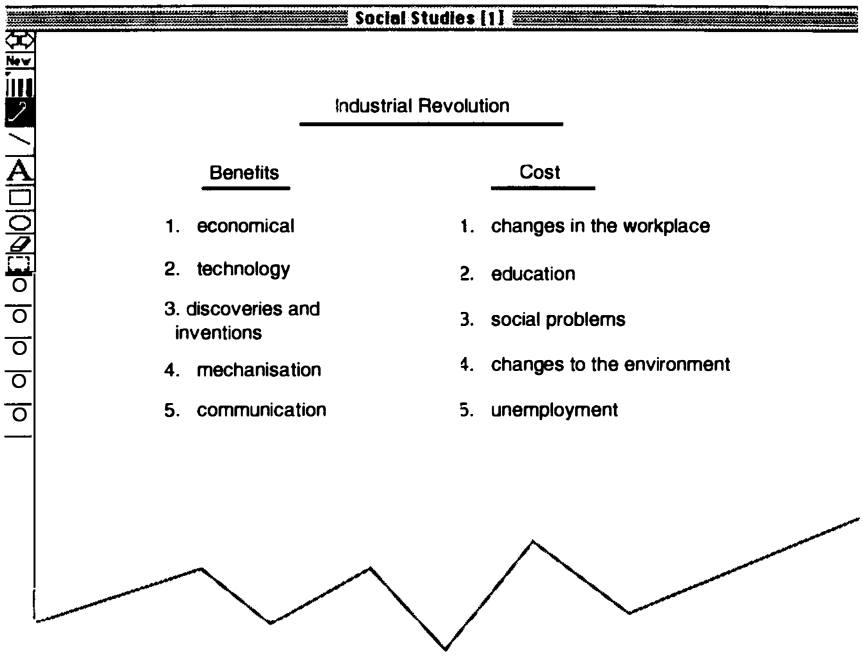


Figure 14.12: Computer visual for Social Studies lesson 6

Some of the dialogue used in this lesson showed that students were thinking and debating and using higher level cognitive processes as they evaluated various viewpoints. The following extract depicts an interchange where students were reviewing all the points they had made on the computer screen about the industrial revolution. Higher order thinking was clearly manifested by students in this sequence.

S: Teacher, one more thing like . <u>I think</u> you can find good and bad things in all of them. — **HOT: interpretation**

cognitive support

T: Yes you can that is correct but how do we argue the point?

S:	I don't think the industrial revolution was worth it, I think in the long term we only ( ) have had to live with, we have destroyed the environment, all the other things, I can't think of them, oh we have more social problems, much more drug abuse, increase in crime, pollution in the environment.	**HOT: Interpretation**
S:	Unemployment.	**expository**
T:	Unemployment yes	**feedback**
S:	all those sorts or things	**expository**
T:	I just don't think it has been worth it, we have too many environmental problems, what do you think?	**Cognitive support: reflective questioning**
S:	This is Michael here, I think it was worth it because if that hadn't of come about we wouldn't have had modern medicines and we wouldn't have had the ways of transport that we have and we wouldn't have had some of the luxuries that we have, life would still be very hard.	**HOT: interpretation**
S:	This is Anita I agree with Michael there would probably be like second to none human race left anyway now, right now anyway because they wouldn't have discovered all the medicine and then it would have just continued being such a horrible thing.	**HOT: hypothesis cognitive accountability**

By providing a focal point for discussion and a means of sharing ideas, the technology use in this lesson served to support higher order thinking. Computer technology use for all Social Studies lessons is summarised in Figure 14.13. where all phases of the study can be seen in a comparative perspective.

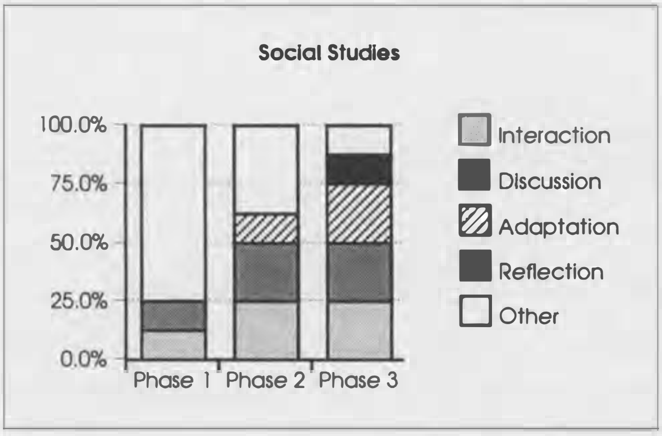


Fig. 14.13: Computer technology use to support HOT in Social Studies lessons

In Phase 1, only discussion and interaction were built into the use of the computer, while in Phase 2, three dimensions of the conversational framework were utilised. In Phase 3, dialogue around the computer showed that reflection, interaction, adaptation and discussion were generated and sustained by the computer visuals. The only change from Phase 2 to 3 was an increase in adaptation and in reflection. In Phase 3, students had greater facility to adapt the ideas discussed and to develop their own interpretations of the subject matter.

In conclusion, computer usage in Phase 3 supported higher order thinking by facilitating student exploration of ideas, by enabling the presentation of multiple ideas and by allowing students to debate a range of issues. In this way, the technology helped to focus students on points of difference and common ideas, leading to discussion, reasoning, argument and interpretation of evidence.

Conclusion: Interpreting changes in the Social Studies Lessons

Both Social Studies lessons in Phase 3 provided examples of a socio-cultural approach to developing higher order thinking in telematics classrooms. The learners worked collaboratively throughout the lessons to achieve the goal of evaluating evidence and to consider opposing points of view. They talked and used language to negotiate and explore ideas. The tasks set by the teacher were contextualised by the resources provided and by the use of the computer to display in visual form the opinions of the group.

Overall, the intervention to increase higher order thinking and reflection was successful. The percentage of HOT increased by 15% from Phase 2 (Figure 14.11) and teacher strategies to support higher order thinking included a range of scaffolding

practices such as promotion of collaborative dialogue, argumentation and stimuli for discussion.

The Italian classroom in Phase 3

In the Italian classroom, the lesson plans showed that the lesson components were supportive of activities where students could practise and extend their language skills. through communicative activities. Table 14.27 shows the main components of the lessons. While Lesson 5 contained a lot of teacher-led dialogue where the teachers modelled language items and students practiced, Lesson 6 also had some student-initiated questioning and self-extension activity. The Italian teacher planned both lessons on syllabus content, and a good deal of each lesson was taken up with oral practice of vocabulary.

At that point in the term, the students still did not have full mastery of the language, and so their level of proficiency was low. The teacher planned activities to improve their understanding of grammatical patterns and vocabulary usage. In this context, the achievement of higher order thinking was more difficult to attain, because much of the lesson was concerned with procedural knowledge.

Table 14.27: Content of lessons in Italian Phase 3

Lesson	Content	Components
Italian 5	• vocabulary for places, time and transport	students give examples
	• asking questions about time and place	teacher models and student s ask questions
	• practicing new vocabulary	students practice pronunciation of new words following the teacher
Italian 6	• revision of food vocabulary and question forms	students are encouraged to generate and apply vocabulary items learnt
	• extending vocabulary through practice	encouragement of student-student practice and questioning

Changes in participation rates

In both Italian lessons, the asymmetry in teacher and student turns was apparent, as the teacher's ratio of talk was greater than the students'. Mean percentages of teacher talk and student talk for Italian lessons 5 and 6 are shown in Table 14.28.

Table 14.28 : Units, turns and teacher/student ratio of talk in Italian Lessons 5 & 6

Talk	Italian 5	Italian 6	Mean	Mean Difference from Phase 2
Teacher Ratio	55%	56%	55.5%	+1%
Student Ratio	45%	44%	44.5%	-1%

The proportion of student talk in both lessons was similar, at approximately 45%. Unlike other classrooms in Phase 3, the participation rates of students in classroom talk did not increase, but instead fell slightly. The decrease from Phase 2 was minimal, at only 1%.

Changes in the quality of student talk

Student talk in the Italian lessons showed a high percentage (65%) of expository talk, and a small percentage, 7%, of higher order thinking. These percentages are displayed in Table 14.29 Procedural talk accounted for 11% of the lesson, when students responded to organisational and administrative matters at the outset and closing of lessons.

Table 14.29: Means and Mean differences in categories of student talk in combined Italian lessons from Phase 2 to Phase 3

Lessons	non task talk %	procedural talk %	socio-cognitive talk %	expository talk %	HOT %	Total %
Italian 3& 4	10.5	16.5	10.5	54	8.5	100
Italian 5 & 6	11.5	11	5.5	65	7	100
Mean difference	+1	-5.5.	-5	+11	-1.5	

In Phase 3, student talk showed some changes from Phase 2. These were a decrease in procedural talk and socio-cognitive talk, and an increase in expository talk. These changes reflected the lesson content where the emphasis was on mastery of new language forms and grammatical features, rather than on communication between students. Higher order thinking decreased by 1.5%, and as such was the only subject area in Phase 3 where HOT decreased. Analysis of the actual lesson transcripts provides some explanation for this occurrence. Nevertheless, there were some exchanges during the lessons where students demonstrated higher order thinking and interpretation in their interactions with content and with each other.

Evidence of higher order thinking In Italian lessons 5 and 6

In the context of the teacher's instructional goals, the overall level of higher order thinking was ambitious, given the constraints of the students in speaking in a foreign language.

Table 14.30 shows the keyword indicators for higher order thinking for each Phase of the Italian lessons. Cognitive accountability was low, at only 1% of student talk, while reflection was absent. The highest category was critical inquiry, at 5% which consisted of students' capacity to ask questions of each other and about the task. Interpretation of text and task was also present, but this accounted for only 1% of student exchanges.

Table 14.30 : Language indicators of HOT in Italian lessons

HOT Category	Keyword Indicators	Stages 1	2	3
Cognitive Accountability	because, cos, so, then, therefore	0%	1%	1%
Critical Inquiry	questions: what if? why, you mean? if; would, maybe, perhaps	0%	5.5%	5%
Interpretation	it means, that means, it says, I think, always, never, for example, whereas	0%	2%	1%
Reflection	meta statement	0%	0%	0%
	Total percentage of HOT	0%	8.5%	7%

Some exchanges are cited which illustrate the quality of thinking in the Italian lessons and show that students were able to apply the vocabulary they had learnt to new situations and employ it in creative ways. In the following extract, students are self-

extending their vocabulary by combining words for *I eat,* and *I drink* with other vocabulary learnt. The dialogue has a strong interpersonal and contextual character, as students looked for ways of expressing their own experience in Italian. Many of the examples of higher order thinking occurred where students self-extended their own vocabulary through asking questions of the teacher, and of each other.

T:	Now can you tell me what is on the page?	**cognitive support: questioning**
S:	There is a sort of picture of a town and there is a guy asking a lady where something Is I think	**HOT: interpretation**
T:	Bravo, yes , anything else?	**elicit information**
S:	and there e is I think a bit of conversation of a man asking a lady for directions	**HOT: interpretation**
T:	Excellent, yes they are trying to find out how to go to a certain place.	**feedback**
S:	Senore, I think, well the word s "al museo" that means museum, I think, so they want to go there	**HOT: interpretation**
T:	Brava, excellent, it is the museum. Altogether, al museo	**feedback**
S:	al museo *(students practise the new word*	

In another interchange, the teacher asks students to use their new vocabulary to ask and give directions and students then created new communicative structures with this vocabulary.

S:	Senore do we start off where we are?	**question**
T:	Yes I would start off with the sentence 'Dove vai' where are you going, and then two of you go in that direction Now what is the word that would link all of those directions?	**cognitive support**
S:	is it 'adesso" , then?	**expository**

T:	Oh it could be, it could also be a word that starts with 'P'	**feedback**
S:	Yes, 'Poi' I know - that means then	**expository**
T:	Good girl, so if you want to say turn to the right and then turn to the left, you can link them with 'poi'	**cognitive support**
S:	Senora, I have written down all the things, but this is in English, and I haven't written it in Italian yet. But I have done it in the way, like if I was maybe there, sort of thing	**HOT: critical inquiry**
T:	Brava, that is how you have to do it. Take it from their point of view.	**feedback**

Although the nature of the thinking processes in the Italian lessons were not argumentative or reasoned judgements but engagement in communicative language practice, it can be claimed that students were developing cognitive skills as they initiated many of the interactions and showed self-direction and motivation in their own learning. These examples in fact contrast with the examples of higher order thinking in other phases of the study, as they are more concerned with students trying to develop domain specific, or content knowledge (Alexander, 1996). These students were novices in Italian and yet they were trying to find connections and links from their own experiences and express them in communicative practice. Nevertheless even with their limited vocabulary, students in the Italian lessons showed an awareness in their questions, of gaps in their own knowledge, and a natural curiosity and self-awareness in asking questions that filled these gaps. For these reasons, higher order thinking in the Italian lessons had a different character from other lessons.

Overall, the percentage of reasoning in the lessons was quite low, at only 7% of the total amount of students talk. This percentage was slight decrease from Phase 2, where higher order thinking was 8.5%. The overall trend for all 3 Phases of the study is shown in Figure 14.13.

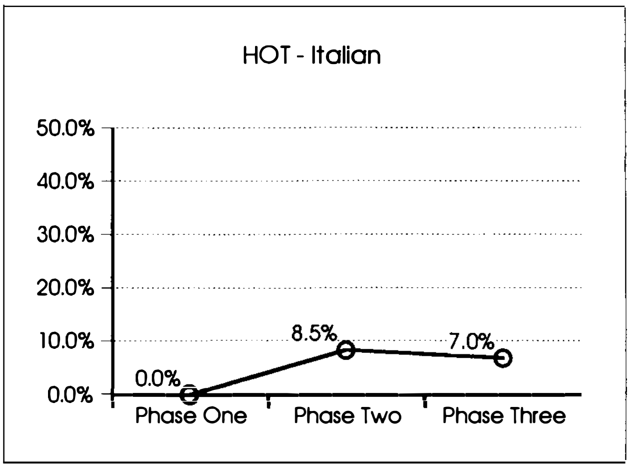


Fig. 14.14: Percentage of HOT in Italian lessons from Phase 1 to Phase 3

Italian was therefore the subject with the lowest percentage of higher order thinking skills in the study, and as such presented an interesting contrast to the other subject areas, a finding that will be discussed in the next chapter.

Changes in teacher Talk

In the Italian lessons of Phase 3, the communicative functions of teacher talk are displayed in Table 14.31 The largest category was cognitive support, at 26.5%, where the teacher scaffolded student learning in a variety of interactive ways. The category of control was also high, at 21%, showing that the teacher directed and managed the class, allocated turns and maintained a strong leadership role in the activities.

Table 14.31 : Means and mean differences in categories of teacher talk in Italian lessons from Phase 1 to Phase 2 (as % of total teacher talk)

Lessons	non task %	procedural %	control %	reconstruction %	cognitive %	feedback %	Total %
Italian 3& 4	5	28	18	3.5	30	15.5	100
Italian 5 & 6	8.5	22	20	5	26.5	18	100
Mean difference	+3.5	-6	+2	+1.5	-3.5	+2.5	

Contrasts with Phase 2 of the study are also shown in Table 14.31. The category of control increased by 2%, while procedural talk decreased by 6%. More important however, was that cognitive support decreased by 3.5% from Phase 2, which signalled a change in pedagogy, and perhaps a focus on content based objectives which would

have required a more controlling pedagogy. This is confirmed by transcript evidence and by considering the teacher's lesson plan. The small increase in non-task talk was due to the complications of sending visuals during the lesson, and checking to ensure that students had the correct resources. The transcripts would seem to confirm this conclusion. The teacher's talk was supportive and offered feedback and encouragement to students, with the percentage of feedback remaining high in both Phase 2 and Phase 3.

Use of technology to support higher order thinking

In both of the Italian lessons, there was extensive use of the computer to support the activities of the lesson. The usage was similar in both lessons, with display of vocabulary the primary function. Table 14.32 reports the results of the analysis of computer technology use in the lessons of Phase 3.

Table 14.32 : Computer technology use in Italian Lessons 5 & 6

Computer Graphics	Lesson 5	Lesson 6
No. of screens	3	3
Prepared by teacher	yes	yes
Purpose of graphic	display vocabulary	display vocabulary
student activity	practice vocabulary	ask and answer questions
locus of control	teacher	shared
interaction by students	yes	yes
discussion by students	yes	yes
adaptation by students	no	no
reflection by students	no	no

This visual support enabled students to see the target vocabulary items throughout the lessons, and to become familiar with the spelling of new words. In addition, the computer gave support for interaction, as students asked and answered questions on the items displayed. However, neither of the lessons enabled students to adapt the screens, or to add items that they considered relevant. In Lesson 6 control of the computer was shared only for a time to allow students to provide examples of their own.

Neither did computer use foster reflection by students on their activities. A summary of the dimensions of computer use through all Phases of the Italian lessons is shown in Figure 14.15, where aspects of computer use are compared.

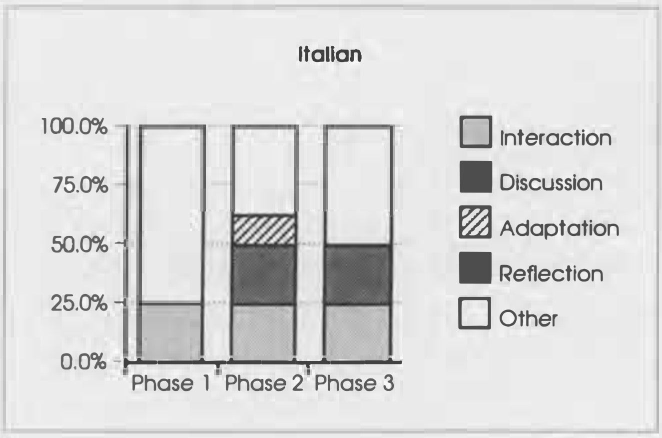


Fig. 14.15: Computer technology use to support HOT in Italian lessons

The visuals in Phase 1, for example, provided some interaction between teachers and students, but did not support discussion of the tasks or student Reflection. In Phase 2, screens were prepared which enabled interaction, adaptation and discussion, as students used the graphics tablet to write up their own contributions and to adapt the teacher's visuals for their own purposes in communicative games. In both lessons, the adaptive quality was missing, with the computer technology serving only to stimulate discussion and support interaction.

Evidence for the lack of adaptability of screens by students is supported by the increased control in the teacher's pedagogy, which was evident from the analysis of categories shown in Table 14.31, where controlling discourse amounted to 31.5% of teacher talk. Adaptation by students could have been achieved by enabling students to write up examples of their own work by using the graphics tablet, but this was achieved only in the Phases 2 for short episodes.

Interpreting the changes in Italian Phase 3

The Italian lessons of Phase 3 appeared to have been impervious to the interventions carried out to improve student reflection and higher order thinking. Neither aspect improved during Phase 3 and the teacher did not adopt any new pedagogic practices to achieve higher order thinking. Nevertheless, the lessons could not be criticised on pedagogic grounds, as students were fully engaged in the tasks and were communicating and active throughout both lessons. The focus of both lessons and

technology was to display and reinforce vocabulary items and grammatical points, and there was no scope for students to display higher order thinking, as the tasks were not conducive to these particular outcomes. The teacher's lesson plans confirmed that curriculum coverage was her main objective at that stage in the term.

Conclusion

This chapter has presented the results of Phase 3 of the study and focused on areas of change in participation rates, teacher pedagogy, and levels of higher order thinking. The chapter also made comparisons between Phases 2 and 3 in terms of student ratio of talk, teachers' pedagogic practices and student levels of higher order thinking. Each of the research questions was answered by investigating each of the classrooms separately. From the observations made, it can be concluded that the second intervention, to make students more aware of their own thinking processes and to encourage reflection, was successful in most of the classrooms. The evidence for this was the increase in higher order thinking in Social Studies, Science and English. In the Maths classroom, the percentage of HOT remained stable, but there was a slight increase in the occurrence of reflection. Likewise, in English and Social Studies a slight increase in reflection occurred. Neither Science nor Italian showed any reflection by students in Phase 3.

Accompanying these changes in HOT, different forms of scaffolding were observed in teacher pedagogies. While in Phase 2 reflective questioning and modelling of thinking were the principal pedagogic approaches adopted, in Phase 3 other teacher strategies were used to extend students' thinking. These included encouraging students to engage in reflective negotiation and investigation of problems, and promoting discussion and argumentation. Accompanying these changes there was progress in student initiative, demonstrated in discourse patterns where students discussed and presented their ideas within the group, rather than in response to the teacher's questioning. These alternative discourse patterns signalled the teachers' handover of control to students, and were evident in both the Social Studies and English classrooms.

In addition, computer technology usage and how it supported higher order thinking was evaluated and the results presented, with comparisons drawn between Phases 2 and 3. Teachers invited students to share control of the design of computer visuals, to interpret topics from their own perspective's and to share ideas. The intervention to increase student awareness of thinking led to increased reflection in many lessons, and

greater reflection was shown in activities and dialogue supported by computer visuals in the English, Social Studies and Mathematics classrooms.

A complete discussion of the results of Phase 3 is given in Chapter 15, which presents an overview of the whole formative experiment and documents the changes that occurred from Phase 1 of the study. Only by considering the whole study can the changes that occurred in Phase 3 be fully explained and contextualised.

Part V

Summary of results with discussion and conclusion

CHAPTER 15

Discussion of results

Introduction

This section will present a summary of the changes that occurred during the study and present an overview and discussion of the findings that occurred as a result of the formative experiment. The discussion is closely tied to the research questions which were related to:

- the changes in participation rates of students;
- the quality of student talk, in particular the level of higher order thinking that was achieved in each subject from Phase 1 to Phase 3;
- similarities and differences in higher order thinking categories across subject areas;
- changes in the pedagogic practices of teachers, and how they scaffolded HOT in students; and
- the role of the technology in supporting higher order thinking.

Each of these aspects of the findings will be presented in summary form.

Changes in participation rates of students

Participation rates were measured by counting the number of communication units in each turn at talk, by both teachers and students. While teachers usually had a similar number of turns at talk as students, they normally had longer turns, as they completed several communicative functions in one turn. By comparison, student utterances were shorter, and in Phase 1 of the study often consisted of short answers or one word responses. A count of the number of communication units in each turn gave a more accurate representation of the quantity of talk of teachers and students. In Phase 1 of the study as Figure 15.1 shows, student talk accounted for 36% of total talk, taken as the mean of all five subjects in all phases of the study. This meant that roles in the classrooms were asymmetric, with teachers talking a good deal more than students. This imbalance in the relative contributions of teachers and students has been found not only in distance learning settings, but also in face-to-face classrooms. The pattern tends to occur as a result of many socio-cultural variables including the authority status of the teacher, the difference between expert and novice, and the lack of attention by teachers to creating participant structures and tasks where students can

make a contribution (Carlsen, 1991; Graesser & Person, 1994; Lemke, 1990). The preponderance of teacher talk in Phase 1 was consistent with the findings of previous studies, (eg Oliver & Reeves, 1994a) where teacher talk dominated entire lessons, leaving little scope for students to participate or initiate. In Phase 1, a good deal of transmissive teaching accompanied this talk, with teachers 'telling' students about content, explaining procedures, and eliciting short factual responses.

Following the interventions, where teachers resolved to plan for higher order thinking, and adopt an operational definition for their own teaching, a change in this pattern occurred. Student talk increased to 45% in Phase 2, and to 49% in Phase 3.

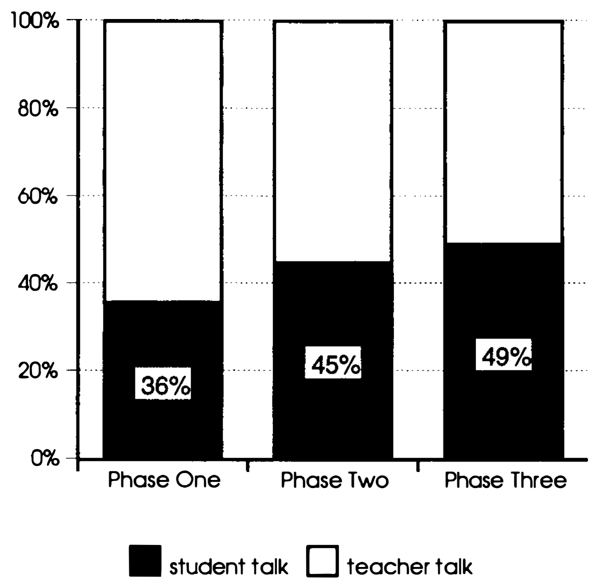


Figure: 15.1: Mean percentage changes in student talk from Phase 1 to 3

The changes in student talk following the interventions can be attributed to the increased emphasis placed by the teachers on student activity and thinking though language, which gave the students more opportunity to talk in class. In the first intervention, (Chapter 11) teachers agreed on broad based strategies that would scaffold learning, and in addition recognised the importance of student initiation and articulation of ideas. This strategy was evident in Phase 2 of the study, where teacher questioning styles changed from didactic, information seeking to encouragement of student explanation and elaboration of responses. In addition, teacher roles changed from emphasising content and information to encouraging involvement and expression of views, evaluation of ideas and justifying positions taken. Following the first intervention, teachers showed in their teaching, strategies to foster higher order thinking, and that the joint efforts of teachers and students were required if conceptual development and thinking were to occur. Overall the pattern of teaching changed

from a focus on transmission of facts to a sharing and building of knowledge through dialogue, reflective questioning and scaffolding. The effect on student discourse was to promote forms of discourse where learners engaged in the practice of inquiry, questioning and evaluation of ideas. These findings concur with those of Coles (1995) and Fisher (1993) who, in separate studies found increased evidence of thinking when the teacher created a social context where talk and sharing of ideas was valued.

Allied to the increase in student patterns of talk, a number of changes were observed to take place in the sequential and interactive structure of the classroom. In Phase 1 of the study, the three part structure, Initiation- Response- Feedback (*I-R-E)*, which typifies many teacher centred classrooms was noted (eg., Cazden 1988a). Teachers initiated, students responded and then teachers gave feedback or evaluated each student's response. In Phases 2 and 3, variations to this pattern occurred in the classrooms of the study, where students talked to each other, built on what each other had said in order to create shared understandings or a common point of view. This type of talk was described as *collaborative talk*. In other lessons of Phase 3, for example in Social Studies, another, more disputational form of interaction occurred between students, in which they argued a point, challenged each other and displayed high level of reasoning. This type of talk can be described as *argumentative talk*. Both forms of dialogue were observed in Phases 2 and 3 of the study and occurred between students, with the teachers making only occasional contributions. The usual patterns of teacher initiation changed. Teachers did not select the next speaker and did not evaluate students' contributions. Instead, teachers tried to limit their own contributions, and simply set up the task for students to interact.

In collaborative dialogue, there was no appeal to correctness, external criteria or evidence, and the learners were engaged more in expressing their own ideas and interpreting the learning experience for themselves. In contrast, argumentative dialogue which occurred extensively in Phase 3 Social Studies and English, was focussed on establishing justifications for claims made. It is this style of discourse that had been nominated by previous research as supportive of higher order thinking (Perkins, 1997; Mercer, 1995; Fisher, 1996).

However, not all classrooms showed evidence of collaborative talk and argumentative discourse, and in many lessons a strong teacher presence emerged with a tendency towards more structured styles of teaching. The evidence for this was the controlling discourse in teacher in many of the classrooms. These differing forms of teacher talk were reflective of a range of pedagogic practices, where teachers scaffolded student thinking through reflective questioning and active participation in dialogue. Both forms of teacher talk were found to be supportive of higher order thinking, but in the

Science classroom, for example, where control talk remained fairly constant at 18% throughout all phases, the percentage of HOT was lower than in other classrooms. This finding suggests that alternative modes of interaction with students may serve to mediate higher order thinking than reliance on a single pedagogic strategy. In other studies (eg., Roth, 1996), it is emphasised that while questioning can be regarded as the teacher's contribution to the construction of knowledge, what is more important is that students appropriate these questioning practices. The results (Table 15.1) showed that student questioning, in the category 'critical inquiry' occurred in many lessons, but in small percentages only, and that this component of HOT was not well supported.

Overall, most scaffolding was provided not by peers at each of the remote schools, but by the teacher, who planned activities, and participated in dialogue with students. In Chapter 7, the potential forms of scaffolding in telematics classrooms were described as scaffolding be peers, by a teacher and by technology (Figure 7.2). The findings showed that the greatest support for higher order thinking came from teacher scaffolding, in the form of questioning, modelling and fostering independent investigation of ideas and collaborative talk. The transcripts provided no strong evidence that peer scaffolding influenced the occurrences of higher order thinking in the classrooms. From Phase 1 to Phase 2, there was also a change in the participation rates of students. The steady increase in student talk from Phase 1 to Phase 3 was accompanied by qualitative changes in talk which illustrated students' capacity to reason and display higher order thinking.

Changes in the quality of student talk

As the formative experiment was concerned with planning interventions to foster higher order thinking, it was essential to analyse all talk from the outset of the study and to observe whether higher order thinking occurred from Phase 1. Analytic categories of higher order thinking were derived from the operational definition which was linked to theoretical accounts of higher order thinking, and language indicators were used to identify instances of higher order thinking in the transcripts. All instances of keyword indicators were considered in context in order to ensure that they functioned as reasoning skills, and that the communicative intention of these linguistic forms, as used by students, was to explain, elaborate, hypothesise, infer, inquire and interpret.

Results of the analysis showed that higher order thinking increased in all subject areas in Phase 1 following the first intervention. In some subject areas, the increase was more notable than in others. For example, classroom talk in Social Studies did not show any HOT in Phase 1, but a considerable amount (25%) in Phase 2.

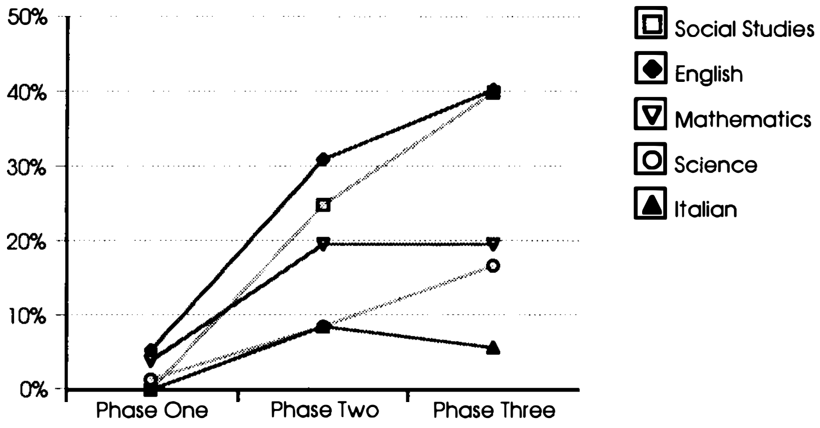


Figure 15.2: Percentage of HOT in student talk in subjects from Phase 1 to Phase 3

Figure 15.2 shows the pattern of increase across all subject areas of the study. Each of the classrooms had similar low levels of HOT in Phase 1, and large increases in Phase 2, when a number of changes occurred. The first of these changes was the deliberate planning for HOT that teachers undertook in preparing lesson plans. For each class, not only were thinking outcomes specified, but so also were the strategies to be used in achieving them. This form of planning enabled the teachers to be more focused. In addition, teachers had been introduced to an operational definition for HOT which they could relate to their classrooms practices, as it entailed using and encouraging language, justification of answers, and enabling students to elaborate on their responses. Their familiarity and ease with the operational definition was evident in the lesson planning sheets, and this increased awareness of HOT permeated their lesson planning. The third change that occurred was teacher pedagogy itself, which changed from a highly controlled and 'transmissive' approach to a more student focused, inquiry-based form of dialogue, where learners were scaffolded rather than directed.

During Phase 3, one subject, Maths, did not show an increase in higher order thinking and the percentage remained at 19.5% for both Phase 2 and Phase 3. In Italian, the percentage of HOT decreased slightly. Overall, the percentage changes in Phase 3 were less, and showed that levels of higher order thinking remained stable in most classrooms. For Italian, the slight decrease in HOT was not a matter of great concern, as the teacher explained that her students were continuing to demonstrate independent thinking both inside and outside class, by extending their own vocabulary and identifying their own areas of need. In the Italian lessons of Phase 3, there was a good deal of new material covered by the teacher, including grammatical explanation, and classes were used less as opportunities for conversation than for

covering essential new ground. Students had only 2 lessons per week in Italian, which was half the curriculum requirements, and they had a further 2 hours of private study during which they completed Italian assignments.

The occurrence of HOT in each subject must be seen in relation to the kinds of pedagogic support offered by the teacher, the overall structure of discourse and the social roles adopted by the teachers in each of the telematics classrooms. Prior to this analysis, an overview of the percentage of HOT in each discipline is presented, so that comparisons can be perceived and drawn.

Comparison of occurrences of HOT across subject areas

Comparing the categories of higher order thinking across all subject areas required a breakdown of percentages of cognitive accountability, critical inquiry, interpretation and reflection at all stages in the study. These results for each classroom and phase are presented in Table 15.1. The classrooms with the largest percentage of HOT, English and Social Studies, were also the subjects where the highest increases occurred from Phase 1 to Phase 2. Science also an showed increase in HOT in Phase 3, while Maths remained stable and Italian declined slightly.

Table 15.1 : Mean percentage of higher order thinking in all phases as a percentage of total student talk

Classroom /Phase	Cognitive accountability %	Critical Inquiry %	Interpretation %	Reflection %	Total %
Maths 1	2	1	1	0	4
Maths 2	8	7	3.5	1	19.5
Maths 3	7.5	8	2	2	19.5
Science 1	1	.5	0	0	1.5
Science 2	4	3	1	0	8
Science 3	7	7	3	0	17
English 1	2	1	2	0	5
English 2	10	12	7.5	1	30.5
English 3	12	15	11	2.5	40.5
S. Studies 1	0	0	0	0	0
S. Studies 2	12	9	4	0	25
S. Studies 3	15	16	7	2	40
Italian 1	0	0	0	0	0
Italian 2	1	5.5	2	0	8.5
Italian 3	1	5	1	0	7

These changes can be attributed to a number of factors, including teacher pedagogy, interaction style, activity type and use of technology. In both English and Social Studies, the pattern of dialogue and activity that characterised Phases 2 and 3 changed from the teacher-led discourse of Phase 1. One of the major changes that occurred was that the percentage of control talk decreased in Phase 2 for both classrooms, by 21.5% in English, and by 9% in Social Studies (Tables 13.17 and 13.21) In Phase 3, control talk decreased further by 2.5% in English (Table 14.18), and by 5.5% in Social Studies (Table 14.25). In contrast to this pattern, the Italian lessons showed increased control in Phase 3, while Science showed no changes in levels of control throughout all phases of the study.

Accounting for the increases in higher order thinking in the English and Social Studies classrooms required looking beyond the data and quantitative findings, viewing the videotapes again and revisiting the transcripts, field notes and lessons planned for these classes. One aspect of change that emerged quite strongly in the videotapes was the changes in the social role of students in these classes. The increased participation in talk (Figure 15.1) signalled a change in students' role as passive listeners and respondents in Phase 1, to active investigators and questioners in Phase 3. These roles are partly reflected in the increased participation rates in classroom talk, which increased to approximately 58% in both English and Social Studies classes (Chapter 12). The change in role and level of participation was accompanied by changes in the pattern of discursive interaction these classes, from one led by the teacher, to one where students assumed more control and showed more initiative in expressing their views, challenging each other and looking at evidence to support their ideas. Many of the extracts shown in Chapter 12 from these lessons provided evidence that the argumentative and collaborative styles of interaction enabled students to articulate arguments, opinions, views and counter arguments, which served as a vehicle for higher order thinking. It is also reasonable to assume that the different discourse roles displayed by students in Phase 3 English and Social Studies, were linked to the expectations they had about the nature of their work, and of the expectation that 'cognitive accountability' was valued by the teacher. The teachers' lesson plans showed that HOT was the intended outcome of most lessons in Phases 2 and 3.

At the outset of this thesis, (Chapter 4 , p. 41) it was stated that there was a need to examine participants structures because as "... students develop patterns of participation that contribute to their identities as learners, which includes the way they take initiative and responsibility for their learning" (Greeno, 1997, p. 9). As the teachers of English and Social Studies changed their expectations of students, they also created opportunities for students to state and share their beliefs, to argue and discuss ideas. Teacher pedagogy and the instructional intention to achieve higher order

thinking enabled them to transform the telematics classrooms into contexts for rational debate and dialogue, where the teacher was not the authority figure, but a participant in the discourse, who modelled cognitive accountability and inquiry behaviours. This climate of rational debate was helped by use of technology to scaffold higher order thinking by using the computer as a resource to display student ideas and as a springboard for further inquiry.

The Maths lessons, which had such a promising start with the teacher emphasising thinking aloud strategies and the language of mathematics to develop students metacognitive awareness, showed no increase in Phase 3 of the study. This can be accounted for partly because of technical problems associated with the teacher trying out new ways of dealing with distribution of resources for her students. Having found delays in transmitting visuals during the first term, the teacher decided to try sending disks to the students, and opening these from her own location in order to synchronise between locations. A multitude of problems were encountered, and a lot of non-task talk ensued, resulting in a loss of valuable teaching time and opportunities for higher order cognition. The teacher was not a confident user of the technology, but she persisted in trying the same technique for several lessons, largely because of the amount of time invested in preparing the materials on disk for the students. This event showed both the limitations of the software and the fragility of the technology in the hands of a non-expert user, who had achieved commendable results while using the standard delivery format. Through observation of the Mathematics classes, it can be said that the teacher's emphasis on language use for the expression of ideas encouraged students to explore, elaborate and explain how they solved mathematical problems, and led to increases in higher order cognition. However, the distraction and disruption caused by the change in technology usage undermined progress towards greater gains in HOT. For teachers inexperienced with technology, it would seem unwise to attempt new and high-risk strategies in telematics classrooms, as the result is likely to be a return to non-task talk and low level expository exchanges.

Each of classrooms differed in the amount of HOT demonstrated by students in each of the four dimensions. A salient difference was that the category of interpretation, where students gave their analysis or opinion of a text, event or problem, was highest in English and Social Studies, and lowest in Science and Italian. In English and Social Studies, there was more encouragement given to the expression of personal opinions and to creative expression of ideas than in Science and Italian, where reliance on texts and teacher prepared material was in evidence. Furthermore, both the Social Studies and English teachers enabled their students to develop a personal interpretation of subject matter, either through fostering individual responses or by setting tasks which enabled students to look at the issue from their own perspective.

There was nothing comparable to this in either the Science or in the Italian lessons, while in Maths, occasional instances occurred when the teacher invited examples and sought alternative perspectives.

The highest percentages of critical inquiry, where students challenged and questioned each other, occurred in English and Social Studies, and in the preceding discussion, the pedagogic roles of teachers in these classrooms became one of encouraging all students to challenge and to value alternative opinions and viewpoints established through rational debate. Cognitive accountability, which entailed justifying a point of view, or reasoning by giving evidence in support of a view expressed was found in all subject areas, and was the second highest category in Maths, English and Social studies. The English and Social Studies lessons showed the greatest increases, while Science lessons showed consistent but small increases during Phases 2 and 3. For the English and Social Studies lessons, this can be attributed to the opportunities provided through discussion and argumentation to justify beliefs and provide evidence for views held. In addition, in the Social Studies lessons, the students were provided with resources, in the form of historical evidence and sources of data, which allowed them to refer to evidence when they responded. A different approach was adopted by the teacher of English, who preferred to immerse or 'situate' the learners tin the cultural or literary context they were studying. Students took on roles, enacted plays, and wrote drama scripts in which they became socialised into ways of thinking and doing that characterised the epoch they were studying. For example, when studying the Industrial Revolution, students assumed the persona of a person living in that time and built meaningful problems and contexts through which they expressed their opinions of that era and also developed skills of interpretation.

The results of the Italian lessons showed a decline in HOT in Phase 3, with the classes showing an increase in expository talk and a good deal of teacher control. The teachers' lessons plans showed her concern with syllabus coverage, and she cannot be criticised for this as the students had a set number of units and topics complete in order to build their vocabulary and knowledge of grammar. The Italian lessons provided interesting contrary data in the study. Not only did the results for HOT decline in Phase 3, but also the level of higher order thinking in Italian was the lowest in the study.

It may be the case that in the initial phases of learning a language, mastery of vocabulary and grammatical form is more important than communicative practice and dialogue, as these constitute domain knowledge, or procedural knowledge that are a prerequisite for higher order cognition, as discussed in Chapter 3. Experts have a command of a broad domain of knowledge encompassing a foundation in the core

ideas, a factual base and a network of ideas and concepts, while novices have limited domain specific knowledge (Greeno, 1991). Italian was the only subject taught where students were novices, and they did not have a foundation in the language. Acquiring a basic core of concepts and language would have been essential to engaging in the kinds of verbal skills that were defined in the study as higher order thinking. Yet, the teacher did scaffold students and enable them to demonstrate higher order thinking (8%) in Phase 2 of the study by fostering questioning, interpretation and by providing communicative practice in the language skills.

Although the students in the Italian lessons displayed few signs of reasoning in their classroom discourse, the same students studying English and Social Studies showed very high levels of reasoning and argumentative skill. This was obviously a case where the task demands and teacher practices created different possibilities or *zones of development* for students. In the Italian language classrooms, the focus as on acquiring vocabulary and a working knowledge of the language, and as beginners, the communicative competence of students was limited. In Social Studies and English, the focus of lesson in Phases 2 and 3 was not the accumulation of facts and concepts, but the engagement of students in active reasoning, and of making connections between the subject and their own experiences. This was also achieved in the Maths classrooms, where the teacher achieved a high level of engagement and students explored ideas.

In the Science classroom, although there was a steady increase in higher order thinking, there was not the dramatic change that occurred in Social Studies and English, and the overall level of HOT remained relatively low, reaching only 17% of total student talk in Phase 3. Teachers remained preoccupied with textbook knowledge and content, and there were few opportunities for students to engage in discussion and debate. Another factor which may have limited the potential of the Science lessons, was that students could not do practical laboratory work and experiments in class, as the teacher could not observe and students were not in a supervised laboratory. For this reason, they lacked the kinds of initiative that would normally be available to students in science, ie, to investigate first hand, and to make connections between these experiences and scientific knowledge. They lacked the first hand knowledge needed to make relevant and meaningful connections, and could provide no credible support for the ideas they read in the textbook. Occasionally, the teacher tried to 'situate' the knowledge by giving examples, or by calling on students to do likewise, but overall, the Science lessons did not have the authentic quality of students 'doing Science' as the Maths classes did. This finding may have implications for the teaching of Science via telematics, as it shows the constraints that are likely to be found if students and teacher rely entirely on discursive practice, instead of practical, laboratory-based experiential Science. By the end of Phase 3, the limitations

of telematics delivery for Science were becoming evident to both the teacher and students in the telematics program, and the difficulty of conducting lessons via telematics had led the Education Department to consider introducing desk-top videoconferencing, with a two-way video capacity, to overcome these problems.

Despite the low level of HOT in Italian, the teacher commented that students' approach to learning Italian, and their study strategies, showed that they had independent learning skills, the ability to extend themselves and look for new examples of items learnt and the self-awareness to identify gaps in their own knowledge. These factors indicated that the situation, or context of reasoning and thinking is vital, and that tasks requiring only procedural knowledge (eg., learning the vocabulary of a language) often does not require higher order thinking to be exercised.

Limited evidence of reflection

Students in all classes of the study showed the capacity to reason, to inquire and to interpret knowledge. In Table 15.1 the overall results are displayed. The highest percentage of cognitive accountability occurred in Phase 3, where the English and Social Studies lessons not only showed the highest overall percentages for HOT, but also the highest percentages for interpretation and critical inquiry. The Maths lessons in Phases 2 and 3 had a small percentage of reflection, as did English and Social Studies, while neither Science nor Italian showed any.

Of all the aspects of HOT, reflection was observed to be the least frequently manifest in discourse. Perhaps this could be attributed to the fact that it required a verbal form of expression or metastatement to be included in the analysis. In the telematics classrooms, where time was at a premium, a certain amount of the teacher attention has to be given to keeping the lesson moving along, ensuring activity and dialogue. Where talk is sign of engagement, silence may be interpreted as a lack of rapport, and teachers may not have allowed sufficient space for students to act on feedback given or to express a personal opinion of how their own learning was proceeding. Yet these elements are vital to learning and thinking, and to the integration of experiential and conceptual knowledge. Laurillard (1995, p. 182) comments that:

> Reflection is rarely supported, except in certain kinds of professional or post-experience education. Reflection is that part of experience where the learner has to consider the implications of their experience, the teacher's description and their own previous conceptions, and bring all these

together into a coherent new description ....It is important and difficult, and largely inaccessible to the teacher because it is internal to the learner.

In the operational definition of higher order thinking developed for the study, metacognitive processes were renamed 'reflection', and were defined as visible expressions of understanding, self-evaluation and cognitive strategy awareness. Occasional instances were observed in student talk in Phase 2 and 3, but it was sparse. The instances that occurred were in the context of problem solving, for example, in Mathematics, where students were given the scope to create new representations and compare their solutions with other students from different locations. This finding is in accord with the Vygotskyan perspective where dialogue and articulation of thought support learning, and the process of explaining one's thoughts in a social context leads to revision of ideas and consequent self-realisation.

Elsewhere in the literature reviewed (Mercer, 1995; Lipman, 1991; Gee, 1990) reflection is regarded as an essential component on learning to think, and so it should remain an outcome that is sought and fostered in telematics classrooms. However, the results of this study showed that reflection is unlikely to occur, even when teachers have the instructional intention of promoting HOT. This means that in telematics classrooms, reflection must be supported by overt and deliberate teacher practices that enable students to consider and comment on their own learning experiences.

Reflection can be achieved in telematics classrooms in a number of ways, and because it is a discursive and visual medium it offers advantages over face-to-face teaching in a number of respects. The 'invisibility' of participants requires greater levels of explicitness and clarity of expression in order to communicate and build rapport. The establishment of communication protocols is a normal procedure for teachers in telematics classrooms, but procedures need to be established to ensure that all participants have an opportunity to speak and teachers also need to be explicit in their goals, expectations and the outcome they expect. Articulation by the teacher of these expectations had been shown by previous research to be productive of a better classroom climate for higher order thinking (Coles, 1995). Similarly, encouragement of students to articulate justify their ideas, and become aware of language use was a strategy undertaken only by the Maths teacher, and to a limited extent by the English and Social Studies teachers. One reason why the second intervention was conducted, which was the use of self-check on thinking for students (*How well do I use my thinking skills?*, Chapter 13) was to foster awareness, articulation and reflection by students on their own thinking processes. Limited success was achieved by the self-check, although reflection did increase marginally in both the English and Social Studies classrooms following its use (Table 15.1).

A further means of encouraging reflection in telematics classrooms was to increase the use and visibility of the computer technology for this purpose, by enabling students to draw, write and share ideas, and then open them up for scrutiny and inquiry in the distributed classroom. This process was observed to occur in the Maths and Social Studies classrooms, where students created concept maps to share and refine their interpretation of octagon loops. Further discussion of how the technology can support cognition is related to its use as a 'cognitive tool' to enable students not only to display their own conceptualisation of content, but also to engage in discussion and refinement of ideas.

Pedagogic practices of teachers

Teacher talk was coded according to the communicative functions in the talk and five major categories that emerged were non-task talk, procedural, reconstruction, cognitive support and control (See Chapter 10). Each of these communicative functions also served to establish pedagogic practices. For example, the category of cognitive support indicated the kind of scaffolding offered to students, by, for example, teachers modelling thinking skills, promoting discussion, coaching, or asking reflective questions. Control in teacher talk indicated correction, overt instruction or directions, closed questions or eliciting information.

In reporting the results of teacher talk and the changes that occurred, particular aspects of talk were selected that best represented teachers' practice. So for example, although the category of reconstruction was included in the analysis of teacher talk, only a small percentage of this category were found, and there was little variation from one lesson to another. In the case of non-task talk, which was occasioned by technical or management problems, there was a marked decrease following Phase 1 of the study. While this might be partly attributed to the fact that teachers and students were more familiar with the technology, and that there were fewer technical hitches, close analysis of the videotapes and transcripts showed that this was not in fact the case. Technical problems still continued, but teachers pursued their objectives of achieving higher order thinking even in cases where they had to rely only on an audio link, as in The Maths and Social Studies lessons of Phase 3.

In Chapters 13 and 14, the changes that occurred in teacher talk from Phase 1 to Phase 2 were documented, as were changes that occurred from Phase 2 to Phase 3.
These changes confirmed the increase in scaffolding offered by teachers, demonstrated by the increase in cognitive support observed from Phase 1 to Phase 2.

Further insights can be gained by comparing teacher talk categories in Phase 1 and in Phase 3. The mean percentage difference in the functional categories displayed is shown in Table 15.2.

The major changes that occurred in teacher talk were changes in the amount of cognitive support, procedural talk and control talk, and while the changes in these categories was were more marked in Phase 2, (Chapter 13), a comparison of Phase 3 with Phase 1 reinforces the nature of teacher talk following the interventions. As Table 15.2 shows, all subjects showed an increase in cognitive support, attesting to the scaffolding role of the teacher.

Table 15.2 : Mean percentages changes in teacher talk in Phase 1 compared to Phase 3

	non task %	procedural %	control %	reconstruction	cognitive %	feedback %
Maths	-4	-17	-3	+.5	+8.5	+5
Italian	+2.5	-12.5	+2	+3.5	+.5	+1
English	-3.5	-3	-24	0	+25.5	+4
Science	-5.5	-9.5	+2.5	+6	+10	+1.5
S. Studies	+4.5	-16	-14.5	+1.5	+23	+2

These functions of control, and cognitive support were found to have the greatest impact on student reasoning and higher order thinking, as the transcripts showed that it was within the particular interactive context that of teacher-student dialogue that higher order thinking occurred. For example, in Science lessons it was observed that students showed more cognitive accountability when they were asked to justify and explain their responses, and where teacher scaffolds were offered. The transcripts showed that cognitive support in the form of reflective questioning increased and diversified as controlling aspects of the teacher's pedagogy decreased. For these reasons, in summarising teacher practices it was decided to focus on teacher behaviours that had an impact on higher order thinking. This entailed an analysis of the changes in cognitive support, control talk and procedural talk that occurred in lessons.

Figure 15.3 shows the pattern of teacher talk in the Science lessons, where higher order thinking increased gradually from Phase 1 to Phase 2, and increased further in Phase 3 to a percentage of 17% (See Table 15.1). In the Science lessons, cognitive support increased from 17% in Phase 1 to 26% in Phase 2, while in Phase 3 it increased to 27%.

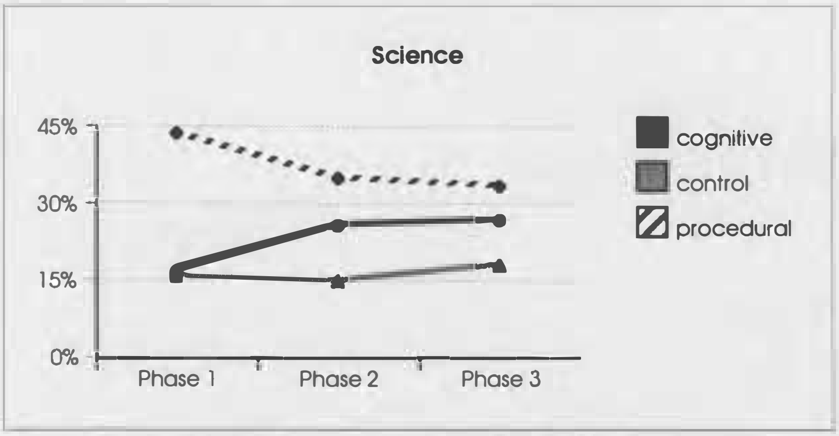


Figure: 15.3 Teacher talk changes in Science lessons

Procedural talk, which was concerned with allocating turns, management of lessons and resources and content talk decreased from Phase 1 through to Phase 3. Control by the teacher remained fairly constant stable throughout all lessons, with a slight increase to 18% in Phase 3.

While the occurrence of HOT increased in Phase 3 Science, the overall percentage was relatively low at 17% (Table 15.1). Although there was a decline in procedural talk indicating greater focus on content and concepts following the intervention, the controlling aspects of the Science teacher's approach did not vary much throughout the phases of the study. In Phase 1, this teacher pedagogy showed a preoccupation with correct answers and adherence to the textbook version of Science. Few lessons were based on tasks which were negotiated and controlled by students, and the pattern of discourse throughout the lessons was initiated by the teacher and followed the traditional Initiation-Response-Feedback sequence. It is also interesting to note that in the Science lessons, there was no reflection by students at any stage, and this could be related to the lockstep way in which the lessons proceeded. Students spent most of the time responding to the teacher's questions, and were not given the scope to conduct any exploratory work during lessons. Discussion among students was also rare, and there were few if any calls by the teacher for students to share control, in the management of their learning. Self-evaluation of independent investigation were not planned for, and consequently, students were not empowered to express personal views about the learning process. This pattern was also mirrored in the use of technology, (Figure 14.4) where the teacher allowed little adaptation of visuals by students, and no reflection through mediation by technology.

The pattern of teacher talk for Social Studies was quite different, as Figure 15.4 shows.

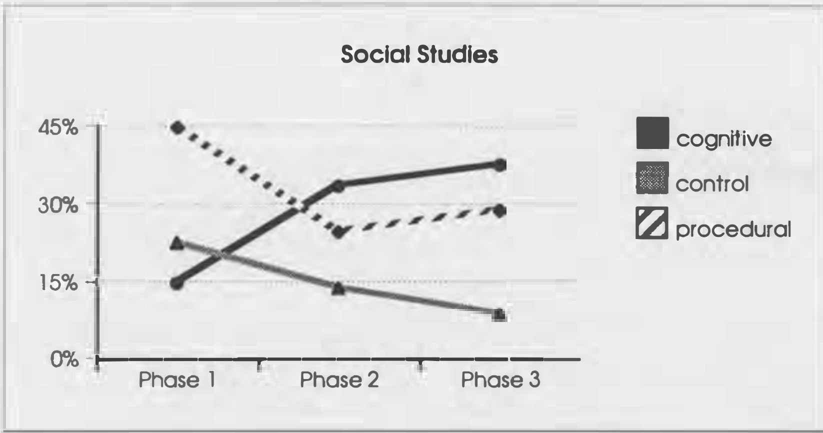


Figure: 15.4: Teacher talk changes in Social Studies lessons

Cognitive support increased from 15 % in Phase 1 to 34% in Phase 2, and 38% in Phase 3. There was a also a sharp decrease in control from 23% in Phase 1 to 8.5% in Phase 3, signalling a change in teacher pedagogy from a controlled and didactic approach, to one which supported student talk and discussion. The level of higher order thinking reached its peak in Social Studies Phase 3, when it accounted for 40% of classroom talk.

Figure 15.4 also shows that cognitive support increased in Phase 3, reaching a peak of 38%. It would seem that the change in teacher strategy, ie the adoption of an interactive rather an interrogative mode of questioning in Phases 2 and 3 may have contributed to the higher order thinking that occurred. Further evidence of the change was that procedural talk, which was very high in Phase 1, decreased in Phase 2, indicating that the focus of talk was less on procedures and technology and more on conceptual content. The slight upward trend for procedural talk in Phase 3 confirmed that the greatest changes occurred in Phase 2, and that this levelled off in Phase 3.

The Italian lessons showed a unique pattern in teacher talk. Figure 15.5 shows the pattern of change for cognitive control and procedural talk. Cognitive support, which increased from Phase 1 to Phase 2, decreased very slightly in Phase 3 to reach 26.5%. This corresponded to a slight decrease in HOT from Phase 2 to Phase 3. Earlier the problem of fostering higher order thinking in Italian was discussed in relation to the kinds of activities that students were engaged in, and the teacher's need to cover syllabus items and introduce new vocabulary. The increased control from Phase 2 to Phase 3 Italian (2%), suggests that the teacher returned to a structured and perhaps more didactic way of teaching, and the decrease in cognitive support to 26.6% in Phase 3 provides evidence of this. Procedural talk declined steadily in all Phases of the lessons, showing that talk was increasingly task focussed, although higher order thinking remained relatively low at 7% in Phase 3.

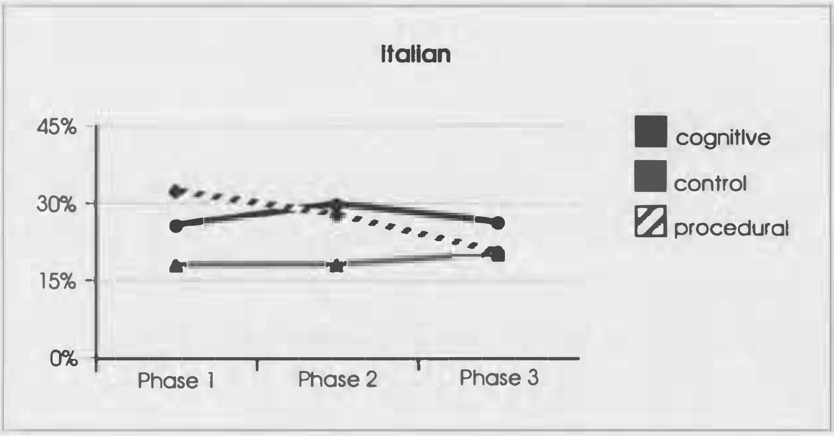


Figure: 15.5: Teacher talk changes in Italian lessons

In the English lessons, cognitive support for students increased sharply from Phase 1 to Phase 3, as did the occurrence of HOT. Teacher control over turns and lesson outcomes decreased sharply from Phase 1 to Phase 3, indicating that students were given more autonomy and self-direction. The English classroom showed the smallest percentage of control in Phase 3, at only 6.5%. This is confirmed by the interaction patterns in Phase 3 English lessons, where student-student talk increased and there was an argumentative style of discourse between the learners.

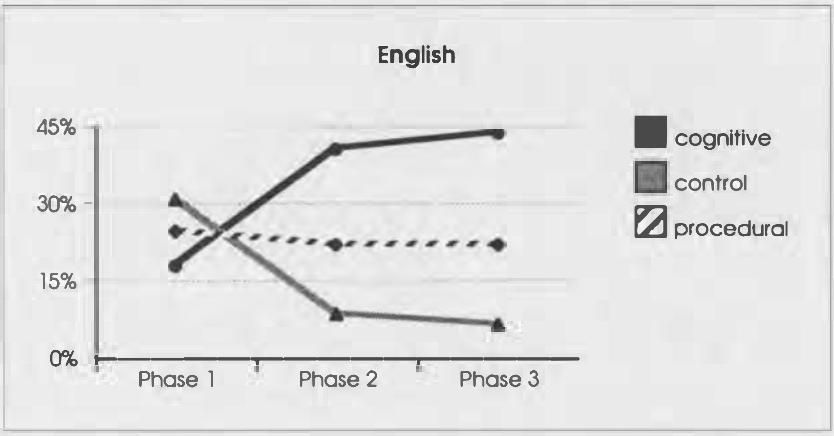


Figure: 15.6: Teacher talk changes in English lessons

Figure 15.6 also shows that the decrease in control talk in the English lessons was matched by a increase in cognitive support, patterns indicating that teacher discourse underwent considerable transformation following Phase 1. In addition, control talk decreased from 30.5 % in Phase 1 to 6.5% in Phase 3, showing that students were given more autonomy, and this was evident in the discussion activities planned for lessons in Phase 2 Phase 3. Cognitive support increased to 44% in Phase 3, consisting of stimuli

for discussion, offering opportunities for collaborative dialogue and encouraging personal responses to the themes in the English syllabus.

In the Maths lessons there a less dramatic change in teacher pedagogy than that found in the English and Social Studies lessons, with cognitive support increasing slightly throughout all phases of the study. However, control in the Maths classroom in Phase 1 was lower than for most other classrooms, at 15.5%, and was the same in Science. The pattern of teacher talk is shown in Figure 15.7. From the outset, there was more cognitive support demonstrated by the Maths teacher than by with the English, Science or Social Studies teachers, and therefore the changes that occurred in her practice were less pronounced than in other subject areas.

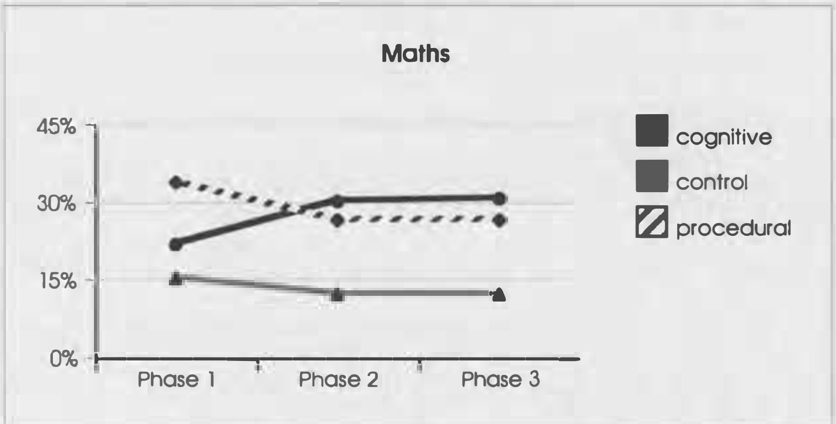


Figure: 15.7: Teacher talk changes in Maths lessons

For example, in Phase 1 Maths there was cognitive support offered to students (22%) and they were reminded to think about using mathematical language and encouraged to expand their ideas. This pattern of support increased in Phase 2, and it remained stable throughout Phases 2 and 3 at 30.5%.

In summary, the changes that occurred in teacher talk can be interpreted as a general decrease in controlling discourse and an increase in cognitive support offered to students. This pattern is confirmed by the general upward in cognitive talk that occurred in all lessons from Phases 1 to 3. Again all subjects showed a decrease in procedural talk in Phase 2, which followed the intervention, and the decrease was sharper in Italian, English, and Social Studies. Nevertheless, in all subject areas procedural talk was a constant part of teacher practice and occupied from between 20% to 35% of teacher talk in all phases of the study.

Considering the telematics classrooms in relation to the patterns of cognitive support shows that in Phase 1, all lessons were low in cognitive support, showing only between

16% to 25% in teacher talk. Following the intervention, cognitive support increased in all classes and ranged from 26% to 41%, and then levelled off in Science, Maths and Italian. In Social Studies and English, cognitive support showed further increases in Phase 3. Overall these results show that the first intervention was highly successful in changing the didactic patterns of teacher pedagogy, by enabling teachers to adopt scaffolding practices and thereby offer cognitive support to students. This pattern was also confirmed by the consistent downward trend in control talk in the English, Social Studies and Maths classrooms from Phase 1 to Phase 3.

Relating cognitive support to higher order thinking

While each subject had its own unique pattern of teacher talk, the overall tendency was for cognitive support to increase and control and procedural talk to decrease. In classrooms where cognitive support increased, student display of higher order thinking also increased. The pattern of cognitive support and HOT for English is shown in Figure 15.8.

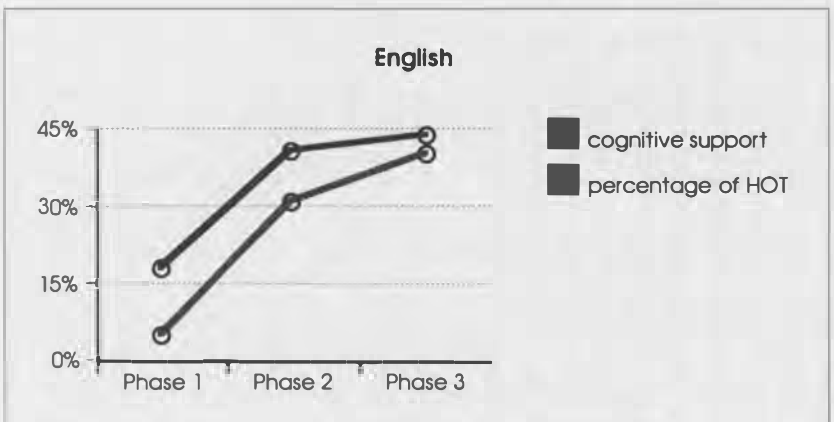


Figure 15. 8: Cognitive support and occurrences of HOT in English lessons

The English lessons showed the highest levels of cognitive support (44%) in Phase 3, and also the highest proportion of HOT (40.5%).

The pattern that emerged from the data showed that where cognitive support decreased, so did higher order thinking. In the Maths lessons of Phase 3, there was no change in either the amount of cognitive support offered to students, nor in the occurrence of higher order thinking. This pattern suggests a strong link between the amount and type of cognitive support provided and the level of higher order thinking displayed by students. Figure 15.9 shows that the level of HOT paralleled the changing levels of cognitive support across the three phases of the study.

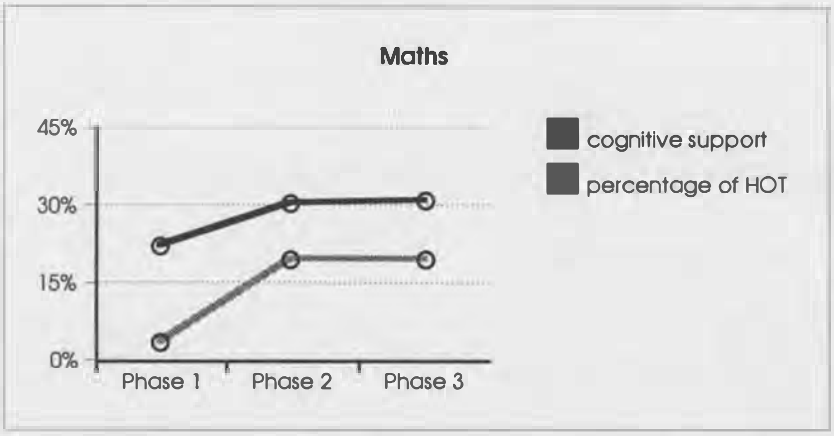


Figure 15. 9: Cognitive support and occurrences of HOT in Maths lessons

The Social Studies lessons displayed the second highest overall percentage of HOT (40%) in Phase 3, and Figure 15.10 shows that the increase in cognitive support from Phase 1 was accompanied by an increase in higher order thinking.

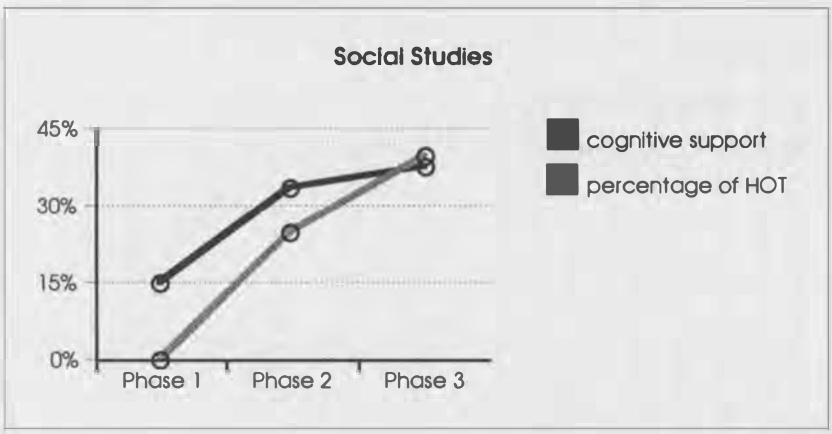


Figure 15. 10: Cognitive support and occurrences of HOT in Social Studies lessons

The particular forms of cognitive support offered by all teachers to promote higher order thinking were in evidence in the discursive forms they used to assist students. In the Social Studies lessons, cognitive support was at a low level in Phase 1 (15%), and no higher order thinking was observed in student talk. The sharp increase in cognitive support in Phase 2 (34%) fostered types of dialogue that showed reasoning skills, and there was a subsequent increase in HOT to 25%. In Phase 3, HOT increased further to 40%, and cognitive support reached 38%.

In the Science lessons, cognitive support increased from 17% in Phase 1 to 26% in Phase 2 and reached 27% in Phase 3. Higher order thinking did not show great increases form Phase 1, but nevertheless, a gradual increase was found to occur from Phase 1. In Phase 3, higher order thinking amounted to 17% of total talk. This pattern is displayed in Figure 15. 11.

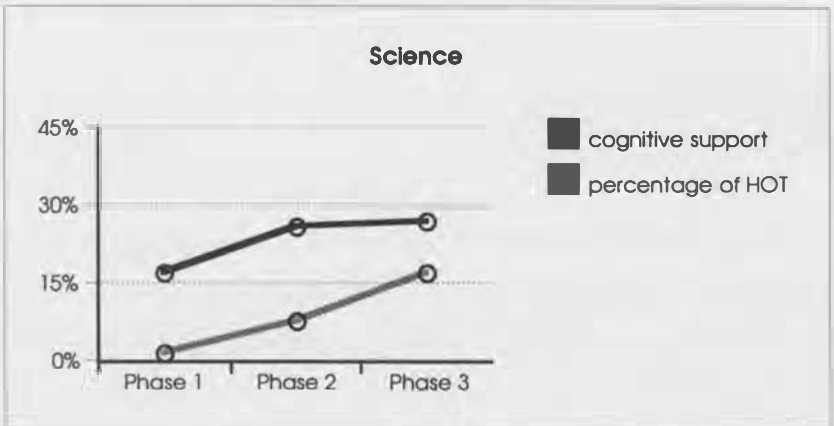


Figure 15. 11: Cognitive support and occurrences of HOT in Science lessons

The Italian lessons too had a unique pattern of cognitive support and higher order thinking. The level of HOT in all three phases was lower than for other subjects, but the level of cognitive support offered in Phase 1 was as higher (26%) than in other classrooms, probably because the students were studying this subject for the first time and needed a good deal of scaffolding. The amount of HOT displayed was lower than in other subjects and in the first phase no higher order thinking was displayed by students. The pattern of cognitive support and HOT is shown in Figure 15.12.

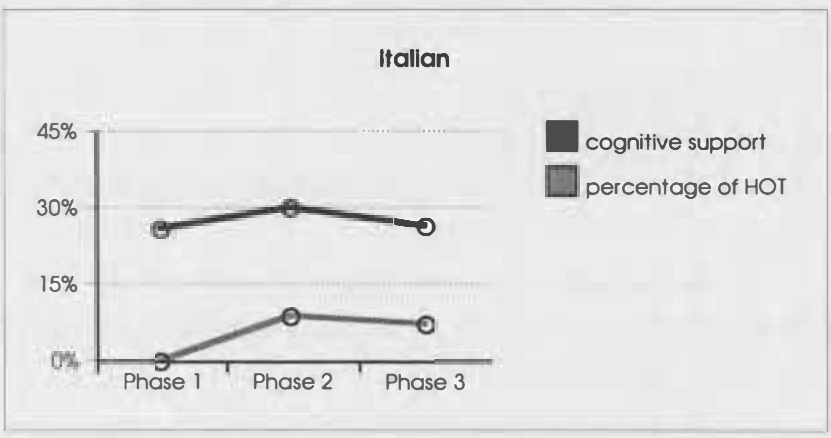


Figure 15. 12: Cognitive support and occurrences of HOT in Italian lessons

In Phase 2, an increase in cognitive support was accompanied by gains in higher order thinking. As cognitive support decreased in Phase 3, HOT also declined.

Thus, across all phases of the study, a critical factor in supporting higher order thinking was the cognitive support or scaffolding provided by the teachers. Various forms of cognitive support contributed to the gains in thinking shown by students and

these suggest that particular patterns of teacher discourse are supportive of higher order thinking in telematics environments.

Teaching strategies

Results showed an increase in the amount of cognitive support offered to students from Phase 1 to Phase 3, in all subject areas. While the quantity of support increased, so did the range and quality of teacher strategies and dialogue. In Phase 1 it was noted that the forms of support offered were related to explaining content or difficult concepts, but did not engage students in initiating or asking questions. The implicit I-R-E structure was still present, and teachers' conversational acts were limited to questioning or soliciting short factual answers. Consequently, there was more teacher talk than student talk in lessons, and much of this talk was focused on imparting the content of the syllabus.

From Phase 2, teacher discourse changed and a great deal more cognitive support was offered to students in the form of :

- asking reflective questions;
- offering ideas and stimuli;
- promoting discussion; and
- modelling thinking skills.

The effect of these changes was to encourage more elaborate responses from students, where they explained, justified ideas, considered and evaluated other perspectives and expressed their opinions on the text. The transcripts provided evidence of these strategies, and extracts were provided in Chapters 12 and 13 to illustrate occurrences of each category. The kinds of questions that were found in the transcripts signalled a change in pedagogy, with teachers demanding more responsive and responsible discourse from students. The range of teacher questioning was found to include:

- questions inviting collaboration and peer cooperation;
- questions which prompted students to interpret and extend their thinking by offering a stimulus;
- 'why' questions, or questions which elicited justifying reasons for answers;
- questions as a stimulus to discussion or elaboration, enabling students to engage in multiple viewpoints.

Taken in the context of the telematics lessons, these strategies had the effect of evoking more thoughtful responses from students, generating explanations and prompting cognitive accountability and justification of responses. Where higher order thinking was displayed, it affirmed the teacher's supportive role as there was a clear interdependence of higher order thinking and cognitive support in the classrooms of the study. This can be inferred from Figures 15. 8, 15.9, 15.10 and 15.11.

These results also showed that higher order thinking could be fostered by direct intervention by teachers. Essentially, development of student discourse was facilitated by teacher questions, which helped focus students on thinking processes. From another perspective, the teacher's discourse enabled students themselves to develop discursive competence, and to adopt similar questioning strategies in their own talk, as they did in the Social Studies and English classes. This increased competence in learners may be partly due to the teacher practices of scaffolding inquiry and reasoning. Student appropriation of questioning practices are all part of the socio-cultural perspective, as learning is regarded as an assisted performance, and students learn by enculturation into the discourse practices of the communities in which they participate (Brown, 1997).

Though some previous research (Lemke, 1990; Carlsen, 1991) sees questioning as the teacher's way of controlling students, or curtailing their interpretation of subject matter, the particular forms of questioning found in the telematics classrooms of the study invited elaboration from students, and could therefore be interpreted as facilitating understanding. In the lessons, these questions gave students the opportunity to develop skills of justifying answers and explaining their own responses, while maintaining a strong teacher-student rapport. These results suggest that the particular discourse strategies used by teachers in telematics classrooms are important both in modelling the kinds of inquiry skills that students need to develop, and also as way of offering 'guided assistance' (Tharp & Gallimore, 1988) to students in the distributed classroom.

Roles of the teachers

Associated with the changes in teaching strategies there were patterns of social change in the classrooms, in particular the roles that teachers adopted. The changing practices of teachers are reflected in the percentages of talk categories described in the results. For most teachers, there was a relaxation in the controlling elements of their teaching in Phase 2, and an increase in supportive dialogue. It was advocated in the first intervention that teachers offer guided participation to students, in order to help them

make the transition to reasoning and thinking at higher levels. There was a movement in the classrooms of the study from a didactic, authoritarian style of teaching in Phase 1 to a more participatory, and student centred approach in Phase 3 for the subjects Maths, Science English and Social Studies. In Phases 2 and 3, as the environment became more supportive of reasoning, the teachers took on different roles from the original 'transmission-of-knowledge' focus in Phase 1. In the words of Prawat & Flowden (1994) : "teachers abandon the orchestrator role and join the fray, becoming active participants as they attempt to guide the group towards the disciplinary high ground." The participatory role of the teacher was apparent particularly in the Maths, English and Social Studies lessons, where dialogue between teachers and students became more like sharing of perspectives and knowledge building, rather than absorption of pre-established facts. However, the controlling elements in the dialogue of the Science and Italian teachers did not vary a great deal from Phase 1 of the study, nor did the pattern of dialogue veer away from the three part structure of teacher initiation, student response, teacher evaluation (IRE).

These results indicated that in telematics classrooms teachers still had a tendency to control or direct students activity, rather than guide or scaffold thinking. This tendency to structure activity and assume a directive controlling role occurred in the Science classrooms, and in Phase 3 Italian, and may be accounted for by the pressures teachers felt to cover the syllabus in a limited amount of time

Use of technology to support higher order thinking

In the telematics classrooms of the study, computer technology was used both to mediate communication and also to provide an interactive screen where text and graphics could be shared. To analyse the capacity of the technology it was essential to evaluate its potential contribution to learning in terms of the socio-cultural framework of the study. The starting point for this study was the link between talk and learning, and this is reconsidered as fundamental to learning in the Vygotskyan theory (Vygotsky, 1978). Computer technology is viewed not merely as a device for delivery of content (Clarke, 1994), but rather as part of the social context which can mediate learning and communication. For example, group work among students around computers has been shown to support collaboration, dialogue and interaction (Wild & Braid, 1996) and to facilitate learning in Mathematics (Hoyles, Healy & Pozzi, 1994). Findings such as these indicate that in technology supported environments where collaboration and higher order learning are in evidence, the pedagogy is not technology driven, that is generated from computer-based activity. Instead, learning takes place where technology is used to facilitate dialogue and interaction, and to

enable learners to formulate hypotheses, share ideas, question each other and reach joint decisions. The theoretical framework adopted for the telematics classrooms of the study was based on Laurillard's (1993) conversational framework where the essential ingredients of the learning process entail interaction, discussion, reflection and adaptation.

For each stage of the research, technology use was analysed by applying these dimensions to interactions with computers, by monitoring the way the technology was integrated into the learning process, and by observing how students used the computer screen to support interaction, discussion, reflection and adaptation. Each lesson was analysed separately and the results collated to produce an overall perspective seen in Figure 15.13. For each lesson, the computer was used to support discussion and interaction between teacher and students, and this increased from Phase 1 of the study through to Phase 3. There was no increase in interactivity from Phase 1 to Phase 3, and a similar pattern occurred for discussion. Nevertheless, the capacity of the computer to support interaction between teacher and students remained high in all classrooms, and this was evident in the dialogue that took place when visuals accompanied the lesson content. The capacity of computer technology to support discussion was evident from the transcripts, where ideas were discussed, and the visual channel provided a shared focus for attention.

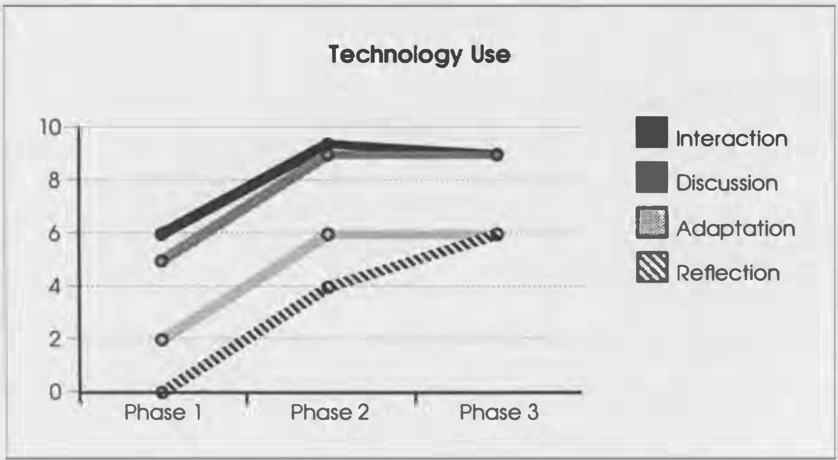


Figure: 15.13 : Dimensions of computer technology use in all phases of the study

Adaptation, or the capacity for students to change or have input into the creation or visual elements, was made possible in some of the telematics classrooms by virtue of the teachers sharing control of the software with students, or assigning control totally to students so that they presented their own ideas, thoughts and conceptual outlines. Students of Social Studies, English and Italian had the use of a graphics tablet, while

students of Maths and Science had to rely on a shared keyboard, which provided potential for adaptability but was much slower.

The adaptive dimension of computer technology increased following Phase 1, but remained fairly stable throughout Phases 2 and 3. In both Phase 2 and 3, control of the computer was shared or in some lessons, given to students. Both the Maths and Science lessons showed that teacher's productions were adaptable by the students, but in the Italian lessons, while the students had the additional facility of a graphics tablet, students rarely used it to contribute ideas or show their own representation of ideas.

Figure 15.13 also shows that levels of reflection were low in Phase 1 of the study, but increased in Phase 2, and then increased slightly again in Phase 3. Reflection was interpreted in the study as the process by which students acted on feedback from the teacher to interpret their experience, or to comment on the learning experience through metastatement or expression of a personal viewpoint. In all subject areas the dimension of reflection was low in student talk, and completely absent in Science and Italian lessons. In classrooms where technology supported reflection (for example in Maths and English Phase 3) students had control over the computer and depicted their won representation of concepts and used these as a basis for discussion.

In the study, the various computer visuals created by students showed that the computer could enable students to:

- depict and represent their ideas;
- display ideas visually and use this as a springboard for discussion; and
- collaborate and create shared representations of ideas and issues.

Many of the visuals created by students showed evidence of shared conceptualisation and problem solving, and the accompanying conversation also displayed reasoning and evaluation of ideas. In discussing audiographic conferencing, Laurillard (1993a) states that a medium which supports discussion, (as telematics does) also has the capacity to support interaction and reflection by students on feedback given. However, in the present study, while the interactive and discursive channels were fully exploited in technology use, there was little adaptation or reflection shown by students. Adaptation is essentially a two-way process, where the teacher adapts instruction to the learner's needs and the learner adapts the teacher's views of events and reinterprets them.

The visual medium of the computer screen was able to support adaptation by the teacher and by the students, but very often in the telematics lessons, when the teacher

had prepared all the screens for the lesson, there was no scope for students to show their conception of the subject matter, or to adapt the ideas that were presented. Additionally, some teachers assumed full control of the computer screen throughout the lesson, projecting only a single view of the content, thereby denying opportunities to students to challenge or propose other ideas. The most fruitful lessons in terms of technology use were those where teachers enabled students to depict their understanding of the subject, collaborate with others and share their representation so that a 'community of inquiry' approach was fostered. This occurred in several Maths lessons, and in some Phase 3 English and Social Studies lessons where all components of the conversational framework were achieved.

Use of the computer to generate reflection was limited, and much of the dialogue that occurred around the computer gave students an opportunity to state and share their beliefs. An example of this occurred in the Maths classroom, when the students created a mind map where they depicted their own ideas of how an investigation of octagon loops could be extended and how predictions could be based on the results (Figure 14.6). Not only did the students exhibit high levels of reasoning, but they also showed how technology could be used to support dialogue and reflection. By sharing a graphical representation of ideas, students not only projected their own ideas, but also had a common point of reference, an anchor for their thoughts and an adaptive, interactive and discursive space for their own expression. In summary, the technology scaffolded higher order thinking.

It was not merely the technology that enabled this usage, but the task, the social context and the collaborative, student-centred task that they were engaged in. Teachers in the study were encouraged to foster a sense of sharing knowledge and a context of guided participation, and the visual medium of the technology afforded this dimension (Chapter 12). However, teachers did always use the technology to create a sense of guided participation, where students had support, choice and self-direction in using the computer to scaffold their own thinking processes. In most lessons, teachers tended not to foster student reflection on the products of the computer visuals generated, but several successful episodes from the Maths and Social Studies lessons of Phase 3 showed that the potential of the technology could have been exploited more fully.

In conclusion, it seems that greater exploitation of the interactive components of the technology could have been sought. The results indicated that teachers needed to achieve stronger links between technology use, social interaction and higher order thinking. Up to now this dimension has not been provided in research on telematics environments (McLoughlin, Oliver & Wood, 1997; Oliver & Reeves, 1996). Telematics

classrooms are ideal contexts for the verbal and communicative aspects of learning, as students have no visual contact with each other apart from the computer screen. The social need to explain, assert and justify ideas is critical to all participants in order to achieve understanding and effective communication. The assumption that the technology is merely there to mediate communication undermines its potential to support higher order thinking, and at many stages the computer visuals were used simply to gain students' attention. Teachers acknowledged that they were tied to the notion that achieving connectivity and interaction between the computers at each site was the most important element of a lesson, and many neglected to plan for use of the technology to support dialogue and higher order thinking.

In contexts where technology is used to mediate the learning experience, as in telematics classrooms, computers may be used as *cognitive tools* to enhance learning. As Jonassen & Reeves (1996, p. 47) have stated:

> Cognitive tools provide an environment that often requires learners to think harder about the subject matter domain being studied or the task being undertaken while generating thoughts that would be impossible without the tools. ....Cognitive tools are reflective tools that amplify, extend, and even reorganise human powers to help learners construct their own realities and solve challenging tasks...

This conceptualisation of technology as a cognitive tool where learners use the media to express what they know and understand, and present it to others for discussion, revision and debate, would equip teachers in telematics classrooms with a view of technology that would support higher order cognition. With respect to cognitive tools to support higher order thinking, this would entail social interaction, collaboration and articulation of ideas through language so that the individual student's representations of knowledge are amplified and supported by reciprocal educational dialogue.

Assertions to guide practice in telematics learning environments

The outcomes and observations derived from this empirical study of teacher and learners in telematics classrooms have provided some generalisations and patterns which can provide guidance for teachers striving to achieve higher order thinking in these environments. These are phrased as assertions and offered to guide teaching and learning practices, but are not intended as prescriptions that will inevitably lead to specified outcomes. Previous studies of telematics environments (Oliver & Reeves,

1996) have suggested several 'dimensions' of interactive learning with telematics. Some of the findings of the present research support the guiding principles proposed by Oliver & Reeves, but are more specific to the teaching and learning interaction, and to the interdependency of the social roles adopted by teachers and learners in these distributed classrooms. Consistent with the socio-cultural framework of the study, the assertions are based on the analysis of interactive and social processes, and the contexts in which higher order thinking was best supported in the classrooms of the study.

Assertion 1: The development and support of higher order thinking begins with the teachers' instructional intention to plan for higher order thinking in the classroom.

During the first phase of the study, teachers did not plan for higher order thinking, although they kept records of the content that they intended to cover in their lessons. Results from Phase 1 of the study showed that the incidence of higher order thinking was low, and that the Italian and Social Studies classrooms showed no occurrences of HOT by students. Furthermore, analysis of the transcripts showed that in the same lessons, the teacher's intent and objectives did not suggest that the purpose of the lesson was to develop thinking skills. Only the teacher of Mathematics explicitly planned for HOT, and told her students that she expected them to say what they were thinking and to explain their own thinking processes as they solved problems. Research has shown that student expectations of learning have a powerful influence on how they communicate in the classroom (Westgate 1993; Wood, 1992) and that teacher intentions and expectations influence how students approach tasks. As most of the teachers had not planned for HOT, there was no evidence in Phase 1 lessons that they expected students to engage critically with content, or to justify beliefs and provide evidence. Teacher talk in Phase 1 (Chapter 11), showed that teachers were more concerned with the accumulation of facts, as their talk displayed mostly procedural, expository and controlling elements.

Research has shown that it cannot be assumed that higher order thinking will simply happen, or that it will arise spontaneously in classrooms where traditionally, teachers occupy positions of authority and power and control opportunities for student participation and talk. Previous research attests to the overly controlling features of pedagogies used in telematics classrooms and how these constrain student expression and inquiry (McLoughlin & Oliver 1995b, Lemke, 1990). Teachers need to plan their strategies and ensure that higher order thinking is at the forefront. In the present study, when teachers explicitly planned for HOT, as in Phases 2 and 3, it was achieved.

From this finding it can be said that in order to foster higher order thinking, a teacher must at the outset, recognise this as a desirable educational outcome and plan for it, both by setting tasks which foster independent thinking and problem solving and by creating a supportive climate in the classroom where it can be nurtured. In addition, a teacher's stated intentions are likely to influence students' own perceptions about their roles as learners. The fact that in Phase 2 and 3 of the study, teachers acknowledged the importance of thinking and asked students to expand, explain and justify their responses accounted for better outcomes in terms of higher order thinking.

Assertion 2: Teachers need an operational definition of higher order thinking to inform their practice.

In the study teachers were asked about their perceptions of higher order thinking. Many teachers had unclear or hazy ideas as to how HOT could be translated into classroom practice, or indeed how HOT might be recognised in the telematics classrooms. The teachers were in agreement that a comprehensive and well formulated definition of HOT would enable them to relate thinking practices to patterns of interaction and dialogue and help them achieve this outcome.

The operational definition adopted for the study was in keeping with the curriculum objectives of courses being taught, and moreover, it extended and clarified the notion of higher order thinking for teachers by linking it with language-based practices in the context of their own classrooms. The interactive, socially based view of HOT was appropriate and relevant to learning in telematics classrooms, where audio channels and communication are fundamental, and language is used to mediate learning. Thus, linking higher order thinking processes with the communicative interactive elements in telematics classrooms, enabled teachers to contextualise the operational definition, and draw connections between it and the outcomes they were striving towards.

A further dimension of the operational definition of HOT was its embeddedness in the curriculum the teachers were following. This connection them to talk about its realisation in their teaching, and plan tasks and strategies that would support forms of reasoning.

In the study, the development and application of an operational definition was part of the process of increasing teacher awareness of HOT, and of linking the definition of HOT with the communicative basis of the theoretical framework of socio-cultural theory.

Assertion 3: Higher order thinking can be scaffolded through the adoption of pedagogies that foster exchange of views, argument and discussion.

The teachers of the study were encouraged to adopt practices that would support the achievement of higher order thinking. Through a research partnership and progressive discussion, teachers decided to adopt an enculturation approach to developing HOT in their classrooms, where they:

- modelled thinking strategies;
- scaffolded HOT; and
- established the ground rules or expectations for thinking in their classrooms.

It was considered inappropriate to specify and define teaching practices for each classroom, as teachers were not only experienced but also because it was important for them to interpret the enculturation approach according to their own subjects and needs. Teachers showed both originality and resourcefulness in developing tasks for higher order thinking, but the guiding principle was the operational definition of HOT, the importance of language use to support thinking, and the development of social dispositions leading to the exchange, sharing and refinement of ideas (Chapter 12).

The striking results in English and Social Studies, where higher order thinking increased in both Phase 2 and Phase 3 to reach 40.5% and 40% total talk in the lessons, invites a closer look at how the teachers of these subjects achieved such outcomes. Instead of teacher-student discourse there was student discussion, with an emphasis on collaborative dialogue and argumentative discourse . Tasks were set to engage students in arguments where they challenged ideas, gathered evidence in support of their views and assessed the validity of arguments according to criteria. On other occasions students engaged in supportive dialogue where they shared perspectives and co-constructed arguments (Chapter 14).

In telematics classrooms where higher order thinking is the objective, the organisation of activities and tasks which support discussion and argumentation would foster higher order cognition.

Assertion 4: Higher order thinking in telematics classrooms can be scaffolded though reflective questioning of students.

While learner independence may be the culmination of teaching activities, it does not diminish the role of the teacher in supporting learning via telematics. Although Oliver & Reeves (1996) have suggested that 'personal autonomy' and control over content pace and review are important, the results of the present investigation suggest a more central role for the teacher. This study has provided ample evidence for a strong scaffolding role for teachers, not only in creating instructional plans for HOT, and setting up collaborative and argumentative tasks, but also in supporting students' thinking. In all subjects the percentage of cognitive support (scaffolding) increased in teacher talk following the intervention, and corresponded to increases in higher order thinking in all classrooms.

One of the most productive ways that teachers were found to support reasoning and cognitive accountability was through reflective questioning, where, instead of demanding an answer to a closed question, the teacher would invite elaboration, expansion or justification of an idea presented by an individual or group. It is suggested that a transition from transmissive style teaching which focuses on elicitation of information from students to a style of teaching which is supportive of cognitive accountability, where students justify and explain their views and responses, is likely to enable higher order thinking.

Assertion 5: Higher order thinking can be supported by teachers adopting roles which are participatory and less controlling.

The authoritative and controlling role of the teacher is a feature of the literature on telematics classrooms (McLoughlin & Oliver 1995b; Oliver & Reeves, 1994a). Students are often socialised into passive roles where they do not participate, or even offer an opinion on what they have learnt. Teacher roles which are authoritative are signalled by controlling discourses, by directives, and by information seeking questions (Wood, 1992; Barnes, 1992). The traditional pattern of interaction is the three part exchange where the teacher initiates, the student responds and the teacher evaluates what has been said. Similarly, the results of Phase 1 of the present study showed that teachers used controlling pedagogies to direct, elicit information and confine lessons to teacher directed activities (Chapter 11). Following the intervention, teachers assumed less controlling and authoritative standpoints and achieved increased HOT in their lessons.

By adopting roles in which they participated in dialogue with students, teachers applied practices where student inquiry and questioning were enabled, and created conditions conducive to higher order thinking in the classrooms of the study. In many lessons, the teacher assumed the role of participant, rather than leader, in order to co-

construct and share knowledge with the learners. Such participatory roles are possible in telematics classrooms, where class sizes are usually small, and the teacher is free of the custodial and disciplinary roles that are sometimes necessary when teaching larger groups.

Assertion 6: Higher order thinking in the telematics classrooms can be fostered by a argumentative and discursive forms of interaction.

The teachers were found to change their pedagogies from the initial phase of the study in ways that impacted on the learning of students. This was evident in two ways. First, students enjoyed higher levels of participation in the classes in Phases 2 and 3, and second the incidence of verbal reasoning was greater following the interventions. The enabling characteristics of teacher pedagogies that emerged from the transcripts and data analysis were:

- an increase in scaffolding behaviours, indicated by an increase in the category of cognitive support;
- opportunities for students to engage in discourse and argumentation;
- encouragement of student to challenge ideas and to evaluate alternative ideas;
- optimising the social environment for HOT by providing resources where multiple viewpoints and perspectives are offered; and
- modelling the practices of thinking and reflection.

Throughout Phase 2 and 3, the change in teacher pedagogy was accompanied by a change in style of discourse, a departure from the ubiquitous Initiation, Response-Evaluation style where teachers talked more and students merely responded. This pattern of dialogue only reinforced the controlling and socially dominant role of the teacher. In Phases 2 and 3, in the Social Studies and English lessons, other forms of discourse facilitated discussion and higher order thinking. These discourse patterns were described as *collaborative* and *argumentative* (Chapter 14) and led to many instances of higher order thinking because students could express, compare and review their ideas without the constant demands for exposition of knowledge that was a feature of Phase 1 verbal interactions. The literature reviewed recognised that argument is a crucial tool in the development of reasoning in learners and this is recognised in many disciplines, including Science, Maths and the Social Sciences (Kuhn, 1993; Craft, 1991; Lipman, 1991; Resnick, Salmon et al., 1993).

It is suggested that an alternative discourse style, that of argumentation, be fostered in telematics classrooms so that students learn to engage with ideas, question knowledge

and learn to justify their views by recourse to evidence and data. In this way, the essential skills of inquiry and cognitive accountably will be fostered. In a discursive medium such as telematics classrooms, dialogue is the essential communicative link, and it can be utilised to support dialogue and conversation which enables students to think critically and independently.

Assertion 7:
Higher order thinking can be improved by utilising technology to support the social processes of cognition and reasoning.

In telematics classrooms teachers can use the technology to scaffold the social processes of thinking. Instead of regarding technology simply as a conduit for communication and messages, the socio-cultural perspective advocates a view of technology as integrated with the social fabric of learning. Through the visual components of the computer, knowledge is continually presented and represented between teachers and students, and ideas are adapted, discussed and reflected upon. By applying Laurillard's conversational framework to the analysis of computer use, it was possible to assess which elements of the learning conversation were supported by the computers used in the telematics lessons. The results (Figure 15.8) showed that in Phase 2 of the study computer usage included interactive, discursive, adaptive and reflective components.
In the same lessons, there was less control of the technology by teachers and on many occasions, control of the computer was shared between teachers and students.

The visual representation of knowledge created by students in Phases 2 and 3 showed that the technology was used to create forums for discussion, shared knowledge and conceptual overviews of the content. In addition, jointly created screens were used as a basis for problem solving and social argument, for discussion, elaboration and challenging of ideas. When students had control of the computer they were less constrained by the teacher and more likely to generate original ideas and depict their own understanding of subject matter. In several of the lessons observed, students created concept maps of the lesson topic, and used these to explain their reasoning. In this way, shared visuals become a focus for interaction and discussion, leading to higher levels of thinking and verbal reasoning.

In conclusion, telematics environments offer a variety of channels for communication, including audio and visual modes, and these can be utilised effectively by teachers to support thinking processes if they enable students to present, discuss and share ideas.

Assertion 8: Higher order thinking in telematics classrooms can be fostered by teachers valuing reflection in learners.

The ongoing continuous dialogue in the telematics classrooms observed did not appear to provide opportunities for reflection, although there was constant two-way communication and task-oriented talk. The findings of the study showed that reflection was a dimension of HOT that was least in evidence. Reflection "enables students to compare their own problem-solving processes with those of an expert, another student, and ultimately with an internal cognitive model of expertise" (Collins, Brown & Newman, 1989, p. 63). It could be therefore be argued that reflection can be made visible in spoken interaction, and articulated by learners. In the present study, reflection was a component of higher order thinking conveyed through a metastatement by learners which showed awareness, or self-evaluation of the thinking processes. These metacognitive acts were regarded as part the process of achieving higher levels of thinking.

Opportunities for students to express personal opinions and views, or to self-evaluate their own learning were rarely achieved in the talk of students in the telematics classrooms, with the exception of one lesson in Phase 3 English. Occasional moments of reflection arose in the lessons, but the transcripts showed that these were spontaneous, and not scaffolded or assisted. The complete absence of reflection in both the Italian and Science classrooms coincided with overall low level of HOT achieved in both subjects, and with the controlling discourse of the teachers.

The second intervention was aimed at enabling teachers to increase awareness of reflection in students through use of a self-check instrument for thinking skills (Chapter 14). Nevertheless, it was not clear that teachers continued to evoke, reinforce and support students' capacities to reflect on their own learning processes. Theorists such as Laurillard (1995) and Young (1997) maintain that reflection is essential to the learning process, as it enables learners to act on feedback and develop conscious awareness and control of their own learning processes, such as planning, self-monitoring and self-correcting. In telematics classrooms, where the teacher is not physically present with the students, such processes may be undetected and underdeveloped. However, the intensity of the social and verbal interaction affords greater scope for promotion of reflection in students, and can support dialogue which could lead to reflection.

If students are given opportunities to express their ideas and comment on their own learning, they would become more aware, and perhaps more adept at evaluating their

own ideas. Here the technology can assist learners to reflect on the products of their own thinking. The visuals created by students can provide scope for them to observe, compare and discuss the products of their own thinking, and allow them to produce multiple perspectives which can be discussed. Telematics classrooms therefore, are potentially ideal contexts for development of reflection.

Furthermore, teachers, through appropriate questioning and pedagogies can provoke reflection, reconsideration of views, analysis of argument and thinking through of issues, so that reflection is no longer an intangible element, but a product of emerging discourse. (See Chapter 6 for discussion of higher order thinking and reflection).

Hypothesis 9. Telematics learning environments can support the development of higher order thinking through a focus on language use to support thinking.

Language is not only the means of communicating, it is also the basis of thinking. According to Vygotskyan theory, when we talk, we engage in a social mode of thinking. Through talk, ideas are shared, and revised, alternative hypotheses are generated and other perspectives are challenged and considered. Talk is a means of sharing and creating knowledge, and is a fundamental thinking tool. Telematics classrooms are ideal environments for verbal and aural skills, as effective listening and speaking skills are fundamental to the teachers and students participating in a lesson. The teachers participating in the present study found that an operational definition of higher order thinking which related to the communicative dimensions of learning in telematics classrooms was immediately relevant to their needs.

Initially, teachers had a limited notion of what HOT entailed, and judging by the results of Phase 1 (Chapter 11) many believed that language was used only for information exchange, as the majority of exchanges that occurred in these lesson were expository and procedural. This reflected a *transactional* view of language and learning. On the other hand, talk can also facilitate reasoning. In this case language is not just transactional, but also *epistemic*. This may happen when language is used to convey and evaluate ideas, infer and justify positions taken. Teachers can promote this sense of language awareness in their classrooms by focussing on the specialised conventions of thinking in their own subject areas. Teachers achieved this by modelling higher order thinking during the telematics lessons. In addition, by enabling students to engage with each other, teachers promoted higher order thinking by encouraging questioning, challenging, argumentation and evaluation of ideas. These language functions are the functional and communicative basis of higher order thinking. By developing awareness in learners that language is a cognitive tool that

can be applied to reflect on one's own thinking, as opposed to being simply a medium for exchange of ideas, higher order thinking was supported in the Mathematics, English and Social Studies classrooms. In the Science lessons, fewer examples of this focus on language were in evidence.

Assertion 10: Higher order thinking can be fostered in telematics classrooms when the technology and the social context are integrated to support dialogue and articulation of ideas.

Technology can be used to support learning rather than merely mediate communication, or act as a conveyor of the teacher's instructions. Computers of themselves, do not transform the learning experience. For telematics classrooms, we need a pedagogy to include technology use that becomes the focus for curriculum action. Teachers using audiographic conferencing for the first time need to have a clear grasp of how to use the technology efficiently, but also they need a conceptual framework to guide their pedagogy. Very often technology use is separated from the learning outcomes of the telematics classrooms, and narrowly conceived as merely a means to connect classrooms.

The interventions in the present study did not include any direct intervention to modify or instruct teachers on technology use. The interventions focused instead on providing teachers with a holistic framework and pedagogical strategies which would inform their practice (Figure 12..4 Chapter 12). In terms of scaffolding higher order thinking, this achieved the desired outcomes and higher order thinking was observed in all classrooms following the interventions. Technology use to support higher order cognition was less consistent in the lessons observed. In some lessons in Phase 3 where HOT reached a high level, the computer was not used in the lesson (for example in English 5). At the end of the study, when asked about computer usage, teachers in the study had a narrow view of their application and mainly perceived them as useful tools to display ideas or motivate students to solve a problem. The formative experiment did not focus on achieving higher order thinking through technology usage, but rather on the achievement of HOT through the educational principles of scaffolding, guided participation and technology use to support dialogue (Figure 15.14). Teachers may have had a narrow view of the link between computer technology and learning. Analysis of the computer visuals and interactions with the computer showed that teachers tended to see it as a display tool that would enhance their teaching, rather than a 'cognitive tool' (Jonassen & Reeves, 1996) to promote student learning. These observations suggest that teachers may have benefited from a fully integrated model of technology use on how it supports learning in telematics classrooms.

For telematics classrooms, the 'extended classroom model' (Burge & Roberts, 1993) would seem to offer advantages as it is based on a number of educational practices which utilise the technology in support of student learning, autonomy and higher order thinking . It involves changes to didactic teacher centred patterns of interaction that have been found to characterise telematics classrooms (Oliver & McLoughlin, 1997). It is characterised by fundamental *changes in perspective* from:

- a view of learning confined to the classroom and controlled by the teacher, to one of a learning environment which is supportive, extended and distributed, consisting of a community of learners;
- a view of technology as a tool or as a teacher, to a view of computers as resources which can display creative ideas, provide a resource for inquiry, and extend thinking by bringing together students from different locations;
- a view of learning as individualised, to one which is communicative, shared and dynamic; and
- a preoccupation with teaching 'content' to multiple sites simultaneously to enabling the distributed students to self-monitor, share ideas, and analyse content, ideas and experiences.

Adoption of the extended classroom model would encourage teachers to create opportunities for higher order thinking by giving students more responsibility for their learning and by fostering communication between remote sites using the communications networks.

Assertion 11: Teachers need to adopt an enculturation approach to teaching thinking, rather than regard it as a discrete skill to be fostered.

On the basis of the observations made in the telematics classrooms of the study, development of higher order thinking would appear to require a comprehensive pedagogy and consideration of the entire context in which thinking can be fostered. Some of the elements which would support higher order thinking classrooms have been discussed in the previous points in this discussion, such as social interaction and articulation through language.

The transcripts of lessons provided an indication of the contexts which can support higher order thinking. What can be seen in the transcripts is that the whole context of the classroom must become a social support system which fosters HOT in students. This approach can be described as an 'enculturation approach' to the development of higher order thinking.

In the first intervention described in Chapter 12, when teachers were introduced to the operational definition of higher order thinking skills, they were also inducted into a particular socio-cultural approach to supporting higher order thinking, as Figure 15.14 shows. (See also Chapter 12.) At that early stage, the intervention did not prescribe pedagogies or attempt to shape teacher practices to conform with an idealised scenario of autonomous student thinking. However, the framework was offered to teachers as an integrated approach to developing higher order thinking, taking into consideration the constraints observed in Phase 1 of the study.

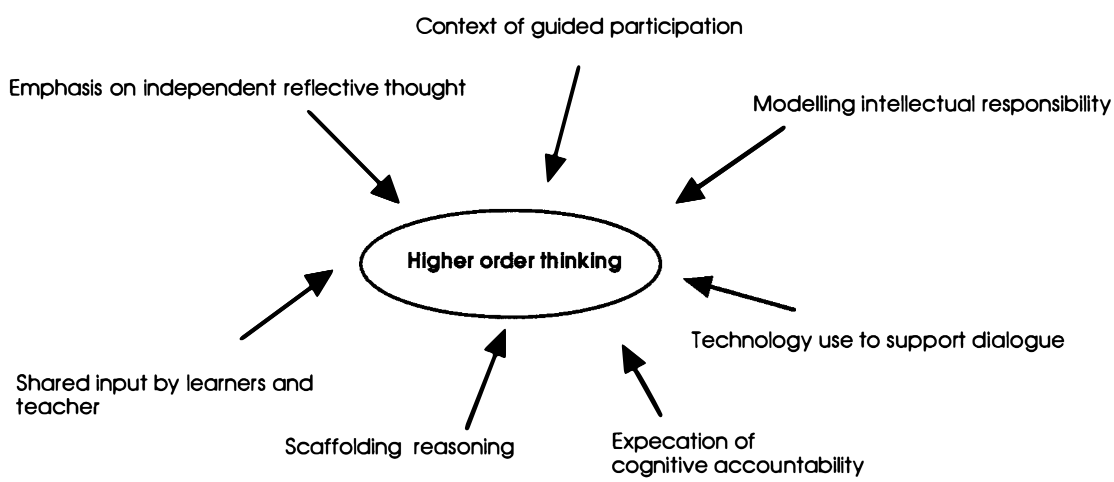


Figure 15.14: Enculturation framework for developing higher order thinking

The dimensions of the framework were taken up by teachers in Phases 2 and 3 of the study through teachers:

- emphasising reflective independent thought;
- scaffolding reasoning; and
- establishing social rules, or expectations for higher order thinking.

One aspect of pedagogy that was not well supported, except by the teachers of Maths and English, was that of modelling intellectual responsibility. While questioning students proved quite successful in promoting independent inquiry and thinking, there were few instances of modelling observed in the Italian, Social Studies and Science classrooms. The results would suggest that such modelling would be productive, as it would provide students with models of thinking in action. If teachers persist in limiting the educational agenda to mastery of content, it is hardly surprising if students do likewise. Once teachers change the social rules or expectations in the classroom, and reasoning is overtly valued and practiced, learners would begin to

make a deliberate attempt to consider evidence for statements, to construct connections and to assess these connections. Teachers would achieve a great deal more reasoning in their own classrooms if they emulated the construction of knowledge in their own approach to student learning.

The findings of the study suggest that social support system in the telematics classroom must be one of guided participation, where teachers participate and share the learning experiences of students, and provide possibilities for collective input. The computer provides an ideal resource for combined input, for teachers to depict their conception of the subject, and for students to discuss, adapt ideas and have tangible sources to support reflection. In addition, the computer may be used as a tool that supports collective cognition by bringing together the ideas of students from remote sites. Students at one location can collaborate and depict their understanding and views and share this with other students, and so gain access to multiple perspectives.

The enculturation approach requires teachers to become intellectual partners, or participators in their learners' thinking processes, so that by scaffolding thinking they can also assist learners to reflect and move away from the controlling and asymmetric patterns of dialogue that have characterised many telematics classrooms (Oliver & Reeves, 1994a; McLoughlin, Oliver & Wood, 1997).

These assertions have described elements of teacher pedagogy, technology use and the social context of telematics classrooms which can be integrated to achieve higher order thinking. An overview of the main themes is provided in Chapter 16.

CHAPTER 16

Summary and conclusion

Introduction

This chapter brings together the main themes of the thesis and summarises the findings in the form of a series of applications to practical teaching strategies to foster higher order thinking in telematics classrooms. In addition, the contributions of the thesis to educational research and to aspects of learning in technology supported environments are drawn out. The final section outlines the limitations of the research while suggesting projects for further research that could develop from this empirical study.

Main Themes

Operational definition of higher order thinking

The rationale for this study was the need to support the curriculum outcome of higher order thinking for rural and remote students in Western Australia. This need emerged when, early in 1996, the decision was made to deliver curricula via telematics to rural students at lower secondary level who need to access the Academic Talent Program. Up until then, telematics had only been used for delivery of supplementary and optional programs. The imperative of providing students with the educational experiences capable of fostering higher order thinking was the objective of the study, and it was conducted in authentic classrooms, with the cooperation of teachers involved in the day-to-day teaching of these students.

In the study, different aspects of the teaching environment were altered or modified in order to investigate their influence on the pedagogical goal of higher order thinking in telematics environments. At the outset of the study observations of teaching and learning in these classrooms found that the technology, resources, pedagogies, and interaction patterns were not conducive to higher order thinking. It was also found through interviews that teachers had different conceptions of higher order thinking and uncertain approaches to fostering HOT. While the curriculum guidelines espoused higher order thinking outcomes, the teachers lacked an operational definition by which to achieve these objectives.

This need provided the motivation for an investigation of the meaning of higher order thinking, and its various interpretations. Problematic aspects of the term were researched, including its elusive quality and the numerous definitions that had been coined to describe it. Applications of these definitions to educational practice were found to be elusive, and it was proposed that a socio-cultural language-based definition of the term higher order thinking could best inform teaching practice in telematics classrooms. Telematics environments depend for their success on the maintenance of a two-way audio communication link via the telephone. Without the audio link, it would not be possible for the lesson to proceed as it is through this medium that classroom rapport and management is established. The development of effective listening and communication skills is critical to students and teachers participating in telematics lessons. Dialogue is therefore critical to learning and teaching as it is through verbal and sometimes visual modes of expression that teachers and learners interact. A communicative and socially based theory of instruction and higher order thinking was established and linked to a socio-cultural paradigm, based on Vygotskyan theory.

Linking the theoretical framework to the purpose of the study involved two stages. First the term higher order thinking had to be clarified and then translated into a clear and workable definition where thinking became the induction into a communicative socially based practices involving reasoning and use of evidence to share and display knowledge, to make statements explicit, and to inquire and evaluate other perspectives in order to achieve understanding and build knowledge. Second, the specific dimensions of higher order thinking were embedded in the subject areas and linked to the actual curriculum outcomes of the classrooms under investigation, in order to ensure relevance and authenticity.

Relevance to the context of the study and flexibility of the operational definition were of paramount importance. Four aspects of higher order thinking were defined as the core of higher order thinking: *cognitive accountability*, *critical inquiry*, *reflection* and *interpretation*. These language based reasoning skills were developed through a intensive review and critique of empirical studies of classroom reasoning, curriculum requirements and in recognition of the needs of the teachers aiming to achieve higher order thinking outcomes in their telematics classrooms. The operational definition was adopted by the teachers and served to guide their planning for higher order thinking.

Planning for change: The formative experiment

Following the initial observation of the telematics classrooms in Phase 1, certain limitations were observed in the interactions and learning and these centred on the asymmetric discourse patterns, teacher and student roles and technology use. In order to bring about change, a research partnership between teachers and researcher was formed at the outset of the study to ensure that all outcomes sought and observations made were discussed. Teachers were involved in assessing their own teaching, and videotaped recordings of their own lessons were made available for them. In order to achieve higher order thinking it was decided to put in place a formative experiment, which entailed progressive evaluations of the outcomes of the classes and interventions to support HOT. Successive interventions in the telematics classrooms were made consisting of:

- advocacy of scaffolding and modelling thinking skills;
- support of reflection;
- emphasis on language to support dialogue and create social support for learning; and
- technology use where students had greater control and were given scope to construct and depict their own understanding of concepts.

The formative experiment involved teachers fully in the research partnership, as they were the key players in transforming their own practices in order to achieve the desired outcome of higher order thinking.

The formative experimental approach to redesigning the environment of telematics classrooms proved sustainable and feasible because:

- it had a clearly defined pedagogical outcome;
- the outcome was one which teachers wanted to achieve in their classrooms;
- the outcomes of higher order thinking was endorsed in the curricula the teacher were seeking to implement; and
- the environment of telematics was new to the teachers, who were inexperienced users of audiographic conferencing, and were seeking to optimise their own teaching approaches.

For teachers, the notion of a formative experiment, a pedagogical goal which could be attained by gradual changes in the teaching environment was a double lesson in professional development. Not only was it an experience which gave

them confidence in their role as scaffolding students' thinking, but it also gave them insight and understanding of their own teaching practices.

Although the study occurred in a technology supported learning environment where communication links were crucial to the establishment and development of rapport between teacher and students, the findings are relevant to all classrooms where dialogue mediates the learning process.

Scaffolding learning: defining the role of the teacher

The role of teacher in supporting learning and higher order thinking was conceived of as scaffolding, following the Vygotskyan principle of learning in social contexts where the support of others builds understanding. In order to support higher order thinking in telematics classrooms teachers needed to have:

- a clear understanding of the meaning of higher order thinking and what it entailed in operational terms;
- an instructional intention to teach for HOT, and to plan learning experience accordingly; and
- a repertoire of strategies that recognise and value the role of talking, thinking and learning, with an understanding of modelling and scaffolding as teaching practices.

The scaffolding role of the teacher was particularly suited to telematics classrooms, where teacher presence is vital in maintaining student-teacher dialogue. In addition, teachers' own perception of their role was in harmony with this view.

Changing the learning environment

As part of the objective of investigating conditions for higher order thinking in telematics classrooms, a preliminary step was to investigate teachers' beliefs about the meaning of higher order thinking and to observe their practices. In an initial exploratory study, only a small percentage of higher order thinking was found in classrooms, although the curriculum being followed had stated that HOT was a primary outcome. Teachers were uncertain about the meaning of HOT and how to achieve it in their classrooms. They did not always link thinking outcomes to the talk and interaction of their students. Most teachers requested some guidance on how HOT outcomes could be achieved in their classroom.

In view of the pedagogical goal of fostering higher order thinking, the first intervention was to bring teachers together in order to :

- clarify the term higher order thinking;
- relate the concept of thinking to language use;
- plan for thinking in the classroom; and
- develop appropriate contexts for thinking in the classroom.

The intervention took the form of a workshop where teachers discussed, planned and exchanged ideas on aspects of pedagogy and planned how to foster thinking in their classroom thinking. They were introduced to the Vygotskyan link between language and thinking and to an operational definition of higher order thinking with the four dimensions of cognitive accountability, critical inquiry, interpretation and reflection. This definition of higher order thinking was sufficiently flexible to be consistent with the curriculum guidelines for each subject and to allow teachers to construct their own approaches to achieving the outcome.

At the conclusion of the workshop, teachers concurred that to achieve higher order thinking in classrooms they should make some changes to their own pedagogies, including:

- make higher order thinking an instructional goal;
- produce lesson plans where higher order thinking is an instructional goal;
- make this goal explicit to students;
- provide opportunities for students to display thinking skills though discussion, and exchange of ideas; and
- enable students to have greater participation on the lesson, by reducing the amount of teacher talk.

Overall, the analysis of the talk that occurred following the intervention showed that teachers achieved their objective in terms of altering the balance of teacher-to-student talk, and of supporting higher order thinking in their own classrooms. Higher order thinking was achieved in all classrooms of the study in Phase 2, following the first intervention, and in three out of five classrooms HOT further increased during Phase 3. There was however, a limited amount of reflection in the classrooms and this finding led to a recommendation that specific metacognitive awareness should be scaffolded and fostered more directly in telematics classrooms. Further articulation by students of their own thinking

processes and teacher modelling of reflection on cognitive processes may be approaches that could be fostered.

The role of the computer

One of the important aspects of teaching and learning in telematics environments is the role of the computer in mediating communication and dialogue. Computers are part of the communication process in many classrooms, and they are also part of the social fabric of learning as they support interaction and provide a focus for discussion through shared screens, problem based collaborative tasks and communicative activities.

Adopting a socio-cultural view of learning has several implications for how technology is viewed. Once it is accepted that cognition is socially grounded, computers may no longer be seen as merely supporting *individual* achievement. This has implications for telematics classrooms and how :

- computers are used to support learning through social interaction; and
- the teacher employs computers to support thinking.

Use of computer technology was evaluated in terms of its capacity to support a learning conversation through discussion, interaction, adaptation and reflection by students.

Technology use reflected the overall pattern of higher order thinking, with Phase 2 showing interactive, discursive, adaptive and reflective use of the technology. Nevertheless, it was clear from the study that not all lessons used the technology to support higher order thinking, but this was balanced by the reality that in telematics classrooms HOT was not contingent upon successfully linking computers and enabling students to represent their understandings. Laurillard (1993a, p. 166) when discussing audiographics teaching and learning states that "Voice alone will not always have the power to elicit the precision of expression that can be achieved by asking someone to draw or add a picture." In some cases this may be true, if the aim of instruction is to achieve understanding of symbolic or representational form, such as mathematics or with conventions. Not all educationists would share Laurillard's view on the limitations of language. Mercer (1995, p. 33) maintains that talk is primary in thinking because "through language there is the possibility of revisiting and reinterpreting that experience, and of using it as the basis for future talk".

Taking into consideration that talk was the primary means of communication, the teachers' decision not to use the computer in all their lessons showed perhaps that they wanted to use other verbal instructional techniques to achieve the objectives of higher order thinking. Analysis of the lesson plans and subsequent conversations with the teachers confirmed that this was the case. The findings suggested that teachers, through deliberate planning and scaffolding, can foster higher order thinking *even in circumstances where the computer is not used to support the teaching and learning interaction.*

The observations of these telematics classrooms showed that technology can support social interaction at a cognitively advanced level, for instance when students discuss their own conceptual representations of subject matter. It was also found that the visual dimension enabled students to achieve reciprocal interaction across geographically distinct sites, for example when they discussed alternative problem solutions in Mathematics lessons.

The findings suggest that instead of using the computer to display knowledge and facts, the teacher can best support higher order cognition by designing activities where the dialogic and conversational elements are fostered and where the learner is given control. Such activities would entail, for instance, allowing students to represent their own understandings, create conceptual overviews of subject matter, collaborate and produce joint interpretations, and use these visual dimensions to support reasoning and provide credible support for views expressed.

The thesis has provided examples of computer use which supported a learning conversation, which involved learner initiation, control, collaboration and dialogue and the creation of conceptual, communicative understanding. Finally, although most computer use provided interaction, there was little evidence of reflection in the language and thinking of the participants, a finding which suggests that greater attention must be given to this aspect of the learning process.

Methodology

In the course of this study two aspects of methodology were explored in order to investigate how higher order thinking could be supported and developed in telematics classrooms. Firstly, the formative experiment was developed and implemented in the form of a research partnership between teachers and researcher. This entailed progressive changes in teaching strategies, use of technology and teacher-student

interaction. Overall, the approach was conducive to teacher change and development and because the changes were implemented with full consultation and collaboration, teachers were engaged in their own self-development throughout the project.

Second, a methodology was developed to analyse the large corpus of talk that was generated by the transcripts of 45 hours of lessons. Initially, the value of a coding scheme was questioned, because of the limitations that such an approach imposes on analysis of data (Chapter 9). With the interpretivist and qualitative orientation of the study, it was decided to adopt an open coding approach where the functional and communicative dimensions were induced from the data. Earlier investigations of telematics environments (McLoughlin & Oliver, 1995a; Oliver & McLoughlin, 1997) had applied a set of categories based on content analysis. This was revised in favour of a theoretically based, open coding approach. Open coding of the data was informed by the socio-cultural framework of the study, where that teacher moves were interpreted as forms of assisting learning, while student dialogue was interpreted as appropriation of forms of understanding through social interaction.

Effectively, a conceptually based functional analysis of talk was combined with socio-cultural discourse analysis in coding the data. Two computer-based text analysis software packages were used to manage the data at different levels. One level was to assign categories to teacher and student talk at the functional level of utterances and the other was the identification of higher order thinking in student talk through keyword indicators of inference and reasoning, hypothesis and interpretation.

This approach achieved two methodological aims. First, it enabled data to be dual coded and analysed in order to provide a multi-layered interpretation of interactions in telematics classrooms. It also enabled the researcher to support the qualitative findings with quantitative data on, for example, the relative participation rates of teacher and students, frequencies of particular patterns of talk and overall discourse patterns. It was also possible to link the quantitative findings on occurrences of higher order thinking and qualitative changes in student talk (Chapter 16). Furthermore this approach enabled quantification of categories of student talk to be related to qualitative changes in student talk, as the context of HOT utterances was recoverable through the computer based text analysis. Overall, the combination of qualitative and quantitative data analysis provided in depth insights both into changes in patterns of talk and also into the quality of teacher and learner talk.

Implications for educational practice

The study was concerned with developing guidelines for practice that would be relevant in contemporary telematics classrooms. As higher order thinking is now a valued educational outcome, the issue of how to foster and support it in classrooms is likely to receive increased attention. Three aspects of this research have implications for current practice in telematics classrooms:

1. the support of higher order thinking through deliberate planning and scaffolding by teachers;
2. the integration of a concept of higher order thinking though an operational definition that can serve to guide teaching practice; and
3. the exploitation of technology to support higher order thinking by enabling students to represent and share their understanding though the visual dimension of computer use.

The results also showed that higher order thinking improved in all subjects, and that intellectual development can be enhanced in telematics classrooms through the adoption of particular pedagogic practices and a communicative, socially based understanding of higher order thinking.

The implications of the study are essentially to emphasise that the social and interactive patterns and roles of teachers and students are interdependent, and influence the development of higher order thinking. As dialogue and interaction are fundamental to learning, teacher pedagogies which support HOT can be conceived as scaffolded instruction, guided practice and reflective questioning. Collaborative talk and argumentation between learners can evoke discussion to support higher order thinking, and the audio channel can be used to build communication between distributed classrooms. Nevertheless, the role of the teacher in evoking, supporting and reinforcing thinking processes was confirmed by the findings of the study.

If teachers are to cultivate higher order thinking in telematics classrooms, they need to have a clear instructional intention to facilitate its occurrence. They also need to have an operational definition of higher order thinking, so that they can encourage language use, model appropriate skills and create conditions in the classroom for cognitive accountability, critical inquiry, reflection and interpretation.

In order to foster higher order thinking in telematics classrooms, technology use cannot be confined to teachers' appropriation and use of the media solely to display content

and motivate students. Instead, the technology must be appropriated by students so that it becomes a means of articulating, displaying and sharing their understanding of subject matter.

Table 16.1 summarises the socio-cultural view of higher order thinking and the associated teaching and learning roles in telematics classrooms that change with the adoption of a perspective on higher order thinking that places social interaction at the forefront.

Table 16.1 : Contrasting views of higher order thinking

Differentiating Aspect	Traditional View	Socio-cultural view
view of thinking	abstract, formal logic	communicative reasoning skills
Student role	passive recipient of knowledge	active partner in dialogue; co-creator of knowledge
pedagogical approach	didactic, teacher centred	scaffolded learning
discourse pattern	I-R-E, teacher initiated	equal and participatory
teaching materials	prescribed, given	negotiable and subject to multiple interpretations
role of media	computer as tutor and instructional tool	computer as cognitive tool to support collaboration and enable multiple representations of knowledge
tasks/activities	teacher directed	authentic tasks/ collaborative discursive

Table 16.1 also serves to summarise the view of higher order thinking proposed by the study, and defined operationally as comprising communicative reasoning skills. Whereas traditional views of higher order thinking regarded thinking as an abstract formalised system of logic, socio-cultural theory offers a view of thinking which is language based, communicative and social, centred around cognitive accountability and reasoning. Ideally, the social arrangement of the classroom is no longer teacher fronted, but offers possibilities for students to collaborate. Instead of working individually, students share tasks and ideas. In classrooms based on socio-cultural pedagogy, teachers scaffold student learning, and initially the discourse pattern may remain asymmetric, as the functions served by teacher utterances offer cognitive

support to learners. Gradually, this fades and students develop autonomous modes of thinking. Traditional classrooms tend to be teacher directed and didactic, while sociocultural classrooms are environments in which collaborative discourse prevails and authentic tasks provide the framework for student understanding. The study had shown that telematics classrooms can incorporate all the elements of a socio-cultural framework and lead to positive student outcomes in terms of higher order thinking.

Limitations of the study

In view of the limited number of participants in this study, only modest claims are made about the findings. Five teachers participated in the study, and these teachers taught telematics classes to several sites simultaneously. The group constituted the entire cohort of students and teachers who participated in the trial of telematics for delivery of the Academic talent Program to rural schools in Western Australia. The students who participated were assessed as being in the top 5% of the students population in rural areas, in terms of academic achievement. However, several students participated in the program who were not especially selected for academic achievement, as participating schools wanted to increase the access of students to curriculum offerings that were not available in their own district. Italian, Social Studies and English were classrooms where this happened. All the students were high academic achievers and the teaching groups were small, both factors which could have contributed to the incidence of higher order thinking.

As second limitation was that all the changes in higher order thinking can not be attributed directly to the interventions, as the study was not experimental and did not control for other effects on student capacity to display higher order thinking. For example, the teachers, at the initial stage of the study were novices to audiographic conferencing, and not proficient users of the technology. With practice they developed skills that may have assisted them in achieving better outcomes in their classrooms.

Furthermore, the research recognises that the social influences on learning extend well beyond the confines of the classrooms and include motivational factors and socio-economic pressures that may impact on students' attitude and performance. This study confined itself to classroom interventions, and as such was necessarily limited in that the focus was on teaching and learning dynamics *in situ,* in the physical setting of the telematics classroom.

With regard to teacher epistemology, the study undertook an intervention to equip teachers to adopt a particular communicative orientation to higher order thinking. It

was anticipated that this would influence teachers approaches to planning for, and fostering HOT, in their classrooms. Indeed the lesson plans produced by the teachers (Appendix 2) show that they incorporated many of the components of HOT in their statements of particular outcomes. However, it was not assumed in the study that the only mediating factors in teacher change were the interventions that were planned, nor can any causal link be attributed solely to the occurrence of HOT and the adoption of the operational definition. Instead, the study does indicate that teacher pedagogies can and do change, and that these changes have an influence how students interact and think.

Further research

Having outlined the various implications and limitations of this study, it remains in the final section to consider some questions that the thesis raised and how these questions might be pursued further. Some of these questions are directly to the present research, while others are broad investigations into technology supported environments and open up further areas of inquiry.

First, some major differences emerged in the pattern of HOT for the different subject areas, and it would be worth investigating how different subject areas make different demands on learners and what particular kinds of generic thinking skills are required in diverse subject areas. For example, interpretation was found to be quite prevalent in both Social Studies and in English, but was found to a lesser extent in Maths and Science lessons.

Second, the corpus of data for the present study was large, and provides a rich data base for further inquiry. The focus of the interpretation was on an in-depth analysis of student talk, and the language indicators of reasoning. Teacher talk was coded more broadly in order to uncover the teaching and communicative functions. Further analysis of teacher discourse could be carried out in order to investigate the occurrence of failed scaffolds, or attempts to assist students that misfired. Some further investigation into the three phases of the study would provide a microanalysis of successful and unsuccessful episodes of scaffolding.

The research suggests that particular aspects of computer use in telematics classrooms are productive of higher order thinking. Some of the examples found were the use of computer visuals to support cognition and reasoning, to enable students to depict their own representations of a cognitive domain and to create shared representations of subject matter. The tools that facilitated these creations were simple devices such as

keyboards and graphics tablets and software which enabled students to control their own input. Further research could investigate students' contributions to telematics classrooms further, in particular the visual representation of knowledge and the relationship between these graphic forms and reflection, inquiry and reasoning. Such research would entail giving students more control over the computer and the drawing tools, and enabling them to demonstrate their understanding in a visible, communicative form that utilises both verbal and pictorial forms. Certainly, the visual dimensions of higher order thinking have been largely unexplored in telematics classrooms, despite the obvious potential of technologies to enable multiple modes of communication.

Recent developments in communications technologies are now superseding telematics as a medium of instruction, for example WWW and Internet based communication applications which also support videoconferencing. Like telematics, these technologies support synchronous, text-based, two-way audio forms of communication, with the additional video component. Both forms of technology support learning in a distributed context, where students communicate synchronously at separate and distant locations. These environments share many features in common with telematics classrooms, and the learning transaction and learning processes are the same. From a practical standpoint, the present study has affirmed the need for a strong scaffolding role for the teacher, where planning for instructional outcomes and particular forms of discourse can enhance the acquisition of language based reasoning skills. The results of the present research can answer certain fundamental questions regarding optimum forms of teacher-student dialogue, and how shared knowledge can be supported via the visual representation properties of the computer in any domain, including the WWW.

On a broader and more general scale, further investigation into the relationship between types of language use, forms of communication and higher order cognition would appear to be a fruitful direction for research into technology supported environments. Much current research is tied to contructivist principles, where learners are regarded as individuals engaged in their own knowledge construction, and communicative, social interactive modes of expression are marginalised. The socio-cultural paradigm recognises that learning is often assisted by teachers, and the location of technology in a social and communicative context where cognition is necessarily connected with social support systems. Because of these dimensions, and the recognition of the essential role of articulation and communication of knowledge through talk, the socio-cultural framework is appropriate to studying learning in distributed environments supported by technology.

Conclusion

This thesis set out to capture, describe and analyse teacher and student interaction in telematics classrooms and to orchestrate pedagogical changes to achieve a particular outcome, the achievement of higher order thinking. The findings of the study show that positive advances can be made by teachers in supporting higher order thinking when they comprehend and apply an operational definition combined with the instructional intention to achieve this outcome. The willingness of the teachers to enter a collaborative research partnership with the researcher and transform their own teaching practices was productive and fostered higher order thinking in the distributed environment of telematics classrooms. The study emphasises the critical nature of teacher planning and strategies to advance students' thinking capacities. Further change and development in telematics classrooms must recognise that participants' own actions, intentions and interactions underlie the teaching-learning relationship, and that technology must serve the social activities of dialogue, shared understanding and communication.

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Appendix 1

Contributions of the study to research on higher order thinking

The research described in this thesis has been the basis for several research papers, some of which were collaborative research on aspects of telematics teaching and learning. Some of the publication also reflect the evolution of the theoretical framework and the analytic categories used to code the transcripts. The initial observations on the quality of learning interactions in technology supported environments were presented in the Australian Computers in Education Conference in 1995, and published in *Learning without Limits* (1995). This paper also developed the initial analytic framework applied to student-teacher interaction, but has since then been modified. The theoretical framework based on socio-cultural theory, emphasises the role of language in learning and advocates a close integration of computer based work with dialogue and student-student collaboration. A paper based on this framework has been accepted by *The British Journal of Educational Technology*, to be published in 1998. Interim work and observations on learning in the telematics classrooms of Western Australia was published in *Australian Educational Computing* (McLoughlin, Oliver & Wood, 1997). Papers based on the findings of the study were presented at two separate talks at the *European Conference for Research on Learning and Instruction*, held in Athens, 1997. The list of published papers based on the research into telematics classrooms includes:

McLoughlin, C. (1996). Telematics for higher order learning: challenges and opportunities. In J. Hedberg, J. R. Steele, & S. McNamara (Eds.), *Learning technologies: Prospects and pathways*, (pp. 92-98). University of Melbourne: AJET Publications.

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Appendix 2

Teacher plans for the lessons in Phases 2 and 3.

At the request of the teachers, these have been typed in order to preserve anonymity.

A Lesson Plan That Promotes Higher Order Thinking

1. **Concept (s) to be explored:**

   Asking for and giving directions in Italian

   Asking questions

2. **Outcomes of the lesson**

   Understanding directions

   Using correct grammar

3. Steps involved in the lesson

   (i) *Students check map and ask questions*

   (ii) *Give directions to each other*

   (iii) *Make examples and practice with each other*

4. List the HOT you expect your students will display.

   Students generate questions; prediction and analysis skills

   Questioning

   Comparing

   Inventing examples

Lesson planning sheet for Italian Lesson 4

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

   Separation techniques

   How to identify and apply techniques

2. Outcomes of the lesson

   Understanding separation techniques

   Able to discuss when different techniques can be used

3. Steps involved in the lesson

   (i) *Show visuals of mixtures*

   (ii) *Discuss techniques*

   (iii) *Apply technique to different examples*

   (iv) *Draw concept map of substances and separation techniques*

4. List the HOT you expect your students will display.

   Brain storming

   Note making

   Classification

Lesson planning sheet for Science Lesson 4

A Lesson Plan That Promotes Higher Order Thinking

1. **Concept (s) to be explored:**

   How to join octagon loops

   Explore sides, edges and angles and dimensions

2. **Outcomes of the lesson**

   Investigate loops

   Conjecture and prove

   Use problem solving strategies

   Use mathematical language

3. Steps involved in the lesson

   (i) *Student generated questioning*

   (ii) *Diagramming*

   (iii) *Prediction*

   (iv) *Listening skills*

4. List the HOT you expect your students will display.

   Students generate questions; prediction and analysis skills

   Generalising

   Inferring

   Using examples

   Problem solving

Lesson planning sheet for Maths Lesson 4

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

    Developing the concept of cultural change

    Change can be beneficial or otherwise

2. Outcomes of the lesson

    Ability to write an argumentative essay

    Students will justify opinions and evaluate each others

3. Steps involved in the lesson

    (i) *Discuss positive and negative aspects of the crusades*

    (ii) *Find examples*

    (iii) *Construct an essay plan*

    (iv) *.Synthesise ideas*

4. List the HOT you expect your students will display.

    Conceiving and stating assumptions

    Active listening

    Giving reasons

Lesson planning sheet for English Lesson 4

A Lesson Plan That Promotes Higher Order Thinking

1. **Concept (s) to be explored:**

    What is history?

    Why detectives are like historians

2. **Outcomes of the lesson**

    Understanding how to use evidence

    Understanding why historical evidence is important

    Investigating a problem

3. Steps involved in the lesson

    (i) *Discussion : What is history? and characteristics of history*

    (ii) *Show and discuss historical method*

    (iii) *Group activity : Body at the side of the road*

4. List the HOT you expect your students will display.

    students generate questions; prediction and analysis skills

    Analysing information

    Decision making

    Discussion and debate

Lesson planning sheet for Social Studies 4

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

    Structure of the plant kingdom

    How plants are classified

    Identification of why plants are important

2. Outcomes of the lesson

    Understanding classification

    Stating reasons why plants are important

3. Steps involved in the lesson

    (i) *Investigate visual of plant structures*

    (ii) *Discussion of classification system*

    (iii) *Group discussion on uses of plants*

4. List the HOT you expect your students will display.

    Classification

    Identification

    Naming parts and discussion functions

Lesson planning sheet for Science Lesson 5

A Lesson Plan That Promotes Higher Order Thinking

1. **Concept (s) to be explored:**

    Observation of nature phenomena

    Students make predictions

    Students infer from data

2. **Outcomes of the lesson**

    Making predictions and inferences as part of a scientific process

3. Steps involved in the lesson

    (i) *Students investigate evidence in the visuals presented*

    (ii) *Students discuss inferences*

    (iii) *Students justify inferences and use evidence*

4. List the HOT you expect your students will display.

    students generate questions; prediction and analysis skills

Lesson planning sheet for Science Lesson 6

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

   Solving equations

   Doing and undoing equations

   Backtracking and checking operations

2. Outcomes of the lesson

   Ability to self check answers

   Show backtracking operations

   Use mathematical language

3. Steps involved in the lesson

   (i) *Students do examples on computer screen*

   (ii) *Students construct their own flow charts*

   (iii) *Students compare and contrast answers*

4. List the HOT you expect your students will display.

   Explaining procedures

   justifying answers

   Using mathematical language

Lesson planning sheet for Maths Lesson 5

A Lesson Plan That Promotes Higher Order Thinking

1. **Concept (s) to be explored:**

   Extending investigation of octagon loops

   Looking for rules to joining octagon loops

   Report writing on results of investigation

2. **Outcomes of the lesson**

   Extending investigations based on evidence

   Applying results

   Developing principles for mathematical investigations

3. Steps involved in the lesson

   (i) *Discussion of examples based on octagon loops investigation*

   (ii) *Students reflect on findings*

   (iii) *Students create concept map of findings*

4. List the HOT you expect your students will display.

   Finding general principles

   Elaborating ideas

   Making connections

Lesson planning sheet for Maths Lesson 6

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

The Industrial Revolution and changes that occurred

Aspects of religious, social and cultural change

2. Outcomes of the lesson

Writing about cultural change

Considering different perspectives

Expressing ideas in language

3. Steps involved in the lesson

(i) *Students read out journal entries*

(ii) *Students compare and contrast their ideas*

(iii) *Students produce a document on the Industrial Revolution*

4. List the HOT you expect your students will display.

Students reflect and comment on each others ideas

Students compare different perspectives

Lesson planning sheet for English Lesson 5

A Lesson Plan That Promotes Higher Order Thinking

1. **Concept (s) to be explored:**

Life in the middle ages

Developing argument based on data from history

2. **Outcomes of the lesson**

Construction of an argumentative essay

Expressing contrasting ideas in language

3. Steps involved in the lesson

(i) *Students construct a concept map of ideas*

(ii) *Students discuss and debate topic*

(iii) *Students summarise and discuss outcomes*

4. List the HOT you expect your students will display.

Elaboration and justification of ideas

Consideration of alternative use

Lesson planning sheet for English Lesson 6

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

    Debate on existence of King Arthur

    Use of evidence in history

2. Outcomes of the lesson

    Understanding how to use evidence

    Comparison of different historical sources

    Drawing conclusions based on historical evidence

3. Steps involved in the lesson

    (i) *Students examine historical sources and extract evidence*

    (ii) *Students use evidence to discuss existence of King Arthur*

    (iii) *Students reach a conclusion based on evidence*

4. List the HOT you expect your students will display.

    Understanding of historical approach

    Justification of ideas by using evidence

    Evaluating evidence

Lesson planning sheet for Social Studies Lesson 5

A Lesson Plan That Promotes Higher Order Thinking

1. **Concept (s) to be explored:**

    The Industrial Revolution, benefits and costs

    Constructing a report

    Showing different perspectives

2. **Outcomes of the lesson**

    Report writing based on investigation of Industrial Revolution

    Using examples to support ideas

    Understanding social change

3. Steps involved in the lesson

    (i) *Brainstorm ideas and present visual overview*

    (ii) *Discuss ideas generated*

    (iii) *Construct argument based on data*

4. List the HOT you expect your students will display.

    Consideration of alternative ideas

    Supporting conclusions by example

Lesson planning sheet for Social Studies Lesson 6

A Lesson Plan That Promotes Higher Order Thinking

1. Concept (s) to be explored:

   Vocabulary for places, time and transport

   Asking questions about time and place

2. Outcomes of the lesson

   Construction questions

   Asking for and giving information

   Understanding direction and location

3. Steps involved in the lesson

   (i) *Students look at map of Rome and locate buildings*

   (ii) *Students practise pronunciation of new structures*

   (iii) *Students generate questions based on map*

   (iv) *Students respond to each other*

4. List the HOT you expect your students will display.

   Questioning and responding

   Students apply knowledge to new structures

Lesson planning sheet for Italian Lesson 5

A Lesson Plan That Promotes Higher Order Thinking

1. **Concept (s) to be explored:**

   Revision of food and beverage vocabulary

   Revision of questioning forms

2. **Outcomes of the lesson**

   Extending vocabulary through practice

   Practising communicative skills

3. Steps involved in the lesson

   (i) *Students discuss items on computer screen*

   (ii) *Students create new examples from their own experience*

   (iii) *Students ask questions and respond to each other*

4. List the HOT you expect your students will display.

   Extending vocabulary through practice

   Developing skills and fluency in questioning and responding

Lesson planning sheet for Italian Lesson 6