University of Technology, Sydney

Investigating Collaboration in Art and Technology

A dissertation submitted for the degree of

Doctor of Philosophy in Computing Science

By

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CERTIFICATE OF AUTHORSHIP/ORIGINALITY

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Abstract

With the rapid development in computer technology in recent years, the arrival of digital media and computational tools has opened up new possibilities for creative practice in art, where collaboration between digital art practitioners and computer technologists often happens. The study of interdisciplinary collaboration in art and technology offers great opportunities for investigation of creativity and the role of new technology.

This thesis presents an investigation into interdisciplinary collaboration between artists and technologists based on a series of case studies selected from actual art-technology projects. Two analysis techniques were used in this research: context analysis, which provides the breadth of the analysis, and protocol analysis, which provides the depth of the analysis. During the analysis process, two coding schemes, which are the context analysis coding scheme and the protocol analysis coding scheme, were developed, evaluated and refined over a series of case studies. Using the coding schemes, the results of the analysis drawn from different cases are compared and the implications are discussed. The findings provide insights into art-technology collaboration in the creative process, in particular, the features of communication and the role of mediation tools.

The outcomes of this thesis are:

- The analysis framework, consisting of the context analysis coding scheme and the protocol analysis coding scheme, which has been developed and applied to a series of case studies and has been tested for effectiveness and reliability.
- The findings, with the assistance of the analysis framework, provide a better understanding of the nature of the interaction between artists and technologists during a creative process. This includes:

- How communication behaviour is distributed between artists and technologists;
- What the role of computer tools is during the creative process and how these tools can affect artists' and technologists' communication behaviour;
- How the collaborative creative process is facilitated by external mediation tools, such as computers, interactive artefacts and physical objects.

There are two main contributions of the thesis: first, the analysis framework can serve as a powerful and robust analysis tool for future research in the filed of art-technology collaboration or other related domains. Second, the findings provide a better understanding of the collaborative process, in particular, how mediation tools support creative practice between artists and technologists.

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1 Introduction

1.1 Motivation

With the rapid development in computer technology in recent years, the arrival of digital media and computational tools has opened up new possibilities for creative practice in art. As computer technologies are applied in the field of digital media art practice, the tendency for artists to collaborate with technologists and scientists instead of working alone has generally increased (Edmonds et al. 2005). However, art-technology collaboration is a relatively new and largely unexplored field of research, and is a highly fertile ground for the investigation of creativity and the role of new technology (Edmonds et al. 2005).

In terms of the context, the research in digital art field can be roughly categorized into two areas: the collaboration process, where artists and technologists work together to create digital artefacts, and the exhibition, where the outcomes created in the collaboration process are exhibited in public. Digital art practices can be understood by investigating the interaction between artists and technologists during the collaboration process or by exploring the interaction between audiences and artefacts during the exhibition. Examples of research in relation to the collaboration process are Edmonds et al (2005) and Fourmentraux (2006) and examples of research carried out during the exhibition, are Costello et al (2005) and Bilda et al (2006), where the interaction between audiences and interactive arts are explored.

What kinds of methods are required for studying art-technology collaboration? A recent report, entitled Creativity Support Tools (CST) (Shneiderman et al. 2005), summarizes some established principles and important research issues raised by a multi-disciplinary group of researchers who are looking for ways to improve creativity support. In the guidelines provided, in order to help develop and evaluate creativity support tools, first, it is necessary to observe the activities and problems users are having in real time activities, either through field study, ethnographic research, computer logging, or via actual participatory design (Hewett et al. 2005). There is research in creativity and collaboration which has been carried out in the processes described in the CST group's guidelines. For example, Terry and Mynatt's work using semi-structured interviews followed by interviewee demonstrations to recognize creative needs in user-interface-design (Terry & Mynatt 2002), Bilda et al's work using retrospective reporting and structured interviews to evaluate the interactive art experience (Bilda, Costello & Amitani 2006) and Turner's work using design practice and observing interactive art practice to make recommendations for tool-making in digital art practice (Turner 2007). However, these studies do not include close observation and in-depth analysis about the collaboration process between artists and technologists during the actual process of developing ideas and creative implementation.

In relation to the above discussion, the motivation of this thesis is to investigate the collaboration between digital artists and computer technologists through a series of studies by observing and analysing the collaboration process in real time. The data used in this research contains two parts. The first part comes from an artists-in-residency project called COSTART (Computer SyStems for Creative Work: An Investigation of Art and Technology Collaboration) (Candy & Edmonds 2002c). The second part comes from a recent art-technology collaboration project named GEO (GEO Narrative Landscapes) (Zhang, Weakley & Edmonds 2007).

In order to support art-technology collaboration and encourage the transfer of ideas between different disciplines, making an artist-in-residency programme available is one of the ways to provide a better environment for artists to develop their creative ideas (Harris 1999). For example, PAIR at XeroxPARC (Harris 1999), SCIART funded by Wellcome (1997-) and SYNAPSE funded by Australian Research Council (1999-). One of the common goals of these programs is to have a strategy in place that encourages creativity across the whole spectrum of collaboration. As those residency projects continue to be an emerging area for research, it is important to have a close look at how artists pursue the creative process in collaboration with technologists.

Among these artist-in-residency programmes, the COSTART project (COmputer SySTems for Creative Work: An Investigation of ARt and Technology Collaboration), is one of the few which not only provided a conducive environment for artists to explore their creative ideas, but also established a research environment for social scientists to study how the process of collaboration took place between artists and technologists (Candy & Edmonds 2002b). Previous COSTART project research revealed that the forms of collaboration varied significantly with different types of work and people. It also claimed that the quality and ease of communication was likely to influence the effectiveness of the collaboration. Three basic models of collaboration were identified from the COSTART analysis: assistant model, full partnership model and partnership model with artist in control (Candy & Edmonds 2002c) (Edmonds et al. 2005).

Following on from the earlier research of the COSTART project, a series of in-depth studies of the collaboration process between artists and technologists was carried out in this research. The concerns of this thesis are: first, identifying what kind of effective methods are needed in order to explore the creative process; second, exploring the role of technology in the creative process of art-technology collaboration. In order to explore these concerns, a review was carried out into literature on relevant topics such as, creative process, interdisciplinary collaboration, computer supported cooperative work and the methodological approaches which have been applied to analyse the creative collaboration process. Following a discussion of the strengths and weaknesses in those methodological approaches, we extended the study methods of art-technology collaboration. This involved studies where continuous observational data using video/audio facilities was gathered and analysed using a combination of context analysis and protocol analysis to provide solid empirical evidence. The resulting analysis framework for investigating creative collaboration between artists and technologists, was developed and refined using case study data. The detail of the analysis framework was represented in two coding schemes: the context analysis coding scheme and the protocol analysis coding scheme. Findings related to the features of art-technology collaboration, communication styles and the role of technology were made by applying the framework. Thus, the analysis framework outcome from the research is a tested method for studying creative collaboration which can be applied to domains outside art and technology.

1.2 Aims and Objectives

Aims

There are two primary aims of this research: the first is to develop a specific analysis framework for effectively analysing art and technology collaboration as it happens; the second is to explore features of art-technology collaboration within the framework. The specific research questions are:

Q1: What kind of analysis framework is needed in order to effectively generate an understanding of the creative process of art-technology collaboration?

Q2: What are the features of art-technology collaboration found using the framework addressed in question 1?

Objectives

1. To explore and evaluate the methods, which have been applied in art-technology collaboration research or similar contexts;
2. To explore some features of art-technology collaboration, in particular:
   - The characteristics of artists' and technologists' communication styles and the way they use computers and their tools during the collaboration;
   - The role that computers and their tools play during the creative process and the way computers and other tools affect artists' and technologists' communication patterns.

1.3 Thesis Overview

Chapter 2 reviews the literature in the related study contexts. The first section aims at reviewing the features of interdisciplinary collaboration. The next section brings together the previous findings of communication in collaboration domain, where both the concept of common language and the role of common background in communication are explored. The third section aims at reviewing different definitions of creativity, as well as how external representations are used during the creative collaboration process. The last section focuses on the review of art-technology collaboration. The literature review revealed that there is little research into how artists' creative ideas are shaped and reframed during the collaboration process with technologists and also, how tools, such as computers and other mediation tools facilitate communication.

Chapter 3 reviews the methodological approaches which have been applied to analyse the creative collaboration process. Based on the discussions of strengths and weaknesses of these methodological approaches, we extend the study methods of art-technology collaboration by conducting a series of case studies with the combination of context analysis and protocol analysis. Four case studies were carried out in this research: three of them come from the artist-in-residency programme COSTART and one of them is from the art-technology collaboration project 'GEO Narrative Landscapes'. At the end of this chapter, the description of the software support for analysis is presented and the research process is illustrated in the context of the studies conducted.

Chapter 4 presents the study in which three COSTART cases were analyzed by using context and protocol analysis approaches. In the first section, the background of the COSTART project is provided, and the specific context and data descriptions of the selected COSTART cases are presented. The rest of this chapter contains two parts: in the first, the context analysis process is described, including the details of the context analysis coding scheme that was developed, and the context analysis results are presented and discussed; in the second, the protocol analysis process and the protocol analysis coding scheme are described and the protocol analysis results are presented. The outcomes of the COSTART study are: first, the analysis framework, which consists of the context analysis coding scheme and the protocol analysis coding scheme; second, the findings within the analysis framework.

Chapter 5 presents the GEO study. In the first section, the background information of the GEO project and the data descriptions are provided. The second section presents the context analysis study and the third section presents the protocol analysis study. Both sections start with the description of the analysis process, where the context analysis coding scheme or protocol analysis coding scheme, developed in the previous COSTART cases (Chapter 4) are applied to the GEO data. The refined coding schemes and the analysis results are presented at the end of each section. The outcomes of the GEO study are: first, the refined analysis framework, which contains the refined context analysis coding scheme and the refined protocol analysis coding scheme; second, the findings within the refined analysis framework.

Chapter 6 is dedicated to the study comparisons and general discussion of the results and analysis framework. It begins with the similarities and differences between the COSTART and GEO cases. It continues to compare the context analysis findings between the COSTART and the GEO studies, where the similarities and differences of the findings are identified and discussed. Following that, the comparison of the protocol analysis findings between the COSTART and the GEO studies are presented. At the end of this chapter, a summary of the analysis framework is provided and the effectiveness and reliability of the framework is discussed.

In Chapter 7, the conclusion of the thesis is presented, where the contribution of the research is described and the future work of the thesis is pointed out.

2 Literature Review

In Chapter 1, the principal aim of the research described in this thesis is to explore the nature of art-technology collaboration. In order to achieve this, an understanding of the methodologies applied in collaborative and creative context is required. Our aim is to identify and develop methods for achieving the principle aim. In Chapter 2, the relevant literature in art-technology collaboration research is reviewed and, in Chapter 3, the methodologies applied in art-technology collaboration research and other related fields are described. The literature review in this chapter consists of four sections: interdisciplinary collaboration, communication in collaboration, collaboration in a creative context and art-technology collaboration. For the review, recent and past research in communication and creativity in interdisciplinary collaboration is examined. In addition, recent research into how artists and technologists collaborate with each other in a creative context is discussed.

2.1 Interdisciplinary Collaboration

Collaboration can be categorized into two types of communities: Community of Practice (CoP) (Nardi 1993) and Community of Interest (CoI) (Brown & Duguid 1991). In a 'Community of Practice', people who work together come from a similar background: for example, a group of programmers developing software applications. In a 'Community of Interest', people from different community of practice groups come together to solve a particular problem of common concern (Arias et al. 2000). For example, a software development team collaborating on a piece of software includes software designers, users, marketing specialists, psychologists and programmers. As the type of collaboration investigated in this thesis is an example of a community of interest group in a creative context, in this section, the review of the 'Community of Interest' is the main focus.

'Community of Interest' is commonly characterized by the shared interest within the groups and usually involves a process of multi-disciplinary collaboration. It has been found that the fundamental challenge facing community of interests groups is to build a shared understanding of the task at hand, which often does not exist at the beginning, but is evolved incrementally and collaboratively and emerges in people's minds and in external artefacts (Fischer 2001). However, amongst collaborators in a community of interest, shared understanding could be difficult to develop and communication might be problematic. C. P. Snow describes these difficulties through an analysis of the interaction between literary intellectuals and the natural scientists:

> "There [collaboration between literary intellectuals and natural scientists] exists a profound mutual suspicion and incomprehension, which in turn has damaging consequences for the prospects of applying technology to the alleviation of the world's problems" (Snow 1967, p. 22).

One of the reasons for the existence of communication incomprehension suggested by Engestrom (2001) is that participants who come from different knowledge domains and have different knowledge systems, inevitably have different perspectives and use a different vocabulary for describing their ideas. During such collaboration, knowledge between individual collaborators evolves from a non-shared situation at the beginning, towards a shared situation at the end (Jeong & Chi 1997). Furthermore, previous research has identified that the shared understanding of interdisciplinary collaboration is not only meant to refer to sets of shared knowledge, but also to "synergistic aggregation of the individual mental models to present similarity, overlap, and complementarity within teams" (Langan-Fox, Anglim & Wilson 2004, p. 332). This means, during interdisciplinary collaboration, the individual team members provide explanations about the task, coordinate their actions and adapt their behaviour to the demands of the task.

Moreover, it has been suggested that the outcomes of collaboration within community of interest can be some shared knowledge, experience and common memories which participants have accumulated (Hardin & Higgins 1996; Klimoski 1994; Sherif 1936). All these claims show that during the collaboration process within a 'Community of Interest', the elements participants shared, which could be knowledge, concepts, experience, are increased as the collaboration moves forward. At the end of the collaboration, the extent of the shared knowledge is constructed and the relationship between the construction of shared knowledge and individual learning is set up.

These findings raise the question as to what is shared-knowledge and why it is important during interdisciplinary collaboration? The categories associated with knowledge-sharing (Steinheider & Legrady 2004) include a shared understanding of objectives and problems, shared terminology, experience with interdisciplinary and motivation to work in interdisciplinary teams. The significance of knowledge-sharing has also been described by Steinheider & Legrady (2004) as follows:

> "...interdisciplinary teams must develop consensus about the project's goals, have a clear understanding of team members' diverse professional areas of expertise and acquire a meta-knowledge connecting the different areas of needed expertise as they relate to the project that has brought them together." (Steinheider & Legrady 2004, p. 315)

The above statement shows that the shared knowledge, referred to a 'meta-knowledge', which connects not only the diverse professional areas of expertise team members have, but the objectives and problems in the projects, serves as an important role in bringing various team members together to achieve common goals. As mentioned earlier in this section, the knowledge sharing process between individual collaborators in multi-disciplinary collaboration is established gradually as the collaboration move forwards. In the next section, the role of communication in that process will be explored.

2.2 Communication in Collaboration

As we know, the ability to communicate well with others is an important part of the collaboration process. Many studies on collaborative communication attend to the issue of 'common ground', which is an important element during communication. Common ground is defined by Clark & Brennan (1991) as "mutual knowledge, mutual beliefs and shared mutual assumptions". Achieving a common ground is a basic premise of social interaction and it would be impossible to communicate without it (Clark & Brennan 1991). Research on interdisciplinary teams shows that this common ground is often missing, and this can cause team members to complain of inefficient work (Janssen & Goldsworthy 1996). Furthermore, Bromme (2000) identifies three factors leading to common ground problems in such teams: differences in technical languages, different approaches to problem-solving and a lack of familiarity with other members' disciplines.

Common ground cannot be properly updated without a process called grounding. Grounding is characterized in Clark's theory of language (1996), to be where both partners in a communication (must) put in effort to make themselves understood by their partner and (must) put in effort in understanding their partner (that is to understand and be understood). For instance, the participants try to establish that what has been said has been understood. In grounding terminology, they try to ground what has been said, which means that they try to make it part of their common ground. The following is an example of how two parties communicate with each other based on a shared common ground:

> "When A speaks to B, A must do more than merely plan and issue utterances, and B must do more than just listen and understand. They have to coordinate on content (Grice 1978). They must also coordinate on process. Speech is evanescent, and so A must try to speak only when A thinks B is attending to, hearing, and trying to understand what A is saying, and B must guide A by giving A evidence that B is doing just this. Accomplishing this, once again, requires the two of them to keep track of their common ground and its moment-by-moment changes" (Clark & Brennan 1991, p. 128).

From this example, we can see that during communication, common ground is updated moment by moment and communication is built on common grounds accumulation. As mentioned in Section 2.1, during the interdisciplinary collaboration process, participants who come from different backgrounds need to seek a shared understanding of the goals and objectives and shared knowledge, which crosses different knowledge domains. From a perspective of communication, this process can be considered as one where participants are using and developing boundary objects (Star 1989). Defined by Wenger (1998), boundary objects can be "artefacts, documents, terms, concepts, and other forms of reification around", where the term 'reification' Wenger uses to describe the process of making more abstract. Boundary objects have been considered particularly important when trying to create common ground in interdisciplinary groups (Hendry 2004) (Boujut & Blanco 2003). Moreover, Fischer (2001) explains the role of boundary objects in community of interests as the media which allow different knowledge systems to interact by providing a shared reference that is meaningful within both systems; and as externalizations of ideas, which are used to "communicate and facilitate shared understandings across spatial, temporal, conceptual, or technological gaps" (Fischer & Ostwald 2003, p. 11).

Two main factors that shape grounding have been identified: one is purpose, which is what the two people are trying to accomplish something by their communication, and the other is the media of communication, which are the techniques available for accomplishing that purpose and what it costs to use them (Clark & Brennan 1991). The media are, for example, face to face, telephone, video teleconference and electronic mail. Luff et al (2003) further extend the scope of the media, which not only includes the facilities people communicate through, such as telephone, emails, as Clark and Brennan refer to, but include environmental artefacts, such as documents, models, or other physical artefacts. They pointed out that artefacts in the environment are as important as a shared access which interpersonal communication can rely on. In addition, Gaver (1992), describes the relationship between shared artefacts and a face-to-face collaboration environment as follows:

> "...situated within a shared, encompassing space, one which is rich with perceptual information about objects and events that can be explored and manipulated." (Gaver 1992, p. 22)

Those artefacts are either used directly for discussion or clarifying points or just passively facilitating communication. For instance, it has been found that artefacts in environments, in particular, those that are near at hand, are used to "illustrate the points we want to make, based on some casual observation of our surroundings" (Edmonds et al. 2005) (Rosenberg & Sillince 2000). For example, the role of pen and paper, which serves as an environment artefact, has been pointed out quite often in literature when related to sketching activities in collaborative design. For instance, Schon & Wiggins (1992) point out that sketching is a activity which can reflect the process of thinking through doing, and often serves as a joint activity during collaborative design. Cross (2006) has recently suggested that sketching can help designers to recall relevant knowledge and assist problem structuring through solution attempts.

We are interested in exploring the questions: what are the commonly used artefacts in art-technology collaboration, and how do these artefacts affect the collaboration process. As this research is situated in art-technology collaboration, where creativity and computer technology is most often involved, the study of creativity itself or collaborative creativity or how creativity could be enhanced by computers is a necessarily related area to review. In the next section, these areas will be reviewed by examining creativity in general and then collaboration in the creative process such as art and design practice.

2.3 Collaboration in a Creative Context

"Creativity" is an evocative, emotion-charged word that can mean very different things to different people (Partridge & Rowe 1994). Although there may be no general agreement on what is creativity, it is hard to deny that creativity does, sometimes, happen (Boden 1990). The history of interest in the nature of creativity is too wide to be properly surveyed. Therefore, a selected background will be provided for a proper understanding of the particular subject which this thesis addresses.

How do we define creativity? The most frequent answers are "new", "unique", "different", and "better". Creativity consultant Joyce Wycoff defines creativity as "new and useful". Creativity is the act of "seeing things that everyone around us sees while making connections that no one else has made" (Wycoff 1991, p. 22). Similarly, Boden

(1990) claimed that creativity is the ability to come up with ideas or artefacts that are new, surprising and valuable. Those ideas or artefacts, in art-technology context, could be, for example, a novel and useful solution for a complex and ill-defined problem (Steinheider & Legrady 2004). Furthermore, creativity can be characterized as the manipulation of problems, in other words, creativity is more about problem finding than problem-solving (Csikszentmihalyi 1999). The definition of a creative individual from Gardner (1993) is,

> "The creative individual is a person who regularly solves problems, fashions products, or defines new questions in a domain in a way that is initially considered novel but that ultimately becomes accepted in a particular cultural setting. Parts of this definition (such as the notion that creativity involves problem solving and that it connotes both initial novelty and ultimate acceptance) would be accepted by nearly every psychologically oriented researcher of creativity. " (Gardner 1993, p. 35).

In this definition, he emphasized three components: creativity involved in problem solving, initial novelty and ultimate acceptance. These three components are widely accepted among researchers in creativity. For example, Hargrove (1998) claimed that:

> "Creativity occurs when people are able to connect different frames of reference in ways that result in creating or discovering something new... Think about how much greater the possibility for creative, high-leverage, catalytic ideas exists when many minds, or an extraordinary combination of people are brought together through the shared context of a dialogue around a common goal or problem."

With respect to the research described in this thesis, the 'many minds' and 'shared context' are explored in the context of creative collaboration in art and technology. Similarly, Badke-Schaub et al (2007) suggest that 'sharedness', a common shared understanding, has an impact on creative problem-solving and they further confirm this difference, which is that in a creative team, it is unlikely that a straightforward transfer of the previous research is possible.

From the diversities of definitions in creativity given above, we can see the common points that define creativity are that it results in something new, and something involved in complicated tasks. Barron (1988) suggests that "creative people distance themselves from others to avoid the negative extrinsic factors, such as surveillance or evaluation, making it important to remove those factors in collaborative situations". A difference between a creative team and a tactical team is noted by Larson and LaFasto (1989):

> "...the main characteristic of tactical teams is the clarity of the task. The emphasis of the process lies on directive, highly focused tasks, unambiguous role clarity, well-defined operational standards, and accuracy. On the contrary, the main characteristic of creative teams is autonomy. Members of such teams are required to explore possibilities and alternatives and to create an atmosphere in which ideas are not prematurely discarded."

As it has been claimed that many creativity tasks are loosely defined at best, the strategies and tactics that people who are working creatively bring to a task are situation-specific and users may have difficulty articulating the task without performing it (Shneiderman et al. 2005). So how are creative tasks performed within team, how does group creativity take place and what are the issues of these collaborative processes? Compared with people who rely on standardized solutions, creative people solve problems in an exploratory mode, examining possibilities, searching for information and making conceptual models. Following this exploration, creative people seem to adopt a highly analytical and evaluative position, identifying flaws as a basis for further elaboration and refining of these ideas (Steinheider & Legrady 2004). Thus, in order to successfully realize a creative installation in collaboration, research has shown that a creative collaboration process involves and requires all team members to define problems, gather information and then progressively refine and extend initial ideas toward successful implementation (Mumford et al. 2002). Since all of these activities are difficult, creative work is a demanding and time-consuming process. Although strict empirical evidence may be lacking, it has been argued that the different views and perspectives in collaboration are essential to help people better understand each other and light the park of the creativity (Hargrove 1998). These heterogeneities and diversity of perspectives among group members appears to stimulate creative thought processes (Cox & Blake 1991) and be linked most strongly to team effectiveness for "creative and intellective tasks" (Guzz & Dickson 1996).

In terms of the relationship between communication and creative collaboration, researchers in Computer Supported Cooperative Work (CSCW) have suggested that the importance of communication is even more central to collaborative creative acts, involving two or more individuals (Lubart 2005), creative communities can facilitate their interaction through computer technology and increase common practice (Fischer et al. 2005), and collaborative projects involving heterogeneous teams can enhance creativity (Edmonds et al. 2005). Moreover, the different ways that computer and their tools can be involved in creative work have been examined. For instance, Selker (2005) notes that speed and facility of computer use are important to allow users to express their creativity without being slowed down by technology. Edmonds (2005), in a case study, demonstrates how visual programming languages can be useful in the collaboration between artistic creativity and technological creativity. Furthermore, Lubart (2005) points out a classification based on four categories of human-computer interaction to promote creativity is proposed: "computer may facilitate (a) the management of creative work, (b) communication between individuals collaborating on creative projects, (c) the use of creativity enhancement techniques, (d) the creative act through integrated human-computer cooperation during idea production." The importance of computers and their tools, as addressed by Hewett (2005), is they allow for multiple representation formats and also, they provide the creator with a kind of virtual notepad to 'write' down easily ideas that come to mind and to store ideas that have been processed.

Another important indicator that affects collaboration between people of different backgrounds, is the question of trust. Research has showed that trust, which is often viewed as a prerequisite for effective team interaction (Nakakoji, Ohira & Yamamoto 2000), plays an important role in support of collaborative creativity (Shneiderman 2000). Basadur & Head (2001) suggested that in order to establish a basis for trust, team members have historically relied on interpersonal similarity and common background and experience. Furthermore, Barnowe (1975) suggests that close supervision and highly detailed work plans tend to inhibit the performance of creative people, in particular, where tight schedules are imposed and precise plans are required. The need to be able to retain flexibility and opportunities for adopting new directions is vital for sustaining the creative impulse for individuals and this equally applies to collaborative situations such as the studies this thesis addresses.

In summary, in this section, the literature in interdisciplinary collaboration research was presented, and some key concepts were identified, such as communication and creativity. During the review, some significant issues were identified, such as what is the role of external artefacts, such as computers, in the creative collaboration process and how grounding between collaborators who come from different backgrounds is developed with these artefacts. The next section will continue to review the art-technology collaboration where these issues will be borne in mind.

2.4 Art-technology Collaboration

As computer technologies are increasingly applied in art-practice, it has been found that in the field of digital media art practice, the tendency for artists to collaborate with computer scientists instead of working alone has generally also increased: the "desire to incorporate digital technology is driving an increase in collaborative practice amongst creative workers" (Edmonds et al. 2005). This kind of collaboration is commonly named art-technology collaboration, where the complexity of technology has caused a shift from individual to team-based production and the art agent and the technology agent work together to achieve shared goal (Terveen 1995) (Steinheider & Legrady 2004). This process collaboration can be defined as building new shared understandings that lead to something new (Hargrove 1998). The final product of art-technology collaboration can be an artefact or a work-in-process artistic idea, which encompasses the artist's creative ideas and technologist's technical expertise. In the following sections, the art-technology collaboration process will be reviewed from two perspectives: the characteristics of artists and technologists and the features of the art-technology collaboration process.

Characteristics of Artists and Technologists

Sonnenwald (1996) and Schleifer (1997) suggest that communication styles and ways of working are in some ways disciplinarily determined, and in art-technology collaboration, art practitioners initiate new media projects where the role of artists is to primarily decide the goals and expectations in new media. Artists are adept and imaginative in pushing the envelope of expectations and defining the new horizons, which appear to be both visionary and mercurial. On the other hand, the role of technologists is to deliver technological expertise to realize these visions. Researchers have found that the art-technology collaboration process can be understood as a process where both artists and technologists are doing something non-traditional in their own field but useful for the others' field. As an interview conducted in "9 Evenings", one of the founders of the project, Billy Kluver said in an interview with Garnet Hertz in 1995,

> "The way I see it is that artists provide non-artists or whomever- a certain number of things which non-artists do not possess. The engineer expends his vision and gets involved with problems which are not the kind of rational problems that come up in his daily routine. And the engineer becomes committed because it becomes a fascinating technological problem that nobody else would have raised. " (Hertz April 19, 1995)

In this statement, we can see that Billy Kluver expressed the opinion that the role of the artist is to provide a certain number of things which non-artists do not possess. For instance, Feist (1999) has observed that artists appear to be more anxious, emotionally adaptable and impulsive than non-artists. Furthermore, the role of the engineers is to expand the vision and get involved with problems which are not the kind of rational problems that come up in their daily routine. However, sometimes the role of artists or technologists can be ambiguous because it is often difficult to separate what is strictly the computer programmer's concern from those of the artist (Fourmentraux 2006). Thus, in art-technology collaboration, where creativity comes from during the teamwork, artists or technologists or both, what are the differences between artists' creativity and technologists' creativity if there is any? From the nature of the art and science perspective, in the classic book 'Science and Human Values', J. Bronowski (1956) states that the creative activity of the scientist and the artist are the same. Partridge & Rowe (1994) further pointed out the difference between artistic creativity and scientist creativity is that 'artistic' creativity is concerned mostly by internal factors, and it involves production for its own sake, while 'scientific' creativity is concerned with the production of a theory to explain within phenomena. Furthermore, Barron & Harrington (1981) have suggested that creative scientist are more emotionally stable, venturesome and self-assured than the average individual. In particular, within the context of artists and computer programmers, Nake & Rosenfeld (1972) have made the following distinctions:

> "... both groups are creative, imaginative, intelligent, energetic, industrious, competitive and driven. But programmers, in my [vast world-embracing] experience, tend to be painstaking, logical, inhibited, cautious, restrained, defensive, methodical, and ritualistic. Their exterior actions are separated from their emotions by enough layers of logical defences that they can always say "why" they did something. Artists, on the other hand, seem to be freer, alogical, intuitive, impulsive, implicit, perceptive, sensitive, and vulnerable. They often do things without being able to say why they do them, and one usually is polite enough not to ask."

However, these differences can not be understood in an absolute way, for example, as Feist comments,

> "this is not to say that creative process in art is exclusively emotional and in science exclusively non-emotional... The discovery stages of scientific creativity

are often very intuitive and emotional, just as the elaboration stages of artistic creativity can be very technical and tedious (Feist 1999, p. 283).

From this comparison between the common features of artists and technologists, we can see that different characteristics and working styles may exist between artists and technologists. For example, technologists usually start with tightly constrained tasks with well-defined solutions and artists usually start with ill-defined problems with no single and correct answer. In the rest of this section, first, the art-technology collaboration will be further reviewed from the perspective of collaboration process; second, the common barriers of the collaborative process in art-technology will be summarized.

Features of Collaboration Process

From research on creativity, it is known that different views and a diversity of thinking can foster a creative problem-solving process and thereby improving the resulting solution. However, it is probably also important to share at least some aspects about the task and the team. For example, discussing the problem definition and requirements of a product facilitates the common understanding within a team when searching for a solution. Moreover, as the outcome cannot be predicted or assured in advance, it involves uncertainty. The process can often be risky and stressful as multiple solutions sometimes are possible. In order to cope with these conditions, creative people need to have high levels of motivation and during collaboration, they also demand an equivalently high commitment from others (Steinheider & Legrady 2004).

As was mentioned (Section 2.3), it is quite common to start with an ill defined goal in creative activities. If this happens within a multi-disciplinary team, the integration of the specialists' diversified approaches, methods and strategies ideally enables a multifaceted view of a given problem and therefore enhances the creative potential of the team members. Mumford (2002) further explains that in order to successfully realize a creative installation, all team members involved have to define problems, gather information and then progressively refine and extend initial ideas toward successful implementation. The art-technology collaboration has been identified as an iterative process starting with an ill defined goal and this goal is refined as the collaboration moves on. In a recent case study about the artist Olafur Eliasson, the artistic process is described as follows:

> "It is not a linear act of following a clearly stated and imagined path, but something quite different. It is a process that is aware of its path being constantly made and shaped during the journey in question." (Hannula, Suoranta & Vaden 2005, p. 130)

From the above quote, we can see that the process of making an artefact starts without a clearly stated path and it needs to be constantly shaped. In order to clearly state this point, here is a detailed description of one particular art-technology collaboration project named Net Art by Fourmentraux (2006) in an ethnographic study:

> "...the artist was asked to reframe his plan and to make choices that would aid its technical development, just as the artist waited for the computer programmers to tell him the possible options. The artist was compelled, even as he was asking for more information, to come to a decision on various options, to the point that the interactions between artist and programmers became so entangled as to raise questions about who exactly formulated, refined, transformed and/or abandoned the options..." (Fourmentraux 2006, p. 46)

From Fourmentraux's description, we can see that in that art-technology collaboration project, the artist's plan was reframed by the computer programmers who were trying to provide the possible technical options. Those options were formulated, refined, transformed and evaluated during the collaborative process. At the beginning, these options were broadly defined and as the process moved on, artists and technologists moved forward to identify some solutions which could be manageable during a timeframe. In addition, Candy and Edmonds (2002b) list some activities involved in the creative process: idea generation, problem-finding and formulation, applying strategies for innovation, acquiring new methods or skills and using expert knowledge, in which the last two of these are considered being especially important to digital artists engaging in innovative collaborative projects that require new knowledge. Similarly, Jones (2005) considers art-technology collaboration as a way of creating an artefact though a spiralling evolution brought by the interactions of artists and technologists within an integrated system of feed forwards (being suggestions or enquiries), feedback (being responses) and adoptions"

Collaboration Barriers

As the features of collaboration process were summarized as above, the rest of the section will review some barriers, which have been pointed out in art-technology collaboration research: first, lack of common ground; second, the technological support provided may or may not be entirely appropriate for the artists' purposes. More explanations of each barrier are made as follows.

The first barrier is a lack of common ground. As was mentioned earlier, creative collaboration involves a diverse set of perspectives, which is likely to generate novel ideas when searching for solutions, and where different views are useful in order to broaden the solution space (Badke-Schaub et al. 2007) (Adamczyk et al. 2007). As we know, art-technology collaboration provides an opportunity where two disparate worlds of artistic and scientific creativity could find common ground to create something bigger than either could do alone (Jackson 1998). The common ground in art-technology collaboration, is an intermediary space of exchange where the two partners try to create, and this space is a territory "in between" where the confrontation of interests and work methods could take place (Fourmentraux 2006). Where a lack of common ground exists, it often takes the form of a lack of shared language. This has been identified as a possible barrier to effective collaborative during art-technology collaboration (Candy & Edmonds 2002c) (Biswas et al. 2006). For example, according to the close observation of several art-technology collaboration cases, Candy and Edmonds (2002c) have pointed out that one of the communication barriers between artists and technologists is lack of a shared language. In their examples, the technologist considered using too much technical language and the artist expressed the need for more understanding of the procedures of software applications. They further suggest that "developing mutually agreed terms of reference which both artists and technologists can understand and work with is essential in inter-disciplinary collaboration, and can facilitate the establishment of joint understanding between artists and technologists" (Candy & Edmonds 2002c). Similarly, Johnston and Hicks (2004) point out that "the more both parties understand each other's concepts and terminology, the better they are able to develop a shared vision and solve problems that unexpectedly arise".

Similarly, Steinheider & Legrady (2004) have suggested that: one of the disadvantages in art-technology collaboration is that discussions of technical details need to remain at a superficial level and that additional interaction is required in order to further clarify expectations and requirements. While most of the art-technology collaboration projects involve digital technologies for creating creative artefacts, from Steinheider & Legrady's claim, we may infer that some artists and technologists are quite likely to have trouble engaging in an in-depth conversation about the technological details of the projects, where shared understanding about technological details of the projects may remain relatively poor quite often. This does not apply to those cases where the artist is also a programmer and has the necessary technological know-how to make technical decisions and implement them at a detailed level. Artist-programmers who collaborate therefore, require different things from their collaborating parties and although these cases are not represented in the COSTART case studies included in the thesis, amongst those who were not, there was evidence of a higher degree of success amongst those artists working together who shared technological skills albeit different kinds. No single individual today is likely to have all the technological expertise necessary to design implement and install an interactive art work and hence collaboration between technically skilled artists will necessarily involve different types of knowledge in those areas.

However, Janis argued (1972) that too much sharing in understanding and common language might lead to a similar phenomenon which can have a negative effect on performances of the multi-disciplinary collaboration. In a recent successful art-technology collaboration (Gemeinboech & Dong 2006), the artist and the engineer acknowledged the existence of different territories of knowledge and a different voice when they were describing their perspectives: "each dialogue is a deliberative 'language game' played out through the metonymy of ideas in their field to produce a subject always different to itself'", and they suggest that the differentiated language formulated between them was related to a way of working and thinking that does not de-legitimize their respective territories of knowledge, but promotes novel idea generation between them.

The second barrier in art-technology collaboration, which has been found, is that the technical support provided may or may not be entirely appropriate for the artists' purposes. There are two reasons: the technologists themselves and the technology they provide. As Leach (2005) described some complaints about technologists in his anthropological study of art-science collaboration that:

> "...the technologists are no longer in touch with the users of their products. Instead, they are caught up in a narrow, insulated trajectory, producing even more complex and involute solutions to technical problems... despite the fact that technology is a human creation, the concern is that it no longer serves social needs but in fact drives social and cultural change in undesirable directions" (Leach 2005, p. 142)

In the above statement, Leach illustrates some constraints that might be imposed on technologists. He implies that technology is a human creation where a social need is served, and emphasizes that technologists are not only providing solution problems, but also serving a social need, even sometimes in undesirable directions. Moreover, apart from the constraints of the technologists themselves, the limitation of the technology they provide can affect the collaboration process, as Fourmentraux (2006) claims: "...the artist became the initiator and discoverer of computer solutions and... the computer programmer claimed his creative sense and intervened in aesthetic choices. The compromises negotiated between artists and computer programmers were governed by two opposite logics: one of coherence with the artistic plan... and one of adaptation to technical constraints, feasibility and technical implications" (Fourmentraux 2006, p. 48).. Similarly, Jones (2005) points out that the extent to which artists accept the constraints of existing technologies determines the extent of the success of the process where they interact and collaborate with technologists in the realization of the artwork.

In this section, the review of art-technology collaboration was addressed from three perspectives: characteristics of artists and technologists, the collaboration process and collaboration barriers. It was found that artists and technologists have quite different features in terms of personal characteristics and working styles; the collaboration between artists and technologists is a spiralling and iterating process, where artists and technologists refined the multifaceted view of a given problem together and apply their individual creativity to this problem; the common barriers of art-technology collaboration are lack of common ground and the technical support provided may or may not be entirely appropriate for the artists' purposes.

2.5 Summary

This chapter has set out some of the most relevant literature to the research described in this thesis. It started with the reviews of three research domains: interdisciplinary collaboration, communication in collaboration and collaboration in a creative context, which cover the context within which we study art-technology collaboration. It then reviewed art-technology collaboration from three perspectives: the differences between role of artists and technologists, the iterative process of collaboration and common barriers in art-technology collaboration.

The key aspects of interdisciplinary collaboration process between artists and technologists as described above are summed up as follows.

- In interdisciplinary collaboration, participants come from different knowledge domains and have different vocabulary for describing their ideas. During the collaboration, the knowledge between individual collaborators evolves from a non-shared situation at the beginning towards a shared situation at the end (Section 2.1).
- Grounding serves as an important role in communication and two factors may shape the grounding: purposes, which are goals that collaborators are trying to accomplish, and media, which are the ways collaborators work together (such as face-to-face and teleconference) or environment artefacts (such as physical objects or facilitating tools) (Section 2.2).
- Collaboration in creative context has some distinguishing features: tasks are loosely defined, creative people often solve problems in an exploratory mode and the collaboration process is iterative (Section 2.3).
- During art-technology collaboration, there exist two common barriers in art-technology collaboration: lack of common ground and insufficient/inappropriate technological supports.

In relation to the literature presented in this chapter, the particular research aim for this thesis is to examine the following two issues: first, how a shared-language between artists and technologists developed during a collaboration process and which kinds of factors could affect the development of this shared-language; second, during the creative collaboration, to what extent, tools, such as computers and their peripherals, are necessary to facilitate communication and common ground across domains. In the following chapter, the methodologies, which have been applied in the research field of art-technology collaboration or other related fields, will be reviewed and the study methods and research process adopted in this research will be discussed.

3 Methodology

Chapter 2 described research in the context of art-technology collaboration and other related fields. This chapter will define the research approach and methods used to investigate the art-technology collaboration process. First, a methodological review is carried out (Section 3.1); second, the detailed study methods selected for this research context are introduced, in particular, the methods for data gathering and data analysis are described (Section 3.2); third, the description of the software support for analysis is presented (Section 3.3); finally, the research process is illustrated in the context of the studies conducted (Section 3.4).

3.1 Review of Methodological Approaches

To begin with this section, we need to distinguish the term 'methodology' from 'method'. Methodology is the study of methods and deals with the philosophical assumptions underlying the research process, while a method is a specific technique for data collection under those philosophical assumptions (Creswell 2003). In other words, methodology is the philosophical basis for method. Methodology can include collection of theories, concepts or ideas; comparative study of different approaches; and critique of the individual methods (Patton 2002). Methodologies can be categorized in many different ways. For example, in social science research, methodologies may be defined quite broadly (e.g. qualitative or quantitative) or more narrowly (e.g. grounded theory or conversation analysis). In many studies in relation to collaboration and creative research, social science methods have been often used. This section starts with a review of a methodology classification made by Mayer (1999) in the context of studying a creative and cognitive process. From this, the type of methodology most suitable for the research concerns defined here is identified.

Mayer (1999) has categorized existing methodologies into six groups: psychometric, experimental, biographical, biological, computational and contextual methods. In psychometric methodologies, creativity is viewed as a mental trait that can be quantified by appropriate measurement instruments. It involves the development of various psychological tests that are intended to assess various traits or characteristics of creative people. Biographical methodologies are based on analysing the case histories of creative people. In these methods, as Mayer claims, the strength is that carefully documented histories can provide both detailed information and a feeling of authenticity. Biological methodologies seek to determine the physiological correlates of creative problem solving. This set of methodologies arises from neuroscience, where details of brain activity can be uncovered using increasingly powerful scanning techniques. Furthermore, computational methodologies are based on the idea that a person's creative thinking can be formalized as a computer program, using the techniques of artificial intelligence. The final set of methodologies discussed by Mayer (1999) is that of contextual methodologies. The strength of these methodologies in the context of creativity studies, as pointed out by Hewett et al (2005), is that they place the study of creativity in a personal, social, societal, cultural and even an evolutionary context where researchers investigate creativity using data based in actual practice.

According to the above discussion of the six groups of methodologies summarized by Mayer, we consider that the most suitable type of methodology in creative research for this research context is the contextual methodology. The reason for this is that the main research concern of this thesis is to understand the collaboration process between artists and technologists during the actual process of developing ideas and implementation of creativity (Chapter 1). Therefore, historical approaches using biographical methodology, and others such as biological and computational modeling approaches do not apply. Moreover, psychometric methods focus on identifying creativity instead of studying the interaction between collaborators during the creative process and experimental methods involve the variables of control over the environment. Studies that apply contextual methodologies, however, are usually based in actual practice, which further confirms the suitability of this methodology in this research context. As Mayer claims that, "the major strength of contextual approaches is a broadening of the study of creativity. The narrow focus on cognition epitomized by the psychometric and experimental approaches should be widened to recognize the social, cultural, and evolutionary context of creative cognition" (Mayer 1999, p. 458). From the above quotation, we can see that Mayer emphasizes the strength of the contextual approach in comparison to psychometric and experimental approaches, and the reason may be that the contextual approach does recognize the social, cultural and evolutionary context of creative cognition. Including this contextual framework in the research here was considered essential to a well-rounded understanding of the protocol analysis. Moreover, Hewett et al (2005) point out that the strength of the contextual methodologies is in the fact that it has a long history and the procedures for developing such tests are well established. They further suggest that in creative research using digital technologies, it is necessary to observe the activities and problems users are having in real time activities, either through field study, ethnographic research, computer logging, or via actual participatory design (Hewett et al. 2005). However, a major weakness of the contextual approach, as Mayer describes, is a lack of rigorous data: "A major obstacle to its implementation is the need for cultural and evolutionary studies of creativity to be based on testable theories and solid empirical evidence" (Mayer 1999, p. 458).

In terms of studying art-technology collaboration, there are a few studies which have been carried out using contextual methodologies: for example, an ethnography study by Lucy Suchman in the Xerox PARC artist-in-residency program (Harris 1999), an in-depth case study by James Leach (2005) in an experimental collaboration of New Technology Artist Fellowships (NTAF) and an ethnographic case study by Jean-Paul Fourmentraux (2006) in the art-technology collaboration project 'Des_Frags'. Furthermore, in CSCW, Pinelle et.al (2003) used the mechanics of collaboration as a basic unit of collaborative interaction to develop a scheme called Collaborative Usability Analysis, focuses on the teamwork aspects of a shared activity, rather than the taskwork aspects. During these studies, some social science data collection techniques, such as observation, field notes and interviews, were applied. The weakness of those studies are: first, most studies are based on field notes and interview data that are likely to give an incomplete picture of the nature of collaboration as it actually takes place; second, they do not provide an in-depth and rigorous analysis with solid empirical evidence. Therefore, in this research, we extend the study methods of art-technology collaboration by conducting a series of case studies where we collected more continuous observation data using video/audio facilities and analyzed the data rigorously with the combination of context and protocol analysis to provide solid empirical evidence. In the next section, first, the case study method will be introduced; second, the research design will be described where the criteria for selecting the study cases, the description of the data collection and data analysis methods will be provided.

3.2 Research Methods

3.2.1 Case Study Method

Case study method is an empirical investigation of a set of events usually in a naturalistic context (Bruce 1993), which brings us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research (Soy 1997). The case study method, defined by Researcher Robert K. Yin, is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (Yin 2002, p. 23). From the above statement, we can see that the case study method targets the complex phenomena in the 'real-life context' and relies on 'multiple sources of evidence'.

Case study research refers to single and multiple case studies, in which researchers may gain a sharpened understanding of why the instance happened as it did, and what might become important to look at more extensively in future research (Bruce 1993). Case study method can include "quantitative evidence" and "benefits from the prior development of theoretical propositions" (Yin 2002, p. 14) and can be used to study observations of existing events or recoveries of past events and study cases are not amenable to control by the investigator (Candy & Edmonds 2002b). Moreover, case study research includes information that would normally be included in any contextual approach. The findings of a case study do not directly generalize although it is common to compare results with other similar ones. In the context of art-technology collaboration, Candy and Edmonds further suggest that "the case study method can be used to study exploratory project developing new art forms in a collaborative environment where artists and scientists can work together as equal partners in the exploration of the use of digital technology in art practice" (Candy & Edmonds 2002b, p. 43).

Based on the above discussion, the rational of applying the case study method in this research can be summarized into three points:

- First, the case study method is a type of contextual analysis method. According to the previous discussion of the six groups of methodologies summarized by Mayer, we considered that the most suitable type of methodology for this research context is the contextual methodology (Section 3.1). In relation to the case study method, it has been considered as one type of contextual analysis method, where an in-depth, longitudinal examination of a limited number of cases is involved (Soy 1997) (Davey 1991).
- Second, the case study method can be used for examining real-life situations and methodological issues. Soy (1997) notes that researchers have used the case study research method with success to examine real-life situations and provide the basis for the application of ideas and extension of methods, which is appropriate for the two main research aims of this thesis: first, to explore the methodological issues in art-technology collaboration; second, to explore the features of art-technology collaboration in actual ongoing situations (Section 1.2).
- Third, the case study method is suitable for the research starting with open-ended research questions. As Candy and Edmonds (2002b) point out, the case study method can be applicable when the research questions are open-ended and multi-factored. This suggestion further confirms the suitability of case study method for this research due to the research questions this thesis addresses are open-ended (Section 1.2).

Therefore, from the above three points, we can see that the case study has a great deal of suitability to help us to achieve the research aim this thesis addresses. In terms of the number of the cases selected for this research, there are four case studies. As discussed in Chapter 1, the case study data comes from two sources: an artist-in-residency program called COSTART (COmputer SupporT for ARTists) (COSTART 2002) and an art-technology collaboration project 'GEO Narrative Landscapes' (Zhang, Weakley & Edmonds 2007) (The detailed description about the COSTART and the GEO projects can be found in Section 4.1 and Section 5.1).

The COSTART project provided an environment for artists to explore their creative ideas, but also established a research environment specifically for social scientists to study how the process of collaboration between artists and technologists took place (Candy & Edmonds 2002b). From the series of studies conducted in the COSTART project, three cases were selected for further in-depth analysis in this research. In order to refine and validate the previous results, a similar research design to the COSTART project was applied to new situation GEO. As Yin (2002) points out that during the design phase of case study research, researchers need to determine what approaches to use to examine single or multiple real-life cases in depth and which instruments and data gathering approaches to use. In the following sections, the data collection methods and the data analysis methods applied in both the COSTART and GEO studies will be provided.

3.2.2 Data Collection Methods

The main data collection approach adopted in this research is a combination of observation and semi-structured interview [1]. During the studies, direct observation method was conducted in order to understand the collaboration process, followed by semi-structured interviews, to provide data about reflection on the process. This

[1] The author did not participate the data collection in the COSTART project but did collect the data in the GEO project.

combination of observation and semi-structured interview provided a richer picture of both 'reflection on the process" and 'the process itself'. More details can be found as follows.

Observation

Observation method enables the researcher to learn what is taken for granted in a situation and to discover what is going on by watching and listening (Morse & Richards 2002). It has been characterized as "the fundamental base of all research methods in the social and behavioral sciences" (Adler & Adler 1994, p. 389) and "the mainstay of the ethnographic enterprise" (Werner & Schoepfle 1987). The strengths of the observation method, as pointed out by Siverman (2000), are: provide direct information about behaviour of individuals and groups; permit researchers enter into situation/context; provide good opportunities for identifying unanticipated outcomes; offer a natural, unstructured, and flexible setting. The weakness of observation can be that, it may be seen as intrusive, and researchers may not have good observation skills. In this research, in order to minimize the bias of the different level of observation skills, the video/audio facilities were used to record participants' activities along with field notes taken by observers. Furthermore, the usage of video recoding allows us to capture nonverbal communications. For instance, what are facial expressions when participants express the opinions, how they arrange themselves in their physical settings.

Moreover, observation method can be expensive and time consuming, and researchers may have little control over situation. In this research, selective observation technique was employed where observers attended as many collaborative activities as possible and detailed field notes were taken throughout the process, at the meantime, observers selected those activities which involved a great deal of interaction between participants to record. Furthermore, as the observation method cannot provide cognitive information, such as attitudes, beliefs, motivation or perceptions (Slack & Rowley 2001), in this research, the gap was addressed by having the observers ask questions and by conducting informal conversations with participants subsequent to the video observation. At the end of the observation, semi-structured interviews were also conducted with each participant. The details of the interview technique can be found in the next section.

Semi-structured Interview

Interviews provide very different data from observations: they allow researchers to capture the perspectives of project participants, which, for example, can provide information on the early states of implementation and problems encountered. Depending at least in part on the purposes for which they are to be used, the research interview may take different forms: structured, semi-structured and unstructured individual and focus group interviews (Fielding & Thomas 2001). In this research, semi-structure interviews were employed where open-ended questions were introduced in order to allow the interviewees to explain more complex feelings and attitudes.

The strengths of the interviews are: provide opportunity to explore topics in depth; afford ability to experience the affective as well as cognitive aspects of responses; yield rich data, details, new insights. The disadvantages of interviews are: first, interviewees may distort information through recall error; second, interviewees may provide selective perceptions or not correctly report to please interviewer. This weakness can be minimized through avoiding asking sensitive questions, such as evaluation of other participants' leadership. The second weakness could be somehow amended through using direct observation, where researchers can have first-hand experience with informants.

3.2.3 Data Analysis Methods

In this research, in terms of the data analysis methods, context analysis and protocol analysis methods were employed together for analysing the data collected in both the COSTART and GEO cases. The context method provided the analysis with a good level of breadth and the protocol method provided the analysis with a good level of depth. The analysis methods, applied in this research, are as follows: it started with context analysis, which provided the breadth analysis about how artists and technologists collaborate with each other, where a big picture of art-technology collaboration was drawn and a series of detailed thematic research issues were generated. Following that, in order to explore these thematic research issues with more analysis in-depth, a protocol analysis using the same data set was carried out.

3.2.3.1 Context Analysis

Context analysis, also known as environmental scanning, establishes the scope and the context of a domain. In terms of studying collaboration, in this research, the 'context' involved the background, the roles and activities of the participants during the collaboration, the profile of the project and any tools they used. In general, the purpose of the analysis is to identify the situations that represent a case study as a whole, which includes understanding the technical, environmental and social settings. Context analysis can be applied to study the situation as it happens, where the researcher becomes familiar with the worksite in order to acquire a concrete understanding of the work taking place (Candy, Amitani & Bilda 2006) (Candy & Bilda 2007).

Context analysis has been broadly applied in many fields, such as human-computer-interaction (Bevan 2001), usability engineering (Rosson & Carroll 2002) and collaborative design study (Gero et al. 2004). For example, in usability testing studies, it examines whether and how the interaction between the physical and social environment and the physiological and psychological characteristics of the user would impact users interacting with the system (Zhang et al. 2005). A context analysis study often involves a continuous direct observation whereby researchers are present at the scene and record the events that take place in field diaries over an extended period of time. Suchman's study of document copier systems is a classic example, where Suchman observed people using a sophisticated photocopier equipped with sensors to track users' actions, and the system offers helpful prompts and feedback (Suchman 1987). As Zhang et al (2005) point out, during context analysis, patterns of communications between users and the system, descriptions of how and why users use the technology to interact with each other can be explored. Furthermore, the context analysis can provide a relatively thorough picture of the study activities from the beginning to the end and provide a broad analysis of the whole situation.

3.2.3.2 Protocol Analysis

Protocol analysis, initially developed by Ericsson & Crutcher (1991), is a rigorous methodology based on observation and analysis of professional work (Ericsson & Crutcher 1991). Protocol data can be texts (such as publications, newspaper etc.), outcomes of creative activities (such as drawing, sketches, annotations etc), recorded communication (where audio recording is taking place), or recorded activities (where video recording is taking place). Two types of reporting have been used in protocol analysis studies: concurrent and retrospective verbalization. In collaboration studies, concurrent verbalization has the potential to reveal the process of the collaboration whilst, on the other hand, retrospective verbalizations are collected to focused on the content (Dorst & Dijkuhuis 1995). The protocol analysis approach has been conducted broadly in the creative process of design such as Neill, Gero & Warren (1998) and Suwa, Purcell & Gero (1998), collaborative design studies such as Cross, Christiaans & Dorst (1996) and Gero et al (2004), design of software engineering fields such as Olson et al (1992) (1996) and Robillard et al (1995) (1998), and understanding audiences' interaction experiences by Bilda (2006).

Using protocol analysis, one of the advantages is that researchers can conduct the analysis at a very rigorous and detailed level. For example, some of the analysis under this approach, such as Cross (1996) and Gero (1998), went as far as analysing each word the collaborators uttered. Furthermore, protocol analysis has been proven to be a good method for understanding a complex human activity. For example, Robillard (1998) used it to understand the software design process by analysing technical review meetings. Protocol analysis is suitable for a highly targeted in-depth analysis; however, it is not good for addressing the existence and value of contextual information. Moreover, during protocol analysis, the analyzed data sample is relatively small and it may only provide an narrow understanding of specific phenomena in the research site instead of a wider and richer picture. Furthermore, as the sample of protocol analysis can not be too large, it is not very suitable for conducting research in exploratory phases where a great deal of data is most likely used.

In comparison to the above, the context analysis approach focuses more on a broad picture of analysis. The protocol analysis approach focuses more on an in-depth analysis and provides a excellent depth about specific features of the research subject, such as communication behaviour of designers within a technical design review meeting (Robillard et al. 1998). Therefore, the combination of these two analysis methods can provide a thorough analysis with a high degree of both breadth and depth perspectives. The idea of applying these two methods together is not completely novel. In a study of understanding collaborative design activities in High Bandwidth Virtual Environments, Bilda, Candy and Gero (2004) have used this combination to capture and analyse example collaborative design sessions. In their study, the context analysis continued over the research timeline and the protocol analysis occurred during the intensive period where the video recording facilities were employed (See Figure 3.1).

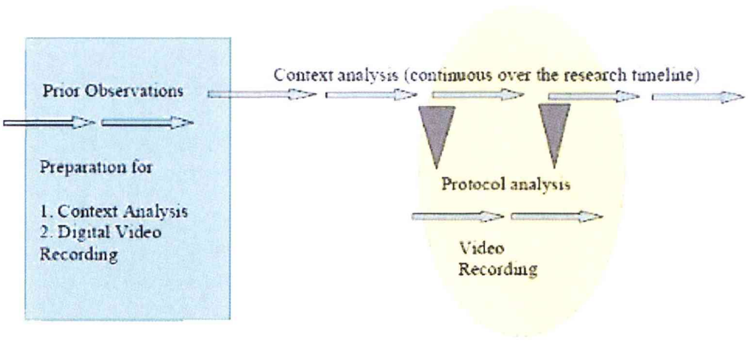


Figure 3.1 Context and protocol analysis (Gero et al. 2004)

The "context" in their study involved the roles and activities of the designers in the office, tools they have used, the holistic view of the design project at hand and team members' interactions with each other and clients/other institutions over the timeline of a design project. As they note, context analysis gave them a perspective on activities in the design practice at a higher level. While context analysis continued over the research timeline, the protocol data collection occurred during intensive periods of collaborative designing where video recording was also needed and employed (Gero et al. 2004). However, during their data analysis, the level of analysis in relation to the contextual data was limited. Therefore, in this research, we further extend Gero, Bilda and Candy's approach towards the situation of art-technology collaboration by developing a detailed analysis method for both context analysis and protocol analysis. The analysis process of these two methods demonstrated in the COSTART and GEO studies will be presented in Section 3.4.

3.3 Software Support for Analysis

As the data collected in this research consisted of a large quantity of data, the process of analysing it manually can be a time-consuming process. There are a number of software applications which are specially designed to enable researchers to organize, code, retrieve large sets of heterogeneous data in a more efficient and reliable way. One of the advantages of using software is that they can organize and control large data sets. As data set can become very large, not only is there a great deal of primary data to deal with, but notes, memos. Using analysis software would make organize those data easier. Furthermore, most programs have tools for supporting the coding of the data. Coding is a key analysis method for keeping a record of researchers' analytic thoughts about the data and a way in which researchers can develop an analytical understanding and interpretation of the data (Taylor & Bogdan 1984). The coding function of analysis software can provide ways of supporting the analytical development of codes, such as coding hierarchies, commenting, definitions, grouping and modelling (Bazeley & Richards 2000). One of the critical disadvantages of using analysis software packages is that many computer-supported analysis softwares have been built with some methodology or particular analysis in mind (Bhowmick 2006). Therefore, these software packages are not capable of dealing with research conducted in different methodological domains, which makes it difficult to be applicable to a wide range of users. For this research, Nvivo (Bazeley & Richards 2000) was identified as suitable for context analysis of textual data and INTERACT (Mangold 2005) as the software package for protocol analysis of audio/video data. A brief description of each software application can be found below.

Nvivo

Nvivo, developed by QSR (Qualitative Software Research), was designed for researchers who need to combine coding with qualitative linking, shaping and modeling. Nvivo supports both qualitative inquiry and quantitative inquiry. Nvivo is appropriate if the research involves very rich text-based information, where deep levels of analysis on both small and large volumes of data are required (Bazeley & Richards 2000). The other special features of Nvivo are:

- It is robust at dealing with non-structured data such as transcriptions, diaries, emails etc. and structured data such as interview, proposal.
- It supports categorizing and comparing text segments by offering 'code-and retrieve' facilities (Richards & Richards 1995), which allow for the attachment of 'code' to text segment, and retrieval of all segments from a defined set of documents to which the same code had been assigned.

During qualitative analysis, there are two types of themes that emerge from data: a descriptive theme and an interpretive theme. Descriptive themes are used to summarize what informants have said or done and interpretive themes are used to summarize descriptive themes and the researchers' interpretation. In Nvivo, descriptive themes can be presented as nodes, which are further categorized into free nodes and tree nodes. Free nodes represent an unstructured collection of nodes and tree nodes represent structured nodes in hierarchies, moving from a general category at the top to more specific categories down the bottom (Bazeley & Richards 2000). Moreover, node sets in Nvivo are used to construct an interpretive theme. Each set contains a group of descriptive themes, which come from tree nodes and free nodes. Nodes in the node set are related to each other to formulate a core interpretive theme, which is interpreted by researchers from the relationships among nodes. The following figure is a screenshot of how analysis is carried out in Nvivo.

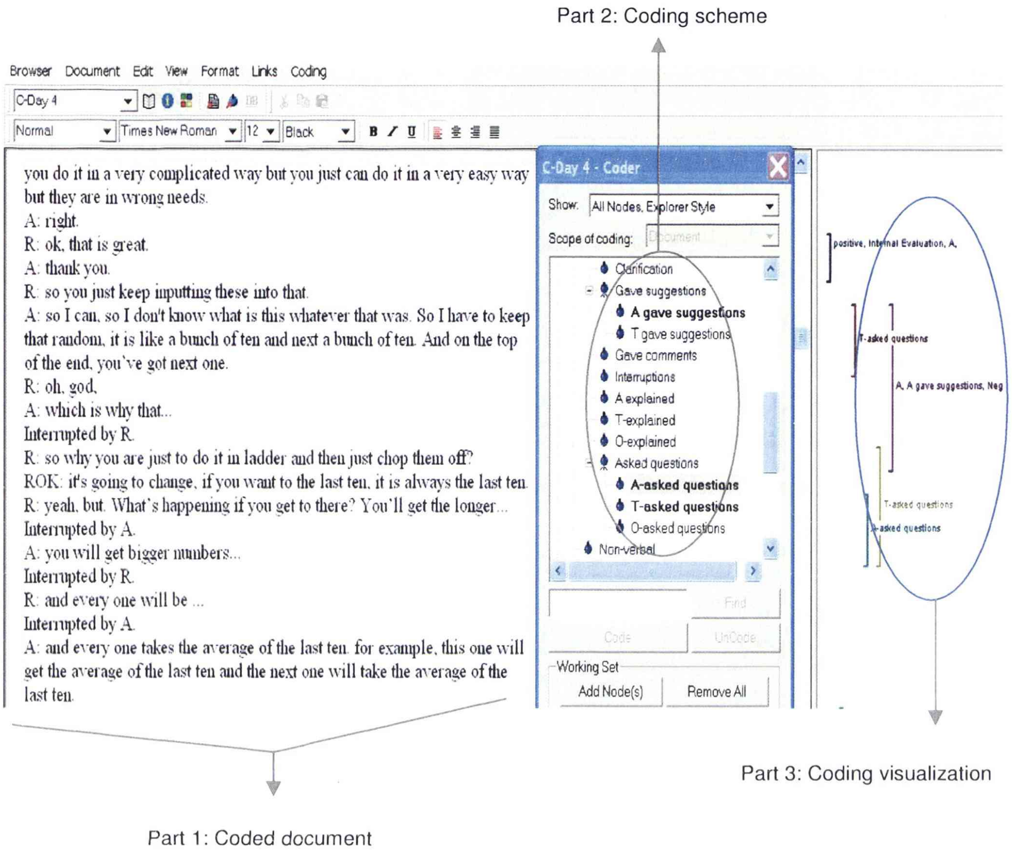


Figure 3.2: Screenshot of the analysis carried out in Nvivo

In Figure 3.2, *Part 1* shows a small portion of conversation transcription between one artist (abbreviated as R) and one technologist (abbreviated as A); *Part 2* illustrates the coding scheme developed during the context analysis; The coding visualization function, shown as *Part 3*, shows approximately which part of the transcriptions was coded under which code.

INTERACT

The video analysis software 'INTERACT' was chosen for this research to assist the protocol analysis process. INTERACT allows video/audio data to be analysed together with transcribed textual documents. INTERACT is particularly designed for dealing with a large amount of video data for behavioural analysis and provides statistical analysis tools. Its other special features are:

- its flexibility in data recording and management, such that, the video sources can be opened and analyzed as many as users wish for in a synchronized way;
- its ease of use overall and very simply error correction possibilities;
- its flexibility in coding process, where a rough preliminary coding can be made first and refinement/corrections at subsequent points in the future.

With INTERACT, it was easy to either obtain a mapping of behavioural patterns along a timeline of the activity or to view the percentage of time spent in each code category (Bilda, Costello & Amitani 200). The following figure is a screenshot of how analysis is carried out in INTERACT.

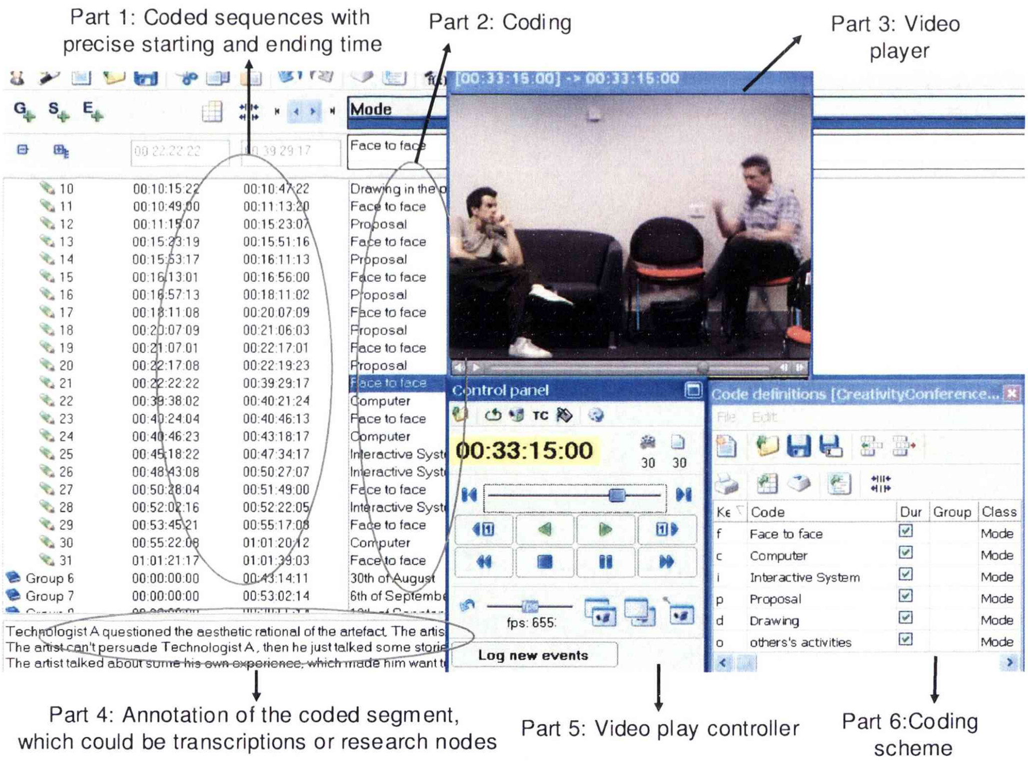


Figure 3.3: Screenshot of analysis carried out in INTERACT

In Figure 3.3, *Part 1* shows the segmentation of the video data with precise starting and ending time; *Part 2* shows the detail of the coding for each segmentation; *Part 3* indicates where the video data is played; *Part 4* shows the annotation of the coding segment where transcriptions or research thoughts about this particular segment are recorded; *Part 5* displays the video play controller; *Part 6* illustrates the coding scheme. In the next section, the development process of coding schemes and the analysis process assisted by software Nvivo and INTERACT within each case and across cases will be described.

3.4 Analysis Process

There are four principle studies in this research: three cases came from the COSTART project and one case came from the GEO project (Section 3.2.1). Both context analysis and protocol analysis were carried out in each case. In this section, the detailed processes of context analysis and protocol analysis are illustrated and the overview of the analysis process within cases is presented.

3.4.1 Context Analysis Process

Segmentation

During the coding process, the data is divided into small units, called 'segments'. One way of identifying segments is based on verbalization events such as pauses, intonations as well as syntactic markers for complete phrases and sentences (Ericsson & Simon 1993). For this method, pauses or syntactic markers start a new segment. This method is broadly used in analysing conversation from the level of semantics and linguistics (Hutchby & Wooffitt 2002), which is not in accord with the primary aim of this research. Another way to divide the data used in this research is based on the subject's intention (Goldschmidt 1991; Suwa, Purcell & Gero 1998; van Someren, Barnard & Sandberth 1994). In this method, one segment can be one sentence or many sentences. A change in the subject's intention or the content of thoughts or actions starts a new segment, such as a topic of conversation change, or a new action is launched, including working in front of computer, sketching with a pen etc. As two different analysis methods applied in each case: context analysis and protocol analysis, there are two different formats of segmentation. The segmentation of context analysis will be discussed in this section and the segmentation related to protocol analysis can be found in Section 3.4.2.

The segmentation for context analysis is based on a sequence, which is a series of utterances made interactively by several speakers. A sequence is defined by the link between the contexts of each utterance. Each sequence may contain two to several utterances. The following figure shows a sample of a coded segment in context analysis in the software Nvivo.

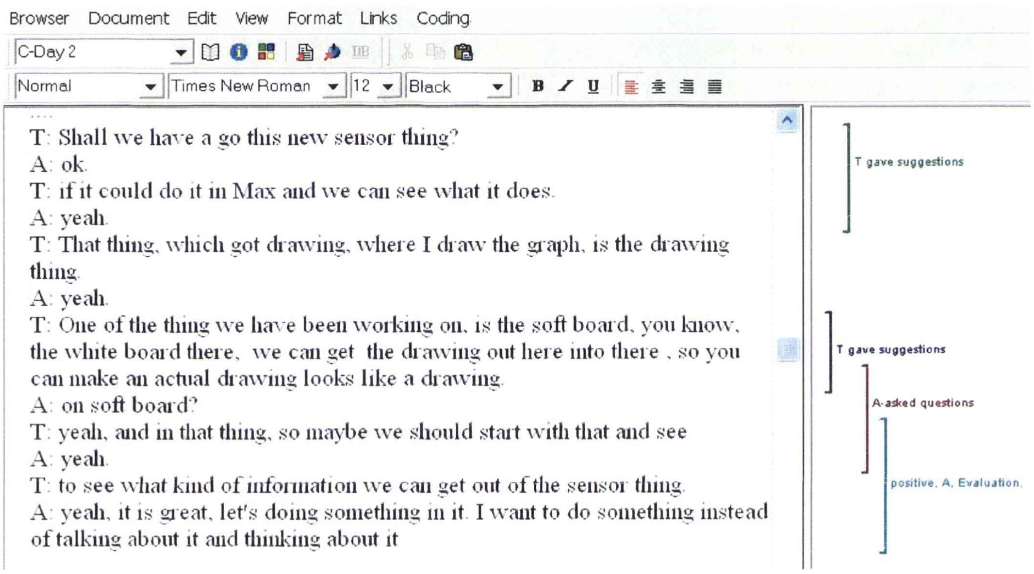


Figure 3.4: A coded segmentation of context analysis in Nvivo

In Figure 3.4, the data (the left side) were segmented and coded based on the context and content of the data by three nodes 'T gave suggestions', 'A asked questions' and 'Positive evaluation from A'. Amongst those coded data, we can see that some were coded by several nodes. From Figure 3.4, we can see that data segmentation is closely connected with the structure of nodes. In the next section, the concept of nodes and coding schemes will be discussed and the development process of the coding scheme will be presented.

Coding

Generally, coding is a process applied to categories of fundamental knowledge (such as concepts, attributes, values, tasks and relationships) to label the data (Richards 2005; Suwa, Purcell & Gero 1998). These labelled data indicate that they are examples of these categories. This labelling or coding process enables researchers to quickly retrieve and collect together all the data that they have associated with a category so that they can be examined together and different cases can be compared in that respect (Richards 2005). A group of these categories is called a coding scheme, which reflects researchers' interests focusing on particular aspects relevant to researchers' questions (Suwa, Purcell & Gero 1998).

Categories in a coding scheme, which are commonly called nodes, are used as tools to find out the answers to research questions. For example, every individual node might be linked to some segments of research materials and those segments could be further analyzed within the schematic system, such as merging two similar nodes or making comparisons among different segments of the same node and so on. Therefore, a coding scheme is one of the core functions to help researchers to conduct research. Since context analysis and protocol analysis offer slightly different ways of coding the data, the coding schemes developed for each type of the analysis are slightly different. The development of the context analysis coding scheme will be discussed in this section, and the relative discussion about the development of the protocol analysis coding scheme can be found in Section 3.4.2.

The new context analysis coding scheme in this research was developed in order to address a broad research question: that is, how do artists and technologists collaborate with each other in terms of communication, context and behaviour perspectives? The following figure represents how the context analysis coding scheme was developed and refined through the COSTART and GEO cases.

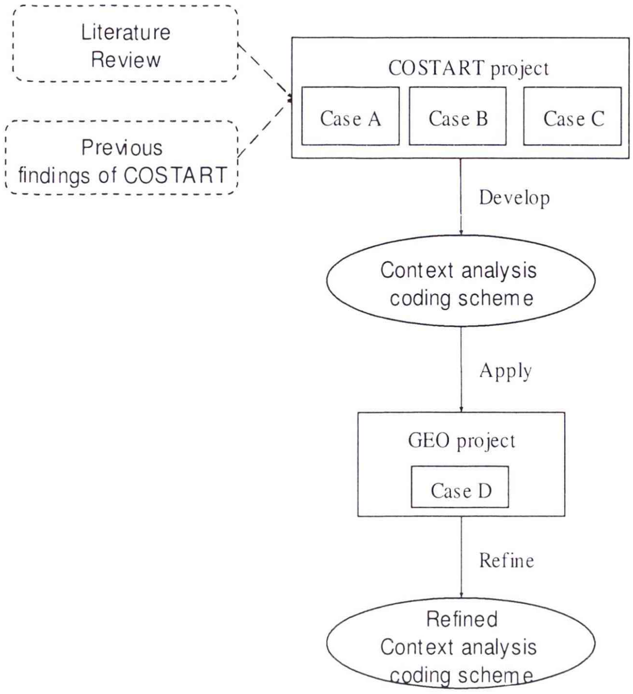


Figure 3.5: Process of development of the context analysis coding scheme

The context analysis coding scheme was developed from three sources (Figure 3.5). The first source is some related literature. For instance, Fourmentraux's study (2006) suggests that leadership has an important influence on the performance of digital art practice. In this research, a node named *Leadership* in the coding scheme was introduced in order to keep track of the role of leadership within the collaborative situations under investigation. Furthermore, two cognitive styles of creative collaboration activities: exploratory and goal-driven, specified by Candy and Edmonds (2002c), were also adopted in the context analysis coding scheme as the nodes *Exploratory* and *Goal-driven*. The second source of the coding scheme development is the data themself. In other words, the nodes were made to record the phenomena disclosed by the data and summarize the thematic meaning of the data. For example, the *Background-A* node contains the data segments about how artists talked about their collaboration experience and education background. The *Outcome* node records the descriptions of any residency achievements, which may include pictures or video shots of artefacts or text representation. The third source of developing the context analysis coding scheme was to include some of the previous findings of the COSTART project, such as the *Common language* node which was made to investigate further the findings related to the concept of 'shared language', which was identified by Candy and Edmonds (2002c) in the previous COSTART research.

After the context analysis coding scheme was initially developed, it was refined through a series of three COSTART case studies. In each case, a heterogeneous type of data set was used, including the conversation records between artists and technologists, interviews, field notes and residency diaries. The coding scheme was further applied and validated to a similar data set collected in the GEO case. The process of how the coding scheme was developed and refined through the COSTART and the GEO cases and the structure of the initial coding scheme and the refined coding scheme can be found in Section 4.2.2 and Section 5.2.2.

3.4.2 Protocol Analysis Process

Segmentation

Compared with the segmentation for context analysis, where the data was segmented based on the context of utterances (Section 3.4.1), the segmentation of the protocol analysis was based on utterances made by a single speaker at one time, which could be very short, such as "yes" or "no", or last for several minutes. The following figure shows a sample of a coded segment in protocol analysis.

Speaker	ID	Transcriptions	Code
A	72	There's quite a lot of difference in the texture. Do you know what I mean, from here.	JUS, CLAR
T	73	One of the reasons for that is you're using such a contrasting background. You would feel it's too big. You can't see the definition. And also secondly there are no lights on it. I can add some lighting, it should do...	JUS, HYPO
A	74	The quality of that would be quite nice for other things because I think that translucent quality...	EVA
T	75	If the object is there, where do you want the object to be lit?	CLAR
A	76	Somewhere so that it's dramatic lighting.	JUS
T	77	What's the effect you are trying to achieve. What's the mood you're trying to achieve?	CLAR
A	78	So that it's hanging in space. It's slightly flat, it's really trying to farce that interpretation.	JUS

Figure 3.6: A coded segmentation in protocol analysis

The first column of this figure shows the speaker of each utterance. The second column displays a unique identifier for each utterance. The fourth column shows the codes for each utterance based on the coding scheme. The example of the coded segmentation in software INTERACT can be found in the following figure.

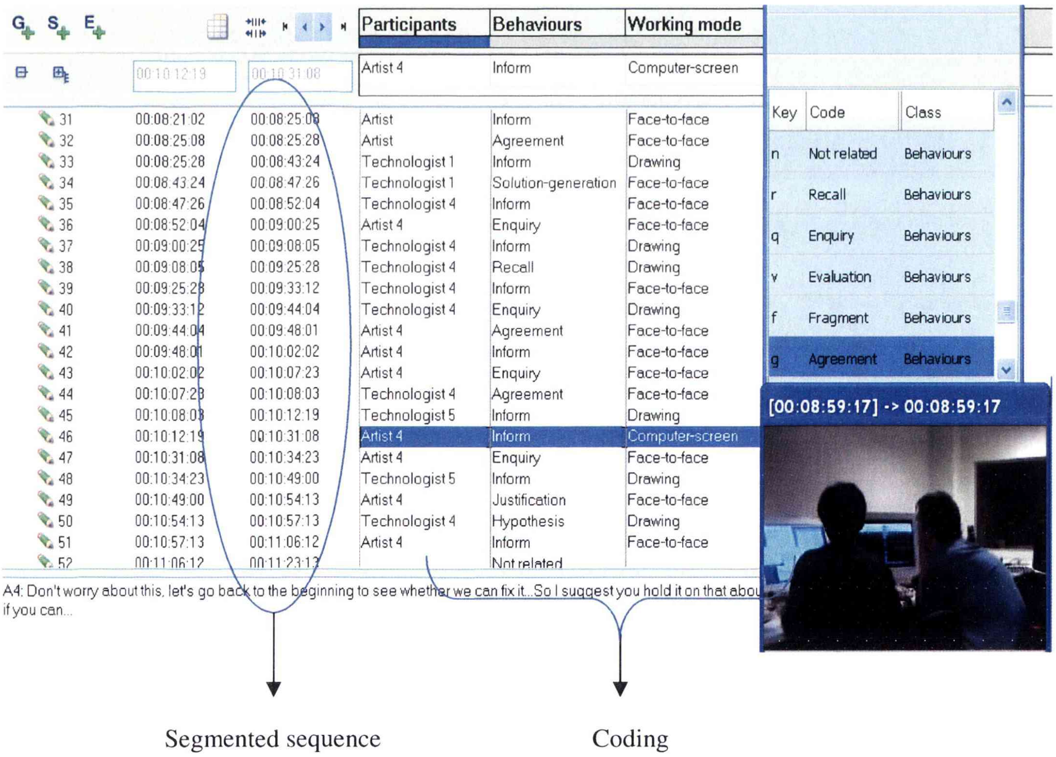


Figure 3.7: A coded segmentation of protocol analysis in INTERACT

Coding

In comparison with the development of the context analysis coding scheme, the development of the protocol analysis coding scheme was different. The context analysis coding scheme was mainly developed from the data itself and with a broad aim (Section 3.4.1) while the protocol analysis coding scheme was developed partially based on other coding schemes and partially based on some results from context analysis which made it possible to focus the aims of the protocol analysis studies. More details can be found in the following section.

In the results of the context analysis from the COSTART cases, one of the findings shows that computers can affect participants' communication patterns (See Section 4.3). This finding influenced the aim of protocol analysis, which is to explore the differences and similarities between artists' communication behaviour and technologists' communication behaviour and how external representations can affect participants' communication behaviour. In some existing works of studying communication behaviour, there are several coding schemes, which have been developed for analysing similar research aims but in different research contexts. For example, Olson (1992; 1996) developed a coding scheme to analyze the communication interactions of a group of experienced software designers during design meeting. Herbsleb and Robillard (1995; 1998) developed a coding scheme to analyse communication behaviour in technical review meetings in order to understand the software design process. For the development of the protocol analysis coding scheme in this research, the coding scheme started with selected nodes from other coding schemes and was refined through the COSTART and GEO case data. The process of the development is summarized in Figure 3.8.

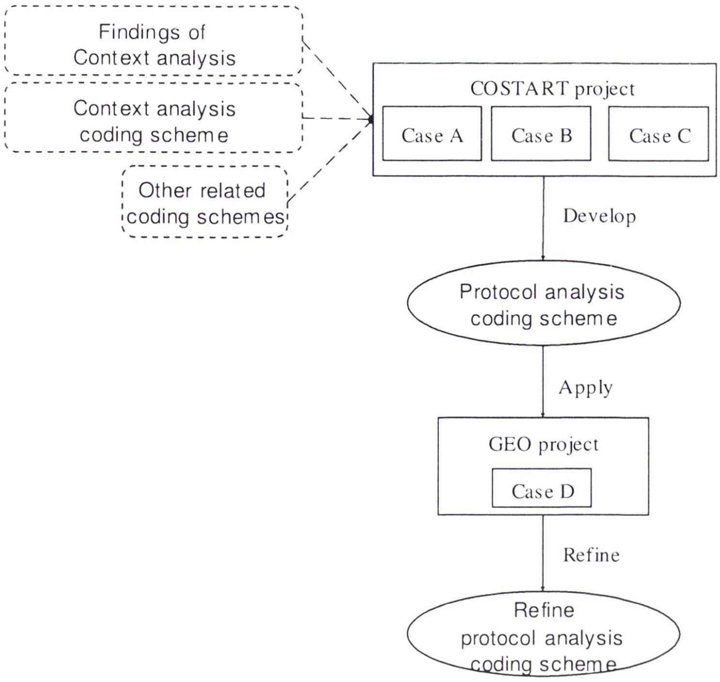


Figure 3.8: Process of development of the protocol analysis coding scheme

In Figure 3.8, we can see that the protocol analysis coding scheme was developed initially from three sources: findings of context analysis, the context analysis coding scheme and other related coding schemes. After it was applied and refined with the three cases from the COSTART project, it was further validated through the GEO case. The process of how the coding scheme was developed and refined through the COSTART and the GEO cases and the structure of the initial coding scheme and the refined coding scheme can be found in Section 4.3.2 and Section 5.3.2.

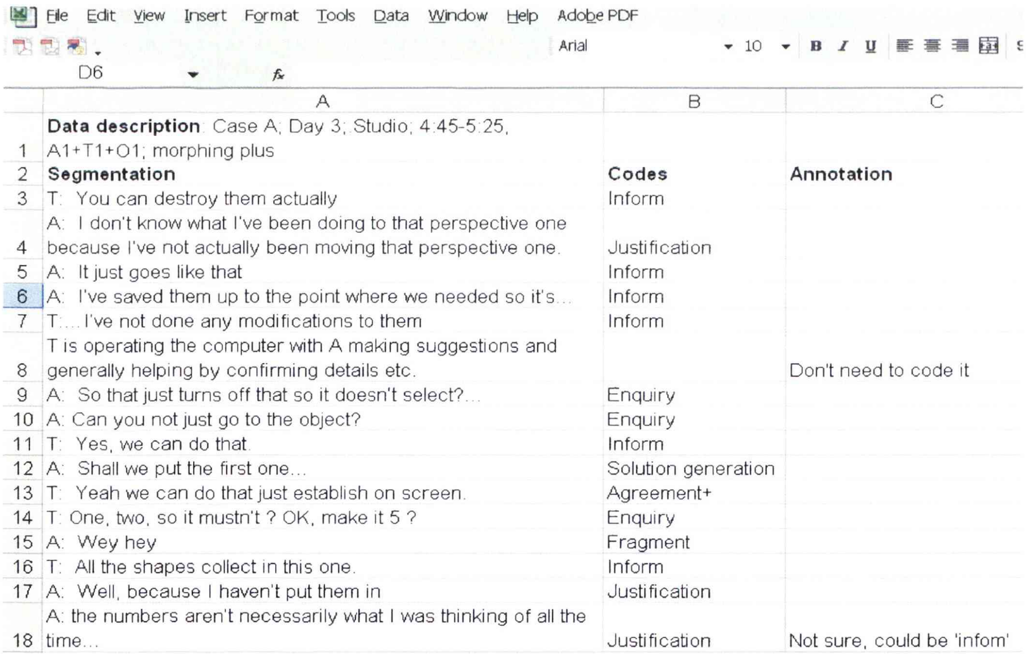
Triangulation

In social science research, there are three issues that researchers are concerned with related to the quality of the data analysis and data collection, which are reliability, validity and trustworthiness. For the first two issues, according to Morse and Richards,

> "reliability and validity involve ensuring that the processes of data creation and interpretation record the phenomena of interest as closely as possible and two researchers working independently obtain data that are as similar as possible"

(Morse & Richards 2002, p. 100).

In the protocol analysis under discussion here, in order to improve the level of reliability, validity and trustworthiness during the analysis, an arbitration process was carried out where the same data set was coded by two coders independently and any disagreement was resolved through discussion. The coding team was composed of three coders: the author, which was the main coder, and two second coders, which are researchers from the field of the HCI or art-technology collaboration. The procedure of the arbitration process carried out in each case is summarized into three stages as follows: first, the data was coded by two coders independently; second, the group meetings were carried out and coding disagreements were resolved; third, the coding reliability was calculated. During the first stage, the data was exported in Excel (a snapshot of Excel containing coded segments may be found in Figure 3.9).



	A	B	C
1	**Data description**: Case A; Day 3; Studio; 4:45-5:25, A1+T1+O1; morphing plus		
2	**Segmentation**	**Codes**	**Annotation**
3	T: You can destroy them actually	Inform	
4	A: I don't know what I've been doing to that perspective one because I've not actually been moving that perspective one.	Justification	
5	A: It just goes like that	Inform	
6	A: I've saved them up to the point where we needed so it's...	Inform	
7	T:... I've not done any modifications to them	Inform	
8	T is operating the computer with A making suggestions and generally helping by confirming details etc.		Don't need to code it
9	A: So that just turns off that so it doesn't select?...	Enquiry	
10	A: Can you not just go to the object?	Enquiry	
11	T: Yes, we can do that.	Inform	
12	A: Shall we put the first one...	Solution generation	
13	T: Yeah we can do that just establish on screen.	Agreement+	
14	T: One, two, so it mustn't ? OK, make it 5 ?	Enquiry	
15	A: Wey hey	Fragment	
16	T: All the shapes collect in this one.	Inform	
17	A: Well, because I haven't put them in	Justification	
18	A: the numbers aren't necessarily what I was thinking of all the time...	Justification	Not sure, could be 'infom'

Figure 3.9: A coded document in Excel for the arbitration process

In Figure 3.9, it shows a sequence of segmented transcriptions between the artist and the technologist in Case A. The first column contains the segmented transcription, the second column contains the coding results made by one of the second coders and the third column contains the annotation where explanations or research concerns were recorded as a further reference during the discussion carried later on with the first coder. During the second stage, group meetings were carried out where coding disagreements were discussed. During the group discussion, some of the coding disagreements were solved while some remained because of the different opinions between coders. During the third stage, the coded data set was re-input into INTERACT (a screenshot of INTERACT containing two independent coding files was displayed in Figure 3.10).

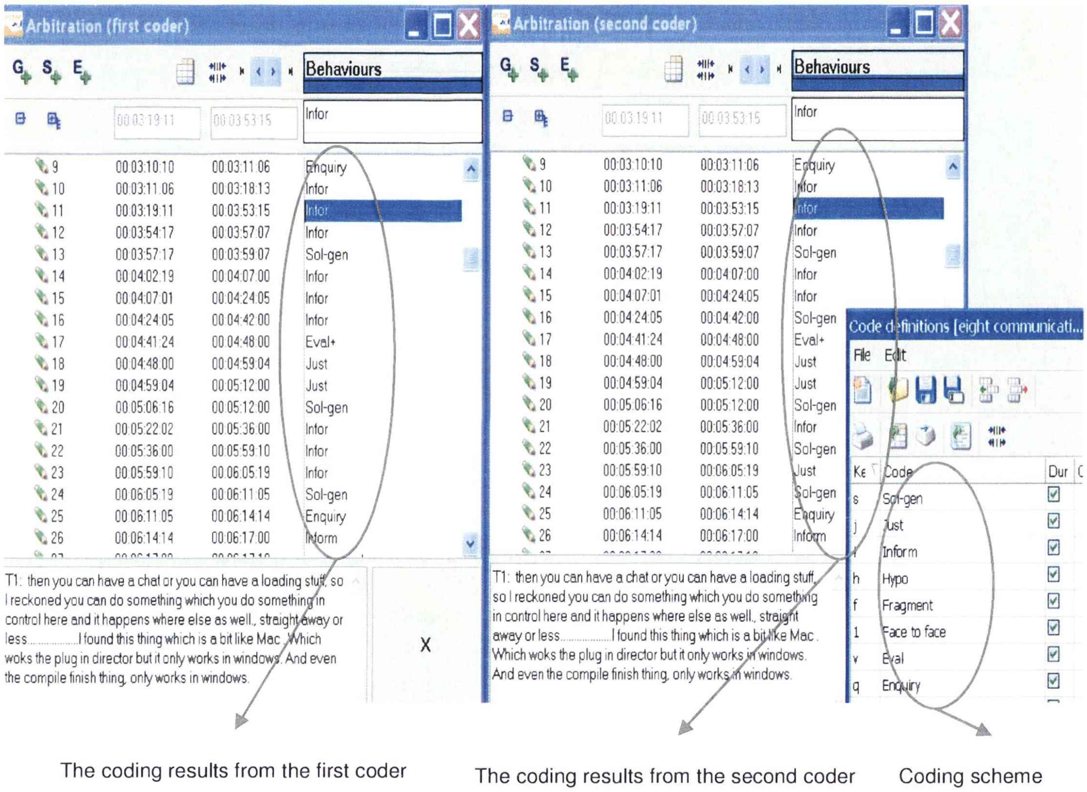


Figure 3.10: A screenshot of arbitration process in INTERACT

In Figure 3.10, the left side illustrates the coding results from the first coder and the right side illustrates the coding results from the second coder. During this step, coding reliability was assessed by calculating the agreement percentage between these two coders; the reliability of the coding process was measured by agreement between two coders and a Kappa value. Kappa value is a statistical measure of inter-rater reliability

(Fleiss 1981), which measures the agreement between two rater (coders). The results of the agreement between two coders and Kappa value in each case were made using the INTERACT software. The results can be seen in Table 3.1.

Table 3.1: Coding consistency between different coders

Case study		Agreement between two coders (%)	Kappa value
COSTART Project	Case A	90.5	0.83054
	Case B	81.3	0.74989
	Case C	78.7	0.72362
GEO project	Case D	79.6	0.73168
Average		82.5	0.75883

In Table 3.1, the average agreement percentage, which was shown, was higher than 75 per cent and the average Kappa value was higher than 0.70, which means the coding process was reliable.

3.4.3 Overview of the Analysis Process within Cases

In this section, the overall research process for the COSTART and the GEO studies is presented. The following figure summarizes the analysis process in this research:

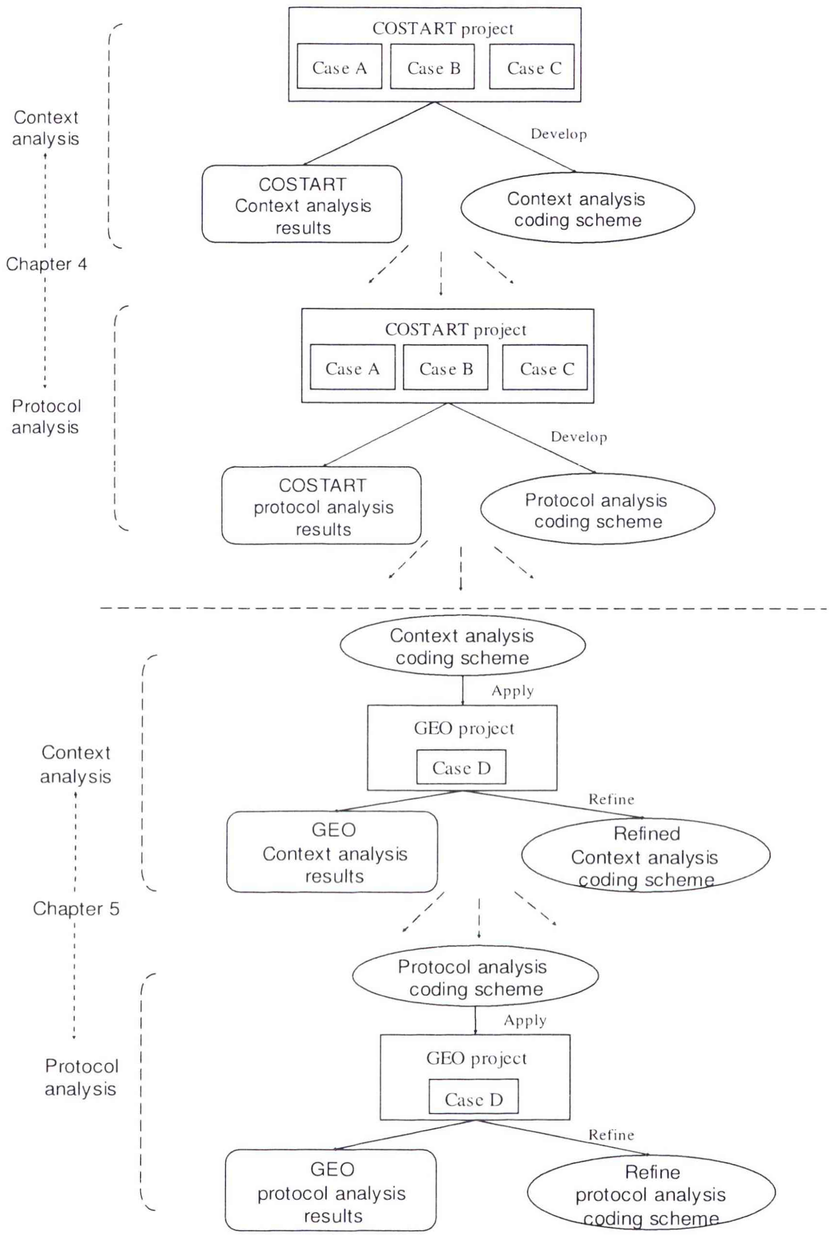


Figure 3.11: Overall research process within the COSTART and the GEO studies

Figure 3.11 shows the overall research process for the COSTART and the GEO studies. It starts with the context analysis study of three COSTART cases, where the context analysis coding scheme was developed and findings were made. Building on the findings from the context analysis approach, a protocol analysis coding scheme was developed and refined through the same cases selected from the COSTART project in the context analysis, where the protocol analysis results were made. Following that, a new study of the GEO project was carried out. The GEO study started with the context analysis approach, where the context analysis coding scheme, developed in the COSTART study, was refined by applying the data collected in the GEO project and the context analysis results within the refined coding scheme were presented. It continued to carry out the protocol analysis study of the GEO project, where the protocol analysis coding scheme developed in the COSTART cases was applied to the GEO data and the refined coding scheme and findings were made.

3.5 Summary

The chapter starts with a review of methodological approaches, where a group of methodologies having been applied in collaboration and creative research were discussed and evaluated (Section 3.1). As the main research concern of this thesis is to understand the collaboration process between artists and technologists during the actual process of developing ideas and implementation of creativity, during the comparisons of the strengths and weaknesses of these methodologies, we considered that the most suitable type of methodology is contextual methodology. The chapter goes on to discuss the methodological weaknesses of some art-technology collaboration studies. One weakness which was identified, is that most studies are based on field notes and interview data, which are likely to give an incomplete picture of the collaboration. The other weakness is that these studies do not provide an in-depth and rigorous analysis with solid empirical evidence, which has been considered by Mayer (1999) as one of the major weaknesses in contextual studies.

Based on the above discussion, in this research, we extend the study methods of art-technology collaboration by conducting a serial of case studies where we collected more continuous observation data using video/audio facilities and analysed the data rigorously with the combination of context and protocol analysis to provide solid empirical evidences. In Section 3.2.1, the rational of the case study method was presented where the criteria for selecting the study cases were provided. Four case studies were carried out in this research, the data of which comes from two sources: the artist-in-residency programme COSTART and the art-technology collaboration project 'GEO Narrative Landscapes'. From the COSTART project, three cases were selected for further in-depth analysis in this research. In order to refine and validate the COSTART results, a similar research design to the COSTART project was applied to a new situation: the GEO art-technology collaboration project. The overall research process within the COSTART and GEO studies were illustrated in Section 3.4.3.

As was reviewed in Section 3.2, both context analysis and protocol analysis methods involve the coding process, where a coding scheme reflecting researchers' interest is developed. In Section 3.4.2, we identified that no existing coding schemes in context analysis or protocol analysis can be appropriated in this research context, thus, the development process of context analysis and protocol analysis coding schemes were illustrated in detailed. In the following chapters, the context analysis and protocol analysis within the COSTART and the GEO cases will be presented with detailed description of the coding schemes and findings.

4 The COSTART Study

In this chapter, the study of three cases, selected from the COSTART project, is presented: first, the background of the COSTART project is presented (Section 4.1.1), in particular, the context of the selected three cases and the description of the data used in each case are given (Section 4.1.2 and Section 4.1.3); second, the context analysis within the three cases is presented, where the analysis process, the context analysis coding scheme and the analysis outcomes are described (Section 4.2); third, the protocol analysis within the same three cases is presented, where the analysis process, the protocol analysis coding scheme are given and the discussion of the analysis outcomes are carried out (Section 4.3).

4.1 Background

4.1.1 Project Background

The COSTART project was an artist-in-residency programme, conducted from 1999-2003. The project was carried out in Creativity and Cognition Research Studios (C&CR studio), Loughborough University, U.K. (Edmonds et al. 2005). The main purpose of the COSTART project was to carry out research into creativity between artists and technologists, bringing experts together in Human Computer Interaction, Creative Media and Digital Art Practice (Candy & Edmonds 2002b). A full account of the COSTART project may be found in Candy and Edmonds (2002b) and Edmonds et al (2005).

Twenty cases of art-technology collaboration were conducted in the COSTART project. In each case, there involved three months pre-residency preparation, five days residency and one month post residency exhibition in Creativity and Cognition conference 2002 (Candy & Edmonds 2002b). There are three different kinds of roles involved in each case: artists, technologists and observers. The main criteria for selecting artists were evidences of artist's interest in collaboration, evidences of prior public exhibition of work, a close match between requirements and resources. Each artist selected in the

COSTART project received individual technical support in selecting and tailoring their computer systems. Technologists were selected from the potential employees of C&CR Studio to match the artists' requirements. A team of three observers, majoring in the field of creative practice, social science or psychology, conducted all monitoring and recording exercises during the residency studies. Three cases were selected for further analysis in this thesis. The criteria for selecting the cases were: the completeness and the quality of the collected data set; the involvement of one artist, one technologist and one observer; the soundness of the proposals and the achievements of the cases. According to the above criteria, three cases from the COSTART project were selected. In the following section, a brief background of each selected case is given.

4.1.2 Case Background

Case A

In Case A, the proposal was to develop a 3D computer model based upon a physical object. The guiding idea from the artist was explained in the artist's original proposal:

> "The project is an example of my current hybrid approach to creating work, combing traditional processes with new technologies, exploring where they connect and differ. The installation involves three distinct sculptural processes of development (both traditional and non-traditional), individually applied to the same conceptual form. My intention was to allow each process to influence the form as it develops, creating three objects which rather than being replicas of one another are shaped by the process of their development."
>
> *Extract of the artist's original proposal*

Based on the above, the residency goal was to present a physical bronze sculpture as 3D holograms by using a software application called 3D Studio Max (Autodesk). In relation to the background information of the participants, the artist had considerable expertise in the use of computer applications, particularly in relation to the design and production of web sites but the artist was not familiar with the 3D Studio Max software. The technologist was a specialist in 3D animation and Virtual Reality but he had very limited knowledge about art practices. The observer was himself an experienced digital art practitioner who had worked in art-technology collaboration projects many times before.

There are two kinds of valuable outcomes in this residency: first, the discoveries about the capabilities of the technology in relation to the production and display of the work; second, a work-in-process model displayed in a virtual reality space. The screen shots of the work in process and final outcome of this residency can be found in Figure 4.1.

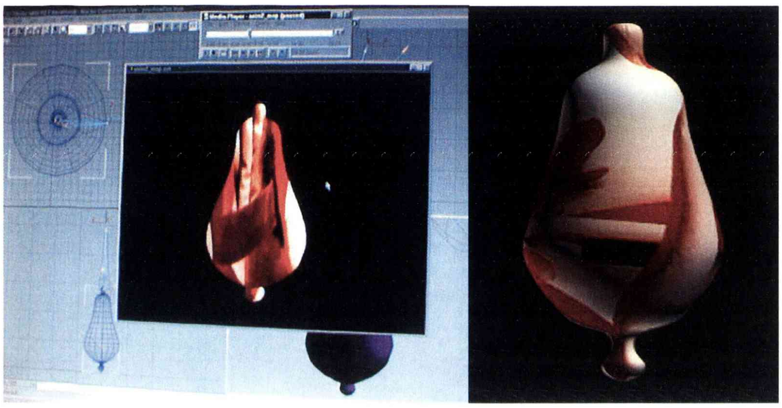


Figure 4.1: Screenshot of the work in progress and the final version (Candy & Edmonds 2002b)

Case B

In Case B, the artist's objective was to create a composition of percussion and orchestral samples which can be executed in real-time by several participants across the Internet. Within this online improvisation environment, several people could see and hear each other's movements as they happened. Here is the artist's inspiration presented in the original proposal:

> "Inspired by the likes of Cornelius Cardew's Scratch Orchestra and the work of Fluxus, I considered the scores and rules for the compositions as works in themselves. A piece created for the Lovebytes 2001 festival embodied these ideas using probability as the sequential score for an analogous film of speech. This work would produce questions, answers, declarations and ambiguities. My

project for COSTART is an extension of these ideas. This piece focuses more on an interactive element with the score as a modular system that can be affected by audience involvement."

Extract of the artist's original proposal

In this case, the artist, who came from a music background, had a great deal of work experience with generative designs for sonic and visual compositions to cope with being indecisive and slightly autistic. In terms of knowledge in the computer science field, he did not have much experience in advanced computing, such as programming and web designing. The technologist in this case was a fully-trained computer technologist and had also worked as a designer for years. The observer was an experienced field researcher, who had done many studies in creative art and design research.

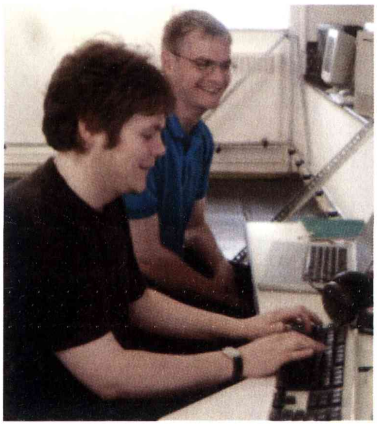


Figure 4.2: Work in Progress (Candy & Edmonds 2002a)

In this case, the original concept was to use the Max/MSP software (Cycling74) or C/C+ language. After a few days of collaboration, they both ended up with a clear idea of what the artist wanted. The detailed description can be found as follows:

"the web page is constructed using a combination of Macromedia Director and the Koan music generation system using Java script to connect the two. The source of the sound is created using Koan and then embedded into the web page with changeable parameters. When a graphic is moved, a Java script message is sent to the Koan code altering the sound parameters. All this information is sent to a multi-user server which updates and returns the changed information to other users." *Extract of the artist's interview transcription*

Differing from the first case, the main outcome of this residency is a clear design of the work. Although the work was not completed by the end of the residency, both the artist and the technologist agreed that they had many interesting discussions and in particular, the artist gained many valuable alternative views on technical and conceptual elements in the work. Working with the technologist, the artist's ideas began to take shape as they discussed design methods where several design methods were evaluated.

Case C

In Case C, the project was concerned with the development of a drawing machine which could be used in performance to create a visual image. The artist's inspiration was explained in the proposal:

> "An increasing interest in drawing and performance led me to the idea of a drawing machine. There seem to be a lot of things of that name around most of which make drawings often where a computer or mechanical device creates the drawing with little input from the user. Rather than a device that created drawings, I was thinking more of an instrument that allowed creativity and skill allowing for scripted and improvised work".

Extract of the artist's interview transcription

The following figure shows one of the animations which the artist wanted to realize in the drawing system.

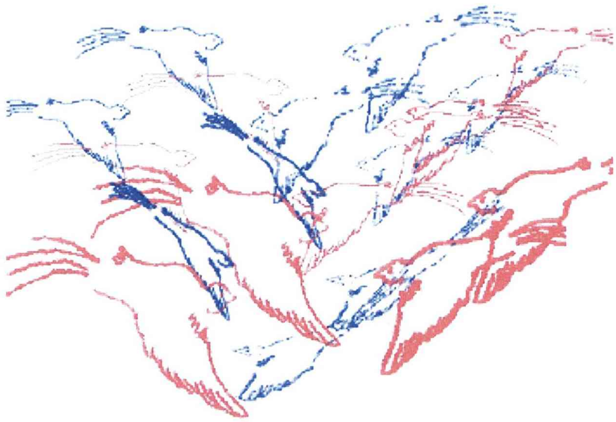


Figure 4.3: Snapshot of the drawing performance (Candy & Edmonds 2002a)

In relation to the background information of the participants, the artist was an experienced digital art practitioner and he also had a great deal of experience in art-technology collaboration. The technologist came from computing science background and was familiar with many software applications. But he did not have much practical experience in some specific software programs, such as Max/MSP (Cycling74) and Director (Adobe). The observer was himself an experienced technologist who had worked in the software engineering field for many years.

The outcome of this residency was the exploration of the technological possibilities. Initially it was thought that the input would be made through keyboard which unveiled layers of a drawing as it interacted with the program. During the assessments of various methods for sensing movement, at the end of the residency, they concluded that in order to meet the artist's particular requirements for portability and flexibility, it would be necessary to create their own system in the future. The artist described the features of the ideal drawing machine in the interview at the end of the residency:

> "What I wanted to do was that when it [the system] was drawing in the air and you'd get a flat drawing on the screen of whatever, if you wanted to draw a head and if you wanted to draw an arm you can do it, which of course if you draw with the light stick it's gone before you've got there, and it would stay, you'd have this music in the background, or having another person erasing the drawing

you was making and putting other things in."

Exact of the artist's interview transcription

4.1.3 Data Description

Four types of data were mainly collected in each case in the COSTART project: the recorded conversation between participants during the five days residency, the residency diaries from participants, the field notes taken by observers and the interview records from participants. In this research, the principle type of data used in each case was a selection of conversation sound tracks between artists and technologists during the five days residency. Other data such as field notes, residency diaries and interviews were also included to provide a picture of the collaboration as detailed as possible. The descriptions of the selected conversation records used in each case, such as time, location and content of each data, can be found in Table 4.1.

Table 4.1: Selected conversation records in three cases

<table>
<tr><th colspan="7">Case A</th></tr>
<tr><td></td><td colspan="3">Day 1</td><td colspan="2">Day 3</td><td>Day 5</td></tr>
<tr><td>Time</td><td>10:00-10:30</td><td>11.55-12.15</td><td>15.05-16.30</td><td>11:45-12:19</td><td>16:45-17:25</td><td>10:50-11:05</td></tr>
<tr><td>Location</td><td>T_1 office</td><td>C&CR studio</td><td>C&CR Studio</td><td>C&CR studio</td><td>C&CR studio</td><td>C&CR studio</td></tr>
<tr><td>Content</td><td>Initial meeting</td><td>Working with model</td><td>Lighting</td><td>Making new models</td><td>Morphing plus</td><td>Exploring animation</td></tr>
<tr><th colspan="7">Case B</th></tr>
<tr><td></td><td colspan="3">Day 1</td><td>Day 2</td><td colspan="2">Day 3</td></tr>
<tr><td>Time</td><td>10:00-10:40</td><td colspan="2">11.55-12.15</td><td>15.45- 16.20</td><td colspan="2">16:45-17:25</td></tr>
<tr><td>Location</td><td>T_2 office</td><td colspan="2">Coffee Room</td><td>O_2's office</td><td colspan="2">Sensor Lab</td></tr>
<tr><td>Content</td><td>Initial planning meeting</td><td colspan="2">Overview Technical Options</td><td>Review</td><td colspan="2">Major Turning point</td></tr>
<tr><th colspan="7">Case C</th></tr>
<tr><td></td><td colspan="3">Day 1</td><td>Day 2</td><td colspan="2">Day 3</td></tr>
<tr><td>Time</td><td>13:30-13:55</td><td colspan="2">11:30-12:00</td><td>11:00-11:30</td><td>10.00-10:20</td><td>2:00-2:30</td></tr>
<tr><td>Location</td><td>C&CR studio</td><td colspan="2">Design studio</td><td>Design Studio</td><td>Design Studio</td><td>Design Studio</td></tr>
<tr><td>Content</td><td>Technical review</td><td colspan="2">Programming testing</td><td>Discussion (CODA)</td><td>Work on MAX/MSP</td><td>Work on Director</td></tr>
</table>

In Table 4.1, T_1 stands for the technologist in Case A, T_2 stands for the technologist in Case B and O_2 stands for the observer in Case B. The 'CODA' mentioned in Table 4.1, is a system, made by Charnwood Dynamics for analysing the body movements in physiotherapy by recording human movement (Dynamics, 2001). As shown in Table 4.1, the selected conversation records in each case present the sequences of the conversation between artists and technologists that took place over three days. Furthermore, Table 4.1 shows that the collaboration location varied from the participants' offices to studios where a purpose for interactive art research is installed. As discussed in Section 3.2.2, the data analysis method employed in this research is a combination of context analysis and protocol analysis. In the rest of this chapter, the context analysis study of these three COSTART cases (Section 4.2) and the protocol analysis study of the same cases (Section 4.3) will be presented.

4.2 Context Analysis

In the context analysis of the COSTART cases, a heterogeneous type of data set was used in each case, including the conversation records between artists and technologists, interviews, field notes and residency diaries (The detailed description can be found in section 4.1.3). In this section, the context analysis process for these data will be illustrated at first, following that, the context analysis coding scheme will be described and the outcomes of the analysis will be provided.

4.2.1 Analysis Process

As presented in Section 3.3, two types of themes emerged from the data during the context analysis process assisted by Nvivo: descriptive theme, represented as nodes and interpretive theme, represented as node sets. The following figure shows the context analysis process in each case, which was summarized into two stages: coding and generating themes.

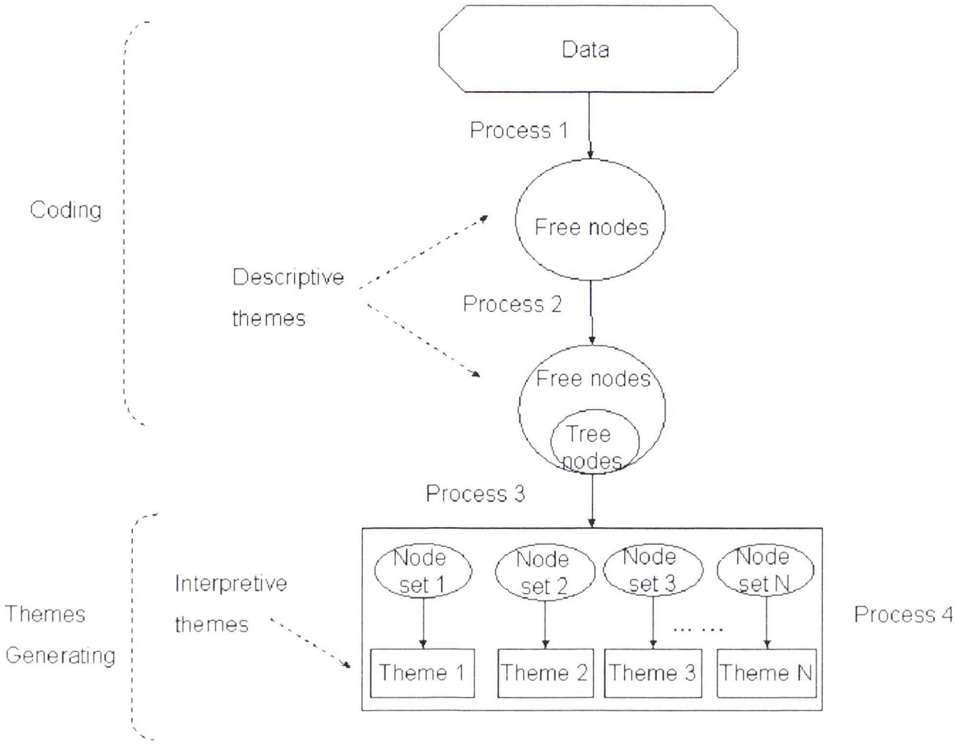


Figure 4.4: Flowchart of the context analysis assisted by Nvivo in each case

In Figure 4.4, during *Process 1*, the data is input into Nvivo and coded by free nodes, which have not been classified in a tree structure. During *Process 2*, free nodes are categorized and refined into tree nodes, which are in a hierarchical structure (more detailed definition about free nodes and tree nodes can be found in Section 3.3). During *Process 3*, some of the free nodes and tree nodes are regrouped further into node sets, where nodes are related to each other to formulate interpretive themes. This process also formulated a coding scheme, which was named the context analysis coding scheme in this study. The detailed description about this coding scheme will be provided in Section 4.2.2. During *Process 4*, themes are generated through node sets, where coded data of nodes in each node set are further analyzed within each node set. In each node set, the data categorized into different nodes in the previous steps is revisited and re-analysed within each node set group. The themes found in the three COSTART cases will be presented in Section 4.2.3.

4.2.2 Context Analysis Coding Scheme

As was discussed in the previous section, two kinds of nodes were formulated during the analysis process: free nodes and tree nodes. As most of the free nodes were developed into a hierarchical tree structure in the *Process 2*, which was illustrated in Figure 4.4 of Section 4.2.1, the context analysis coding scheme presented in this section is mainly related to the tree nodes. The following figure shows the top three levels in the hierarchy of the context analysis coding scheme, which consists of three master nodes: *Context*, *Communication* and *Behaviour*.

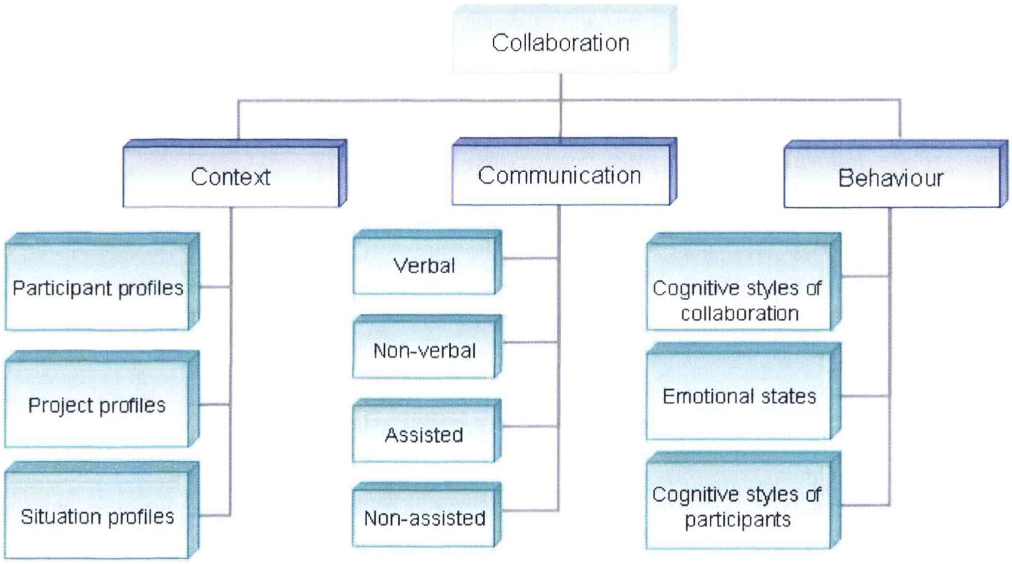


Figure 4.5: Top three levels of the context analysis coding scheme

The master nodes, *Context*, *Communication* and *Behaviour* (Figure 4.5), represent three different perspectives in categorizing the data. For example, the master node *Context* is for analysing the context in each case, such as the profiles of the participants and the profiles of the projects. The master node *Communication* is for analysing the recorded conversation between participants during the collaboration, such as the talking conflicts occurring during the collaboration and the level of language shared between participants. The master node *Behaviour* is for analysing the collaborative styles of participants and the styles of the collaboration, such as the goal driven style of the collaboration and the exploratory style of the collaboration. In the rest of the section, each master node will be discussed in great details.

Context Master Node

In terms of the *Context* master node, according to the types of context information, it is summarized into three categories: *Participant Profiles*, *Project Profiles* and *Situation Profiles* (Figure 4.5). The *Participant Profiles* category contains each participant's expertise background. The *Project Profiles* category contains information of project proposals and outcomes. The *Situation Profiles* category records information about how technical environments are set up for participants, where physical working environments are and so on. More detail can be followed in Table 4.2 below (the examples of each node can be found in Appendix A2.1).

Table 4.2: Nodes in the *Context* master node

Category	Node	Description
Participant Profiles	Background-T	Technologists' collaboration experience, education background and background of expertise and particular skills related to the project
	Background-A	Artists' collaboration experience, education background and background of expertise and particular skills related to the project
Project Profiles	Proposal	Artists' proposals
	Outcomes	Outcome descriptions (including pictures or video shots of artefacts and word documents)
Situation Profiles	Physical-environment	The residency's physical location
	Technical-environment	The types of software and hardware they used in the residency
	Collaboration-history	Whether they collaborated with each other before

Communication Master Node

In the *Communication* master node, the nodes are summarized into two pairs: *Verbal* and *Non-verbal*, *Assisted* and *Non-assisted* (Figure 4.5). In the first pair, the *Verbal* category records some verbal communication components, such as the *Interruption* node, the *Talking-conflicts* node, the *Common-language* node. The *Non-verbal* category records the *Silent* node and the *Laugh* node. The *Assisted* category and the *Non-assisted* category are used to classify whether the communication between participants is assisted by the computers and their tools. For example, the *Computer-assisted* node under the *Assisted* category records the conversation conducted while artists/technologists are operating the computers and their tools, whilst the *Non-computer-assisted* node under the *Non-assisted* category records the conversation conducted without the mediation of computers. More detail can be followed in Table 4.3 below (the examples of each node can be found in Appendix A2.1).

Table 4.3: Nodes in the *Communication* master node

Category	Node	Description
Verbal	Talking-conflicts	Includes misunderstanding, clarification, disagreement etc.
	Interruption	Interruption during the conversation
	Common-language	The language, as demonstrated by terminology used, was shared or restricted to one or other individual
Non-verbal	Silent	Break between the conversation
	Laugh	Laugh during the conversation
Assisted	Computer-assisted	Conversation when participants use computers and their tools as media, such as talked in front of computer
Non-assisted	Non-computer-assisted	Communication without any mediation of computers, such as talking with each other without a presence of a computer

Behaviour Master Node

In the *Behaviour* master node, the nodes are summarized into three categories: *Cognitive Styles of Collaboration*, *Cognitive Style of Participants* and *Emotional States* (Figure 4.5). The *Cognitive Style of Collaboration* category contains a group of nodes classifying the collaborative features. For example, evidence about the style of exploratory collaboration are recorded in the *Exploratory* node or if participants talk about specific goals, the conversation will be coded in the *Goal-Driven* node. Under the *Cognitive Styles of Participants* category, there is a group of nodes that categorize participants' cognitive style. For example, evidence about the learning process in the collaboration are recorded in the *Learning* node. The last category *Emotional States* in the *Behaviour* master node is used to record participants' evaluation of the collaboration and emotional feelings. More details can be followed in Table 4.4 below (the examples of each node can be found in Appendix A2.1).

Table 4.4: Nodes in the *Behaviour* master node

Category	Node	Description
Cognitive Styles of Collaboration	Leadership	Whether artists or technologists dominated the collaboration or they have an equal role
	Goal-driven	Collaboration process involved with specific goals
	Exploratory	Collaboration process involved with non-specific goals
Cognitive Styles of Participants	Learning	Learning process was described
	Flexibility	Artists show strong interests in the technical parts of the project or technologists show strong interests in the artistic aspects of the project.
Emotional States	Evaluation	Participants' comments about collaboration process or outcomes.
	Expression of Emotion	The expressed emotion could be positive (e.g. happy, satisfied), or could be negative (e.g. frustration, worry, fear).

4.2.3 Results

The analysis process, as described before (Section 4.2.1), can be summarized in three steps: the first step is to identify descriptive themes from the data and input these themes into Nvivo as nodes; the second step is to refine the nodes and group them into a hierarchy structure such as a coding scheme, which was presented in Section 4.2.2; the last step in the data analysis is to formulate node sets, where a group of nodes from different tree master nodes are bound together to reveal some interesting insights into the data. With the coded information each node contains from these three cases and the correlative comparison between nodes, some findings have emerged in each node set.

In this section, three node sets identified in the COSTART cases are presented: 'sharing', 'mediation' and 'collaboration styles'. The first node set 'sharing' explores aspects of the relationship between interests, common language and background of artists and technologists in Case A, Case B and Case C. The second set 'mediation' explores aspects of participants' communication assisted by computers and their tools. The third node set explores the differences between the goal-driven type of collaboration and the exploratory type of collaboration.

4.2.3.1 Sharing

The first node set contains four nodes selected across the three master nodes of the context analysis coding scheme. The nodes selected from the *Context* master node are *Background-A* and *Background-T*. The node selected from the *Communication* master node is *Common-language*. The node selected from the *Behaviour* master node is *Flexibility*.

Table 4.5: Node set 'sharing'

Master node	Category	Node
Context	Participant Profiles	Background-A
		Background-T
Communication	Verbal	Common-language
Behaviour	Cognitive Styles of Participants	Flexibility

Three steps in the analysis process were carried out in this node set: first, summarize the data coded by each node presented in Table 4.5; second, according to the summaries drawn in the first step, analyse the coded data in detail to get a deeper understanding of the data; third, identify findings based on the summaries from the first step and the specific analysis from the second step. In the rest of this section, the discussion of the shared background between participants, features of common language and flexibility in Case A, B and C will be provided.

Shared Background

The 'background', considered as shared or unshared in this research, includes the participants' major knowledge domain, participants' related collaboration experiences and their expertise (Table 4.2). The summaries of the data coded in the nodes *Background-A* and *Background-T* in Case A, B and C are as follows.

In Case A, the artist A_1 had considerable expertise in the use of computer technology, particularly in relation to the design and production of web sites. The technologist T_1 had advanced expertise in the computing science field but limited knowledge about digital art. In relation to the specific knowledge about the software application used in this residency (3D Studio Max), A_1 had no knowledge about this 3D software and T_1 was had advanced experiences in this software. In Case B, the artist A_2 came from music background and also had some reasonable knowledge about computers and the technologist T_2 was a fully-trained computer technologist and had also worked as a designer for years. In terms of the specific knowledge about the software applications mainly used in this residency (Director and Koan), T_2 had some knowledge about them and A_2 had no knowledge about them. In Case C, the artist A_3 was a digital artist who was experienced in the interactive art field and had advanced computing skills, such as programming, whilst the technologist T_3 came from computer science and design background. In relation to the specific knowledge about the software mainly used in the residency (Max/MSP and Director), T_3 did not have much practical experience about them and A_3 had very limited knowledge about them.

The summaries of participants' background and expertise in each case presented as above show that participants in the three cases had different levels of shared common background between each other. In Case A, A_1 and T_1 shared limited common background. Compared with Case A, A_2 and T_2 in Case B had more shared common background. In Case C, the artist A_3 had reasonable amount of experience in advance computing, such as programming, and the technologist had experience in creative activities such as design. Thus, participants in Case C had more shared background than participants in Case A and B.

Flexibility

The 'flexibility', in this research, as described in Table 4.4, refers to the circumstances where artists show strong interests in technical parts or technologists show strong interests in aesthetic consideration. From the coded data in the *Flexibility* node under the *Behaviour* master node, we found that the participants in Case A showed less interests to each other's field compared with Case B and C. A few transcription segments, extracted from the cases, are presented below. To some extent, these examples reflect the level of shared interests between participants.

In Case A, it was found that A_1 showed some strong interest in technical issues, but T_1 did not show that much interest in aesthetic issues. Here is an example which shows that the artist had shown strong intention to know the technical aspects of the project:

> A_1: I'd like to do some of the modelling because I'd like to get some advice as well about how to...I'd like to learn about 3D modelling. I'd like to get some advice about how to approach these sorts of shapes.
>
> T_1: OK, so what I'll do is I'll just draw a few things.
>
> *10:05-10:25, Day 1, Case A*

Compared with the strong interest that artist A_1 showed towards the technical issues of the project, the technologist T_1 did not show much interest in the aesthetic issues of the project. When the process came to the aesthetic issues, such as what kind of light effects was required by A_1, T_1 usually accepted A_1's ideas and tried implementing the ideas in the software as best as he could understand them. In comparison, in Case B and C, the participants showed equally strong interests in each other's domain, where a great deal of discussion was made on some shared topics, such as technical requirements and features of artefacts. During these discussions, the role of artists and technologists sometimes became less distinguished. For instance, in Case B, A_2 was very interested in the technical issues, such as what kind of music upload protocol was used, and T_2 was interested in the aesthetic issues, such as the specific requests about music editing. In Case C, it was found that the technologist T_3 and the artist A_3 also had strong interests in each other's expertise. In particular, A_3 was not only curious about the technological issues, but also he did participate in the realization of technical parts. For instance, as he said in the final review session in Day 5,

"... although I look at various people and I think they're so lucky... and I think I'd love to be able to do that and then ask them technical things and they don't know anything about it ... and I think that's bad, I think you're tempted to think that would be good but it's bad because you can't realize these things yourself and you don't have an understanding of what could be done. I don't think an artist needs to be able to do absolutely everything because somebody else can learn everything and somebody else can do something else you know, but I just think you've got to have a greater understanding than that... "

2:00-2:15, Day 5, Case C

Thus, the above discussion about the coded data of the *Flexibility* node in three COSTART cases shows that participants in Case B and C showed more interest in each other's domain than the participants in Case A did.

Common Language

The 'Common language', in this research is defined as the terms and phrases which were shared by at least one participant. According to the analysis under the *Common-language* node in Case A, B and C, the language between the participants in Case A is more distinct than in Case B and C. Explanations as to why are provided below, with examples extracted from the data.

Here are two examples from Case A, which demonstrate the differentiated talking styles between the artist and the technologist.

T_1: So in the beginning she drops the ink and then starts dissolving.

A_1: It works really well, almost like a layer...seaweed...

11:55-12:15, Day 1, Case A

T_1: Because I remember when you said you touched it rippled.

A_1: yeah, but if you touched it, it wouldn't be so much of a ripple it would be more of a - if you put your finger into a balloon it would be more of an indent really. *3:05:-3:30, Day 1, Case A*

The context of the first example is that they were discussing a colour effect in the physical object. The context of the second example is that they were talking about a ripple effect in the 3D model that they were developing. In these two examples, the artist used very descriptive terms to explain what kind of effects she wanted to make in the 3D model; by contrast, the technologist used simple terms to present similar content. These differentiated terms indicate that there exists a limited level of shared language between the artist and the technologist. As discussed previously in this section, the artist and the technologist did not show much interest in each other's domain, thus, we may summarize that in Case A, there was not much shared language demonstrated between the participants and, at the same time, the participants did not show much interest in each other's domain.

In comparison, in Case B and C, the artist and the technologist had a reasonable level of common language. Here are two examples of the common language between participants in Case B and C:

A_2: ...it is stream down. What I am thinking was, if you have a computer and run on the Macintosh, receive the information, and then, it seems like a right way to do it, but you can send the sound files back to the computer with producer.

T_2: right, then the real producer will send it, because we've got a quick server, I suppose that we could find out it would work with that.

A_2: Hum, yes. *10:00-10:20, Day 1, Case B*

T_3: it might be easier to draw all these in Max and record that if you want to.

A_3: and do that in Director or Flash.

T_3: and then we could do the sound thing.

A_3: yeah, we can do that. Or that will be so easy. I could just stay...

11:00-11:30, Day 3, Case C

The context of the first example is that they were talking about the way to send sound streams from one computer to another. The context of the second example is that they were talking about what kinds of software can be used and in what order to act in. Compared with the two previous examples from Case A, these two examples indicate that the artists and the technologists in Case B and C used more shared terminologies and exhibited more shared understanding within the context. As discussed previously in this section, the participants in these two cases also exhibit a high level of interest in each other's work. Therefore, from the comparative results in the node set 'common language' within three case studies, a link can be drawn between the level of shared background, the level of shared language and the level of shared interests between artists and technologists (Figure 4.6). From this figure, we may suggest that the more common background participants shared with each other, the more interest they showed in each other's domain and the more shared language they used during the collaboration.

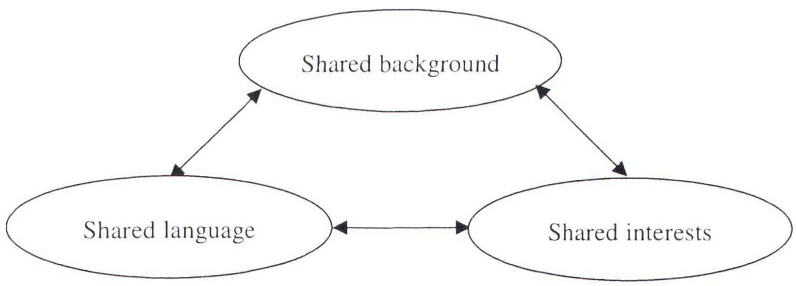


Figure 4.6: Relationship between shared background, shared language and shared interests

However, from the analysis of Case A, B and C, the lack of shared language did not necessarily cause the projects to fail. In Case A, participants achieved a successful outcome, which was exhibited after the residency but Case B failed to have an outcome for exhibition. Although participants in Case C had a similar level of shared language as in Case B, they reached a similar level of achievements as in Case A. Thus, how did participants in Case A overcome a lack of common language to achieve a reasonable outcome? One possible explanation is that in Case A the degree of talking conflicts decreased when computers and their software applications were involved during the collaboration. More details about this finding can be seen in the discussion of the next node set 'mediation', which was derived from another group of nodes.

4.2.3.2 Mediation

The second node set 'Mediation', contains six nodes of the context analysis coding scheme: five nodes come from the *Communication* master node and one node comes from the *Behaviour* master node. The five nodes from the *Communication* master node are *Talking-conflicts*, *Interruption*, *Common-language*, *Computer-assisted* and *Non-computer-assisted*. The single node coming from the *Behaviour* master node is *Evaluation* (Table 4.6).

Table 4.6: Node set 'Mediation'

Master node	Category	Node
Communication	Verbal	Talking-conflicts
		Interruption
		Common-language
	Assisted	Computer-assisted
	Non-assisted	Non-computer-assisted
Behaviour	Emotional States	Evaluation

The analysis process in this node set is: first, the general circumstances are described with specific examples related to when and why artists and technologists communicated with each other with computers; second, a quantitative result is presented, which shows the differences between the communication assisted with computers and without.

Computer-assisted

According to the coded data of *Computer-assisted* node within each case, it was found that in comparison between cases, the motivation/intention for participants to communicate with each other by using computers and their software applications was quite different in each case. In Case A, it was observed that when the artist A_1 and the technologist T_1 had computer-assisted communication, they were mainly working on a 3D model in the environment of the 3D Max Studio software application and they mainly discussed specific features of models, such as light effect, animation or colour. Here is an example, where they were talking about a light effect in the model:

> T_1: You want this to be brighter now?
>
> A_1: You see there at the moment the second object is sitting like that, if that could be like there…So not that it's getting wider but it's getting narrower rather than…there. Because there's already one big one isn't there.
>
> T_1: When you say narrower
>
> A_1: More of a spotlight. *15:55-16:30, Day1, Case A*

In this example of computer-assisted communication, we can see that T_1 asked A_1 about what kinds of lights A_1 needed by referring to some specific components from the computer screen. This shows that the use of computers in communication may improve the level of understanding between participants, which can be one of the reasons that Case A succeeded, even when they did not build up much shared language as was discussed in the previous section.

Compared with Case A, A_2 and T_2 in Case B had slightly different intentions. T_2 used the computers to make demonstrations to A_2 to explain what the software could and could not do for the project. Here is a segment of computer-assisted communication selected in Case B, where the technologist was showing a demonstration using the software Director to the artist:

> T_2: So, this is Director.... It seems like if you like some songs, then you play some samples.
>
> A_2: err.... yeah. It is like MP3 player.
>
> T_2: so you could log in... you are looking at whole of other people doing stuff. And first of all, it downloads of a lot of samples. *10:00-10:20, Day 1, Case B*

From this example, we can see that A_2 and T_2 talked more generally in computer assisted communication than participants in Case A. One of the reasons to explain this might be that they had not yet defined a very specific goal in the project.

In Case C, the technologist used computers to demonstrate what, in terms of the requirements from the artist, could be achieved by using a particular software application. Compared with Case B, the participants in Case C had a very similar intention to conduct computer-assisted communication as in Case B. However, it was observed that, in Case C, the level of discussion between participants during computer-assisted communication was deeper than for Case B. For instance, the following transcription segment shows that the technologist in Case C was trying to show the artist how the Max/MSP software application could make pointer movements less erratic while drawing in the air:

> T_3: so you can see what it is doing, it's doing something.
>
> A_3: when you print it, it kinds of slow it down.
>
> T_3: which I should switch that off and print it then.
>
> A_3: yeah. I would do. Is this normal like this? ... there is the object right; you've got the object but not that file.
>
> T_3: right.
>
> A_3: and what we want to do is, you want to get the last ten numbers, is that right?
>
> T_3: yeah. *11:00-11:30, Day 3, Case C*

From this example, we can see that Case C shared a similar feature in computer-assisted communication as Case B, which is that they referred to the detailed components of the computers or their software during the communication in order to understand each other better. One of the reasons that A_3 could demonstrate the software to T_3 in a more detailed level than in Case B may be that A_3 came with a more detailed proposal and more specific artistic requirements than A_2 in Case B.

In summary, from the above three examples of each case, we may indicate that the circumstances of using a computer as a mediation tool in the communication was different between the three cases. In Case A, they were using computers as a tool to achieve the goals of the project. In Case B, they were using computers as a tool to demonstrate the potential possibilities of current computer technologies. In Case C, they were using computers as a tool to assess different software applications based on the artist's requirements.

Talking Conflicts and Interruption

In order to further investigate the differences between computer-assisted communication and non-computer-assisted communication, in each case three similar-length data segments of coded data were selected from the *Computer-assisted* node and the *Non-computer-assisted* node. The following table shows the statistical comparisons between the three cases across the *Talking-conflicts* node and the *Interruption* node.

Table 4.7: Comparisons across nodes in node set 'mediation'

Case A			Total number of interruption	A Interrupted T	T interrupted A	Talking conflicts
	CA	S_{C1}	19	6	13	8
		S_{C2}	4	2	2	2
		S_{C3}	12	3	9	1
	NCA	S_{N1}	9	7	2	0
		S_{N2}	4	3	3	1
		S_{N3}	2	2	1	0
		Total	50	23	27	12
Case B	CA	S_{C1}	6	5	4	0
		S_{C2}	4	5	3	1
		S_{C3}	5	3	3	0
	NCA	S_{N1}	19	3	16	1
		S_{N2}	25	6	19	0
		S_{N3}	6	0	6	1
		Total	59	22	37	5
Case C	CA	S_{C1}	7	4	3	2
		S_{C2}	9	2	7	0
		S_{C3}	4	1	3	1
	NCA	S_{N1}	12	3	9	2
		S_{N2}	13	8	5	2
		S_{N3}	9	4	5	1
		Total	52	22	31	8

In the above table, CA stands for Computer-Assisted and NCA stands for Non-Computer-Assisted. S_{C1}, S_{C2}, and S_{C3} stand for three selected data segments which were coded by the *Computer-assisted* node. S_{N1}, S_{N2} and S_{N3} stand for three selected data segments which were coded by the *Non-computer-assisted* node. The numbers in the rows of '*Total Interruption*', '*A interrupted T*', '*T interrupted A*' and '*Talking-conflicts*' represent the occurrence of certain activities, such as interruption and conflicts of talking, during the computer-assisted communication segment or non-computer-assisted communication segment. Table 4.7 shows that in Case A and C, during the computer-assisted communication, the frequency of interruption and talking conflicts was lower than in non-computer-assisted communication. In Case B, although there were no significant differences between CA and NCA, we can still see that the presence of computers decreased the level of talking conflicts (Table 4.7). Thus, the results showed in Table 4.7 may infer that computers improved the level of communication between participants by decreasing the frequency of interruption and talking conflicts. In other words, artists and technologists were talking more smoothly with computers as a mediation tool than without.

In conclusion, the results of the second node set analysis shows that in Case A, B and C, talking conflicts occurred less often in computer-assisted-communication than in non-computer-assisted communication. As was discussed in the first node set (Section 4.2.3.1), the language is less shared in Case A than in Case B and C but Case A was more productive than Case B and C, which may infer that a lack of shared language did not necessarily mean that there was a corresponding lack of success in the projects. From the discussion of this node set, especially evidence shown in Table 4.7, we can see that in Case A, B and C, the involvement of computers during the communication decreased the level of miscommunication and improved the smoothness of conversation between participants. According to this finding, a suggestion can be made that one of the ways which may be used to overcome a lack of common language between artists and technologists is to use computers as a mediating tool during the communication.

4.2.3.3 Collaboration Style

The third node set 'collaboration style', contains seven nodes across three master nodes of the context analysis coding scheme. The nodes selected from *Communication* master node are *Talking-conflicts*, *Interruption* and *Common-language*; the node selected from *Context* master node is the *Outcomes* node. The nodes selected from *Behaviour* master node are *Evaluation*, *Exploratory* and *Goal-driven* (Table 4.8).

Table 4.8: Node set "collaboration style"

Master node	Category	Node
Communication	Verbal	Talking-conflicts
		Interruption
		Common-language
Context	Project Profiles	Outcomes
Behaviour	Emotional States	Evaluation
	Cognitive Styles of Collaboration	Exploratory
		Goal-driven

According to the coded data from *Cognitive Styles of Collaboration* within each case, it was found that the collaboration style is different in three cases: Case A is goal-driven, in terms of Case B and C, the collaboration style is exploratory. The differences between these two styles of collaboration are identified and discussed as follows.

The first difference between the exploratory type of collaboration and the goal-driven type of collaboration is that the levels of shared language and talking conflicts are different. As was mentioned in the first node set (Section 4.2.3.1), in Case A, the language is relatively distinctive between the artist A_1 and the technologist T_1; in Case B and C, the language is relatively shared between artists and technologists. Furthermore, from the coded data of the *Talking-conflicts* node and the *Interruption* node, it was found that the talking conflicts occurred more often in Case A, less often in Case C and the least often in Case B (Table 4.7 in Section 4.2.3.2).

The second difference between the exploratory type of collaboration and the goal driven type of collaboration is related to the collaboration outcomes and the evaluation results from participants. From the coded data of the *Outcomes* node, it was found that the outcome of Case A was a working model of a physical object, made in 3D Studio Max, while the main outcomes of Case B and Case C were refined artistic proposals that the artists were able to take away. From the coded data of the *Evaluation* node, it was found that participants in Case A were more satisfied with what was achieved during the residency than those participants in Case B and C. From the interviews and diaries of Case B and Case C, it was found that although participants expressed the opinion that they had learnt a great deal in the residency, they often showed some negative emotions. For example, in Case B, it was discovered during the residency that the artist's original proposed model had been achieved somehow by other researchers. This significant turning point made the artist and the technologist feel overwhelmed and frustrated, as the artist said "I feel devastated" (Day 3, 16:35, Case B). Furthermore, the artist in Case C, for example, expressed his frustration on getting not enough technical support from the technologist because T_3 did not have much advance knowledge about Max/MSP as the project required. He said "I felt nothing has been achieved... we just went on in a circle over and over again" (Day 3, 11:10, Case C).

In summary, the above discussion of this node set shows some distinctive features between the exploratory style of collaboration and the goal-driven style of collaboration:

- Within an exploratory style of collaboration, the language is more likely to be shared and communication conflicts do not happen very often. However, from the physical achievement perspective, the collaboration is relatively less productive, which can cause some negative evaluation from participants, such as lack of satisfaction and frustration.
- Within a goal driven style of collaboration, the language is more likely to be differentiated and communication conflicts are more likely to happen. Moreover, participants are more likely to be productive and participants' evaluation is relatively positive.

4.3 Protocol Analysis

In this section, the protocol analysis study of Case A, B and C in the COSTART project is presented. As one of the findings in the context analysis study revealed that the mediation by computers and their applications may help artists and technologists overcome the difficulties of a shared language (Section 4.2.3.2), one of the aims of protocol analysis is to further investigate the features of communication between artists and technologists, in particular, how computers and other mediation tools can affect participants' communication. This section starts with the protocol analysis process, and following that, the development process of the protocol analysis coding scheme is illustrated, where the description of the protocol analysis coding scheme is made. In Section 4.3.3, the results of the protocol analysis study are provided.

4.3.1 Analysis Process

In the context analysis, heterogeneous data sets were included in order to provide as detailed a picture of art-technology collaboration as possible (Section 4.2.1). In comparison, in protocol analysis, only one type of data was used in each case: the recorded conversation data between participants. The format of the recorded conversation data used in the protocol analysis is also different from the previous context analysis: the format used in the context analysis is transcription only and the format used in the protocol analysis is a combination of transcription and audio/video data. The protocol analysis process is summarized into three stages (More detailed description of protocol analysis process may be found in Chapter 3):

- Stage 1: a coding scheme was developed;
- Stage 2: the coding scheme was applied to the data in each case and was refined during the process;
- Stage 3: the results were presented.

In the following sections, how the initial protocol analysis coding scheme was developed and refined within three cases will be presented and description of the refined protocol analysis coding scheme will be introduced.

4.3.2 Protocol Analysis Coding Scheme

As described in Section 3.3, the behaviour analysis software INTERACT was used for video/audio analysis in the protocol analysis study. The use of INTERACT software had an effect on the shape of the coding scheme because it limits the node hierarchy to a maximum of two levels. This constraint discourages researchers from creating a third tier for any node structure, which can possibly lead to the creation of more first level nodes (Bilda, Costello & Amitani 2006). For this research, the coding scheme developed for the protocol analysis studies was not developed as a hierarchical structure in contrast to the one developed in the context analysis study described previously in Section 4.2.2.

The protocol analysis coding scheme was developed from two sources: related coding schemes developed by other researchers and the context analysis coding scheme developed previously. As described in Section 4.2.2, the context analysis coding scheme consists of three master nodes: *Context, Communication* and *Behaviour*, which represent three different categories of data collected in Case A, B and C (More detail about this coding scheme can be found in Section 4.2.2). In the development of the protocol analysis coding scheme, two nodes were selected from the *Communication* master node of the context analysis coding scheme: the *Assisted* node and the *Non-assisted* node. These two nodes were used to categorize whether the conversation between participants were assisted by external mediation tools, such as computer, paper, and whiteboard (Section 4.2.2). In addition, in order to analyze communication behaviour in the creative process, coding schemes developed by other researchers in related research contexts also provided useful categories. These coding schemes include Olson's activity categories (Olson et al. 1992) (Olson et al. 1996) and Herbsleb's and Robillard's coding schemes (Herbsleb et al. 1995) (Robillard et al. 1998) (More details can be found in Section 3.2.2.2).

After the initial protocol analysis coding scheme was developed, it was applied to the data in the sequence Case A, Case B and then Case C. During the application process, the initial protocol analysis coding scheme was further refined. The development process of the coding scheme is illustrated in the following figure.

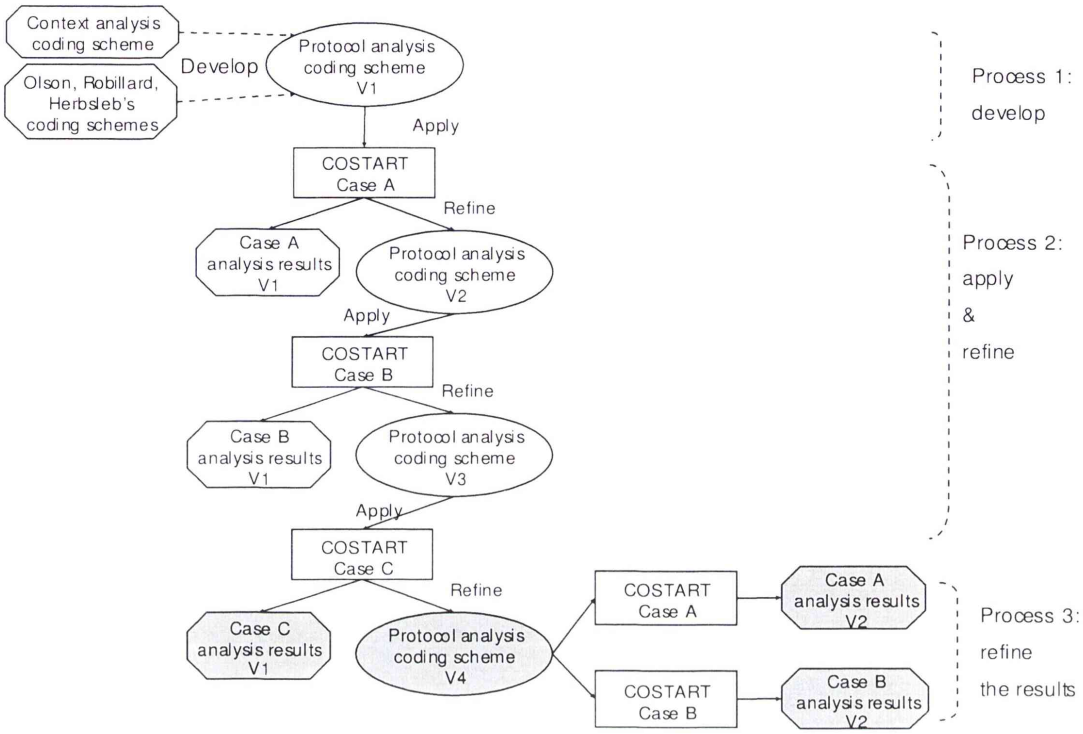


Figure 4.7: Development of coding scheme

In Figure 4.7, *Process 1* illustrates the development of the initial protocol analysis coding scheme; *Process 2* presents the procedure of applying the protocol analysis coding scheme, where the coding scheme was refined; *Process 3* illustrates the process where the refined coding scheme (V4) was applied again to the data in Case A and B in order to keep the consistency of the analysis. The protocol analysis coding scheme developed in this research contains two parts: nodes related to communication behaviour and nodes related to types of communication mediation, which can be computer-assisted or non-computer-assisted. In the following table, the protocol analysis coding scheme (V4) is presented with brief explanation (The examples of each node can be seen in Appendix A2.2).

Table 4.9: Protocol analysis coding scheme

Communication behaviour	
Node	**Definition**
Agreement	Agree or disagree with others.
Enquiry	Ask questions, which commonly start with 'when', 'where', 'how' and 'what'.
Evaluation	Analyse an object according to a criterion. It can be either positive or negative.
Hypothesis	Express a personal representation of a subject.
Inform	Provide information with respect to the nature of an object or criterion; illustrate a fact; explain some knowledge new to others; inform a state.
Justification	Argue or explain the rationale of a certain choice.
Solution-generation	Provide suggestion, potential solutions for the problems, detailed plans for the problem solving.
Recall	Retrieve knowledge about previous experience
Fragment	Sentences which are hard to be understood or do not make much sense.
Communication mode	
Node	**Definition**
Computer-assisted	Conversation conducted when participants talk with each other while constantly referring to some components of a computer screen, which can be a desktop screen or laptop screen.
Non-computer-assisted	Conversation conducted when participants talk with each other without using any medium, such as computers, physical objects etc.

4.3.3 Results

In this section, the results drawn from the analysis process are discussed. The results are presented from two perspectives: the patterns of communication behaviour between participants in each case and how the patterns of communication behaviour are changed in a computer-assisted communication environment and in a non-computer-assisted communication environment.

4.3.3.1 Patterns of Communication Behaviour

In order to identify the patterns of communication behaviour, the total time participants spent on communication behaviour was calculated and the distribution of these types of behaviour was made. The findings are discussed for each case below.

Case A

The following figure presents the time distribution of participants' communication behaviour in Case A.

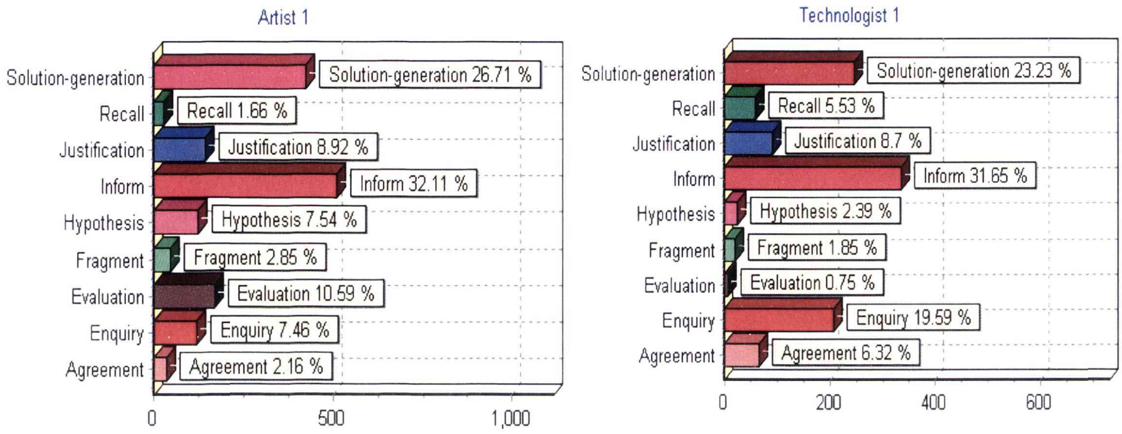


Figure 4.8: Time distribution of participants' communication behaviour in Case A

From Figure 4.8, the communication patterns between the artist and the technologist in Case A are summarized as follows:

- First, the artist and the technologist conducted most of the communication behaviour in a relatively similar way: solution-generation (A_1: 26.71%; T_1: 23.23%), justification (A_1: 8.92%; T_1: 8.7%), inform (A_1: 32.11%; T_1: 31.65%);
- Second, in terms of the differences between the artist's communication behaviour and the technologist's communication behaviour, the artist spent much more percentage of the time in the evaluation communication behaviour than the technologist did (A_1: 10.59%; T_1: 0.75%) and the technologist spent much more percentage of the time in enquiry communication behaviour than the artist did (A_1: 7.46%; T_1: 19.59%);
- Third, the types of communication behaviour both the artist and the technologist spent a great deal time on are solution-generation (A_1: 26.71%; T_1: 23.23%) and inform (A_1: 32.11%; T_1: 31.65%). Moreover, more than half of the time was spent on these two kinds of behaviour (A_1: 58.82%; T_1: 54.88%).

Case B

The following figure presents the time distribution of participants' communication behaviour in Case B.

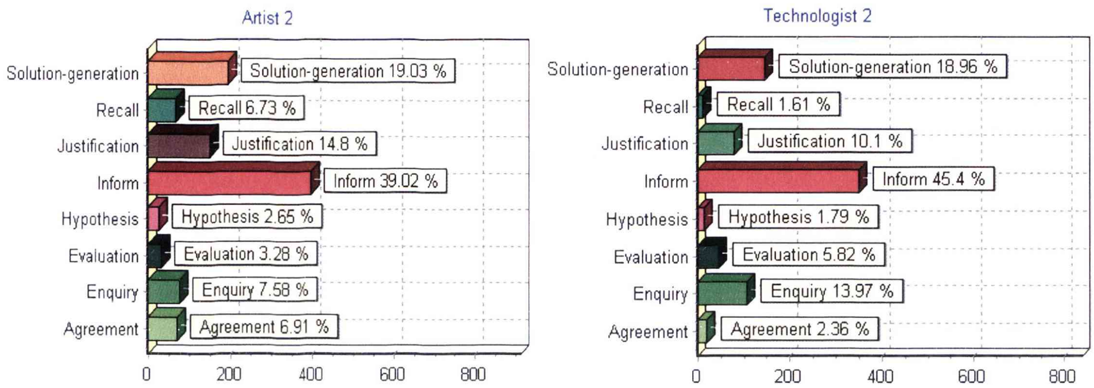


Figure 4.9: Time distribution of participants' communication behaviour in Case B

From Figure 4.9, the communication patterns between the artist and the technologist in Case B are summarized as follows:

- First, the type of communication behaviour the artist spent the most percentage of the time is inform (39.02%), the second most is solution-generation (19.03%) and the third most is justification (14.8%). The type of communication behaviour the technologist spent the most percentage of the time on is inform (45.4%), the second most is solution-generation (18.96%) and the third is enquiry (13.97%);
- Second, the artist and the technologist conducted most of their communication behaviour in a relatively different way. For example, justification (A_2: 14.8%; T_2: 10.1%), recall (A_2: 6.73%; T_2: 1.61%), enquiry (A_2: 7.58%; T_2: 13.97%);

Case C

The following figure presents the time distribution of participants' communication behaviour in Case C.

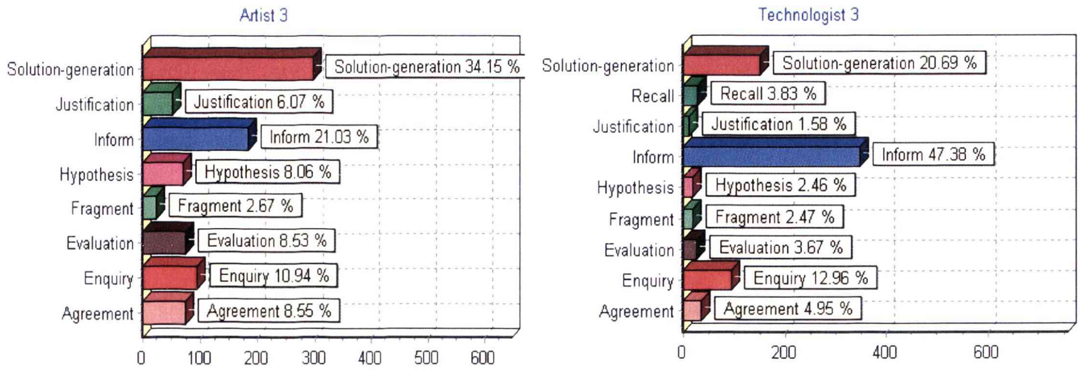


Figure 4.10: Time distribution of participants' communication behaviour in Case C

From Figure 4.10, the communication patterns between the artist and the technologist in Case C are summarized as follows:

- First, the type of communication behaviour the artist spent the most percentage of the time is solution-generation (34.15%), the second is inform (21.03%) and the third is enquiry (10.94%). The type of communication behaviour the technologist spent the most percentage of the time on is inform (47.38%), the second is solution-generation (20.69%) and the third is enquiry (12.96%);
- Second, in terms of similarities, the artist and the technologist conducted the enquiry behaviour (A_3: 10.94%; T_3: 12.96%);
- Third, in terms of differences in time distribution, most of the artist's and the technologist's communication behaviour are very different, such as inform (A_3: 21.03%; T_3: 47.38%), evaluation (A_3: 8.53%; T_3: 3.67%) and justification (A_3: 6.07%; T_3: 1.58%).

Comparisons Between Three Cases

The comparative results between artists' communication behaviour and technologists' communication behaviour across Case A, B and C are listed as follows.

Similarities

The following table illustrates the top three kinds of communication behaviour participants spent most time on within Case A, B and C, where INF, SO-GE, EVA, ENQ, JUS and REC represent the respective types of behaviour in order: inform, solution-generation, evaluation, enquiry, justification and recall. The 'level 1', 'level 2' and 'level 3' in Table 4.10 represent the type of communication behaviour which has the highest percentage, the second highest percentage and the third highest percentage in terms of time distribution.

Table 4.10: Top three types of communication behaviour participants spent most time on in COSTART cases

		Level 1		Level 2		Level 3	
		Behaviour	**Percent**	**Behaviour**	**Percent**	**Behaviour**	**Percent**
Case A	A_1	INF	32.11%	SO-GE	26.71%	EVA	10.59%
	T_1	INF	31.65%	SO-GE	23.23%	ENQ	19.59%
Case B	A_2	INF	39.02%	SO-GE	19.03%	JUS	14.8%
	T_2	INF	45.4%	SO-GE	18.96%	ENQ	13.97%
Case C	A_3	SO-GE	34.15%	INF	21.03%	ENQ	10.94%
	T_3	INF	47.38%	SO-GE	20.69%	ENQ	12.96%

Table 4.10 shows the related information about the top three kinds of communication behaviour participants spent most of the time on: five out of six participants spent the highest percentage of time on inform behaviour; five out of six participants spent the second highest percentage of time on solution-generation behaviour; four out of six participants spent the third highest percentage of time on enquiry behaviour. Furthermore, two other similarities were found between Case A, B and C:

- All artists spent less percentage of the time in the enquiry behaviour than the technologists did (A_1: 7.46%; T_1: 19.59%) (A_2: 7.58 %; T_2: 13.97%) (A_3: 10.94%; T_3: 12.96%);
- All artists spend relatively more percentage of time in the solution-generation behaviour than the technologists did (A_1: 26.71%; T_1: 23.23%) (A_2: 19.03%; T_2: 18.96%) (A_3: 34.15%; T_3: 20.69%).

Differences

In comparing the results between Case A, B and C, three differences were identified:

- In Case A, the artist's behaviour distribution is relative similar to the technologist'; on the contrary, in Case B and C, the artist's behaviour distribution is relatively different to the technologist';
- In Case A and C, the artist spent more percentage of time in the evaluation behaviour than the technologist did (A_1: 10.59%; T_1: 0.75%) (A_3: 8.53%; T_3: 3.67%), while in Case B, the artist spent less percentage of time on the evaluation behaviour than the technologist did (A_2: 3.28%; T_2: 5.82%);
- In Case A, the artist spent more percentage of time in the inform behaviour than the technologist did (A_1: 32.11%; T_1: 31.65%), while in Case B and Case C, the artist spent much less percentage of time on the inform behaviour than the technologist did (A_2: 39.02%; T_2: 45.4%) (A_3: 21.03%; T_3: 47.38%).

4.3.3.2 Relationship Between Communication Behaviour and Modes

In the previous section, the overall patterns of participants' communication behaviour were identified within each case, the differences and similarities between the artist' and the technologist' communication behaviour were discussed and comparisons between cases were made. In this section, a further analysis is made in order to explore how the types of communication behaviour were distributed during computer-assisted environment and non-assisted environment within each case and across cases. The total time distribution of participants' communication behaviour within three cases was made (Figure 4.11).

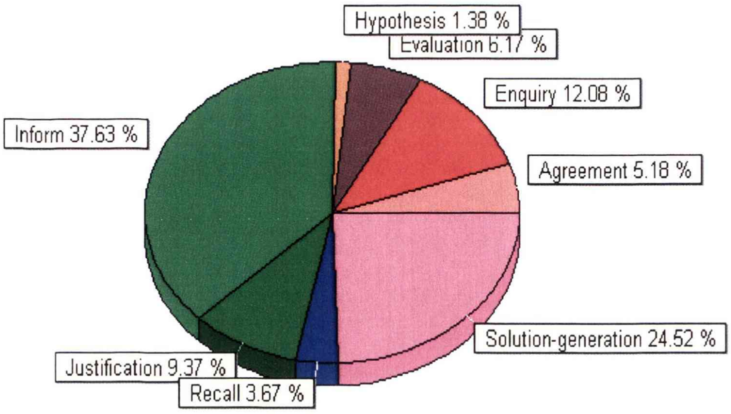


Figure 4.11: Distribution of communication behaviour within three cases

From Figure 4.11, we can see that within the three cases, participants mainly spent most time on three types of communication behaviour: inform (37.63%), solution-generation (24.52%), and enquiry (12.08%). In order to explore these three kinds of communication behaviour participants mainly spent time on, a further analysis was made. Moreover, in terms of exploring the relationship between the evaluation behaviour and mediation of computers, the evaluation behaviour was also further analyzed. In the next section, the time distribution of these four kinds of communication behaviour will be presented in terms of computer-assisted environment or non-assisted environment within each case.

Case A

The artist A_1's and the technologist T_1's selected communication behaviour are presented in terms of time distribution under two communication modes (Figure 4.12). The selected four types of the communication behaviour are solution-generation, inform, enquiry and evaluation. 'Other' in Figure 4.12 represented the other four types of communication behaviour which are not analyzed further: justification, agreement, recall and hypothesis.

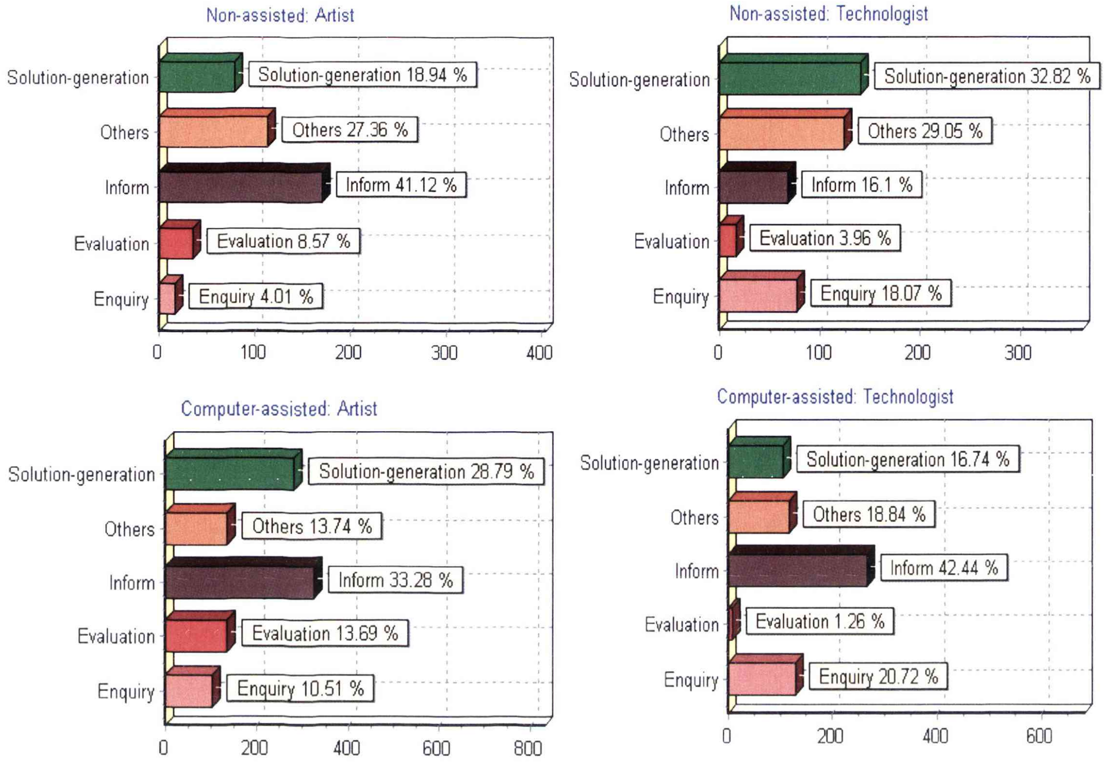


Figure 4.12: Time distribution of a selected group of the communication behaviour within the non-computer-assisted and the computer-assisted in Case A

From Figure 4.12, the findings can be summarized as follows:

- **Solution-generation behaviour**: for the artist, it increased from non-assisted (18.94%) to computer-assisted (28.79%); for the technologist, it decreased from non-assisted (32.82%) to computer-assisted (16.74%);
- **Inform behaviour**: for the artist, it decreased from non-assisted (41.12%) to computer-assisted (33.28%); for the technologist, it increased from non-assisted (16.1%) to computer-assisted (42.44%);
- **Enquiry behaviour**: for the artist, it increased from non-assisted (4.01%) to computer-assisted (10.51%); for the technologist, it also increased from non-assisted (18.07%) to computer-assisted (20.72%);
- **Evaluation behaviour**: for the artist, it increased from non-assisted (8.57%) to computer-assisted (13.69%); for the technologist, it decreased from non-assisted

(3.96%) to computer-assisted (1.26%).

In summary, in terms of changes from non-computer-assisted to computer-assisted, three types of communication behaviour of the artist and the technologist were affected by computers in a different way: the artist's solution generation behaviour and evaluation behaviour increased with computers than without, while for the technologist, these two types of behaviour decreased with computers than without. Moreover, the artist's and the technologist's inform behaviour were affected by computers in a different way: the artist's inform behaviour decreased with computers than without, while the technologist's inform behaviour increased with computers than without. However, the artist's and the technologist's enquiry behaviour were affected by computers in a similar way: both of their enquiry behaviour increased with computers than without.

Case B

The time distribution of participants' four types of communication behaviour (solution-generation, inform, enquiry and evaluation) in Case B is illustrated in the follow figure in terms of the comparisons between the non-computer-assisted mode and the computer-assisted mode ('Other' in the figure represents the four other types of communication behaviour which are not analyzed further: justification, agreement, recall and hypothesis).

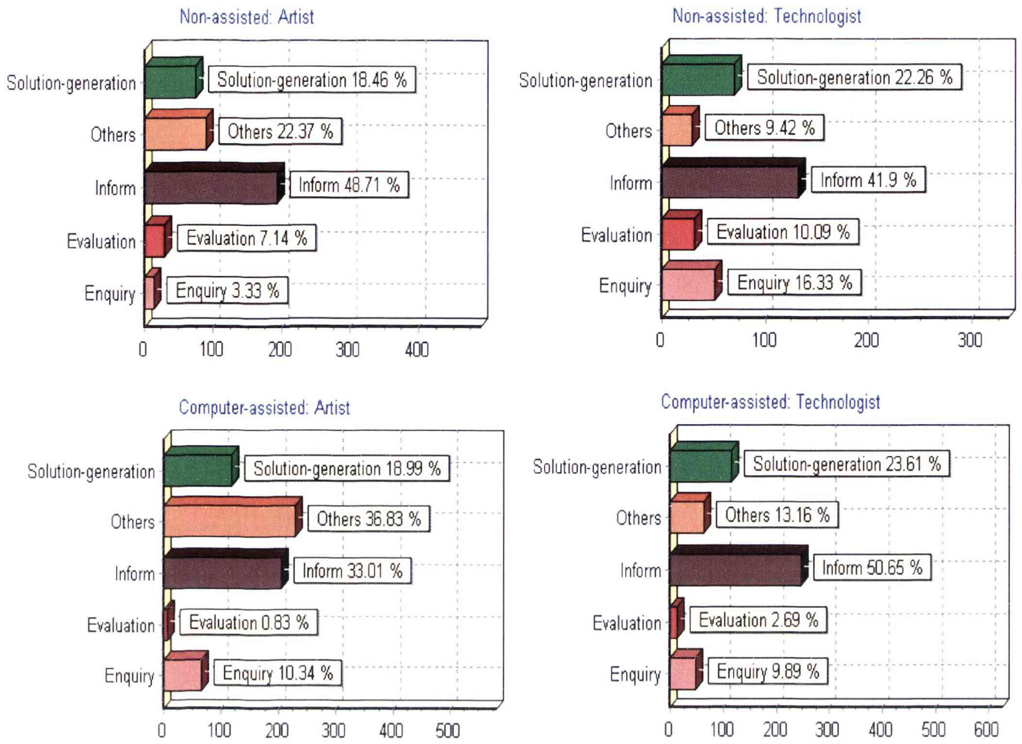


Figure 4.13: Distribution of selected group of communication behaviour within the non-assisted and the computer-assisted in Case B

From Figure 4.13, the findings can be summarized as follows:

- **Solution-generation behaviour**: for both the artist and the technologist, it increased from non-assisted (A_2: 18.46%; T_2: 22.26%) to computer-assisted (A_2: 18.99%; T_2: 23.61%);
- **Inform behaviour**: for the artist, it decreased from non-assisted (48.71%) to computer-assisted (33.01%); for the technologist, it increased from non-assisted (41.9%) to computer-assisted (50.65%);
- **Enquiry behaviour**: for the artist, it increased from non-assisted (3.33%) to computer-assisted (10.34%); for the technologist, it decreased from non-assisted (16.33%) to computer-assisted (9.89%);
- **Evaluation behaviour**: for both the artist and the technologist, it decreased from non-assisted (A_2: 7.14%; T_2: 16.33%) to computer-assisted (A_2: 0.83%; T_2: 9.89%).

In summary, in terms of changes from non-assisted to computer-assisted, the artist's and the technologist's inform and enquiry behaviour were affected by computers in a different way and the participants' evaluation and solution-generation behaviour were affected in a similar way. In terms of the enquiry behaviour, the artist's behaviour increased with computer than without and the technologist's decreased with computer than without. On the contrary, the artist's inform behaviour decreased with computers than without and the technologist's increased with computers than without. Moreover, both the artist' and the technologist' solution-generation behaviour were affected by computers in a similar way: it increased with computers than without. Similarly, the participants' evaluation behaviour was affected by computers in a similar way: it decreased with computers than without.

Case C

In terms of the comparisons between the non-computer-assisted communication mode and the computer-assisted communication mode, the time distribution of the participants' four types of communication behaviour (solution-generation, inform, evaluation and enquiry) in Case C is illustrated (Figure 4.14) ('Other' in the figure represents the four other types of communication behaviour which are not shown in this figure: justification, agreement, recall and hypothesis).

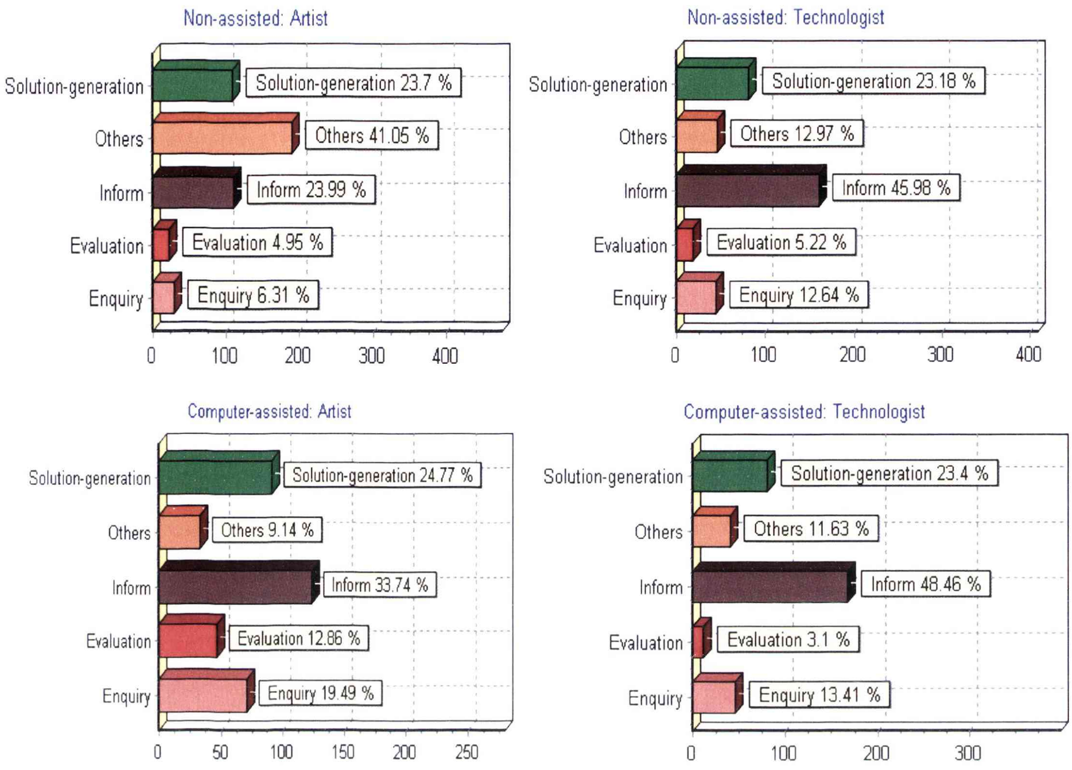


Figure 4.14: Distribution of a selected group of communication behaviour within the non-assisted and the computer-assisted in Case C

From Figure 4.14, the findings can be summarized as follows:

- **Solution-generation behaviour:** for both the artist and the technologist, it increased from non-assisted (A_3: 23.7%; T_3: 23.18%) to computer-assisted (A_3: 24.77%; T_3: 23.4%);
- **Inform behaviour:** for both the artist and the technologist, it increased from non-assisted (A_3: 23.99%; T_3: 45.98%) to computer-assisted (A_3: 33.74%; T_3: 48.46%);
- **Enquiry behaviour:** for both the artist and the technologist, it increased from non-assisted (A_3: 6.31%; T_3: 12.64%) to computer-assisted (A_3: 19.49%; T_3: 13.41%);
- **Evaluation behaviour:** for the artist, it increased from non-assisted (4.95%) to computer-assisted (12.86%); for the technologist, it decreased from non-assisted (5.22%) to computer-assisted (3.1%).

In summary, in terms of changes from non-assisted to assisted, the artist's and the technologist's communication behaviour were affected by computers in a similar way: both the artist's and the technologist's inform behaviour and enquiry behaviour increased with computers than without; both the artist's and the technologist' solution-generation behaviour decreased with computers than without. Moreover, the artist's and the technologist's evaluation behaviour were affected by computers in a different way: the artist's evaluation behaviour increased with computers than without and the technologist's evaluation behaviour decreased with computers than without.

Comparison Between Three Cases and Discussion

The comparisons of the above results are carried out and the implications are discussed.

Solution-generation Behaviour

In terms of solution-generation behaviour, the above results show that two out of three technologists exhibited the solution-generation behaviour more often with computers than without, whilst two out of three artists exhibited the solution-generation behaviour more often without computers than with. As the solution-generation behaviour was defined previously as "suggestions for problem solving and specific applicable plans" (Table 4.9), this finding may indicate that computers might help the technologists to provide more solutions during the collaboration. However, computers do not appear to offer a similar effect for the artist's solution-generation behaviour. It would seem that the artists produced more solutions without using a computer than with. For instance, in case A, the artist was not sufficiently expert with the software Max 3D to work independently, while the technologist was expert in this programme. During the collaboration, the artist provided many potential solutions and suggestions because she had a clear vision of what she wanted the outcome to be although did not possess the means to achieve it herself. On the other hand, the technologist presented his proposals for addressing the artist's vision using the software because the computer realisation needed to be directly evaluated by the artist and could not be understood with that being done. From this case, we infer that the reason for the differentiation that exists between artists and technologists is more likely to lie in the particular role each played in the creative collaboration than solely the degree of ease or familiarity with the computer medium.

Inform Behaviour

In terms of inform behaviour, it was found that the technologists' inform behaviour in all three cases increased from non-computer-assisted communication to computer-assisted communication and two out of the three artists' inform behaviour decreased from non-computer-assisted to computer-assisted. Inform behaviour, as defined previously, was mainly used for distributing information (Table 4.9). We further found that during the case studies, the information type the technologists were mainly concerned with was related to technological know-how, such as functions of software applications. In comparison, the artists were mainly concerned with artistic knowledge, such as artistic concepts and aesthetics (Section 4.3.2). Thus, we suggest that the artists used the inform behaviour to illustrate their artistic knowledge more often in the non-assisted environment than the computer-assisted environment, and on the contrary, technologists used the inform behaviour more often in the computer-assisted environment than the non-assisted environment. For instance, in Case B, when the artist talked with the technologist about his motivation behind the artwork, he barely used any computers to demonstrate his ideas; instead, he mainly verbalised his thinking face to face without any computer mediation. On the contrary, the technologist, when he needed to talk with the artist about his part of experience or knowledge, often used computers or their tools to demonstrate or explain them. The reasons for this differentiation may lie in the artists' and technologists' familiarity with the medium, and in their preference for the way ideas are communicated.

Enquiry Behaviour

In terms of enquiry behaviour, the artists in all three cases spent more time on this behaviour in computer-assisted situation than without, while two out of three technologists had spent less time on the enquiry behaviour when they were with computers than without. In other words, the artists asked more questions when they were under computer-assisted environment than non-assisted environment. This finding may suggest that working in front of computers can raise more questions for artists to ask, and the more questions artists asked, the better artists and technologists can understand each other. For example, artists can understand better the potential of the technology for their artistic goals and technologists can become more aware of what the artistic requirements are and what artists' concerns are.

Evaluation Behaviour

In term of evaluation behaviour, two out of three artists spent more time on evaluation behaviour with computers than without, while all of the technologists spent less time on this behaviour with computers than without. This finding may suggest that communication with the assistance of computers and their tools allows artists to lead the shaping and realizing of their visions for the project's outcomes by taking an active role in the use of a computer mediating environment. For instance, in Case B, the artist provided more feedbacks when the technologist was showing him some prototypes in the environment of a visual programme Max/MSP than they were talking with each other without any type of mediation.

In summary, based on the results of Case A, B and C, we can see that computers affect artists' and technologists' solution-generation behaviour, inform behaviour and enquiry behaviour differently. For solution-generation and inform behaviour, computers can increase these types of behaviour from the technologists and decrease these types of behaviour from the artists. On the contrary, for enquiry behaviour, computers can increase this behaviour of the artists and decrease this behaviour of the technologists. From these findings, we can see that during computer-assisted environment, the artists asked more questions, generated less solutions, shared less of their own knowledge, made more evaluations than they did in the non-assisted environment. In comparison, during computer-assisted environment, the technologists asked fewer questions, generated more solutions and shared more of their own knowledge and made less evaluations.

These findings reveal some features of communication during the art-technology collaboration. From our results, we may suggest that, during the creative collaboration, artists and technologists mainly communicated with each other in three ways: exchange their knowledge or experience, generate potential solutions or provide suggestions to move projects forward, and raise questions and clarify ideas. In terms of the role of computers during this collaborative process, we may indicate that, computers, as a mediation tool, can prompt artists to ask more questions and help artists realize their visions in the outcomes by making evaluations; for technologists, computers can help them to inform artists more about the technology itself and also it can help technologists to produce a greater range of solutions to the problems through the discussion with artists.

4.4 Summary

In this chapter, the study of three selected cases from the COSTART project was carried out. It started with the background information, where the overall context of the COSTART project was introduced and the specific background and data descriptions of those selected cases were presented. As the analysis methods adopted in this research is a combination of context analysis and protocol analysis (Section 3.2.2), this chapter went on to present the context analysis of the studies, where the process was illustrated, the context analysis coding scheme developed through the COSTART case studies was described and the analysis results were presented (Section 4.2). Following that, in Section 4.3, the protocol analysis process was presented, the protocol analysis coding scheme was introduced and the protocol analysis results were provided.

The outcome of the COSTART study is: first, the analysis framework, which contains the context analysis coding scheme (Section 4.2.2) and the protocol analysis coding scheme (Section 4.3.2); second, the findings, which were drawn from the context analysis (Section 4.2.3) and the protocol analysis (Section 4.3.3). In the next chapter, a study of a recent art-technology collaboration project 'GEO' will be carried out, where the analysis framework, developed in this chapter, will be further applied and refined.

5 The GEO Study

In this chapter, a study of an art-technology collaboration project "GEO Narrative Landscapes" (GEO) is described. As mentioned in Section 3.2.1, there are two aims of this study. The first aim is to refine the analysis framework, developed in the previous COSTART case studies, by applying new data that was collected in a similar context to COSTART. The second aim of conducting this new study is to compare the findings drawn from the COSTART cases with another art-technology collaboration situation. This chapter starts with the study context including the background of the GEO project and the data description (Section 5.1). It continues to present the context analysis of the GEO project (Section 5.2) and the protocol analysis of the GEO project (Section 5.3).

5.1 Study Context

5.1.1 GEO Project Background

The GEO project is a work-in-progress for an interactive artwork that aims to transport audiences to Sydney's newest architectural attraction, the Brickpit Ringwalk, an elevated circular walkway at the Sydney Olympic Park (Figure 5.1). The artist aimed to convey his impressions of the site in words, photography and video images in order to create a layered virtual environment in which audiences can move around and explore.

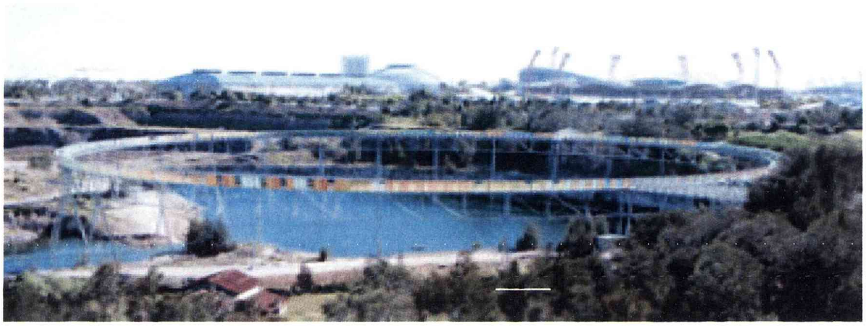


Figure 5.1: Still image of Brickpit Ringwalk

The interactive-system developed in the GEO project is an immersive environment where the user can explore a remote location seen through the eyes of other people. The user interacts with the system by moving around in front of a wall-sized rear projection screen. Beneath the carpet, a six-by-six grid of pressure sensors detects where the users are standing. Displayed on the screen is video and text material relating to the remote location. The artwork is designed for installation in a museum location. Within the system, the user can explore the remote space at several levels of interaction, and explore different people's views of particular aspects of the site (Zhang, Weakley & Edmonds 2007). Three views of the GEO interface in a test environment are shown in Figure 5.2. The final outcome of this work was exhibited from April to May 2007 at the Beta-space in Sydney Powerhouse Museum, which is an exhibition space where the general public can engage with art outcomes of leading research in art and technology (Costello et al. 2005).

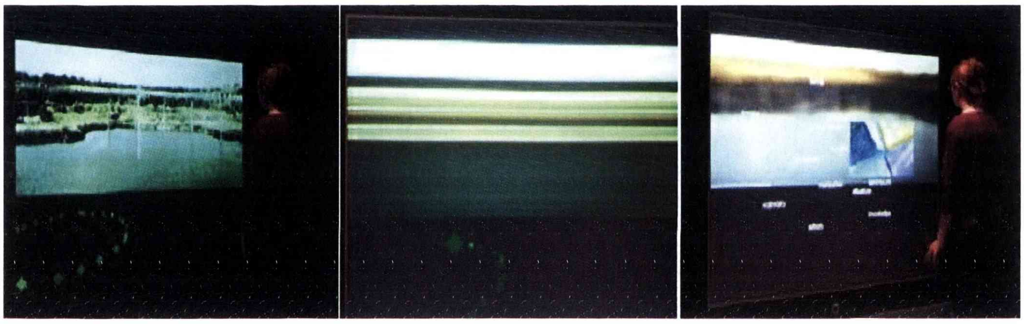


Figure 5.2: View of three layers in the GEO interface

The GEO project was carried out in a multi-disciplinary research team comprising of an artist, two technologists, one designer and one observer. All participants were co-located in the same city. The artist was the designer of the digital artefact and also the leader of the team. The two technologists were in charge of different parts of the technical functions of the project: one was mainly working with the software application MAX/MSP (Cycling74), the other was mainly working with the programming language Java. The designer mainly worked on the image design and the observer, who is also the author of this thesis, monitored the collaboration process on site for five months.

The basic collaboration mode for this project was via group meetings. The duration of the group meetings was from between approximately thirty minutes to one hour based on on-site-demand and the frequency of the meetings was once a week. In addition to the weekly meetings, the remaining time was spent working individually or in person to person communication by emails or telephones. The meeting location was in the Creativity and Cognition Studios (CCS) at the University of Technology, Sydney. In the studio, an environment built for developing interactive art systems was available, where a projector was installed at the far end of the studio, and in front of the screen a grid of six by six pressure sensitive floor pads were installed under the carpet (Figure 5.3).

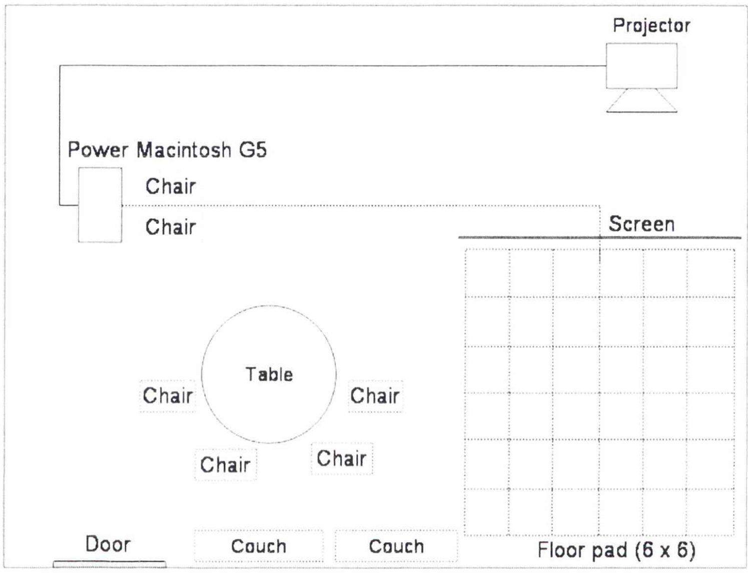


Figure 5.3: Equipment layout of the studio

These floor pads listed in Figure 5.3 are simple switches that return an "on" message when they are stepped on and an "off" message when they are not being stepped on. Using this technology a work can be created that responds to a participant's position in front of the screen. These pads are mainly controlled using the Max/MSP software application, where the movements of the floor pad are captured and processed.

5.1.2 Data Description

As presented previously, the main data collection approach adopted in this research is a combination of observation assisted by audio/video facilities and semi-structured interviews (Section 3.2.2). During the observation of this project, the author (as the observer) used video facilities to record the meetings. As observation cannot provide cognitive information, such as attitudes, beliefs, motivation or perceptions, this was addressed by having the observer ask questions and conducting informal conversations with participants subsequent to the observation (Section 3.2.2). In the mean time, field notes were taken for each meeting by the observer. At the end of the five-month observation, semi-structured interviews were conducted with each participant (The interview protocol can be seen in Appendix A1.1). In addition, the project related emails between participants were also included as part of the data collection in order to arrive at as detailed a picture of the collaboration as possible.

During the observation period, eighteen group meetings were observed and video-recorded. The following table provides the overview of observed sections in terms of sequence, time, attendee, location and content (A presents the artist, T_a and T_b present the two technologists, D present the designer).

Table 5.1: Observed meetings during the GEO project

Meeting sequence	Time	Attendee	Location	Content
1st	11:00-12:00, 13 of July	A, T_a, T_b, D	Studio	Initial meeting
2nd	11:00-12:00, 21st of July	A, T_a, T_b	Studio	1st version of proposal was presented
3rd	10:00-11:00, 1st of August	A, T_a, T_b, D	Studio	Demo of Max/MSP system was presented
4th	11:30-12:30, 16th of August	A, T_a, D	Studio	Plans of filming the work's environment
5th	10:00-11:30, 23rd of August	A, T_a, T_b, D	Studio	Moving texts
6th	11:30-12:30, 30th of August	A, T_a, T_b	Studio	Combination of Max/MSP and Java
7th	11:30-12:30, 6th of September	A, T_b, D	Studio	2nd version of proposal was presented
8th	11:30-12:00, 13th of September	A, T_a, T_b	Studio	Design the layout of the artefact
9th	11:00-12:00, 18th of September	A, T_a, T_b, D	Studio	Evaluation of the first demo
10th	11:00-12:00, 26th of September	A, T_a, T_b	Studio	Animating the texts
11th	11:30-12:30, 11th of October	A, T_a, T_b	Studio	Increasing the sensitivity of the artefact
12th	15:00-16:00, 18th of October	A, T_a, T_b	Studio	Test the breaks between layers of the artefact
13th	11:00-12:00, 27Th of October	A, T_a, T_b	Studio	Changes in the artefact's components-'sphere of the ring'
14th	10:00-11:00, 2nd of November	A, T_b	Studio	Changes in the artefact
15th	2:00-3:00, 2nd of November	A, T_b	Studio	Making instructions of the artefact
16th	10:00-11:30, 6th of November	A, T_b	Studio	3rd version of proposal was presented
17th	11:30-12:30, 15th of November	A, T_a, T_b	Studio	Sound correction
18th	11:30-12:30, 6th of December	A, T_a, T_b	Studio	Further refinement

Table 5.1 shows that the artist, as the project leader, was the only participant who attended all the meetings; in each meeting, at least one of the technologists was present; the designer attended up to six meetings. In addition, the content information provided in Table 5.1 shows that the proposal was revised three times during the collaboration. The proposal, made by the artist, was a schematic storyboard containing the design information for the artefact, such as the interface design of the artefact and the relationship between movements on floor pads and layers of the artefact. Different versions of the proposal can be found in Appendix A1.2. The major difference between

these versions is that the artistic ideas embedded in the third version were much clearer and more specific than the first two versions. The refinement of the proposal suggests that the artist's creative ideas were developed, refined and shaped into more details during the collaboration with the technologists. In the next section, the study of context analysis and protocol analysis will be described, where the types of data analyzed in each analysis will be provided.

5.2 Context Analysis

In this section, the context analysis of the GEO project will be presented. It starts with the illustration of the analysis process, following that, the refined context analysis coding scheme will be introduced and the findings will be presented.

5.2.1 Analysis Process

In context analysis, all heterogenous types of data, presented in Section 5.1.2, were analyzed. Compared with the context analysis process within the COSTART cases, the analysis process in the GEO case was quite different. Instead of developing a coding scheme as happened in the COSTART cases (Section 4.2.1), in the GEO case, the context analysis coding scheme developed in the COSTART cases was applied to the data collected in the GEO case and refined during the analysis process. The analysis process in the GEO case can be summarized as follows: first, apply the context coding scheme developed in the COSTART cases to the GEO data; second, apply the node sets developed in the COSTART cases to the GEO data and summarize the results; third, refine the coding scheme and summarize the results within the refined coding scheme. The following figure summarizes the analysis process.

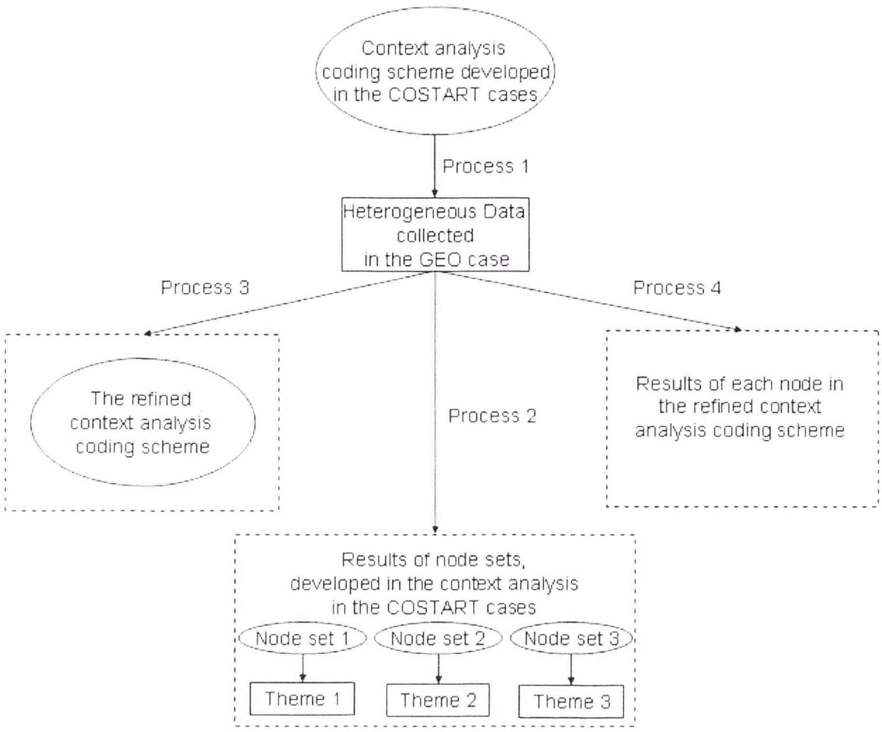


Figure 5.4: Context analysis process in the GEO case

The above figure summarizes the analysis process into four stages: in *Process 1*, the context analysis coding scheme developed in the COSTART cases (presented in Section 4.2.2) was applied to the data set of the GEO case; in *Process 2*, the node sets, developed from the context analysis within the COSTART cases (Section 4.2.3), were applied in the GEO case and the themes of each node set were drawn; in *Process 3*, the coding scheme developed in the COSTART cases was refined; in *Process 4*, the summary of each node in the coding scheme was made based on the related coded data from the GEO case. The refined context analysis coding scheme and the results of other processes listed in Figure 5.4 will be presented in the following sections.

5.2.2 Refined Context Analysis Coding Scheme

When the context analysis coding scheme, developed in the COSTART cases, was applied to the GEO data, the refinement was made where the assisted category was extended to contain four nodes instead of one due to the fact that the GEO case offered the opportunity to identify more types of mediation circumstances. The four nodes are

Drawing-assisted, *Object-assisted*, *Computer-screen-assisted* and *Interactive-system-assisted*:

- The *Drawing-assisted* node is used to code the communication while participants are making sketches on a paper/whiteboard;
- The *Object-assisted* node is used to code the communication while participants are referring to a physical object presented in front of them;
- The *Interactive-system-assisted* node is used to code the communication while participants are interacting with interactive artefacts;
- The *Computer-screen-assisted* node is used to code the communication while participants are constantly referring to the components on a computer screen.

The refined context analysis coding scheme in the GEO case is presented in the following table.

Table 5.2: The refined context analysis coding scheme in the GEO case

Master node	Category	Node	Description
Context	Participant Profile	Background-T	Technologists' background
		Background-A	Artists' background
	Project Profiles	Proposal	Artists' proposals
		Outcomes	Outcome descriptions (including pictures or video shots of artefacts and word documents)
	Situation profiles	Physical-environment	The residency's physical location
		Technical-environment	Types of software and hardware used during the collaboration
		Collaboration-history	Whether they collaborated with each other before
Communication	Verbal	Talking-conflicts	Includes misunderstanding, clarification, disagreement etc.
		Interruption	Interruption during the conversation
		Common-language	Language, as demonstrated by terminology used, was shared or restricted to one or other individual
	Non-verbal	Silent	Break between the conversation
		Laugh	Laugh during the conversation
	Assisted	Computer-screen-assisted	Conversation when participants use computer as media, such as talked in front of computer
		Interactive-system-assisted	Conversation when participants communicated with each other while interacting with the artefact
		Drawing-assisted	Conversation when participants draw something on the white board or paper
		Objects-assisted	Conversation when participants use some physical objects, such as paper, a balloon filled with water
	Non-assisted	Face-to-face	Face to face communication without any medium.
Behaviour	Cognitive styles of collaboration	Leadership	Whether artists or technologists dominated the collaboration or they have an equal role
		Learning	Learning process was described
	Cognitive styles of participants	Goal-driven	Talking involved with specific goals
		Exploratory	Talking involved non-specific goals
		Flexibility	Artists show strong interests in technical parts or technologists' show strong interests in artistic aspects.
	Emotional states	Evaluation	Participants' comments about collaboration
		Expression of emotion	Positive emotion, e.g. happy, satisfied;or negative emotion, e.g. frustrated, irritated.

In the next section, the context analysis results in the GEO case will be presented.

5.2.3 Results

In this section, the analysis results will be presented from two perspectives: the content summary of five communication modes, listed in Table 5.2 under the *Assisted* category and the *Non-assisted* category: face-to-face, computer-screen-assisted, interactive-system-assisted, drawing-assisted and object-assisted. The content summaries of these five communication mode are listed in Section 5.2.3.1 and the results in relation to the node sets are listed in Section 5.2.3.2 (the summary of the coded data under each node in the refined context analysis coding scheme is shown in Appendix A3.1).

5.2.3.1 Content Summaries of Communication Modes

In this section, with respect to the main types of content that participants exchanged with each other during the mode, the analysis results of each communication mode are provided with an added illustration of the transcription segments.

Face-to-face

This type of communication, as defined in Table 5.2, happens where participants communicate with each other without referring to any medium. Two examples of face-to-face communication are shown in Figure 5.5.

Figure 5.5: Face-to-face communication mode

Four topic areas were identified within face-to-face communication mode:

- The artist and the technologists were exploring project goals and plans;
- The artist and the technologists were exchanging knowledge and expertise;
- Other project issues, such as deadlines, funding;
- Digressions, such as personal greetings, news.

The conversations in relation to goal/plan participants conducted are, for example, what participants wanted to achieve in the next couple of weeks and what kind of general effects the artist wanted the artwork to have. The following transcription segment is an example of the goal/plan content circumstance, where the participants were talking about the plans to reduce the CPU capacity in future activities:

> T_b: …next week, I will work on how to reduce the CPU power usages. [As we know], each component takes a lot of CPU power…
>
> A: Yeah, I probably could help it too. I can stop using these big files…
>
> *00:18-00:39, 11th of October (A: artist, T_a/T_b: technologists, D: designer)*

Furthermore, in the face-to-face mode, participants were likely to report their individual outcomes and how they achieved them during the week. For example:

> A: …how have things been working between two of you?
>
> T_a: While he [technologist T_b] was working on those 3D texts and I have been working on other parts of interaction..."
>
> *07:18-07:28, 26th of September*

Apart from the above topics, it was also found that, in this mode, participants spoke a great deal about deadlines, funding and meeting arrangements as well as topics not directly related to the project.

Computer-screen-assisted Communication Mode

In this mode, as defined in Table 5.2, participants communicate with each other while referring to and manipulating objects in front of a computer (Figure 5.6).

Figure 5.6: Computer-screen-assisted communication mode

Two circumstances were identified where the computer-screen-assisted communication mainly occurred:

- The technologists were showing the artist what they had achieved or explaining technical aspects of the artefact;
- The technologists and the artist were addressing a technical problem or the technologists were working together to resolve technical problems.

During the first circumstance, the programming software Max/MSP was usually displayed on the computer screens and the technologists were usually trying to explain to the artist how to achieve a specific effect of the artefact in Max/MSP, such as how Max/MSP controlled the movements of the floor pad. The following transcription segment comes from a context where the technologists demonstrated to the artist how they made the texts respond to the interaction from the floor pad:

> T_a: ...you can control where it has to go... you can move cross that... you can control to make it stop. So I think with those kinds of things, we can make some quite different looking of texts...
>
> A: So can we have something like a sentence or...
>
> T_a: We think could do that or we could do it in another way...
>
> *01:09-01:38, 26th of September*

The technical problems in the second circumstance where computer-screen-assisted communication happened can be very specific. For instance, the following transcription segment is drawn from when the participants were working on the relationship of the moving instruction and the video:

T_b: …it was manageable, I don't know why it is here, it shouldn't be...

A: Don't worry about this, let's go back to the beginning to see whether we can fix it...So I suggest you hold it on that about thirty seconds... as that is sort of cut out, this trunk of text starts to enter, if you can...

T_b: Yeah, now actually it's like that...

30:20-31:34, 2nd of November

Object-assisted Communication Mode

In this mode, participants communicated with each other while referring to a physical object. During the GEO case, it was observed that physical objects that participants mainly referred to the majority of the time were proposals, where the design information of the artefact was illustrated in details, which includes the layout descriptions of the interface, what audiences see on the screen and how long the time frames are designed for audiences to activate certain effects. The left-hand side of the following figure shows a panel selected from the proposals, which describes what the audiences see on the interface of the artefact, how it is intended to respond according to the movements on the floor pads and what the time frames are for audiences to activate this interface. During this mode, the presence of the proposal during the group discussion was a printed document (see the right-hand side of the following figure) or a digitalized PDF file displayed in a computer screen.

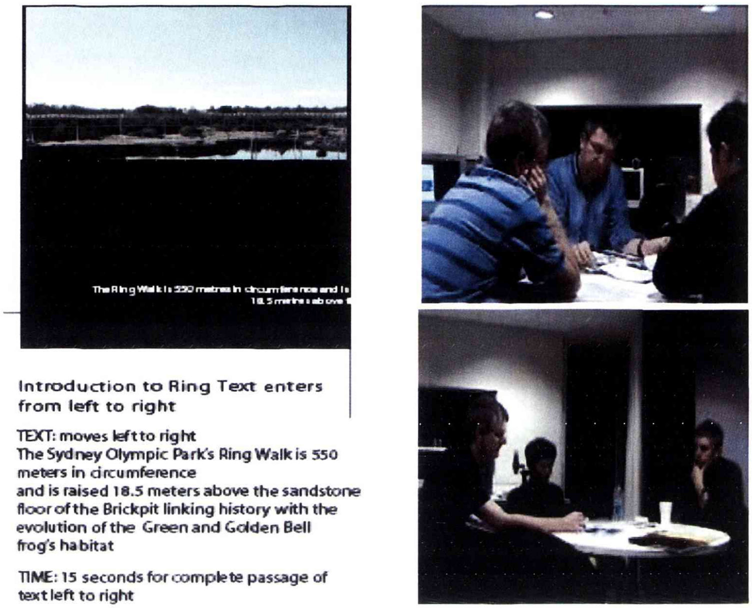


Figure 5.7: Object-assisted communication mode

Two circumstances were identified where the participants conducted this communication mode: the artist tried to explain what kinds of effects he wanted to achieve or the technologists tried to connect what they had done to the design information illustrated in the proposals. The example of the first circumstance is listed as follows, where the artist was trying to explain the proposal to the technologists as they sat with a printed proposal in front of them.

> A: ...I'm interested in opening up these as an area of visual exploration...If we need to justify why we move into these different levels, I could probably put a case together in terms of how that sense of the experimentation is part of the research...
>
> T_a: Do you have any ideas of what these forms can be?
>
> A: In terms of?
>
> T_a: Using static image... *13:24-14:20, 13th of July*

The following segment is an example under the second circumstance. Here the technologist was telling the artist what he has done during the week in relation to the requirements listed in the proposals. During this example, the technologist was pointing to a specific paragraph of the printed proposal while talking to the artist:

> T_a: ... what I have done is, in the interactive mode, if we move back, it'll tilt back. If we move forward, it'll tilt forward...
>
> A: Looking up down is tilting up and down?
>
> T_a: Yeah, but not zoom in... *07:08-07:35, 6th of September*

Interactive-system-assisted Communication Mode

The interactive-system-assisted communication mode, as defined in Table 5.2, happens where participants communicate with each other while interacting with the digital artefact (Figure 5.8).

Figure 5.8: Interactive-system-assisted communication mode

Two major circumstances were identified during the occurrence of this mode:

- The technologists were interacting with the artefact to demonstrate how the interaction behaves based on different kinds of floor pad movements;
- The artist was interacting with the artefact whiling asking questions, giving feedback about the current version of the artefact and making suggestions for changes.

Here is an example under the first circumstance. In this example, the technologist T_a was interacting with the artefact while talking to the artist at the same time:

T_a: ....if I stand on the edge, it should go quite quickly, you can see it go along, and then ... at the same time, it becomes quite abstract and I can still go and cross...

A: Excellent... *07:14 -07:40, 21st of July*

Below is an example in the second circumstance, where the artist was asking some questions while interacting with the artefact:

A: ...is it possible to move the texts like a stream, for example, from left to right, right to left?

T_b: Yeah, I think so.

A: It obviously will depend on how you interact with it.

T_b: Yes... *03:55-04:17, 30th of August*

Drawing-assisted Communication Mode

As defined in Table 5.2, the drawing-assisted communication mode happens when participants communicate with each other while drawing with a pen on a notebook or on a white board (Figure 5.9).

Figure 5.9: Drawing-assisted communication mode

In the drawing mode, only one circumstance was observed, which is when participants were trying to articulate an idea or potential solution. For example, the following exchange occurred when the technologist was trying to explain how to visualize the images by sketching a graph on the paper:

T_a: ...you've got these six places, as you go to one, it will go to the centre and the other ones will move around the place

A: oh, right... *05:59-06:10, 13th of July*

In summary, from analysing the main types of conversation content within five communication modes, the results for each mode were summarized as follows:

- The face-to-face mode was used to exchange knowledge and expertise, explore project goals and plans, discuss other project issues, such as deadline, funding;
- The computer-screen-assisted mode was used to demonstrate technical knowledge, address a technical problem and explain technical aspects of the artefact;
- The interactive-system-assisted mode was used to gain evaluations, demonstrate how the interactive artefact works and provide suggestions and feedbacks;
- The object-assisted mode was used to explain the design information listed in the project proposals and clarify specific requirements;
- The drawing-assisted mode was used to explain ideas/solutions not accessible under other modes.

In the next section, the second part of the context analysis results in the GEO case will be presented, where the node sets previously developed in the COSTART cases were applied to the GEO data and the findings are described in the following.

5.2.3.2 Results From the Node Sets

In the context analysis study of the COSTART cases, node sets, which are groups of nodes related to each other to formulate core interpretive themes, were formulated. Three node sets were developed in the COSTART cases: 'Sharing', 'Mediation' and 'Collaboration style' (Section 4.2.3). In this section, the results of the node sets, where the GEO data was applied, will be presented.

Node Set 'Sharing'

Compared with the node set 'sharing' in the COSTART cases (Table 4.5 in Section 4.2.3.1), the results of the *Background-T* node in the GEO case summarize two participants' background information due to the fact that two technologists participated in the GEO project. The following table shows the results of the nodes in this node set (Details about these results can be seen in the Appendix A3.1).

Table 5.3: Node set 'Sharing' in the GEO case study

Master node	Category	Node	Results
Context	Participant Profiles	Background-A	Experienced in the several art-related fields, such as design, film, digital art but not experienced in the field of computer science.
		Background-T	Background T_a: Expert in computer science especially familiar with software application Max/MSP and also majored in design practice, especially product design.
			Background T_b: Expert in computer science especially familiar with software application Java.
Communication	Verbal	Common-language	In comparison, the artist did not share very much common language with T_a and T_b, but the technologist T_a and the technologist T_b shared a great deal of common language.
Behaviour	Cognitive Style of Participants	Flexibility	The artist and technologists did not show much interest to each other's field. The technologist T_a and the technologist T_b showed many interests to each other's work.

Under the *Context* master node, the coded data of the *Background-A* node and the *Background-T* node shows: the artist and the technologists shared less background in common than the background that the technologist T_a and technologist T_b shared. The impact of this difference was expressed by the technologist T_b during the interview:

> "I think discussion with [the technologist T_a] is quite straight forward and quite easy because he is very familiar with Max/MSP. It's far easier to talk with [the technologist T_a] than talking with [the artist]... in science field, people are quite logical, such as in background, methods, conclusion... [From this project] I just realize that we [artists and technologists] have got a very different mind set, very different way that we construct the logic and the construct of the way we speak.

> It feels like sometimes he [the artist] has a lot threads in his mind, but I don't know which threads we should follow, I am not familiar with having a lot of threads at the same time..." *Extract of the technologist T_b's interview*

In terms of the analysis result of the *Common-language* node in this node set, it was found that the common language between the artist and the technologists is less shared than the common language the technologist T_a and the technologist T_b shared. Similarly, from the *Flexibility* node, it was known that the artist and the technologists showed less interest in each other's field compared with the interest the technologists T_a and the technologist T_b shared. Furthermore, it was also observed that, as the collaboration went on, the level of shared common language was improved and the effectiveness of the communication between participants increased. For instance, the word 'mode' means 'a Max patch' to the technologists, but it means 'persona' to the artist. In the beginning, this different terminology, to some extend, caused a few misunderstanding and confusion between the participants. But eventually, both the technologists agreed that a set of modes in Max/MSP can be considered as a persona and they found it less confusing. Even the artist occasionally used 'mode' and 'persona' interchangeably. As the technologist T_b said in the interview:

> "Sometimes it is confusing but somehow I found that I am getting used to it... now it seems to be far better than before. So the language is kind of problematic." *Extract of the technologist T_b' interview*

Therefore, the pattern drawn from this node set in the GEO case is that the more common background participants shared with each other, the more interest they showed in each other's domain and the more common language they shared during the collaboration.

Node Set 'Mediation'

The node set 'mediation' developed in the context analysis of the COSTART cases contains five nodes (Table 4.6 in Section 4.2.3.2). The following table shows the results of the nodes in this node set (Details about these results can be found in the Appendix A3.1).

Table 5.4: Node set 'Mediation' in the GEO case study

Master node	Category	Node	Results
Communication	Verbal	Talking-conflicts	Talking conflicts between the artist and the technologist T_a happened quite often but talking conflicts between others did not happen very often.
		Interruption	Interruption between the artist and the technologist T_a happened quite often but interruption between others did not happen very often.
		Common-language	In comparison, the artist did not share very much common language with T_a and T_b, but the technologist T_a and the technologist T_b shared a great deal of common language.
	Assisted	Computer-assisted	It happened mainly under the circumstances where participants were interacting with the artefact or working in front of computers and their software applications.
	Non-assisted	Non-computer-assisted	It happened mainly under the circumstances where participants were talking with each other without any mediation (face to face) or with a physical object (e.g. paper) or with drawing/sketching on a paper/white board.

As was observed, computer-assisted communication occurred under two circumstances: participants communicated with each other while interacting with the interactive systems or while they were in front of computers. During interactive-system-assisted communication, it mainly happened when the technologist was interacting with the system to demonstrate to the artist what was achieved so far, or when the artist was interacting with the systems to give feedback (Section 5.2.3.1). During both conditions, it was found that participants did not experience many talking conflicts and the shared level of the common language was relatively high. During the other circumstance of computer-assisted communication, where the artist and the technologists were talking to each other in front of computer screens, it was found that the technologists were mainly explaining some technical issues to the artist and the artist raised some questions or concerns occasionally but overall the communication pattern did not exhibit many talking conflicts.

Moreover, during non-computer-assisted communication, it was found that participants did not have many talking conflicts either. As discussed in Section 5.2.3.1, the topics participants discussed were plans, project budgets or discussion about broad issues in the project, such as the contribution or the inspiration of the project. Thus, we may suggest that the main reason could be that during non-assisted communication, the artist was leading the conversation most of the time and in terms of the topics discussed in non-computer-assisted communication, the technologists were more listeners rather than debaters.

Therefore, the conclusion drawn from the node set 'mediation' in the GEO case is that no significant difference exists between computer-assisted communication and the non-computer-assisted communication in terms of talking conflicts. However, in terms of common language, it shows that participants had more shared common language during computer-assisted communication than non-computer-assisted communication.

Node Set 'Collaboration style'

The last node set 'Collaboration style' developed in the COSTART cases contains seven nodes (Table 4.8 in Section 4.2.3.3). The following table shows the results of the nodes in this node set (Details about these results can be seen in the Appendix A3.1).

Table 5.5: Node set 'Collaboration style'

Master node	Category	Node	Results
Communication	Verbal	Talking-conflicts	Talking conflicts between the artist and the technologist T_a happened quite often but talking conflicts between others did not happen very often.
		Interruption	Interruption between the artist and the technologist T_a happened quite often but interruption between others did not happen very often.
		Common-language	In comparison, the artist did not share very much common language with T_a and T_b, but the technologist T_a and the technologist T_b shared a great deal of common language.
Context	Project Profiles	Outcomes	A multi-media interactive system, which can be explored using the floor pads. The work was exhibited in Beta-space of Sydney Power House Museum from April to May, 2007.
Behaviour	Emotional States	Evaluation	All participants involved in this project provided positive evaluation about the achievement but they also expressed that they wished they had more time to render the system.
	Cognitive Styles of Participants	Exploratory	The first three months in the collaboration was more of an exploratory type of collaboration. During this period, technologists helped the artist to shape his ideas and explore the possibilities about the design of the interface, the design of the interactive system and the quality of the video sequence.
		Goal-driven	The last two months in the collaboration was more of a goal-driven style of collaboration. During that period, all participants focused on very specific goals, such as the quality of the sound, the sensitivity level of the floor pad.

From Table 5.5, we can see that over the five-month collaboration, the first two months of collaboration was exploratory and the last three months of collaboration was goal-driven. In comparing the exploratory style of collaboration and the goal-driven style of collaboration, participants had fewer talking conflicts or interruptions during the exploratory style of collaboration than in the goal-driven style of collaboration. Furthermore, from the *Evaluation* node, the artist was not very pleased during the first two months that some time was not used efficiently. For example, the artist said in the interview that he wished that they spent less time at the beginning of the collaboration on a photographic issue, about how to use visual presentation about the ring walk, so that they could have had more time at the end of the project to work on more important issues.

During the exploratory stage of the collaboration, the activities between participants can be summarized into three steps: first, the artist expressed or explained what he would like to achieve; second, the technologists went away to explore the possibilities of realizing these requirements or making some software components according to these requirements; third, the artist gave feedback about the technologists' achievements. The above three steps were repeated progressively and during the process, as the artist's ideas were shaped, revised and refined, the level of understanding between the artist and the technologists improved and the level of the shared common language between the artist and the technologists was increased. However, during this exploratory stage, the artist's ideas went through various changes, and it is possible that this may have caused some parts of the work made in the beginning less relevant for the final product. For instance, the interface of the GEO project was originally designed with four layers: the passive mode, the interactive mode, the abstractive mode and the persona mode. As was discovered later on in the project, the passive mode could mislead audiences quite often, which affected the audiences' overall understanding of the interactive system. Thus, in the final product, only three layers remained.

In comparison, during the goal-driven stage, which mainly happened in the last two months of the collaboration, participants worked in an intensive period to meet the deadline. At this stage, the majority of the time was spent on the specific goals, such as the sensitivity of the system, movie control and the structure of the text. Moreover, it was found that talking conflicts in the goal-driven style of collaboration appeared quite often especially when certain requirements from the artist could not be achieved within the time limitation. For instance, three weeks before the completion, the artist wanted to change the shape of the navigation sphere on the interface but the technologist T_a turned down this option because it was very difficult to achieve this in the remaining time.

During the explanation, the conversations between these participants during that incident were not going very smoothly because the technologist T_a explained this in a technical way which the artist could not understand thoroughly.

In summary, the results of the node set 'Collaboration style' in the GEO case are: participants had fewer talking conflicts and more shared common language during the exploratory style of collaboration than during the goal-driven style of collaboration; from the evaluation and outcome point of view, participants achieved more during the period of goal-driven style of collaboration than the period of exploratory style of collaboration.

5.3 Protocol Analysis

The study of the GEO case using the context analysis approach was described in the previous section. This section will present the study of the GEO case using protocol analysis approach.

5.3.1 Analysis Process

As mentioned in Section 5.1.2, the data collected in the GEO protocol analysis study consists of direct observation data, field notes and interviews. In contrast to the context analysis study (Section 5.2), only one type of data was used in the protocol analysis: the video-recorded meetings between participants. There were eighteen sections of group-meetings that were observed during the observation period (The detail of each meeting can be found in Table 5.1 of Section 5.1.2). Moreover, the format of the recorded conversation data used in the protocol analysis is different from the previous context analysis: the format used in the context analysis is transcription only and the format used in the protocol analysis is a combination of transcription and audio/video data.

As was mentioned earlier (Section 3.3), the protocol analysis process was assisted by software INTERACT. In the GEO case, the protocol analysis process can be summarized into three steps. First, all the video data was imported into INTERACT software. Second, the protocol analysis coding scheme developed in the COSTART cases (Table 4.9 in

Section 4.3.2) was applied to the GEO data and refined. Third, the analysis results were drawn from the refined protocol analysis coding scheme.

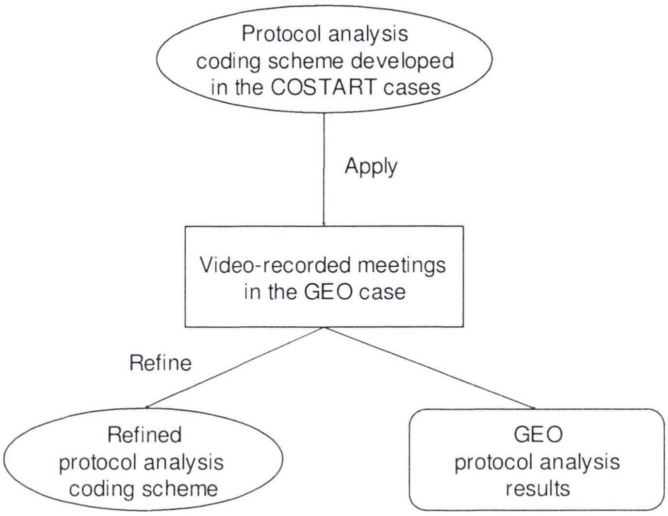


Figure 5.10: Protocol analysis process in the GEO study

5.3.2 Refined Protocol Analysis Coding Scheme

During the refinement process of the coding scheme, in the *Communication mode* category, the two nodes (*Computer-assisted* and *Non-computer-assisted*), which were developed in the COSTART cases, were extended into five nodes: the *Face-to-face* node, *Drawing-assisted* node, the *Object-assisted* node, the *Interactive-system-assisted* node and *Computer-screen-assisted* node. The following table is the refined protocol analysis coding scheme with detailed description.

Table 5.6: Refined protocol analysis coding scheme within the GEO case

Communication behaviour	
Node	**Definition**
Agreement	Agree or disagree with others.
Enquiry	Ask questions, which commonly start with 'when', 'where', 'how' and 'what'.
Evaluation	Analyse an object according to a criterion. It can be either positive or negative.
Hypothesis	Express a personal representation of a subject.
Inform	Provide information with respect to the nature of an object or criterion; illustrate a fact; explain some knowledge new to others; inform a state
Justification	Argue or explain the rationale of a certain choice.
Solution-generation	Suggestions for problem solving and specific applicable plans.
Recall	Retrieve knowledge about previous experience.
Fragment	Sentences which are hard to understand or do not make much sense.
Communication mode	
Node	**Definition**
Computer-screen-assisted	Conversation conducted when participants talk with each other while constantly referring to some components of a computer screen, which could be a desktop screen or laptop screen.
Drawing-assisted	Conversation conducted when participants made some drawing on the paper while communicating with each other
Object-assisted	Conversation conducted when participants talk with each other while constantly referring to an object. In the GEO project, participants spent majority of the time on only one object, a proposal, which is a schematic story board developed by the artist. During this mode, the proposal could be a printed version or a document in PDF format on computer screens.
Interactive-system-assisted	Conversation conducted when participants interacted with the artefact or constantly referring to the digital artefact showing in the interactive space, such as walking around the interactive floor pad area while communicating with each other.
Face-to-face	Conversation conducted when participants talk with each other without using any medium, such as computers, physical objects etc.
Others	Other non-related communication, such as participants made phone calls; or participants work individually and quietly.

5.3.3 Results

In this section, in order to provide insight into these types of communication behaviour and communication modes, three types of analysis were carried out: first, occurrence and the time participants spent on five communication modes within each individual meeting and across meetings were analyzed; second, time distributions of the communication behaviour between participants during the collaboration were analyzed; third, time distributions of the communication behaviour among participants during different communication modes were analyzed. In the following sections, each type of analysis is discussed in detail.

5.3.3.1 Patterns of Communication Behaviour

The following figure presents the distribution of the artist and two technologists' communication behaviour in the GEO case.

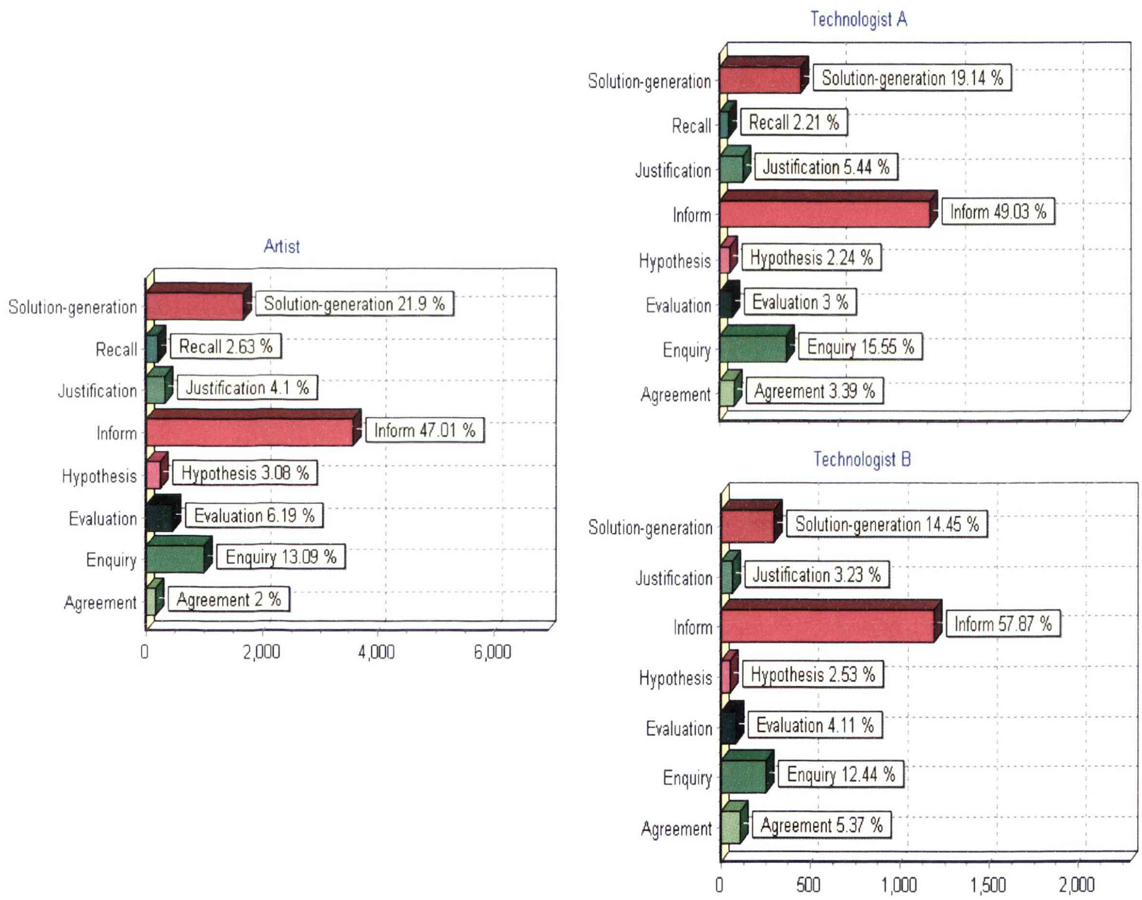


Figure 5.11 Distribution of participants' communication behaviour in the GEO case

According to Figure 5.11, the results were summarized as follows:

- First, the top three types of communication behaviour participants spent most time on are the same, which are inform (A: 47.01%; T_a: 49.03%; T_b: 57.87%), solution-generation (A: 21.9%; T_a: 19.14%; T_b: 14.45%) and enquiry (A: 13.09%; T_a: 15.55%; T_b: 12.44%);

- Second, some communication behaviour distributions between the artist and the technologist T_a are relatively similar, such as inform (A: 47:01%; T_a: 49:03%), and solution-generation (A: 21.9%; T_a: 19.14%). In comparison, the artist's and the technologist T_b's communication behaviour distributions are relatively different. For example, inform (A: 47.01%; T_b: 57.87%) and solution-generation (A: 21.9%; T_b: 14.45%);
- Third, in terms of evaluation behaviour, the artist had the highest percentage between the two technologists (A: 6.19%; T_a: 3%; T_b: 4.11%).

The first result illustrates the types of communication behaviour that participants mainly exhibited: inform, solution-generation and enquiry. This result indicates that, during creative collaboration, artists and technologists communicated with each other mainly in three ways: to inform others with their own knowledge, produce solutions to solve the problems, and ask questions and clarify opinions. The second result, related to the similarities and differences between participants' three major types of behaviour, indicates that the artist and the technologist T_a served a relatively similar role during the majority of the collaboration in terms of informing knowledge, asking questions and generating solution. The third result, related to the evaluation behaviour, shows that the artist made evaluation related decisions more often than the technologists. This indicates that the artist was the leader in that he controlled the evaluation process within the collaboration, such as potential solutions generated in the collaboration or outcome of the collaboration.

In the following sections, communication behaviour will be further investigated under different types of mediation.

5.3.3.2 Patterns of Communication Modes

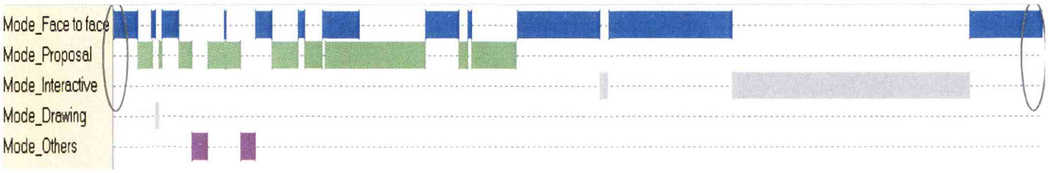
The analysis results of five communication modes was presented in three different forms: sequences of five communication modes in individual meetings, frequencies of each of the five communication modes in every individual meeting and across eighteen meetings and the time participants spent on each communication mode in every meeting and across eighteen meetings.

Sequences

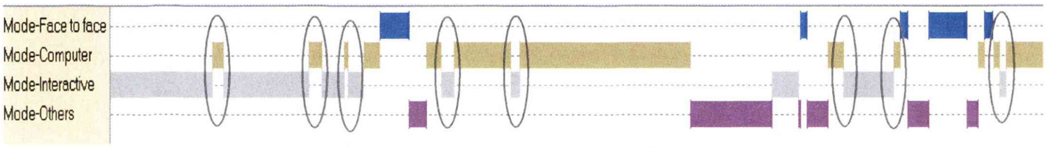
With the assistance of INTERACT software, the mode of communication with precise starting and finishing time in each meeting was captured. In the INTERACT software, these segments were presented and visualized in a time-line based graphic: interaction graph (Mangold 2005). This type of data representation has been found to be very useful for comparing the trajectory of participants' communication modes over a period of time. In this study, an interaction graph was made for each meeting across eighteen meetings (the interaction graphs can be found in Appendix A3.2). From the comparison of the individual meeting's interaction graph across eighteen meetings, three interesting patterns in terms of the sequences of five communication modes within each meeting were found:

1. In fourteen out of eighteen meetings, where the face-to-face mode occurred, the face-to-face mode happened both at the beginning of the meeting and at the end of the meeting;
2. In ten out of fourteen meetings, where both the computer-assisted and the interactive-system-assisted modes happened, the computer-screen-assisted mode and the interactive-system-assisted mode were sequenced one after another.
3. In seven out of eight meetings, where the drawing-assisted mode and the interactive-system-assisted mode were both conducted, the drawing-assisted communication mode took place immediately after the interactive-assisted communication mode.

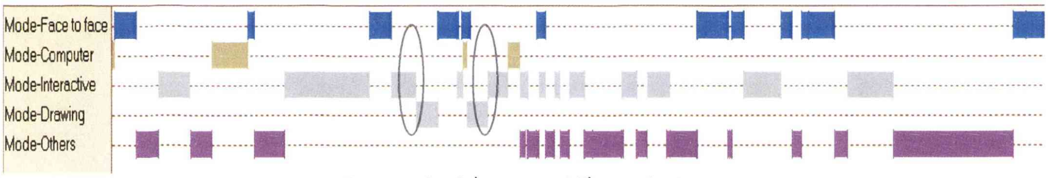
The examples of interaction graphs selected to represent these patterns are illustrated in the following figure.



Present the 1st pattern (9th meeting)



Present the 2nd pattern (17th meeting)



Present the 3rd pattern (13th meeting)

Figure 5.12: Selected interaction graphs to illustrate the 1st, 2nd and 3rd pattern

From the 9th meeting, the first interaction graph of Figure 5.12 shows the first pattern, which is the face-to-face mode conducted at the beginning and end of the meeting. From this interaction graph, we can see that participants started their meeting with the face-to-face communication mode, and then they moved to using the object-assisted mode. During the first half of this meeting, they used these two types of communication mode interchangeably, but in the second half of this meeting, we can see that participants started to use the interactive-system-assisted mode and they finished this meeting with the face-to-face mode. Thus, in the first interaction graph in Figure 5.12, we can clearly see that participants started the meeting with the face-to-face mode and finished the meeting with the face-to-face mode.

Generated from the 17th meeting, the second interaction graph in Figure 5.12 shows the second pattern, which is that participants conducted the computer-screen-assisted and the interactive-system-assisted modes sequentially. This interaction graph shows that participants started the meeting with the interactive-system-assisted mode and finished this meeting with the computer-screen-assisted mode. In between, a great deal of time had spent on the interactive-system-assisted mode and the computer-screen-assisted mode, and only small amount of time had spent on the face-to-face mode. Furthermore, these seven circled places in this graph show that the interactive-system-mode and computer-system-mode were conducted one after another.

The third interaction graph in Figure 5.12, as generated from the 13th meeting, represents the third pattern, which is that participants conducted the drawing-assisted communication immediately before or after they conducted interactive-system assisted communication. This interaction graph shows that participants started and finished the meeting with the face-to-face mode; participants conducted the face-to-face mode and interactive-system-assisted mode with a similar amount of time. Furthermore, the two places marked in this graph indicate that participants conducted drawing-assisted communication in between the interactive-assisted communication.

The patterns identified from the interaction graphs, in relation to the sequences of communication modes, provide us with a view of how participants used these five types of communication modes within a timeline and what the relationship is between these communication modes in terms of time sequences. For instance, one of findings shows participants conducted the interactive-assisted mode and computer-screen-assisted mode sequentially, which indicates that these two modes have a strong inter-relationship. For example, when participants communicated with the mediation tool of interactive artefact, they quite often raised some ideas that they might be able to change the artefact in a certain way, such as, changing the shape of the sphere. Then they left the interactive floor pads area and went to the area where computers were located. These two areas are approximately three metres away from each other (Figure 5.3 in Section 5.1.1). In the computer areas, they worked on some adjustments to the software application, such as changing certain parameters, to realize ideas that had been raised previously in interactive-assisted communication. Moreover, another finding in relation to the sequences shows that drawing-assisted mode happened quite often before or after the interactive-assisted mode, which suggests that participants used drawing on paper to explain ideas which were hard to explain with the mediation tool of having the interactive artefact or computers.

Occurrences

The following table shows the occurrence of each communication mode within eighteen individual meetings, where the last row shows the total number of actions in each mode and the meetings where the value of the occurrence is zero are shaded.

Table 5.7: Occurrence of five communication modes in each meeting

	Face-to-face	Computer-screen-assisted	Interactive-system-Assisted	Object-assisted	Drawing-assisted
1st	31	14	0	13	9
2nd	6	3	2	1	2
3rd	14	5	5	5	0
4th	11	0	14	0	0
5th	14	3	5	5	4
6th	6	3	2	5	0
7th	11	2	1	11	0
8th	4	3	0	4	2
9th	12	0	2	10	1
10th	5	9	3	2	0
11th	5	5	1	1	0
12th	14	9	12	5	0
13th	16	5	22	0	3
14th	3	9	11	1	2
15th	5	12	5	0	0
16th	6	1	10	1	3
17th	5	14	11	0	0
18th	4	10	9	0	0
Total	172	107	115	64	26

The results summarized in Table 5.7 are as follows:

1. Participants did not conduct every type of communication mode in each meeting: there are two meetings where the computer-screen-assisted mode and the interactive-system-assisted mode did not occur; five meetings where the object-

assisted mode did not occur; and ten meetings without the drawing mode. Furthermore, the 3rd and 4th column of Table 5.7 show that the meetings where the computer-screen-assisted mode was not conducted (4th and 9th) are different to those where the interactive-system-assisted mode was not conducted (1st and 8th);

2. Comparing the five communication modes, the communication mode participants conducted most often is the face-to-face mode (172 times); the communication mode participants conducted least often is the drawing-assisted mode (26 times). In addition, the number of times the computer-screen-assisted mode (107 times) took place is very similar to the times of the interactive-system mode (115 times);
3. The 5th column in Table 5.7 shows that the object-assisted mode happened much more often in the first half of the collaboration (from 1st meeting to 9th meeting: 54 times) than the second half of the collaboration (from 10th to 18th meeting: 10 times).

The results illustrated above show some interesting features of these communication modes. The first result shows that the meetings without computer-screen-assisted mode (4th and 9th) or interactive-system-assisted mode (1st and 8th) are different. This indicates that participants used technical facilities, such as computers, software applications and interactive floor pads, as mediation tools to communicate with each other every meeting. The second result shows that there are less than half the meetings where the drawing-assisted mode was conducted and the total occurrence is much smaller than the other modes. This implies that drawing as a traditional way of expressing ideas, did not play a very important mediation role in the art-technology collaboration.

Moreover, the third result indicates that the object-assisted mode occurrence decreased dramatically from the first half of the collaboration to the second half of the collaboration. The proposals, which the artist made to express his artistic ideas about the project, serve as an important mediation role in assisting building up shared understanding between the artist and technologists. During the first half of the collaboration, as the shared understanding between participants was at an initial stage and a great deal of communication was required to make ideas embedded in the proposals applicable and understandable, the occurrence of the object-assisted communication was relatively high. When the collaboration went into the second half, participants decreased the time of the object-assisted mode, where the printed or the digitalized version of the proposal was used. This reflects the fact that participants had built up a better understanding of the artist's goals and requirements than the first half time and participants did not need to refer to the proposals any more. Thus, from this finding, we can suggest that the role of the proposals as a mediation tool for communication can be used to measure the level of understanding between artists and technologists.

Time Distribution

Following the analysis presented in the previous section, the total time length of all instances of each mode across eighteen meetings was further calculated. The following figure presents the time distribution of the five communication modes across eighteen meetings.

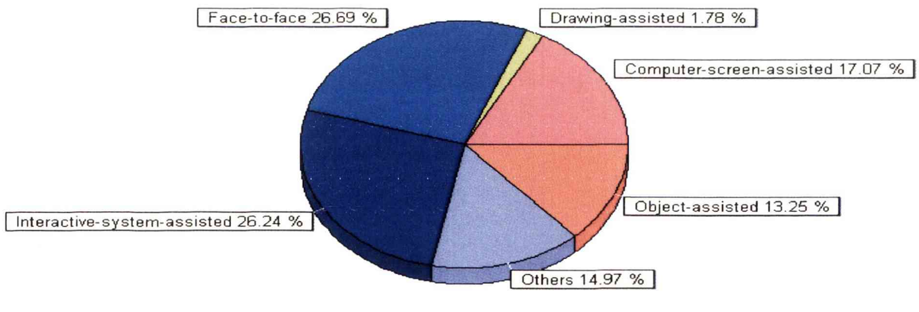


Figure 5.13: Time distribution of each mode in the GEO case study

The order of the communication modes that participants spent the most percentage of the time on to the least percentage of the time is identified from Figure 5.13 as follows: face-to-face (26.69%), interactive-system-assisted (26.24%), computer-screen-assisted (17.07%), object-assisted (13.25%) and drawing-assisted (1.78%). Moreover, it shows that participants spent 43.34% of the time communicating with each other by conducting either the interactive-system-assisted mode or the computer-screen-assisted mode. This finding shows that participants spent almost half the time on the communication modes where computers and their tools were involved. As the previous table 5.7 reveals, the fact that participants conducted either computer-screen-assisted mode or interactive-system-assisted mode each meeting, further confirms and strengthens the conclusion that high technical facilities, such as computers, software applications and interactive floor pads, play a very important role in the creative collaboration between artists and technologists. This suggests that studying creative collaboration involving computer facilities may be able to help artists and technologists to improve the communication between each other and furthermore, improve the collaboration overall. In order to achieve this, in this research, the study of participants' individual communication behaviour under the computer-screen-assisted communication mode and interactive-system-assisted communication mode in the GEO case, was carried out and the results of this study can be found in Section 5.3.3.3.

In addition, the following table shows the total time participants spent on each mode in each meeting in the GEO case. The format of the data presented in the table is hh:mm:ss.

Table 5.8: Time participants spent time on each mode across eighteen meeting

	Face-to-face	Interactive-system-assisted	Object-assisted	Computer-screen-assisted	Drawing-assisted
1st	00:27:03	00:00:00	00:09:17	00:07:58	00:04:19
2nd	00:16:44	00:07:07	00:02:23	00:07:50	00:02:14
3rd	00:36:26	00:07:06	00:05:25	00:06:15	00:00:00
4th	00:09:45	00:18:27	00:00:00	00:00:00	00:00:00
5th	00:31:33	00:05:44	00:06:40	00:09:13	00:03:07
6th	00:08:33	00:05:23	00:16:01	00:10:17	00:00:00
7th	00:11:32	00:06:54	00:30:43	00:01:08	00:00:35
8th	00:02:35	00:00:00	00:25:16	00:08:23	00:00:58
9th	00:23:54	00:19:35	00:20:50	00:00:00	00:00:18
10th	00:15:43	00:05:51	00:07:32	00:15:57	00:00:00
11th	00:07:48	00:02:31	00:03:06	00:03:58	00:00:00
12th	00:12:43	00:18:28	00:04:17	00:06:42	00:00:00
13th	00:15:39	00:24:02	00:00:00	00:03:41	00:03:28
14th	00:03:20	00:37:38	00:00:29	00:12:05	00:01:51
15th	00:04:29	00:35:11	00:12:47	00:00:00	00:00:00
16th	00:18:20	00:27:24	00:00:34	00:01:33	00:01:12
17th	00:06:12	00:24:49	00:23:24	00:00:00	00:00:00
18th	00:04:20	00:14:44	00:40:32	00:00:00	00:00:00
Sum	04:26:48	04:23:01	02:12:39	2:49:50	00:17:31

From Table 5.8, we can clearly see the duration sum of all instances of each mode in each meeting and the total duration of each mode across eighteen meetings. In order to show the insight of this statistical data more clearly, the following line chart was made based on Table 5.8.

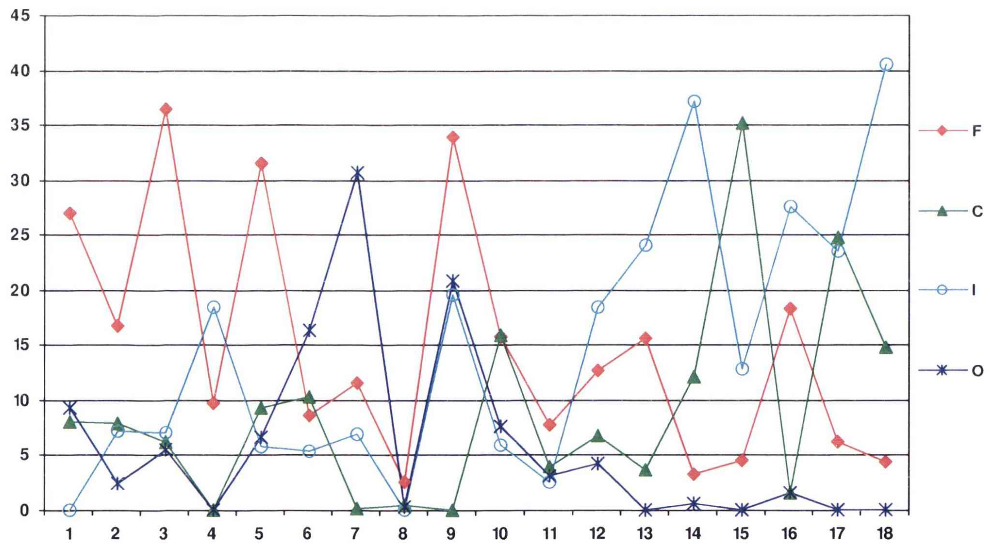


Figure 5.14: Time participants spent on each mode across eighteen meetings

In Figure 5.14, F, C, I and O presents face-to-face, computer-screen-assisted, interactive-system-assisted and object-assisted. The drawing-assisted mode was omitted because it was a very low percentage of the time compared to the other modes as shown in Figure 5.13. The further analysis was mainly carried on the other four modes. The features identified from this figure were summarized as follows:

- The time participants spent on the face-to-face communication decreased gradually from the first meeting to the eighteenth meeting;
- The time participants spent on the interactive-system-assisted communication and computer-screen-assisted communication increased gradually from first meeting to eighteenth meeting;
- The time participants spent on the object-assisted communication increased gradually until the 8^{th} meeting and after the eighth meeting, the time decreased gradually.

These results indicate that the communication time participants spent with the mediation of computers and the interactive artefact gradually increased from first meeting to the eighteenth meeting, the communication time participants spent without any mediation tools gradually decreased from first meeting to the eighteenth meeting, and the communication time participants spent with the mediation of proposals increased during the first eight meetings and decreased in the rest of the ten meetings.

These results can be better understood when they are placed in the context of the whole collaboration. At the beginning of the collaboration, when the understanding between artists and technologists was not fully established, it was observed that participants were mainly working on knowledge exchanges, generation of solutions and goals and refinements of ideas. During this period, the face-to-face communication and the object-assisted communication predominated. However, as the collaboration went on, the shared understanding between artists and technologists was gradually established and participants moved towards spending a great deal of time on computers and interactive system as mediation tools to communicate with each other. During this period, the ideas or goals participants worked on were relatively concrete, such as the quality of the image, the sensitivity of the interactive system etc. This suggests that the use of mediation tools reflects the stages participants work on: when the face-to-face mode and the object-assisted mode are spent a great deal of time on, it is more likely that participants are working in the early stage of the collaboration and there is not much shared understanding which has yet to be built up. In comparison, increasing the time spent on the computer-screen-assisted mode and the interactive-system-assisted mode seems to indicate that a good level of shared understanding has been established.

In order to investigate further how participants used these mediation tools to assist their communication, the distribution of participants' communication behaviour and the relationship between participants' types of communication behaviour and types of communication modes are discussed in the following sections.

5.3.3.3 Relationship Between Communication Behaviour and Modes

In this section, a selected group of communication behaviour will be further analyzed under different types of communication modes for investigating the relationship between communication behaviour and mediation tools. As presented in Section 5.3.3.1, the communication behaviour that participants mainly spent time on is solution-generation, inform, enquiry. In this section, these three types of communication behaviour will be further investigated. Moreover, in order to understand more about the relationship between evaluation issue and communication modes, the evaluation behaviour is also included for further analysis.

The communication modes defined in the COSTART cases are categorized into two types: non-computer-assisted communication mode and computer-assisted communication mode (Section 4.3.2). In the GEO case, the communication modes are further extended into five categories: face-to-face, drawing-assisted, object-assisted, computer-screen-assisted and interactive-system-assisted (Section 5.3.2). In this section, in order to understand the relationship between communication behaviour and the mediation of computers, the selected group of communication behaviour will be analyzed in two communication modes: computer-assisted and non-computer-assisted at first. It is followed by analysing the communication behaviour in four types of communication mode: face-to-face, object-assisted, computer-screen-assisted and interactive-system-assisted to further explore the relationship between communication behaviour and various mediation tools used in the GEO case.

Communication Behaviour Distribution in Two Modes

The following figure presents the communication behaviour distribution in the GEO case under the non-computer-assisted communication mode and the computer-assisted communication mode. 'Other' in Figure 7.5 represents the other four types of communication behaviour which are not shown in detail in this figure: justification, agreement, recall and hypothesis.

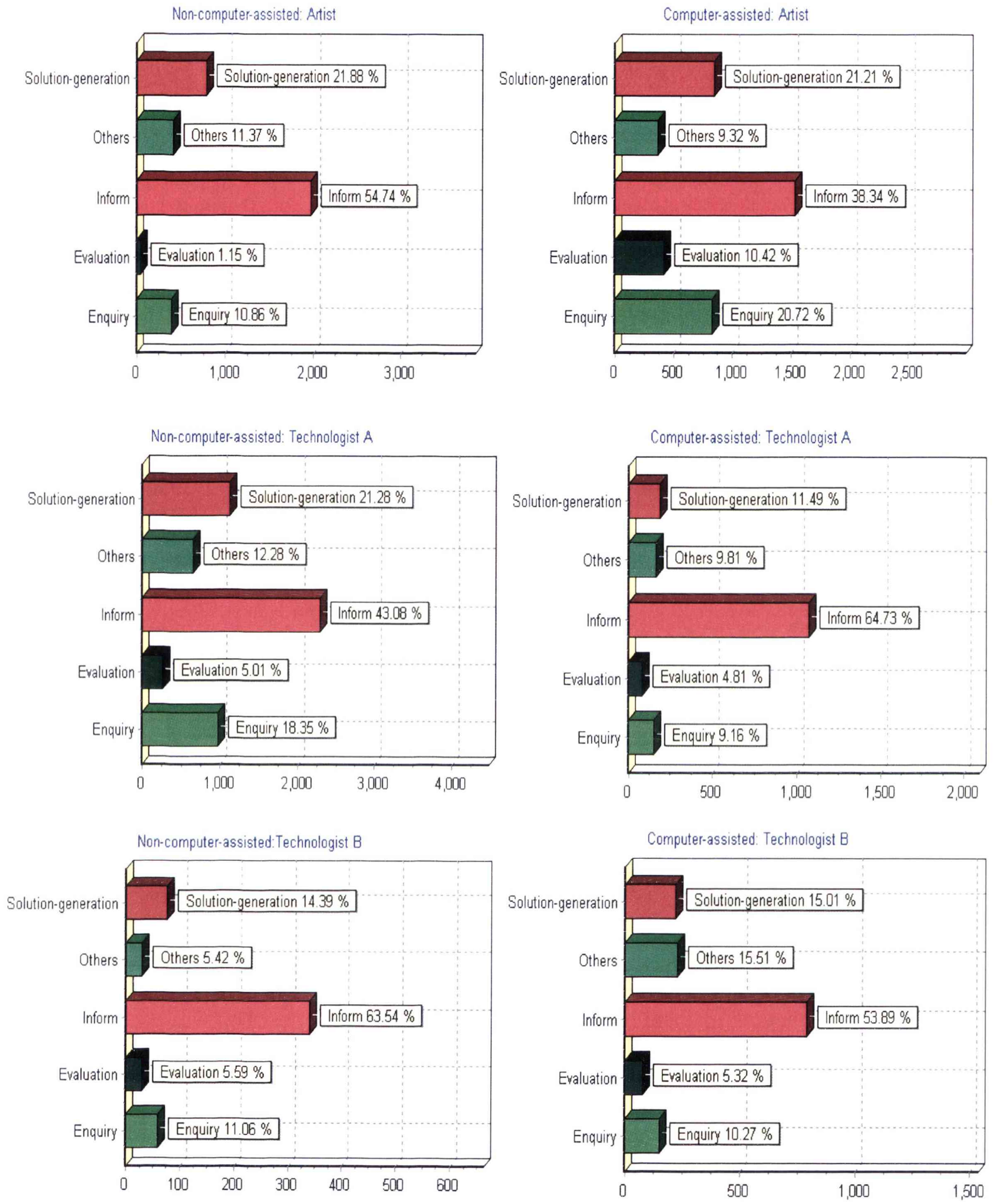


Figure 5.15: Communication behaviour distribution in the GEO case under the non-computer-assisted communication mode and the computer-assisted communication mode

From Figure 5.15, the findings can be summarized as follows:

- **Solution-generation behaviour**: for the artist, it decreased from non-computer-assisted (21.88%) to computer-assisted (21.21%); for the technologist T_a, it decreased from non-computer-assisted (21.28%) to computer-assisted (11.49%); for the technologist T_b, it inceased from non-computer-assisted (14.39%) to computer-assisted (15.01%);

- **Inform behaviour:** for the artist, it decreased from non-computer-assisted (54.74%) to computer-assisted (38.34%); for the technologist T_a, it increased from non-computer-assisted (43.08%) to computer-assisted (64.73%); for the technologist T_b, it decreased from non-computer-assisted (63.54%) to computer-assisted (53.89%);
- **Enquiry behaviour**: for the artist, it increased from non-computer-assisted (10.86%) to computer-assisted (20.72%); for the technologist T_a, it decreased from non-computer-assisted (18.35%) to computer-assisted (9.16%); for the technologist T_b, it decreased from non-computer-assisted (11.06%) to computer-assisted (10.27%);
- **Evaluation behaviour**: for the artist, it increased from non-assisted (1.15%) to computer-assisted (10.42%); for the technologist T_a, it decreased from non-computer-assisted (5.01%) to computer-assisted (4.81%); for the technologist T_b, it decreased from non-computer-assisted (11.06%) to computer-assisted (10.27%).

The above results show the way that the mediation of computers affected artist's and technologists' communication behaviour, which are summarized as follows:

- **Solution-generation**: Two out of three participants' solution-generation behaviour decreased with computers than without. This indicates that participants provided less solution with the mediation of computers than without.
- **Inform behaviour**: the artist's and the technologist T_b's inform behaviour decreased with computers than without whilst the technologist T_a's inform behaviour increased with computers than without. This means that the artist and the technologist T_b tended to exchange more of their own knowledge to each other with the mediation of computers while the technologist T_a tended to use

non-computer-assisted communication to exchange his own knowledge.

- **Enquiry behaviour**: the artist's enquiry behaviour increased with computers than without whilst both the technologists' enquiry behaviour decreased with computers than without. This may show that during the computer-assisted communication the artist asked more questions and made more clarifications and during the non-computer-assisted communication both the technologists tended to raise more questions.
- **Evaluation behaviour**: the artist's evaluation behaviour increased with computers than without whilst both the technologists' evaluation behaviour decreased with computers than without. This indicates that with the help of computers, the artist could provide more evaluation about the artefact or the collaborative process, which may suggest that the artist may have had a more active role than the technologists during the computer mediation environment for evaluating the digital artefact.

In summary, the above findings show that the way that mediation of computers may affect participants' communication behaviour. In terms of the solution-generation behaviour and the inform behaviour, the mediation of computers may decrease both types of behaviour of the artist. In terms of the evaluation behaviour and the enquiry behaviour, the mediation of computers may increase both types of behaviour of the artist but decrease both types of behaviour of the technologists.

Communication Behaviour Distribution in Four Modes

In the previous section, the time distribution of participants' four types of communication behaviour (inform, solution-generation, enquiry and evaluation) was presented in terms of two communication modes: computer-assisted and non-computer assisted. In this section, participants' the time distribution of those four types of communication behaviour will be presented in terms of four communication modes: face-to-face, computer-screen-assisted, drawing-assisted, object-assisted and interactive-system-assisted. The results are presented as follows.

Artist

The following figure presents the distribution of the artist's communication behaviour under four different communication modes (Figure 5.16), where 'Other' in Figure 5.16 represents the other four types of communication behaviours which are not shown in detail in this figure: justification, agreement, recall and hypothesis.

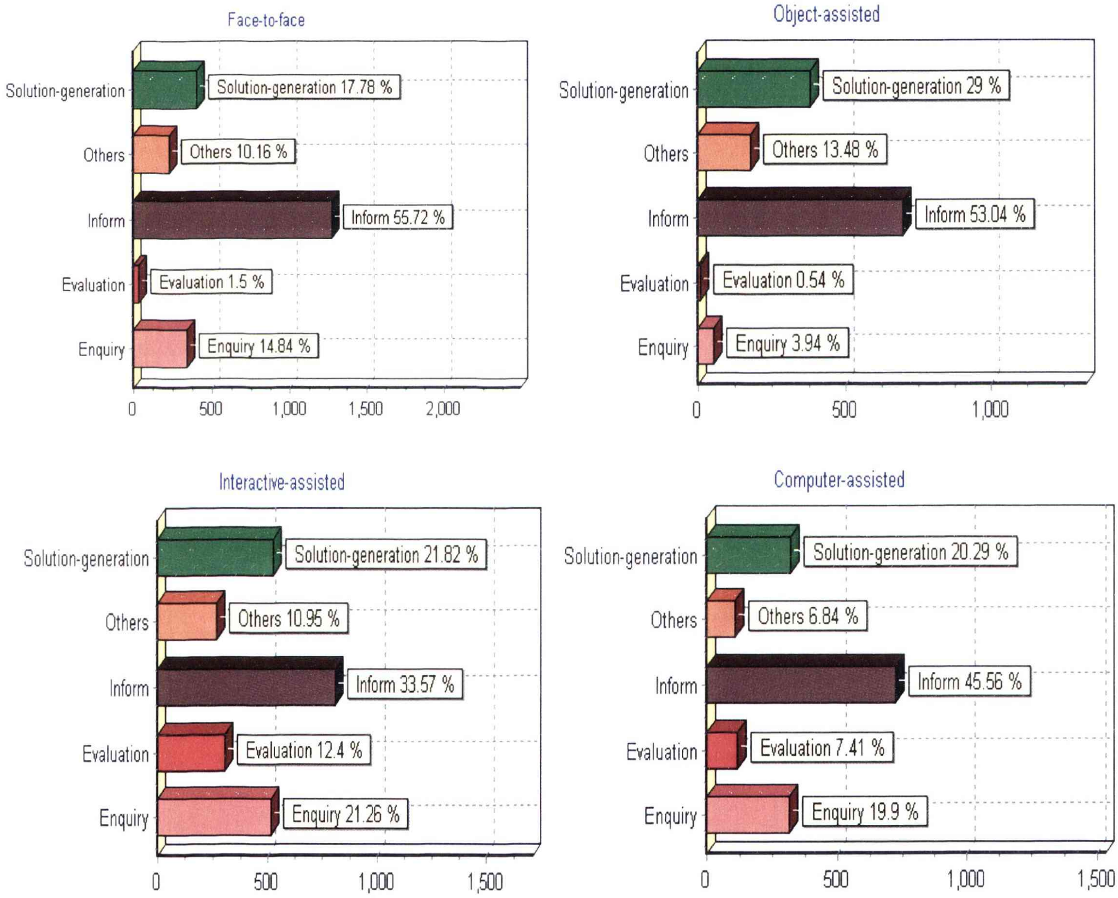


Figure 5.16: Distribution of the artist' selected group of communication behaviour during four communication modes in the GEO case

According to Figure 5.16, the results of the comparisons of the distribution of the artist's communication behaviour between four types of communication modes are:

- In terms of the solution-generation behaviour, the distribution of this behaviour is the highest in the object-assisted mode (F: 17.78%; O: 29%; I: 21.82%; C:

20.29 %);

- In terms of the inform behaviour, the distribution of this behaviour is the highest in the face-to-face mode (F: 55.72%; O: 53.04%; I: 33.57%; C: 45.56%);
- In terms of the enquiry behaviour, the distribution of this behaviour is the highest in the interactive-assisted mode (F: 14.84%; O: 3.94%; I: 21.26%; C: 19.9%);
- In terms of the evaluation behaviour, the distribution of this behaviour is the highest in the interactive-assisted mode (F: 1.5%; O: 0.54%; I: 12.4%; C: 7.41%).

The above results show that:

- First, during the face-to-face mode, the artist tended to inform more about his artistic knowledge and the aesthetic issues of the project more often than when he was in other three types of communication mode;
- Second, during the interactive-system-assisted communication mode, the artist tended to ask more questions, such as the possibility of changing the artefact in a particular way and the inside of the technical components of the system, with the mediation of interactive artefacts. Furthermore, during this mode, the artist exhibited more evaluation behaviour, which indicated that the artist gave more instructions about his preferences during the interactive-system-assisted mode than in the other three modes;
- Third, during the object-assisted mode, the artist suggested many solutions in relation to the proposals he presented and within the solutions, he explained the reasons why he wanted the artefact to be designed in a particular way.

Technologist T_a

Figure 5.17 shows the distribution of the technologist T_a's group of selected communication behaviour under four different communication modes. ('Other' in Figure 5.17 represents the other four types of communication behaviours which are not shown in detail in this figure: justification, agreement, recall and hypothesis).

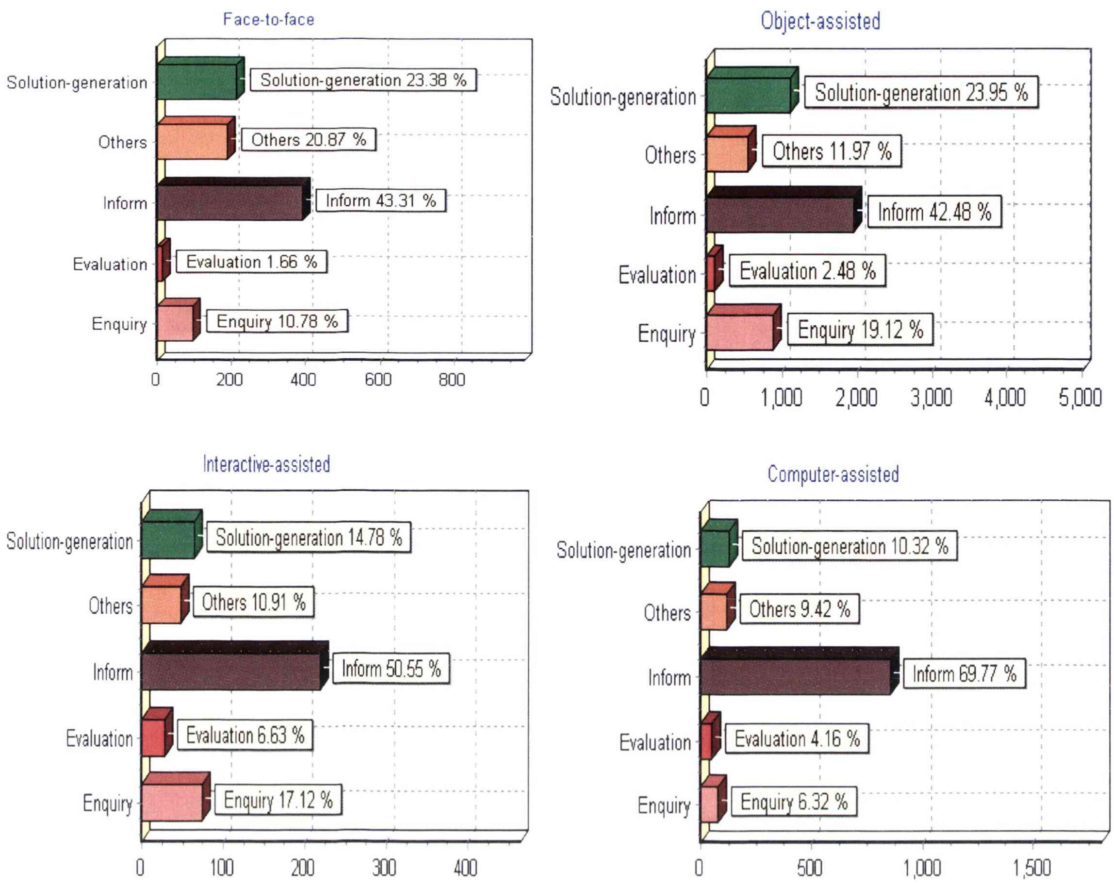


Figure 5.17: Distribution of T_a' selected group of communication behaviour during four communication modes in the GEO case

According to Figure 5.17, the results of the comparisons of T_a's communication behaviour between four types of communication modes are:

- In terms of the solution-generation behaviour, the distribution of this behaviour is the highest in the object-assisted mode (F: 23.38%; O: 23.95%; I: 14.78%; C: 10:32%);
- In terms of the inform behaviour, the distribution of this behaviour is the highest in the computer-screen-assisted mode (F: 43.31%; O: 42.48%; I: 50.55%; C: 69.77%);
- In terms of the enquiry behaviour, the distribution of this behaviour is the highest in the object-assisted mode (F: 10.78%; O: 19.12%; I: 17.12%; C: 6.32%);
- In terms of the evaluation behaviour, the distribution of this behaviour is the highest in the interactive-assisted mode (F: 1.66%; O: 2.48%; I: 6.63%; C:

4.16%).

The above results show that:

- First, under the object-assisted mode, the technologist T_a exhibited the following types of behaviour more often than under the other three modes: solution-generation and enquiry. This indicated that with the mediation of proposals, T_a tended to provide more solutions and asked more questions;
- Second, under the interactive-assisted mode, the percentage of T_a's evaluation behaviour is the highest between four modes, which indicated that T_a intended to express his opinions more often about his evaluation related to the artefact when participants were interacting with the artefact than in other circumstances;
- Third, under the computer-screen-assisted mode, the percentage of T_a's inform behaviour is the highest in the computer-screen-assisted mode between four modes, which means that T_a intended to inform to others of his knowledge, such as knowledge of the Max/MSP software application, while the communication was mediated with computers.

Technologist T_b

Figure 5.18 represents T_b's communication behaviour distribution under four different communication modes. (Other' in Figure 5.18 represents the other four types of communication behaviours which are not shown in detail in this figure: justification, agreement, recall and hypothesis).

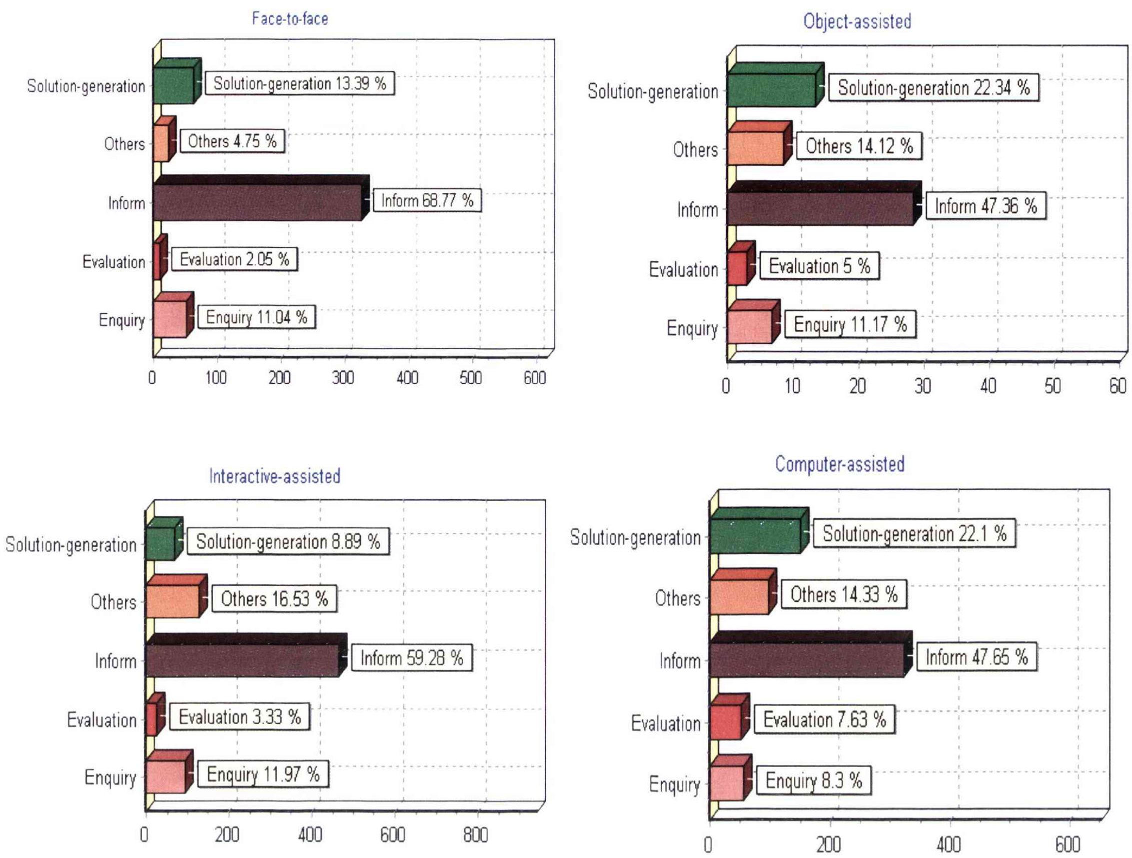


Figure 5.18: Distribution of T_b' selected group of communication behaviour during four communication modes in the GEO case

According to Figure 5.18, the results of the comparisons of T_b's communication behaviour between four types of communication modes are: in terms of the solution-generation behaviour, the distribution of this behaviour is the highest in the object-assisted mode (F: 13.39%; O: 22.34%; I: 8.89%; C: 22.1%); in terms of the inform behaviour, the distribution of this behaviour is the highest in the face-to-face mode (F: 68.77%; O: 47.36%; I: 59.28%; C: 47.65%); in terms of the enquiry behaviour, the distribution of this behaviour is the highest in the interactive-assisted mode (F: 11.04%; O: 11.17%; I: 11.97%; C: 8.3%); in terms of the evaluation behaviour, the distribution of this behaviour is the highest in the interactive-assisted mode (F: 1.4%; O: 5%; I: 3.33%; C: 7.63%).

The above results show that: first, the distribution of the inform behaviour is the highest in the face-to-face mode between these four modes, which means that T_b provided his knowledge to others more often without mediation than with mediation; second, the distribution of the solution-generation behaviour is higher in the object-assisted mode than in the other modes, which means that T_b preferred to generate solutions with the proposal as a mediation tool; third, the distribution of the enquiry behaviour is higher in the interactive-system-assisted mode than in other three modes, which means that with the mediation of interactive-system, T_b tended to ask questions, such as whether the artist wanted some particular effects on the artefact to be made.

In summary, these results show that, in terms of the three types of communication behaviour that participants exhibited most often (solution-generation, inform and enquiry):

- In terms of the inform behaviour, the finding suggests that the artist used the inform behaviour to illustrate his artistic knowledge more often and the technologist T_b used this behaviour to illustrate his technological knowledge more often in the face-to-face mode than the other types of mode. On the contrary, the technologist T_a used the inform behaviour more often in computer-screen-assisted mode than other types of communication mode. The reasons for this differentiation may be that, during the creative collaboration, the artist' and technologists' familiarity with the medium is different. For instance, the artist was not familiar with the Max/MSP visual programming in the computers while technologists were spending a great deal of time demonstrating works in progress or explaining certain technological concepts.
- In terms of the solution-generation behaviour, all participants produced more solutions with proposals as a mediation tool than with other types of mediation. This finding could indicate that proposals might help the participants provide more creative solutions during the collaboration. The reasons may possibly be that the content of the creative proposal itself contains solution-related information and when participants communicate with each other over the proposal, they mainly discuss the possibilities and the actual plan to realize these

ideas embedded in the proposals. The proposal itself is a realisation of the artist's ideas that is a tangible artefact to work with as distinct from a verbalised and, possibly less fully thought out verbal description given in early project meetings.

- In terms of the enquiry behaviour, most participants asked more questions with the interactive artefacts as a mediation tools than others. This finding may suggest that working with an interactive artefact could raise more questions for participants to ask and the more questions the participants asked, the better they could understand each other. For example, the artists could understand better the potential of the technology for their artistic goals and the technologists could become more aware of what the artistic requirements were and what the artists' concerns were.

5.4 Summary

This chapter presented a study of a recent art-technology collaboration project named GEO. During the study, the analysis framework developed in the COSTART study (Chapter 4), consisting of a context analysis coding scheme and a protocol analysis coding scheme, was applied to the data collected in the GEO project. During this process, the analysis framework was further refined. The major refinement of both of the coding schemes in the GEO case is related to the types of communication modes: five communication modes were further identified: face-to-face, computer-screen-assisted, interactive-system-assisted, object-assisted and drawing-assisted. The refined context analysis coding scheme was presented in Section 5.2.2 and the refined protocol analysis coding scheme was presented in Section 5.3.2. The findings of this study contain two parts: the context analysis results drawn within the refined context analysis coding scheme (Section 5.2.3) and the protocol analysis results drawn within the refined protocol analysis coding scheme (Section 5.3.3). In the next chapter, the findings of the context analysis and the protocol analysis in the COSTART and the GEO studies will be compared and the results will be discussed.

6 Study Comparisons and Discussion

In this chapter, the study comparisons between the COSTART and the GEO cases are presented, the general discussion of the findings and the effectiveness of analysis framework is made. In the first section, the similarities and differences between the COSTART and GEO projects are described. In second section, the context analysis findings of the COSTART study (Section 4.2.3), and the GEO study (Section 5.2.3) are compared and the results are discussed. In the third section, comparisons between the protocol analysis findings of the COSTART study (Section 4.3.3) and the GEO study (Section 5.3.3) are made and the results are discussed. Following that, a discussion of the results from the GEO study is presented. Finally, the analysis framework, developed in the series of case studies is summarized and the effectiveness of this framework is discussed.

6.1 Study Features

In this section, a comparison of the features in the COSTART and GEO projects is provided. The findings and implications given in the following sections need to be considered in that light. As presented previously, the COSTART project contains several cases, which were designed and conducted in similar settings and three cases (Case A, Case B and Case C) from this project were investigated further in this research (Section 4.1). In order to compare the features of the three COSTART project cases with the GEO project, the COSTART project as a whole was compared with the GEO project. The similarities are summarized from three perspectives: research aims, project settings and study approaches. Details are as follows:

- Research aims

  Both projects aimed to investigate/understand the creative process of art-technology collaboration, where digital artists interact with technologists to produce digital artefacts. In both projects, the focus was the actual creative collaboration in progress instead of retrospective accounts of the creative process that most studies of creativity have drawn on.

- Project settings

  Both projects were set in an environment with the notion of 'studio as laboratory', which is an experimental or development place for practice and research to coexist and combine two key ingredients: creativity in naturalistic settings and actual creative work in progress. At the end of the project, the outcomes were exhibited in a public place: in the COSTART project, the outcomes were exhibited in the Creativity and Cognition Conference 2002, while in the GEO project, the outcome was exhibited from April to May, 2007, in Beta-space of Sydney Powerhouse Museum.

- Study approaches

  In terms of data collection, a similar data collection method was used in both the COSTART and the GEO studies: a combination of observation and semi-structured interviews. During the observation, participants' activities were audio/video recorded and field notes were taken and at the end of each project semi-structured interviews were conducted. In terms of data analysis, in both studies, context analysis was carried out to provide an analysis in breadth and protocol analysis was followed to provide an analysis in depth.

In summary, the similarities discussed above show that the cases in the COSTART project have a great deal of similarity with the GEO case in terms of research aims, the way the research was set up and most importantly, the methods used for data collection and data analysis. In this research, the data analyzed in the COSTART cases includes field notes, interviews and a selection of audio/video conversation records between artists and technologists over the collaboration period. In comparison, the data analyzed in the GEO case includes a similar data set: field notes, interviews and conversation/collaboration activity records. Both of the data sets went through a similar analysis process, where a combination of context analysis and protocol analysis was carried out, and two correspondent coding schemes were developed and refined.

Despite these similarities, in addition, there exist some variations between the COSTART and GEO cases, such as project structures, group composition, observation opportunities and facilities. More details are as follows:

- Project structures

  Each case conducted in the COSTART project consisted of three stages over five months: three-month pre-residency preparation, five-day-residency and one-month exhibition. The GEO project consisted of a series of group meetings which occurred once a week for five months and one month exhibition.

- Group composition

  In each COSTART case, mainly one artist and one technologist participated while in the GEO project, the participants included two technologists, one artist and one graphic designer.

- Observation opportunities and facilities

  The data collection methods in the COSTART project were carried out using audio/video-recording facilities to record selected collaboration activities over an intensive five days residency, whilst during the GEO project, the observer video-recorded the group meetings/activities every week over the five months period.

In the way this research was carried out, the impact of the variations listed above have been minimized. For example, the data analyzed in the COSTART cases represented sequences of conversations between artists and technologists over several days during the intensive collaboration period, and in comparison, the data analyzed in the GEO case represented a similar sequence of conversations between artists and technologists with a lower-frequency of occurrence (once a week) and a longer span of collaboration (five months). Furthermore, in relation to the differences of the observation facilities, using video facilities during the observation of the GEO case permits a refined analysis where results have more variety than in the COSTART cases.

In the following sections, at first, comparisons will be made between the COSTART and GEO studies in terms of context analysis and protocol analysis and followed by the discussion from the findings of the GEO study.

6.2 Comparisons Using Context Analysis Method

In this section, a comparison of context analysis results between the COSTART and GEO studies will be made in terms of the findings drawn from three node sets: 'Sharing', 'Mediation' and 'Collaboration style' previously presented (Section 4.2.3 and Section 5.2.3.2). The 'Sharing' node set explores aspects of the relationship between shared language, shared background and shared interest of artists and technologists. The 'Mediation' node set investigates aspects of the role of computers as mediation tools during the communication between artists and technologists. The last node set 'collaboration style' identifies the differences between a goal-driven type of collaboration and an exploratory type of collaboration. The findings, drawn from each node set in the COSTART and GEO studies, are discussed as follows.

6.2.1 Sharing

In this section, in relation to participants' shared background, shared interests and shared language, the results in the COSTART and the GEO studies are summarized. As defined previously in Section 4.2.3.1, background includes participants' major knowledge domain and their related expertise; shared interest refers to the circumstances where artists showed strong interests in technical parts or technologists showed strong interest in aesthetic issues; shared language is the language, demonstrated by terminology used, that is commonly held between each individual participant.

The results from the COSTART study (Section 4.2.3.1) show that the more background participants shared with each other, the more interest they showed in each other's domain and the higher level of shared language they used during the collaboration. For instance, the level of shared language between participants in Case B and Case C, was observed to be higher than the level of shared language in Case A due to both the artists in Case B and Case C having relatively more experience in programming than the artist in Case A. In relation to shared interest, a similar pattern was found: the level of shared interest was higher in Case B and Case C than in Case A.

During the GEO study (Section 5.2.3.2), it was found that the level of shared background is much higher between the technologist T_a and the technologist T_b than the level of shared background between the technologist T_a and the artist or the technologist T_b and the artist due to both of the technologists having strong expertise in computer programming and limited knowledge in artistic vision while the artist having limited computer expertise but extensive knowledge in art practice. Moreover, it was found that the level of shared language and shared interest between both technologists was much higher than the level of shared language between the technologist T_a and the artist or the technologist T_b and the artist.

In order to compare the results between the COSTART and the GEO studies, a three-level scale was made: *Very Little To None Shared*, *Evenly shared* and *A Lot To Completely Shared*. *Very Little to Non Shared* means there is a limited amount of sharing between participants. *Evenly shared* means there is a good level of sharing between participants. *A Lot To Completely Shared* means there is a great deal of sharing. In terms of the level of the shared-background, a *Very Little To Non Shared* example is in Case A: the artist did not have any expertise in 3D studio Max and the technologist did not have a great deal of knowledge in artistic practice. An *Evenly-shared* example is in Case C: the artist did have some reasonable knowledge about programming and the technologist had some work experience in design practice and art-technology collaboration. In addition, in the GEO case, the level of the shared background between the technologists T_a and T_b is a good example of *A Lot To Completely Shared*, where both the technologists majored in computer science. Similarly, these three levels are used to compare the level of shared interest and shared language between participants in each case. The following table presents the summary of the comparison where 1 represents *Very Little To None Shared*, 2 represents *Evenly Shared*, 3 presents *A Lot To Complete Shared*.

Cases		Participants	Shared-background	Shared-interest	Shared-language
COSTART	Case A	A1& T1	1	1	1
	Case B	A2 & T2	2	2	2
	Case C	A3 & T3	2	2	2
GEO	Case D	A4 & Ta	1	2	2
		A4 & Tb	1	2	2
		Ta & Tb	3	3	3

Table 6.1: Comparison between the COSTART and the GEO studies in relation to shared background, shared interest and shared language between participants

From the summary of the findings from both the COSTART and GEO cases, shown in Table 6.1, we may suggest that there exists a link between the shared background, shared interest and shared language of participants in art-technology collaboration: the more background participants shared with each other, the more interest they showed in each other's domain and the more language they shared with each other. Further discussion can be found in Section 6.2.4.

6.2.2 Mediation

In this section, the findings in relation to the 'Mediation' node set from the COSTART and GEO cases are summarized. The 'Mediation' node set, as mentioned in Section 4.2.3.2 (COSTART) and Section 5.2.3.2 (GEO), aims at studying how computers, as mediation tools during the collaboration, affect the communication between artists and technologists. The results in the COSTART cases indicate that the mediation of computers decrease the level of talking conflicts and improves the level of shared language between artists and technologists (Section 4.2.3.2). In the GEO case, there are no significant differences between computer-assisted communication and non-computer-assisted communication in terms of talking conflicts. However, in terms of shared language, it was found that participants had more shared language during computer-assisted communication than the communication they conducted without any mediation tools (Section 5.2.3.2). Thus, the finding drawn from this section between the COSTART and the GEO cases is that computers may improve the level of shared language between artists and technologists. The discussion of this finding can be found in Section 6.2.4.

6.2.3 Collaboration Style

The findings related to the feature of different styles of collaboration from the COSTART and GEO cases are summarized in this section. Two styles of collaboration were identified: goal-driven and exploratory. During the goal-driven style of collaboration, the subjects participants worked on were very specific, such as the colour and the movements of the artefact. During the exploratory style of collaboration, participants worked on some more general solutions; such as the potential possibility of certain software (Table 4.4 in Section 4.2.2).

The context analysis results in the COSTART study (Section 4.2.3.3) show that participants had fewer talking conflicts and more shared language during the exploratory style of collaboration than during the goal-driven style of collaboration. Furthermore, in terms of the evaluation of the process and outcomes, participants in Case A, where the goal-driven type of collaboration was mostly carried out, were relatively productive and the evaluation of their final outcome was relatively positive. While in Case B and Case C, where an exploratory style of collaboration was conducted the majority of the time, participants were observed to be less productive and the final outcome was not given a high evaluation.

In the GEO study, it was observed that during the first three months, participants engaged in a more exploratory style of collaboration and during the last two months, participants engaged in a more goal-driven style of collaboration (Section 5.2.3.2). It was also found that participants were more productive during the goal-driven style of collaboration than during the exploratory style of collaboration. Thus, the findings from the GEO case confirmed what was found in the COSTART cases, which was that during the exploratory style of collaboration, participants had a higher level of shared language, a lower level of talking conflicts and are less productive than during the goal-driven style of collaboration. The discussion of this finding can be found in Section 6.2.4.

6.2.4 Discussion

In this section, the context analysis findings listed previously will be discussed. As Candy and Edmonds (2002c) suggest that developing a common language which both parties can understand and work with is essential in art-technology collaboration, this research further investigates the aspects of shared language between artists and technologists (Section 2.4). For example, it was found that shared language is related to the level of common background: if participants have more shared background with each other, they are more likely to develop a higher level of shared language during the collaboration (Section 6.2.1). Furthermore, we observed in these case studies that the collaboration process involved the development of shared language. As was discussed previously, during communication, common ground includes mutual knowledge, mutual beliefs and shared mutual assumptions and through communication, common ground is updated moment by moment (Clark & Brennan 1991). This finding indicates that the development of shared language, might coincide with the accumulation of common ground. In other words, during the process of each successful conversational exchange, the common ground has accumulated to that point. Moreover, computers as mediation tools may improve the level of shared language (Section 6.2.2) and additionally, shared language can be affected by styles of collaboration: the language in the exploratory style of collaboration is more likely to be at a higher shared level than in the goal-driven style of collaboration (Section 6.2.3).

These findings identify the factors which can affect shared language and help us understand the development process of shared language between artists and technologists. It was found in art-technology collaboration, developing a shared language can facilitate the establishment of a common understanding between artists and technologists (Edmonds et al. 2005) (Section 2.4). The findings in this research suggest that, in order to build up a good common understanding, artists and technologists should be aware of some ways that could increase the level of shared language, such as:

- Increase the level of shared background by learning knowledge from others, such as, technologists acquire more knowledge about aesthetic concepts and artists learn about computer programming;

- Increase the level of shared interest by participating more actively in the parts which are non-traditional for the participants, such as, artists take part in technological related discussions and technologists take part in artistic related discussions;
- Increase the usage of computers as communication mediation tools during the collaboration, such as, use computers to demonstrate ideas/potential solutions/concepts as much as possible during the collaboration;
- Increase the possibilities to conduct a more goal-driven style of collaboration instead of a more exploratory style of collaboration, such as making a plan as detailed as possible and as realistic as possible.

However, interactive art practitioners also need to keep in mind that shared language does not necessarily result in a successful outcome (Zhang & Candy 2006b). In other words, it does not mean that more sharing leads to better outcomes. For example, in Case A of the COSTART project, the shared language participants developed was relatively poor but the outcome of this case was positive; while in Case B of the COSTART project, in comparison, participants did have a very good level of shared language, but the outcome was not as successful. Thus, shared language is not the only predictor of a successful outcome. It is important to realize that building up a reasonably good level of shared language is beneficial for an effective and productive collaboration. However, the existence of a differentiated language between artists and technologists also needs to be acknowledged as an unavoidable component of the nature of creative collaboration. Just like the example discussed in Section 2.4 previously: in a recent successful art-technology collaboration project (Gemeinboech & Dong 2006), the artist and the engineer acknowledged the existence of different territories of knowledge and the different voice when they were describing their perspectives. They considered that the differentiated language formulated between them was related to a way of working and thinking and that neither de-legitimizes their respective territories of knowledge nor minimizes the novel ideas generated between them. This example indicated that during the collaboration between artists and technologists, a high level of shared-language between artists and technologists does not necessarily result in a successful collaboration and it is possible to overcome language differentiation in order to achieve an effective and successful collaboration. The key factor was being able to establish a set of agreed objectives and acknowledge the different contributions each person would be able to make to the collaboration albeit working with different languages.

6.3 Comparisons Using Protocol Analysis Method

In this section, the comparisons of protocol analysis results between the COSTART cases (Case A, Case B, Case C) and the GEO case (Case D) are made in terms of two perspectives: the time distribution of the eight types of communication behaviour and the time distribution of a group of selected communication behaviour across two communication modes: the non-computer-assisted communication mode and the computer-assisted communication mode.

6.3.1 Behaviour Comparisons Between Artists and Technologists

6.3.1.1 Comparison

In this section, findings related to the differences and the similarities between artists' communication behaviour and technologists' communication behaviour will be illustrated.

Similarity between artists' and technologists' communication behaviour

The following table shows the top three types of communication behaviour participants spent most time on in the COSTART and GEO cases, where INF, SO-GE, EVA, ENQ and JUS represent the behaviour of inform, solution-generation, evaluation, enquiry and justification.

Table 6.2: Top three types of communication behaviour participants spent most time on in the COSTART and GEO cases

			Level 1		Level 2		Level 3	
			Behaviour	Percent	Behaviour	Percent	Behaviour	Percent
COSTART	Case A	A_1	INF	32.11%	SO-GE	26.71%	EVA	10.59%
		T_1	INF	31.65%	SO-GE	23.23%	ENQ	19.59%
	Case B	A_2	INF	39.02%	SO-GE	19.03%	JUS	14.8%
		T_2	INF	45.4%	SO-GE	18.96%	ENQ	13.97%
	Case C	A_3	SO-GE	34.15%	INF	21.03%	ENQ	10.94%
		T_3	INF	47.38%	SO-GE	20.69%	ENQ	12.96%
GEO	Case D	A_4	INF	47.01%	SO-GE	21.9%	ENQ	13.09%
		T_{mean}	INF	53.45%	SO-GE	16.8.%	ENQ	13.95%

The results listed in Table 6.2 can be referred back to Figure 4.8, Figure 4.9 and Figure 4.10 in Section 4.3.3.1 and Figure 5.11 in Section 5.3.3.1. In order to be able to make the comparisons between the COSTART and GEO cases, the average time distribution of communication behaviour between T4 and T5 in the GEO was made (presented in Table 6.2 as T_{Mean}). The 'level 1', 'level 2' and 'level 3' in Table 6.2 are used to present the communication behaviour which had the highest percentage, the second highest percentage and the third highest percentage in terms of time distribution. The results shown from Table 6.2 show that the top three types of communication behaviour participants in the GEO case spent most time on are inform, solution-generation and enquiry. In the COSTART cases, from Table 6.2, in terms of the top three types of communication behaviour participants spent most time on, we can see that fifteen out of a total number of eighteen kinds of behaviour are inform, solution-generation and enquiry, which equate similarly to the GEO results.

Thus, we can conclude in both the COSTART and GEO studies, in terms of eight types of communication behaviour (inform, solution-generation, enquiry, evaluation, justification, recall, hypothesis and agreement) investigated in the research, the top three types of behaviour that participants spent a substantial amount of time on are the inform behaviour, solution-generation behaviour and enquiry behaviour. The discussion of the similarities between artists' communication behaviour and technologists' communication behaviour can be found in Section 6.3.1.2.

Differences between participants' communication behaviour

The differences between the artists' and the technologists' communication behaviour, presented in the COSTART study (Section 4.3.3.1) and the GEO study (Section 5.3.3.1), have a great deal of similarity. In both projects, the aspects of two types of communication behaviour are same in terms of time distribution. Table 6.3 summarizes the results of these types of behaviour (The results listed in the table can be referred back to Figure 4.8, Figure 4.9 and Figure 4.10 in Section 4.3.3.1 and Figure 5.11 in Section 5.3.3.1). 'T_{Mean}' in Table 6.3 is used to present the average communication behaviour distribution between T4 and T5 in the GEO case.

Table 6.3: Two types of communication behaviour in COSTART and GEO cases

	COSTART						GEO	
	Case A		Case B		Case C		Case D	
	A_1	T_1	A_2	T_2	A_3	T_3	A_4	T_{mean}
Solution-generation	26.71%	23.23%	19.03%	18.96%	34.15%	20.69%	21.9%	16.8%
Enquiry	7.46%	19.59%	7.58%	13.97%	10.94%	12.96%	13.09%	13.95%

From Table 6.3, we can see that in both the COSTART and GEO studies:

- All artists spent a lower percentage of time on enquiry behaviour than the technologists did;
- All artists spent a higher percentage of time on solution-generation behaviour than the technologists did.

The differences listed above show that: artists spent a higher percentage of time on generating solutions to solve the problems than technologists did while technologists spent a higher percentage of time on asking questions, clarifying concepts and ideas. More discussion about the differences of participants' communication behaviour can be found in the following section.

6.3.1.2 Discussion

In this section, the similarities and differences in communication behaviour between artists and technologists, as presented in the above section, are discussed.

One of the similarities is that inform behaviour is the type of communication behaviour participants in art-technology collaboration spent most time on (Section 6.3.1.1). As inform behaviour was defined as the type of behaviour participants mainly used to handout information and distribute knowledge (Table 5.6 in Section 5.3.2), this finding reveals that in both projects, participants took a great deal of time on informing each other about their knowledge, providing information with respect to the nature of objects or criteria. However, it does not necessarily mean that it is the most important behaviour in terms of the contribution to establishing shared understanding. Previous research has identified that the shared understanding of interdisciplinary collaboration is not meant to only refer to sets of shared knowledge, but also to synergistic aggregation of the individual mental models to present similarity, overlap, and complementarity within teams (Langan-Fox, Anglim & Wilson 2004), by which they mean, during the interdisciplinary collaboration, the individual team members provide explanation about the task, coordinate their actions and adapt their behaviour to the demands of the task (Section 2.1). From Langan-Fox's statement, we can assume that the solution-generation and the enquiry behaviour are more likely to directly impact the process of synergistic aggregation than the inform behaviour does. In addition, it was suggested that in the literature review previously (Section 2.4) that when searching for solutions, different views are useful in order to broaden the solution space (Badke-Schaub et al. 2007) but in order to use distributed knowledge, at least a reasonably good level of shared understanding was required.

Moreover, the differences between artists' and technologists' behaviour show that artists in both the COSTART and GEO cases spent more time on solution-generation behaviour than the technologists did and the technologists in all cases spent more time on enquiry behaviour than the artists did (Section 6.3.1.1). As was observed that when artists asked questions or clarified statements, they were more likely to ask technology related questions and when artists provided solutions, those solutions were more based on aesthetic aspects (Section 4.3.2). Similarly, the questions raised by technologists were more likely related to the aesthetic requirements and the solutions provided by technologists were more likely technologically related. Therefore, we may propose that for enquiry behaviour, artists need a greater percentage of time to ask technological related questions but technologists do not require that much percentage of time to ask aesthetic related questions. For the solution-generation behaviour, the artists need a greater percentage of time to provide the aesthetic solutions they want to achieve but technologists do not require as much percentage of time to illustrate the technological solutions they can possibly achieve. In the next section, the results in relation to how the communication behaviour can be affected by computer tools are presented.

6.3.2 How Computers Affect Communication Behaviour

In this section, the findings related to how computers affect communication behaviour are presented. The changes in communication behaviour of the participants in the COSTART cases between the non-computer-assisted communication mode and the computer-assisted communication mode were presented previously in Section 4.3.3.2. The changes in communication behaviour of the participants in the GEO case between these two communication modes were presented previously in Section 5.3.3.3. In the next section, the comparison between the results of the COSTART and GEO studies will be made.

6.3.2.1 Comparisons

The comparative results between the COSTART and GEO studies in terms of communication behaviour distribution within the non-computer-assisted communication mode and the computer-assisted communication mode are displayed in Table 6.4. The results listed in Table 6.4 can be referred back to Figure 4.12, Figure 4.13 and Figure 4.14 in Section 4.3.3.2 (COSTART) and Figure 5.15 in Section 5.3.3.3 (GEO). The average communication behaviour distribution between the technologist T_a and the technologist T_b in the GEO was made as T_{Mean}.

Table 6.4: Comparisons between the COSTART and GEO cases in terms of behaviour distribution within non-computer-assisted and computer-assisted modes

		Solution-Generation		Inform		Enquiry		Evaluation	
		Non-assisted	Assisted	Non-assisted	Assisted	Non-assisted	Assisted	Non-assisted	Assisted
COSTART Case A	A_1	18.94%	28.79%	41.12%	33.28%	4.01%	10.51%	8.57%	13.69%
	T_1	32.82%	16.74%	16.1%	42.44%	18.07%	20.72%	3.96%	1.26%
COSTART Case B	A_2	18.46%	18.99%	48.71%	33.01%	3.33%	10.34%	7.14%	0.83%
	T_2	22.26%	23.61%	41.9%	50.65%	16.33%	9.89%	10.09%	2.69%
COSTART Case C	A_3	23.7%	24.77%	23.99%	33.74%	6.31%	19.49%	4.95%	12.86%
	T_3	23.18%	23.4%	45.98%	48.46%	12.64%	13.41%	5.22%	3.1%
GEO case	A_4	21.88%	21.21%	57.74%	38.34%	10.86%	20.72%	1.15%	10.42%
	T_{mean}	34.57%	26.68%	55.22%	59.31%	14.71%	9.72%	5.3%	5.07%

Comparing the results of the COSTART cases with the results of the GEO case (Table 6.4), it shows that some participants' communication behaviour from both the COSTART and GEO cases were changed in a similar way from the non-computer-assisted communication mode to the computer-assisted communication mode. These types of communication behaviour are:

- **Inform behaviour**: Artists spent a lower percentage of time on the inform behaviour with the mediation of computers than without, while technologists spent a higher percentage of time on the inform behaviour with the mediation of computers than without.
- **Evaluation behaviour**: Artists spent a higher percentage of time on the evaluation behaviour with the mediation of computers than without, while technologists spent a lower percentage of time on the evaluation behaviour with the mediation of computers than without.
- **Enquiry behaviour**: Artists spent a higher percentage of time on the enquiry behaviour with the mediation of computers than without while technologists spent a lower percentage of time on the enquiry behaviour with the mediation of computers than without.

Moreover, in terms of the way that participants' solution-generation behaviour changed from the non-computer-assisted communication mode to the computer-assisted communication mode, the difference between the COSTART and GEO cases are summarized as follows:

- **Solution-generation behaviour**: in the COSTART cases, both artists and technologists spent more time on the solution-generation behaviour with the mediation of computers than without; while in the GEO case, both artists and technologists spent less time on the solution-generation behaviour with the mediation of computers than without.

The reason for this difference can be drawn from the observation data of these cases. During the COSTART cases, it was observed that when participants conducted non-computer-assisted communication, they mainly communicated with each other face-to-face; while during the GEO case (Section 5.3.3.2), it was observed that when participants conducted communication without the mediation of computers and their tools, they mainly communicated with each other in two ways: face-to-face and object-assisted. As was mentioned before, during the object-assisted communication in the GEO project, proposals containing detailed design information about the artefact (such as layouts of the artefact, contents of the personas) serve the role of main mediation objects (Section 5.3.3.2). During the object-assisted communication, it was found that both the artist (A_4) and the technologists (T_a, T_b) spent a reasonably large amount of time on solution-generation behaviour (Figure 5.16, Figure 5.17 and Figure 5.18 in Section 5.3.3.3). One explanation for participants in the GEO case spending less time on solution-generation behaviour with computer mediation than without was that participants were spending a substantial amount of time on solution-generation behaviour during the object-assisted communication, which was included as part of the non-computer-assisted communication. More discussion related to the above comparisons can be found in Section 6.3.2.2 below.

6.3.2.2 Discussion

The comparisons, presented in the above section, show how computer mediation has different kinds of effects on some of the artists' and the technologists' communication behaviour: artists spent more time on enquiry and evaluation with the mediation of computers than without, while they spent less time on inform behaviour with the mediation of computers than without; technologists spent more time on inform behaviour with the mediation of computers than without, while they spent less time on enquiry and evaluation behaviour with the mediation of computers than without. From these results, we can see that computers as mediation tools affect artists' and technologists' communication behaviour in a different way: computers may assist artists to provide more evaluation and ask more specific questions while they may help technologists to distribute more knowledge.

The differences between the COSTART and GEO cases in terms of the way computers and their tools affect participants' communication patterns, is that participants in the COSTART cases spent more time on the solution-generation behaviour with the mediation of computer tools than without; while participants of the GEO case, spent less time on the solution-generation behaviour with the mediation of computer tools than without. A plausible explanation for this is that during the non-computer-assisted communication mode of the GEO case, a substantial amount of time was spent on the object-assisted communication mode, where the solution-generation behaviour was conducted relatively often (Section 5.3.3.3). If compared with the time participants spent on the solution-generation behaviour in the GEO project with the non-computer-assisted communication where the object-assisted communication was excluded, the result is similar to the results of the COSTART cases, which is that participants spent more time on the solution-generation behaviour within computer mediated communication than without. Thus, according to the discussion of the differences between the results of the COSTART and GEO cases, we can conclude that participants spent more time on solution-generation behaviour with the mediation of computers than without any mediation.

Both Section 6.3.1 and Section 6.3.2 show the comparisons between artists' and technologists' communication behaviour, what types of communication behaviour computer tools can affect artists and technologists in a similar way, and what kinds of communication behaviour computer tools can affect artists and technologists in a different way. The results show that there are some distinctive differences between artists and technologists in terms of how much time they spent on some types of behaviour and how those types of behaviour can be affected by using computer tools. As mentioned previously, communication styles and ways of working are in some ways disciplinarily determined (Sonnenwald 1996) (Schleifer 1997) (Section 2.4). The findings listed above tell us in detail about what kinds of communication styles the artists and technologists had in these cases. In addition, previous literature in art-technology collaboration considered "the collaboration as a way of creating an artefact though a spiraling evolution brought by the interactions of artists and technologists within an integrated system of feed forwards (being suggestions or enquiries), feedbacks (being responses) and adoptions" (Jones 2005) (Section 2.4). From this point, the findings shown in this research extend our understanding of art-technology collaboration by illustrating the patterns of communication behaviour and relationship between communication behaviour and computer tools.

In summary, in Section 6.2 and Section 6.3, the results of context analysis and protocol analysis drawn from the COSTART and GEO cases were summarized and implications were discussed. The following table illustrates the results summarized in this section:

Table 6.5: Finding summary of the COSTART and GEO cases

Context analysis	Sharing	The more common background participants shared with each other, the more interest they showed in each other's domain and the more shared language they used during the collaboration (Section 6.2.1)
	Mediation	Talking conflicts occurred less often in computer-assisted-communication than in non-computer-assisted communication (Section 6.2.2)
	Collaboration style	Features between the exploratory style of collaboration and the goal-driven style of collaboration: e.g. participants had fewer talking conflicts and more shared language during the exploratory style of collaboration than during the goal-driven style of collaboration (Section 6.2.3).
Protocol analysis	Patterns of communication behaviour	In terms of eight types of communication behaviour (inform, solution-generation, enquiry, evaluation, justification, recall, hypothesis and agreement) investigated in the research, the top three types of behaviour that participants spent a substantial amount of time on are the inform behaviour, solution-generation behaviour and enquiry behaviour (Section 6.3.1).
	Relationship between communication behaviour and mediation tools	Computers affect artists' and technologists' solution-generation behaviour, inform behaviour and enquiry behaviour differently. For solution-generation and inform behaviour, computers can increase these types of behaviour from the technologists and decrease these types of behaviour from the artists. On the contrary, for enquiry behaviour, computers can increase this behaviour of the artists and decrease this behaviour of the technologists (Section 6.3.2).

In the next section, the findings in the GEO case where the communication modes were further categorized into five types (face-to-face, object-assisted, drawing-assisted, computer-screen-assisted, interactive-system-assisted) and how these different types of communication mode can affect communication behaviour are presented.

6.4 Discussion in Relation to the GEO Study

In the previous section, findings related to two types of communication mode: the non-computer-assisted mode and the computer-assisted mode in the COSTART and GEO cases were compared and results were discussed. In this section, the above two types of communication mode were further categorized into five types: face-to-face, object-assisted, drawing-assisted, computer-screen-assisted, interactive-system-assisted (the definition of each mode can be found in Table 5.6 of Section 5.3.2). The findings related to the five types of communication mode in the GEO case will be discussed in terms of the combination of context analysis results and protocol analysis results, which were presented in Chapter 5.

6.4.1 Features of Five Communication Modes

Face-to-face

From the context analysis results, it was shown that face-to-face communication was used to exchange information, such as deadlines, progress reports and budgets (Section 5.2.3.1). Thus, we can see that the information the face-to-face communication mode provided to the collaboration was broader in comparison to other types of communication modes. Furthermore, face-to-face communication which occurred every meeting, had the highest frequency between five communication modes and the total time participants spent on face to face communication decreased gradually from the first meeting to the eighteenth meeting (Section 5.3.3.2). These results indicate that participants used the face-to-face communication mode as a basic way to exchange background information, which contributed to the collaborative process in a general sense. At the beginning of the collaboration, providing the background information was essential as an understanding of the project was not fully established amongst all participants. As the collaboration went on, participants spent less time on face-to-face communication, having established a level of shared understanding that enabled the project to progress. After this point, they moved to the other three types of communication modes, in which the content types shifted to a more detailed level: for example, goal clarification and refinements, technical feasibility, demonstrations and artefact evaluation. Therefore, from the patterns of face-to-face communication mode in the GEO case, we see that this form of communication was a crucial first step in creating the foundations of shared understanding, which participants continued to build up using other modes as the collaboration went on.

Object-assisted

As was observed during the object-assisted communication in the GEO case, the objects participants used to refer to during the communication were proposal related documents (Section 5.3.2). From the protocol analysis results, it was found that communication mediated with proposals decreased dramatically from the first half of the collaboration to the second half in terms of occurrence and duration (Section 5.3.3.2). In addition, it was observed that the proposal was developed throughout the collaboration in relation to the specification of image layouts, the movement of the text objects and the interaction with them. In relation to the findings of the context analysis, where the mediation of the proposals was used, the artist mainly expressed what he wanted to achieve and the technologists mainly clarified their understandings of the artist's requirements (Section 5.2.3.1). During the first half of the collaboration, the occurrence and duration of the proposal-assisted communication were relatively high, which indicates that the comprehension of the artist's goals and technologist's technical capability was in an initial stage and a great deal of communication was necessary before the ideas embedded in the proposals were fully understood by all parties. When the collaboration went into the second half, participants decreased the time spent on proposal-assisted communication, indicating a relatively good understanding of the artist's goals and requirements.

Computer-screen-assisted and Interactive-system -assisted

The results of the computer-screen-assisted communication and the interactive-system-assisted communication are similar and, therefore, they will be considered together in this section. As one of the protocol analysis results shows that participants used the computer-screen-assisted mode and the interactive-system-assisted mode alternately (Section 5.3.3.2), this indicates that computer-screen-assisted communication and interactive-system-assisted communication have a strong inter-relationship. From the context analysis, during the interactive-system-assisted communication, the artist usually evaluated the artefact and provided suggestions (Section 5.2.3.1). By achieving this, participants moved from the interactive test area to the computer to make changes to reflect the artist's suggestions, which could be, for instance, changing certain parameters of the computer program. From this, we argue that an important element of the collaboration process mediated by a physical artefact under construction is enabling the aesthetic evaluation by the artist to be implemented by the technologists immediately. The opportunity for evaluation and development of the work to happen in parallel is a significant benefit to a collaborative process. This also allows the artist to lead the shaping and realizing of his visions of the project's outcomes by taking an active role in the use of the interactive mediating environment.

In addition, during the computer-screen-assisted mode, it was observed that, between the two programming systems in use, Max/MSP was displayed on the computer screen for the majority of the time. The reason we suggest is that Max/MSP, designed as a visual programming tool, was helpful as a shared representation to facilitate the multi-disciplinary collaboration. Previous research found that Max/MSP codes are quite understandable without much training (Edmonds et al. 2003) (Candy & Edmonds 2004) (Section 2.2.2). In the GEO study, it was found that the artist sometimes discussed the MAX/MSP codes with technologists in great detail and understood in a certain level how these codes were related to some behaviour in the artefact. However, in comparison, it was not observed in the GEO case that the Java language, which was used as the other programming language during the collaboration, provided a similarly shared representation as Max/MSP (Cycling74) did.

Drawing-assisted

From the protocol analysis results, drawing-assisted communication occurred in eight out of eighteen group activity sections and usually occurred before or after the interactive-system-assisted communication mode and the object-assisted communication mode (Section 5.3.3.2). In relation to the context analysis results (Section 5.2.3.1), it was found that the reason participants use drawing on paper was related to explaining ideas/potential solutions which were hard to articulate with other types of mediation tools. As recent literature has pointed out, sketching, as a design medium, reflects on the process of thinking through doing (Schon & Wiggins 1992) and during collaborative design, sketching, as often a joint activity, is done to recall relevant knowledge and assist problem structuring through solution attempts (Cross 2006). In the GEO case, participants used the sketches to clarify the artist's requirements and make tentative explanations/suggestions during problem solving. In some senses, the role of sketching in design research is similar to the role of the visual programming Max/MSP in this project. By communicating with one another via Max/MSP, participants can develop tentative solutions. The difference is that in design collaboration, every designer is able to sketch, but in this art-technology collaboration project, only the technologists were able to manipulate the software tool while the artist stood to one side and gave instructions and feedback.

6.4.2 Mediation Tools and Stages of Collaboration

In terms of the relationship between communication modes and stages of collaboration, it has been found that the information about the mediation tools in use can indicate certain stages in the collaborative process and a certain level of shared understanding between the artist and the technologists in the GEO case. From the results presented previously, we can see that at the early stage of the collaboration, when a relatively great deal of time was spent on face-to-face communication and object-assisted communication, participants were mainly involved in knowledge exchanges, solution generation and refinement of goals. The ideas they formulated were relatively abstract and unstable, and the understanding between the artist and the technologists was not very well established. In particular, the artist's concept proposal in which visions for the creative work were expressed served as an important tool for mediating between the artist and the technologists at the beginning of the work and this became less important as shared understanding of the goals are established. As the collaboration went on, participants moved towards spending a greater amount of time on computers and the interactive artefact as a mediation tool to communicate with each other. During this period, the ideas or goals participants worked on were relatively concrete, such as the quality of the image, the sensitivity of the interactive system, which implies that a great deal of shared understanding between artists and technologists had been gradually established. In addition, it was found that during the computer-screen-assisted mode and the interactive-system-assisted mode, many questions were raised and the level of uncertainty was reduced significantly.

Therefore, we see that the usage of different types of communication mode can be used to identify which understanding level participants reached and in addition, at which stage of the collaboration process they were. On the basis of the finding that face-to-face communication mode and the object-assisted mode may effectively improve the shared understanding between participants at the early stage, we suggest that artists collaborating with technologists and other contributors in a creative process could be advised to construct their project proposals during the process of collaboration, as an effective way to communicate with each other. Beyond that, computers and interactive-systems-systems, as mediating tools, could be substantially effective in improving the development of shared understanding between participants and, in particular, for reshaping artists' perception and cognition in terms of transferring ideas from the artistic concepts to computer technology.

6.5 Summary and Discussion of the Analysis Framework

There are two methods which were used in this research: context analysis and protocol analysis. During the analysis under each method, a coding scheme was developed and refined through the analysis of the COSTART and GEO cases. In this section, the two coding schemes: the context analysis coding scheme and the protocol analysis coding scheme, will be presented as a analysis framework from two perspectives:

- First, the relationship between the coding schemes and how the coding schemes were related to the findings;
- Second, the effectiveness and reliability of the coding schemes are discussed.

6.5.1 Relationship Between Coding Schemes and the Findings

In order to state clearly the relationship between the coding schemes, it is necessary to briefly state the development and refinement process of each coding scheme and the structure of each coding scheme.

For the context analysis coding scheme, it was developed and refined through three case studies in the COSTART project and was then applied to the data collected in the GEO case and further refined during the analysis process (Figure 6.1) (The detailed development process of the context analysis coding scheme can be found in Section 3.4.1).

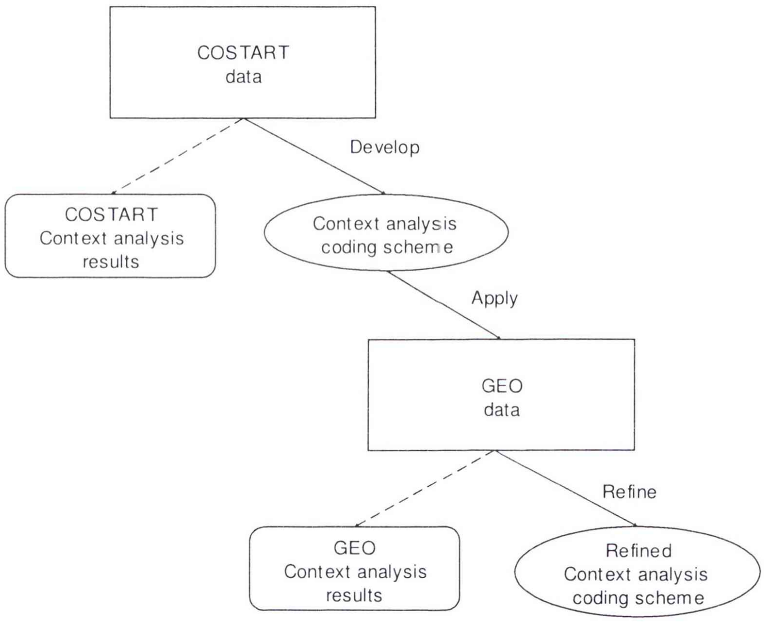


Figure 6.1: The development process of the context analysis coding scheme

The refined context analysis coding scheme in Figure 6.1 can be found in the following table, which contains thirty-seven nodes which include twenty-four root nodes (The description of each node can be found in Section 5.2.2).

Table 6.6: Context analysis coding scheme

Master node	Category	Node
Context	Participant Profiles	Background-A
		Background-T
	Project Profiles	Proposal
		Outcomes
	Situation Profiles	Physical-environment
		Technical-environment
		Collaboration-history
Communication	Verbal	Talking-conflicts
		Interruption
		Common-language
	Non-verbal	Silent
		Laugh
	Assisted	Computer-screen-assisted
		Interactive-system-assisted
		Drawing-assisted
		Objects-assisted
	Non-assisted	Face-to-face
Behaviour	Cognitive Styles of Collaboration	Leadership
		Learning
	Cognitive Styles of Participants	Goal-driven
		Exploratory
		Flexibility
	Emotional States	Evaluation
		Expression of emotion

During the context analysis process, some of those nodes were regrouped into three groups of node sets and within each node set, a group of nodes are related to each other to formulate a core interpretive theme. In each node set, findings were drawn from the COSTART cases (Section 4.2.3) and the GEO case (Section 5.2.3.2).

For the protocol analysis coding scheme, similarly, it was developed and refined in the COSTART cases and further refined in the GEO case (Figure 6.2) (Detailed development process of the protocol analysis coding scheme can be found in Section 3.4.2)

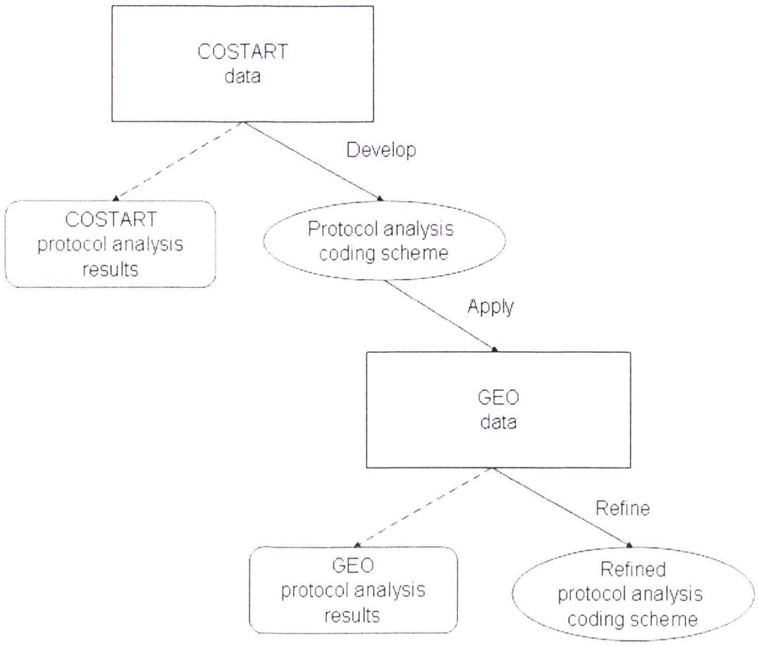


Figure 6.2: The development process of the protocol analysis coding scheme

The refined protocol analysis coding scheme in Figure 6.2 is presented in the following table, which is compose of nine nodes related to different kinds of communication behaviour nodes and six nodes related to different types of communication mode (the description of each node can be found Section 5.3.2).

Table 6.7: Protocol analysis coding scheme

Category	Node
Communication behaviour	Evaluation
	Agreement
	Justification
	Enquiry
	Solution-generation
	Recall
	Inform
	Hypothesis
	Fragment
Communication mode	Computer-screen-assisted
	Drawing-assisted
	Object-assisted
	Interactive-system-assisted
	Face-to-face
	Others

From Table 6.6 and Table 6.7, we can see that the nodes related to communication mode in the protocol analysis coding scheme were shared with the context analysis coding scheme. Thus, the following figure illustrates the relationship between the coding schemes themselves and moreover, it illustrates the relationship between the coding schemes and their corresponding analysis results and findings.

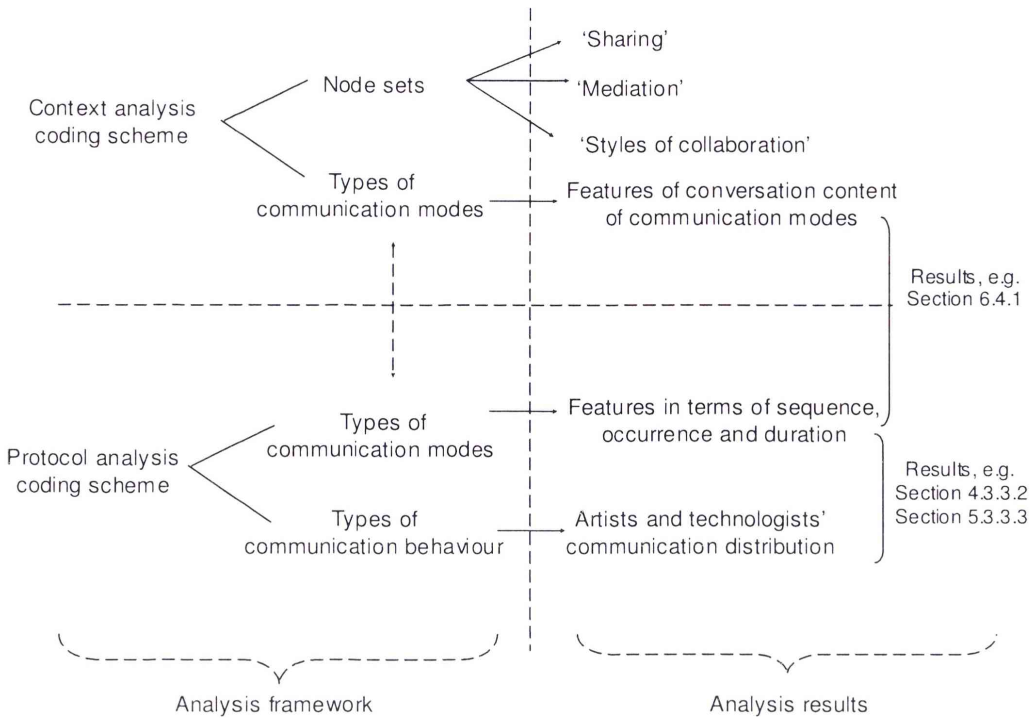


Figure 6.3: Summary of the analysis framework and related findings

In Figure 6.3, the analysis framework shown consists of two coding schemes and their derived groups of categories: node sets, types of communication modes and types of communication behaviour. Findings related to the context analysis coding scheme are further presented in relationship to the node sets and the communication modes. The findings related to the protocol analysis coding scheme are further related to the features of communication modes in terms of sequence, frequency and time distribution and participants' communication behaviour distribution. Figure 6.3 also shows the relationship between the coding schemes in terms of findings: first, the results in 'types of communication mode' from the context analysis coding scheme were combined with the results in 'types of communication mode' from the protocol analysis coding scheme to provide a better understanding of the relationship between mediation tools and stages of collaboration (The findings can be found in Section 6.4.2). Second, the results in 'types of communication mode' and the results in 'types of communication behaviour' are combined to provide a better understanding of the relationship between communication modes and communication behaviour (The findings can be found in Section 6.3.2).

6.5.2 Reliability and Effectiveness

As in the previous section, the coding schemes and how they were related to the findings of the research were presented. In this section, the features of the coding schemes will be discussed.

Reliability

Each of the coding schemes developed from two sources: the data came from a series of art-technology collaboration cases and some nodes from other related coding schemes, such as in collaborative design activity (Olson et al. 1992) and interactive-art experience study (Bilda, Costello & Amitani 2006) (Section 3.3.1 and Section 3.3.2). Through a series of case studies, the coding schemes were well-tested and may be reliably applied to a similar research context. Furthermore, during the coding process, in order to increase the reliability of the coding process, arbitration by two independent coders was conducted (Section 3.4.2). The results of the coding consistency (Table 3.1 in Section 3.3.2) show that the average agreement percentage was higher than 75 per cent, which means that coding process was reliable and the coding schemes were coder-independent.

Effectiveness

As the context analysis coding scheme provides the breadth of data analysis and the protocol analysis coding scheme provides the depth of data analysis, the combination of two coding schemes can serve as a powerful tool to investigate a similar context of creative collaboration. In addition, the findings listed in Section 6.2 and Section 6.3 show that the results from the COSTART cases and the results from the GEO case are consistent, which further confirmed the coding schemes' effectiveness and reliability.

Therefore, the coding schemes developed in this research and the way the analysis was carried out provides an effective and reliable way to:

- explore the factors which can affect the establishment of shared-understanding and common language;
- identify differences and similarities between artists' communication behaviour and technologists' communication behaviour;
- investigate the preferred way for participants in art-technology collaboration to distribute their knowledge, provide solutions, clarify misunderstanding, ask questions and evaluate the situations.

These features indicate that the analysis framework could be adopted as a tool for analysing creative processes in similar research settings.

6.6 Summary

In this chapter, the features of the COSTART and GEO cases were compared at first (Section 6.1). It went on to present the comparative results of context analysis (Section 6.2) and the protocol analysis (Section 6.3) between the COSTART and GEO cases. Following that, the further analysis results in the GEO case were discussed (Section 6.4). Finally, the analysis framework of this research was summarized and the effectiveness of this framework was discussed (Section 6.5).

In the next chapter, the contribution of these findings will be made and the future work will be proposed.

7 Conclusion and Future Work

7.1 Conclusion

This thesis addresses an investigation of how artists and technologists collaborate with each other during the creative process. For the purpose of the studies, an innovative analysis framework, assisted by context analysis and protocol analysis, was developed and refined over a series of case studies of art-technology collaboration. The analysis framework consists of two coding schemes: the context analysis coding scheme and the protocol analysis coding scheme. By bringing the findings together within the analysis framework, an understanding of the nature of the collaboration which includes insights into the creative process was achieved.

The thesis begins with a review of the literature according to four main themes (Chapter 2): interdisciplinary collaboration, communication in collaboration, collaboration in creative context and art-technology collaboration. From the review, the particular research aim for this thesis is identified, which is to examine the process of creative collaboration in particular features of communication and the role of computer technologies. Following the literature review, methodological approaches which have been applied in art-technology collaboration or similar research contexts, were evaluated (Chapter 3). Based on the discussions of the strengths and weaknesses of the methodological approaches, we extend the study methods of art-technology collaboration by conducting a series of case studies where we collected more continuous observational data using video/audio facilities and analysed the data rigorously with the combination of context and protocol analysis to provide solid empirical evidence.

During the analysis process of the case studies, an analysis framework was made, which consists of context analysis coding scheme and protocol analysis coding scheme. Each coding scheme was developed and refined over a series of cases selected from the COSTART and GEO projects (Detailed process can be found in Section 3.3.1 and

Section 3.3.2). The analysis framework has a great deal of reliability and effectiveness (Section 6.5.2 of Chapter 6). Within the analysis framework, a rich account of the insight into art-technology collaboration was presented, such as, the factors which may affect the level of shared language, the differences and similarities between artists' and technologists' communication behaviour and the way mediation tools (such as computers) affect the communication behaviour patterns between artists and technologists.

7.2 Contribution

There are two contributions of this thesis. The first contribution, which is also the primary contribution, is that it demonstrates a novel approach to analysing the nature of the interaction between artists and technologists during a process of developing digital art (More detailed can be seen in Section 7.2.1). The second contribution is the findings themselves. These findings provide a better understanding of the collaboration process between artists and technologists (More detailed can be seen in Section 7.2.2).

7.2.1 Analysis Framework

Digital Art Research

The contribution of the analysis framework developed in this research needs to be explained in the context of studying creative collaboration, in particular, art and technology collaboration. As was mentioned in Chapter 1, there are two significant stages in developing interactive arts: collaboration between artists and technologists, which often happens in laboratories, and evaluation between audiences and artefacts, which often happens in public exhibition places. For understanding audiences' interaction experiences, some reliable analysis frameworks have been developed, such as Bilda (2006) and Costello (2005), but no effective analysis framework was built for particularly analysing the collaboration process between artists and technologists in the laboratory settings. The innovative analysis framework, developed in this research, significantly fills this gap. It addresses the need for close analysis of the nature of the creative process of art-technology collaboration, and in doing so contributes to advances in methodological approaches in digital art research. The framework developed in this research can be used, along with those existing analysis frameworks which evaluate interactive experiences between audiences and artefacts, and serves as a tool for analysing creative collaboration between artists and technologists from the beginning where artefacts are produced collaboratively in laboratories to the end where outcomes are evaluated in public exhibition places.

Collaboration Studies

The contribution of the analysis framework can be also presented in a broader context: collaboration studies. The analysis framework, developed from art-technology collaboration projects happening in real time and refined through a series of case studies, has been shown to be reliable and effective. Moreover, it demonstrates a successful example of combining the context analysis method and the protocol analysis method to provide an analysis with both depth and breadth levels. Therefore, the analysis framework could be used as a resource for other researchers who are interested in analysing similar situations in interdisciplinary collaboration, particularly those which involve the creative process, such as collaborative design.

7.2.2 Findings

The second main contribution of this research comes from the findings within the analysis framework. The findings provide rich insights into art-technology collaboration. In the literature of communication in the creative process, creative groups rely on effective communication across disciplinary boundaries while maintaining an atmosphere that preserves distinctive contributions. The effectiveness of communication during creative collaboration was explored in this research in terms of the features of the way artists and technologists communicated, the features of different types of communication behaviour and how different types of mediation tools can affect various types of communication behaviour, such as the preferred way artists and technologists distribute their distinct knowledge between each other. These findings contribute to our understanding of how the creative collaboration between art and technology is facilitated by media, such as computer and their tools, and how communication's effectiveness can be improved at different stages of the creative collaboration.

Compared with the existing literature in art-technology collaboration and creative collaboration practice, the results in this research build a closer relationship between the collaboration process in real time and what is known about art-technology collaboration. For instance, findings reveal that computer tools meant to support creative collaboration are able to accurately reflect relevant aspects of both artistic and technical practice: for artists, they facilitated the evaluation activity in order for artists to control the collaborative outcome and they can also express the requirements in great detail; for technologist, they permit demonstration of how technologists understood artists' requirement and what the potential technological possibilities were. Furthermore, these findings make a significant contribution to a better understanding of some key features of the creative practice of art-technology collaboration, such as shared-language, the role of computers and other tools. For instance, the findings in relation to shared language implicate that one of the ways to improve shared language between artists and technologists might be to increase the usage of computers or other mediation tools during the collaboration. These findings may help to facilitate the success of collaboration in the future between artist and technologists.

7.3 Future Work

In terms of the analysis framework developed in this thesis, the future work may be that it can be applied in more cases in similar research contexts to further validate its reliability and effectiveness. It will be interesting to find out that whether this framework can be generic or context independent; if yes, which part of the analysis framework is more context independent, such as the context analysis coding scheme or the protocol analysis coding scheme. Moreover, the extended data collection method by using video-recording facilities in the GEO case can be applied in more cases to validate the extra findings shown from the study.

This research may open new possibilities for studying art-technology collaboration. For instance, as we found out that the mediation of computers may help both artists and technologists produce solutions, it might be worth conducting an experimental study where participants use different software programs to implement a similar artistic idea within the same timeframe. We might be able to discover which existing software programs are more effective in facilitating the collaboration process between artists and technologists. In addition, other questions that have arisen from the work can be further explored in the future work. For example, as we found that proposals can help artists to articulate artistic concepts and help technologists to clarify the artistic requirements, does it mean such proposals need to be made as detailed as possible or will a proposal with too much detailed information limit the creative process between artists and technologists? Moreover, as was found that the mediation tools varied at different stages of a project, so in the future, it could be valuable to develop a series of specialized strategies and methods to select the mediation tool most significant at each stage.

In conclusion, the central issue of this thesis is to explore and apply methodologies by which artists, a particular subgroup of creative professionals, may be systematically studied in their collaboration with technological support experts or specialists. The approach and the analysis techniques demonstrated in this research may easily generalize to the study of collaboration between other working professionals, such as designers, architectures, engineers and so on. Additionally, the work addressed in this thesis makes a contribution to improving the supportive process in art-technology collaboration. Let us consider an analogue involving the history of bibliographic database library searching that illustrates this point. In the 70s and 80s, bibliographic database library searches required training in specialised database languages. Today, owing in part to studies of database searches and the improving the supportive process, the searching has been simplified to the point where users, with only a couple of hours of training, are capable of doing the database searching themselves. The intermediary support is no longer a necessary link in the process of cooperation. In the context of art-technology collaboration, this thesis contributes to a point of time in the future when the creative worker is free to focus on their own work, and the technologist is free to focus on the teaching.

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Appendix

A1 Study Data and Analysis Segments

A1.1 Interview Protocols

The interview protocols in the COSTART and GEO projects are listed as follows:

COSTART interview protocols

1. Plans and Outcomes

    Q1. What were your motivations/Inspirations for the current work?

    Q2. Have your initial aims changed?

    Q3. What has been achieved in the residency?

    Q4. Have your longer term aims changed in relation to this project?

2. Issues and Implications: Support, Technology and Art Practice

    Q5. How would you described the kind of support have you received during the residency?

    Q6. What has been most valuable aspect?

    Q7. What has been least valuable aspect?

    Q8. What have been the most challenging aspects?

    Q9. Is there anything missing that is crucial to the progress of your work?

    Q10. Do you feel hampered by any lack of technical knowledge?

    Q11. Has your experience during this residency made you revise your previous expectations?

    Q12. What do you think the impact of bringing technology into your work has on the way you work as an artist?

    Q13. What knowledge and skills do you think you will need in the future in order to continue this line of work?

    Q14. How do you think the residency could have been improved?

    Q15. Have you developed as an artist as a result of your experience in this particular residency? Can you compare the experience with another residency?

    Q16. In an ideal world what conditions suit you best for creative work?

GEO interview protocol

1. Plans and Outcomes

    Q1. Could you list some motivation or inspiration for this work?

    Q2. Have your initial aims changed a) since the project began or b) during the course of the project?

    Q3. What has been achieved in this project? How do you feel about the achievement in this project?

Q4. Have your longer term aims changed in relation to the achievement so far?

2. Support and achievements

Q5. Is there anything missing that is crucial to the process of your work?

Q6. How do you think about the effectiveness of the tools used during the collaboration, For example: those tools could be Max/MSP, floor pads, Macintosh computer systems?

Q7. How do you think the project could have been improved?

Q8. If you have the chance to do this all over again, is there anything you would do differently?

Q9. Can you say what the high points and low points were?

A1.2 Comparisons Between Three Versions of the Proposal

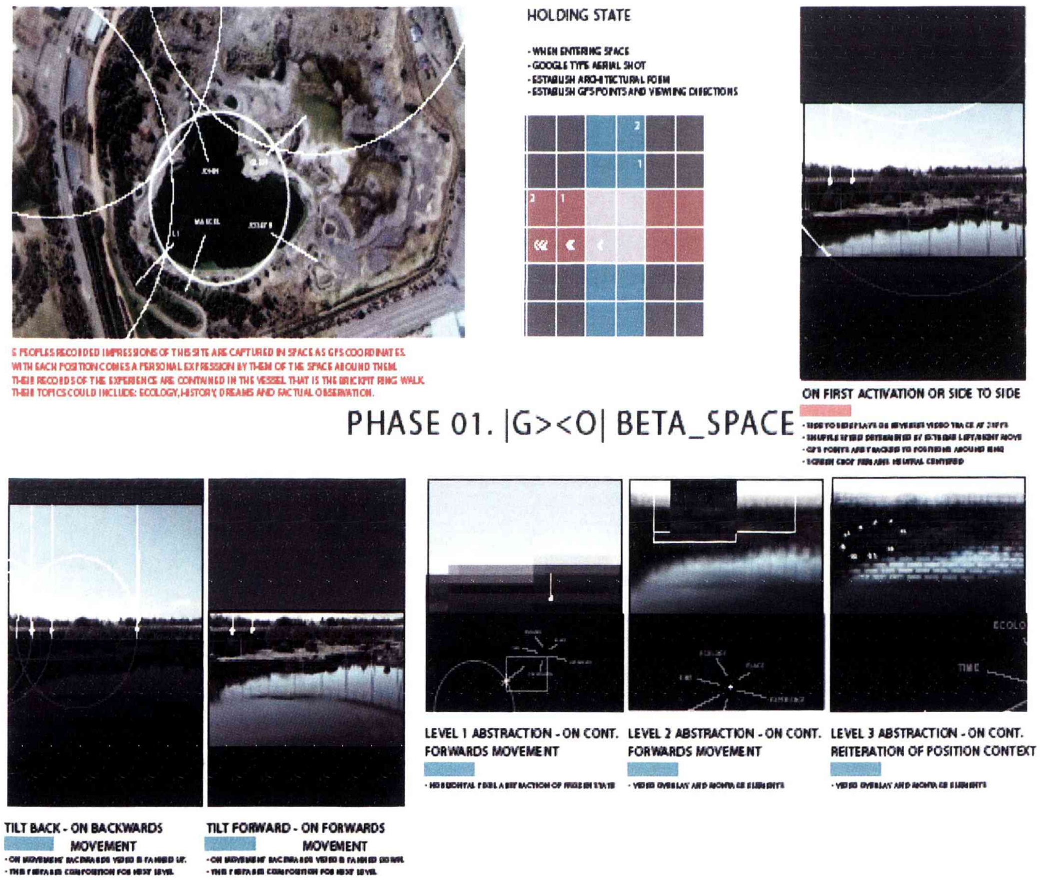

Figure A1.1: Segment of the first version

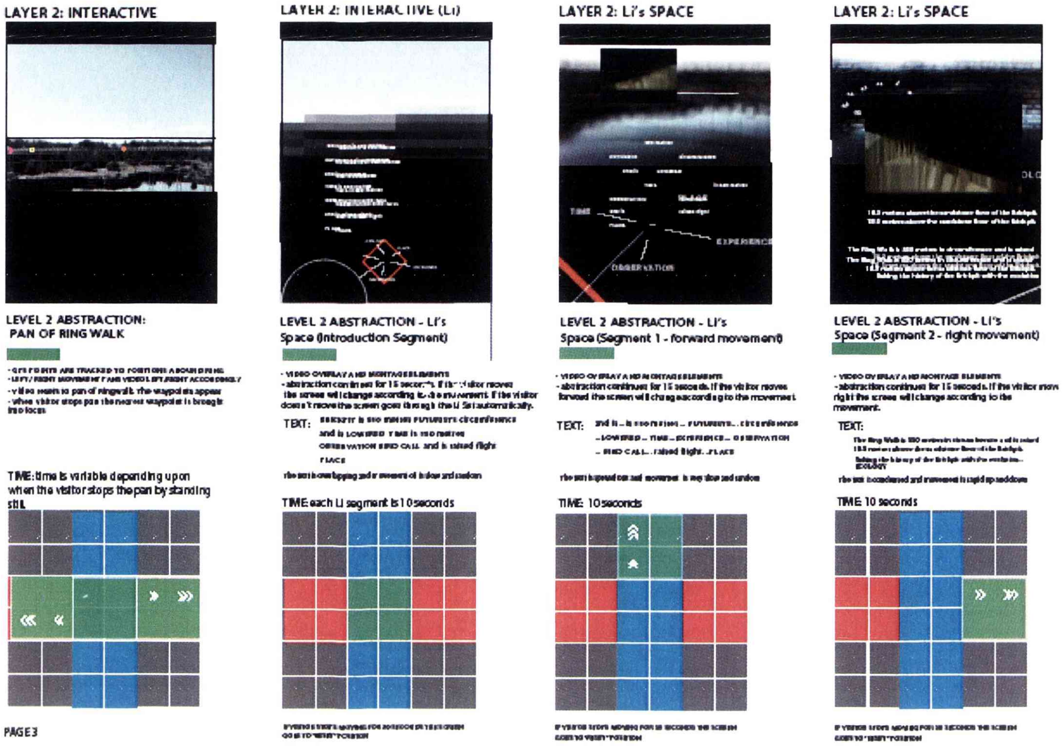

Figure A1.2: Segment of the second version

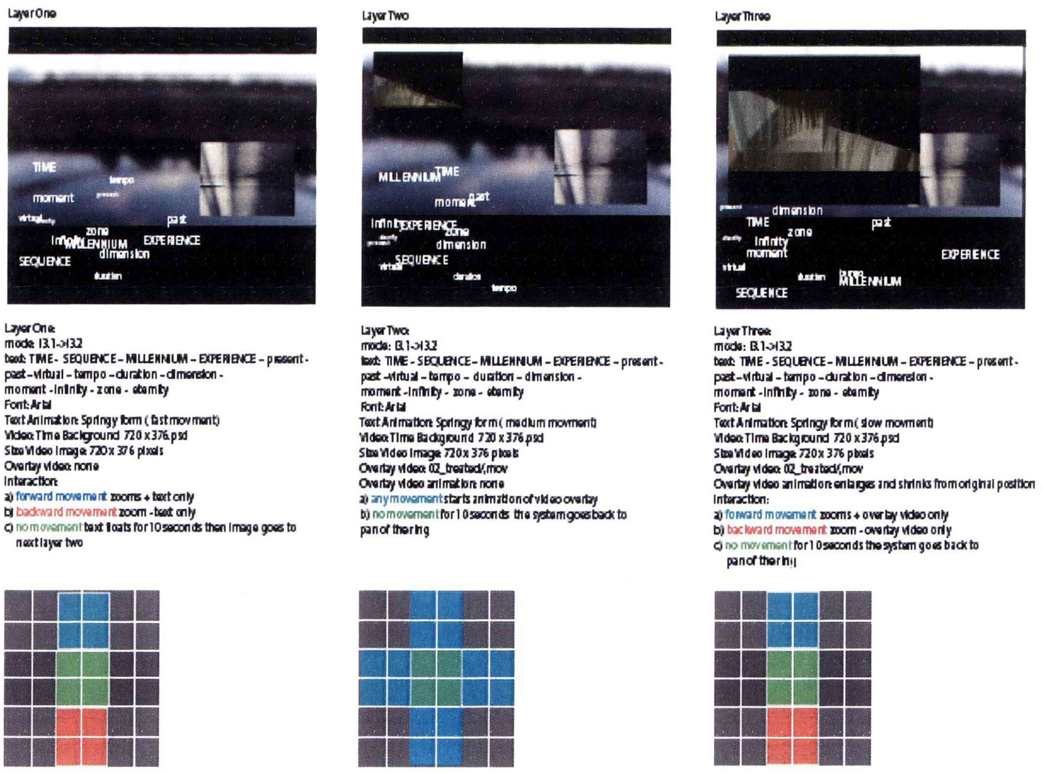

Figure A1.3: Segment of the third version

A2 Examples of Coding Schemes

A2.1 Context Analysis Coding Scheme

The context analysis coding scheme developed in the COSTART cases are listed below:

Table A2.1: Context analysis coding scheme

Master node	Category	Node
Context	Participant Profiles	Background-A
		Background-T
	Project Profiles	Proposal
		Outcomes
	Situation Profiles	Physical-environment
		Technical-environment
		Collaboration-history
Communication	Verbal	Talking-conflicts
		Interruption
		Common-language
	Non-verbal	Silent
		Laugh
	Assisted	Computer-screen-assisted
		Interactive-system-assisted
		Drawing-assisted
		Object-assisted
	Non-assisted	Face-to-face
Behaviour	Cognitive Styles of Collaboration	Leadership
		Learning
	Cognitive Styles of Participants	Goal-driven
		Exploratory
		Flexibility
	Emotional States	Evaluation
		Expression of emotion

The coded examples of the master node *Context* in the above Table A2.1 are

- Background-T

"So I was interested in computers but I was already thinking about coming back here to do IT, because I'd been developing my own systems for design as well but to help me with my work then I was given a goal everyone was given a goal and my goal was that 10% of sales should come from products less than 1 year old."

- Background-A

"Because my background's sculpture and I'm working with technology that I've not previously used... I started to use the 3D modelling about a year and thought why did I never try this, it just didn't make sense. But there was also as well I was moving back from completely using the computer all the time from the majority of web projects to starting to make more sculptural."

- Proposal

"Inspired by the likes of Cornelius Cardew's Scratch Orchestra and the work of

Fluxus, I considered the scores and rules for the compositions as works in themselves. A piece created for the Lovebytes 2001 festival embodied these ideas using probability as the sequential score for an analogous film of speech. This work would produce questions, answers, declarations and ambiguities. My project for COSTART is an extension of these ideas. This piece focuses more on an interactive element with the score as a modular system that can be affected by audience involvement."

- Outcomes

"As discussed with [the technologist] earlier, much of the practicalities of the 3D-model animation have been established and resolved this week. This groundwork will allow me to have a realistic plan of action towards the installation. There will be some refinements to be done in the short-term, but I now realized that a section of the work, such as rendering in only necessary to do at a later stage, as this is dependent on what means I use to show the work."

- Physical-environment: Studio, Lab, etc.
- Technical-environment: Max/MSP, Koan, etc.
- Collaboration-history: No, the artist and the technologist in Case A did not collaborate with each other before the residency.

The coded examples of the master node *Communication* in the above Table A2.1 are:

- Talking-conflicts

"T: Well we'll have to paint the texture, on the texture itself. So the texture will be kind of…Or, I make the texture more white in it's nature

A: No…because it's more the…of white on the…what it's doing is it's transferring it to an acidic colour which flattens, do you know what I mean…Like sort of small subtle white patches then that would spring out from the yellow, but that's…

T: Yeah, but the texture is like that it's bouncing. It is a white light and it is bouncing off the yellow object, so it's yellowish. You tend to fell it is yellow, it is not yellow."

A: But that's how it looks…you know it looks as if it's burning, it's bright yellow…"

- Interruption

"A: I don't know, I mean really it's manufactured, you can't really say what sort of lights it doesn't matter…(T Interrupts A)

T: Spotlight or…(A Interrupts T)

A: But what I'm saying is it doesn't really matter though what sort of lights they are what I'm talking about is the effect, do you know what I mean. I know on this, yes, there's a spotlight, there's a…but in actuality they're not and I'm not thinking of it as being, how actual lights would be because it's just to make it manufactured to sit there…"

- Common-language
    - A conversation segment which exhibits a reasonably good level of common-language:

      "A: ...it is stream down. What I am thinking was, if you have a computer and run on the Macintosh, receive the information, and then, it seems like a right way to do it, but you can send the sound files back to the computer with producer.

      T: right, then the real producer will send it, because we've got a quick server, I suppose that we could find out it would work with that."
    - A conversation segment which exhibits a limited level of common-language:

      "T: So in the beginning she drops the ink and then starts dissolving.

      A: It works really well, almost like a layer…seaweed… "

      T: Because I remember when you said you touched it rippled.

      A: yeah, but if you touched it, it wouldn't be so much of a ripple it would be more of a - if you put your finger into a balloon it would be more of an indent really."
- Computer-assisted

  "T: ...you can control where it has to go... you can move cross that... you can control to make it stop. So I think with those kinds of things, we can make some quite different looking of texts...

  A: So can we have something like a sentence or...

  T: We think could do that or we could do it in another way..."
- Drawing-assisted

  "T: ...you've got these six places, as you go to one, it will go to the centre and the other ones will move around the place

  A: oh, right..."

  "This is the scratch about what I want to show in 3D."
- Object-assisted

  "if I poke here, the object can show a indent..."
- Face-to-face

  "T: …next week, I will work on how to reduce the CPU power usages. [As we know], each component takes a lot of CPU power…

  A: Yeah, I probably could help it too. I can stop using these big files… "

The coded examples of the master node *Behaviour* in the above Table A2.1 are

- Leadership:
  "I would like to you to change the light..."
  "I want this to be done like..."
- Learning
  "I've learnt ..."
  "I am very interested in this software and I want to learn it"
- Goal-driven:
  "...first we need to see how it's reacting. Then all that is done and then we take it to a virtual world. Now after that comes the question of building the reactions, we can work on that but it won't be possible to complete them individually because once this goes into virtual we will see how first of all it behaves in that world and then it's a question of writing the programmes, the programming of the interaction and the type of interaction etc"
- Exploratory
  "...ideally I'd like to try out the headset and possibly gloves and the headsets, but I'd really like to try gloves to see how that works. But it might work better as a projection. That's something I'm thinking would be good to try out. The actual presentation of it we're thinking quite long term. It would be good to try out things. Sort of think of where this could actually develop to be - use this week making tests and see how it works so that I can sort of think further into the future about it as well. The presentation of it at the moment it doesn't matter too much but I would like to try the headsets, particularly thinking it would be difficult to try those in the situation."
- Flexibility:
  "... although I look at various people and I think they're so lucky... and I think I'd love to be able to do that and then ask them technical things and they don't know anything about it ... and I think that's bad, I think you're tempted to think that would be good but it's bad because you can't realize these things yourself and you don't have an understanding of what could be done. I don't think an artist needs to be able to do absolutely everything because somebody else can learn everything and somebody else can do something else you know, but I just think you've got to have a greater understanding than that... "
- Evaluation
  "...yeah, definitely. I'm learning lots and that's only two days. You're just sort of skipping over loads of different chapters. It's good. We have achieved most of the parts compared with the original plan."
- Positive-emotion:
  "Woh, I am so impressed that this could be done..."

"I am very happy with the outcome of the residency"

- Negative-emotion

  "I feel a little bit frustrated..."

A2.2 Protocol Analysis Coding Scheme

The context analysis coding scheme developed in the COSTART cases are listed below:

Table A2.2: Protocol analysis coding scheme

Category	Node
Communication behaviour	Agreement
	Enquiry
	Evaluation
	Hypothesis
	Inform
	Justification
	Recall
	Solution-generation
	Fragment
Communication mode	Computer-screen-assisted
	Drawing-assisted
	Face-to-face
	Interactive-system-assisted
	Object-assisted
	Others

The examples of the *Communication mode* category of the protocol analysis coding scheme can be found in the above section due to the fact this group of nodes were shared between the protocol analysis coding scheme and the context analysis coding scheme. The coded examples of the category *Communication behaviour* in the above Table A2.1 are:

- Evaluation

  "then when you suggested the stream , I thought it would be a much better way to doing it"

  "In the way, I don't like the current thing because it doesn't work."

- Agreement

  "yeah. OK. So let us have a go and see what happened"

  "yeah, you can go like that"

- Recall

"What I was doing first of all was actually sort of making a few different shapes and variations on the shapes"

"in her case, she found that she wanted quality so we stuck to that part rather than other aspects such as the size."

- Solution-generation

  "right. So there is still easy to do anyway. We might need to have a list of sound files, which everybody has got, which they will play."

  "makes new file and replaces. I mean that is really the speculation. It is just an idea of how you can have the sound files, have them more changing, more by using Max. "

- Justification

  "because I would like to have a lot of samples of sounds... also it makes any changes too and modulation"

- Enquiry

  "but what do you think of that kind of sound? It did not sound like MIDI, did it?"

  "And Coen is only for playing back, isn't it? "

- Hypothesis

  "hum, because I was thinking that err...., I have not thought how it works in that kind of game scenarios and streaming thing. Err... I was thinking that the sound would be, err...."

  " suppose to play sound MID thing, must be one of those. "

- Inform

  "but anyway, now we've got.....Now we've got Mac patch, if you type two character messages or something, then it knows it is two characters, and if you type three character messages, then it knows that as well, so you could send messages by pressing buttons and know what messages were, you know"

  "So the sound files. So when you open and log in loads of the sound files, and everybody gets one and then they just receive the instruction to play this now and this one, whoever..."

A3 Results

A3.1 Results within Context Analysis Coding Scheme of GEO Data

Context Master Node

The summary of each node under the *Context* master node, made based on the coded data from the GEO case, is presented in the following table.

Table A3.1: *Context* master node summary

Category	Node	Results
Participant Profiles	Background-A	The artist' background: experienced in the several art-related fields, such as design, film, digital art but not experienced in the field of computer science.
	Background-T	The technologist T_a' background: expert in computer science, in particular, he was familiar with software application Max/MSP, majored in product design.
		The technologist T_b' background: expert in computer science, in particular, he was familiar with software application Java.
Project Profiles	Proposal	The aim is to build an interactive system, which can contain artist's aesthetic design. It is a combination of aesthetic perspective and technological perspective.
	Outcomes	A multi-media interactive system, which can be explored using the floor pads. The work was exhibited in Beta space of Sydney Powerhouse Museum from April to May, 2007.
Situation profiles	Physical-environment	Studio, exhibition space
	Technical-environment	Macintosh with software Max/MSP, Java and interactive floor pads.
	Collaboration-history	Except the technologist T_a collaborated with the artist before, there are no other pre-collaboration history.

The category *Participant profiles* in TableA3.1 shows that the background information of each participant involved in the GEO case.

- From the coded data of the *Background-A* node, it was summarized that the artist had good experience across several art related fields, such as design, film and interactive art.
- From the coded data of the *Background-T* node, the background information of the technologist T_a and the technologist T_b were summarized. The technologist T_a came from a computer science and design background, and in particular was an expert in the Max/MSP software. The technologist T_b came from a computer science background, and in particular was an expert in Java programming.

The category *Project Profiles* in Table A3.1 shows that the detailed information about the project's proposal and the outcomes of the project. The proposal in this project was mainly represented as a schematic story board, which was designed by the artist, contained further descriptions about the layout of the interface, the relationships between three layers of the interface and the detailed information about each persona mode. This story board was revised three times during the collaboration, and it was treated as a way to communicate the artist' ideas to the technologists.

- The coded data of the *Proposal* node shows that the project involves both aesthetic issues and technological issues. The examples of technical issues are how computer systems process the data from a grid of six by six pressure sensitive floor pads, how Max/MSP can be used to control the interaction between the floor pad, and a selection of audio, video files. The examples of aesthetic issues of the project are the quality of the panorama of the Brickpit Ringwalk, the layout of the interface and the design of audio and video files of the system.
- The coded data of the *Outcomes* node shows that in the GEO project, the participants made a three-level interactive system which is the interactive mode interface, the abstractive mode interface and the persona mode interface. This system contains several types of multiple media data, such as video and audio, and the interactions of a single person moving around the floor with the floor pad installed. This interactive artefact was exhibited in 'Beta-space' of Sydney Powerhouse Museum from April to May, 2007.

The category *Situation Profiles* in Table A3.1 shows where participants were working with each other, what kinds of software and hardware they used, and whether participants had collaborated with each other before.

- The coded data of the *Physical-environment* node shows that participants were mainly working with each other in the Creativity and Cognition Studios located in University of Technology, Sydney. In addition to the studio as the main working environment, they also worked at the 'beta space', where the exhibition was held.
- The coded data of the *Technical-environment* node shows that during the collaboration, participants mainly worked with software Max/MSP and Java in the Mac OX platform. The hardware includes a six by six floor pad, speakers, Macintosh G5.
- The coded data of the *Collaboration-history* node shows that the technologist T_a had worked with the artist previously on a project named "Kenji".

In summary, the above summary about the *Context* master node in the GEO case provides a rich picture about the various types of information in the GEO project, such as participants' background, the physical and technical environment where participants worked and the outcomes of the project. Next, the summary of the master node

Communication is presented.

Communication Master Node

The summary of each node under the *Communication* master node, made based on the related coded from the GEO case, is presented in the following table.

Table A3.2: *Communication* master node summary

Category	Node	Results
Verbal	Talking-conflicts	Talking conflicts between the artist and the technologist T_a happened quite often but talking conflicts between others did not happen very often.
	Interruption	Interruption between the artist and the technologist T_a happened quite often but interruption between others did not happen very often.
	Common-language	In comparison, the artist didn't share very much common language with the technologist T_a and the technologist T_b, but the artist shared a reasonable common language with the designer. The technologist T_a and the technologist T_b shared a lot of common language. The designer shared a reasonable common language with the technologist T_a and the technologist T_b.
Non-verbal	Silent	Silence had been observed across meetings when participants were working independently within the studio.
	Laugh	Laughter had been observed across meetings, but it did not happen very often.
Assisted	Computer-screen-assisted	It happened a lot mainly under the circumstances where participants were interacting with the artefact or working in front of computers and their software applications.
	Drawing-assisted	It happened several times. The drawing mainly was conducted by using pen and paper or white board.
	Objects-assisted	It happened a lot. The objects mainly used during the conversation were several working versions of the project proposal.
Non-assisted	Face-to-face	Face to face communication without any media, such as computer, paper etc.

The category *Verbal* of the above table shows a summary of some verbal communication components, such as talking conflicts, interruption and common language between participants, more details as follows:

- The *Talking-conflicts* node shows that, in the GEO case, talking conflicts happened between the artist and the technologist T_a quite often, but talking conflicts between the artist and the technologist T_b, or the technologist T_a and the technologist T_b, did not happen as often. In particular, talking conflicts seldom happened between the artist and the technologist T_b.
- The *Interruption* node shows a similar pattern as the *Talking-conflicts* node: interruption between the artist and the technologist T_a happened quite often but interruption between the artist and the technologist T_b or the technologist T_a and the technologist T_b did not happen as often. Furthermore, the artist interrupted the technologists more often than the technologists interrupted the artist. Compared between the technologist T_a and the technologist T_b, the technologist

T_a interrupted the artist more often than the technologist T_b interrupted the artist.

- In terms of *Common-language* node, it was found that in the GEO case, the artist did not share much common language with the technologist T_a and T_b. The language between the artist and the technologists is quite different: the artist used a great amount of artistic terminologies to describe the aesthetic issues of the project, such as the colour effect of the abstract mode of the system, the discrete movement of the texts in the interactive mode; in comparison, the technologists used a great amount of technological terminologies to describe the technical issues of the project, such as how to use the Max/MSP software to connect the movement of the floor pad and the audio or video files of the interactive systems. In comparison, the technologist T_a and the technologist T_b had a high level of shared common language between each other. Amongst the time that the technologist T_a and the technologist T_b were talking with each other, it was found that they spent most of time talking about the specific technical issues of the project, such as how Java can be compatible with some functions of Max/MSP.

The category *Non-verbal* in TableA3.2 was designed to catch some non-verbal related communication components during the collaboration, such as no-conversation moments and the moments participants laughed during collaborative activities.

- The *Silent* node shows that during the collaborative activities in the GEO project, participants sometimes chose to work independently during the weekly meetings. For instances, the technologists worked in front of the computers attempting to optimize the interface of the artefact while the artist was designing the text files by himself.
- The *Laugh* node shows that participants did not laugh quite often during the GEO project. The whole project was carried out in a relatively formal atmosphere.

The category *Assisted* in TableA3.2 was designed to categorize the communication according to different kinds of mediation tools used during the communication, such as computers, pen and paper, or physical objects. More details as follows:

- The coded data of the *Computer-screen-assisted* node shows that, there were mainly two circumstances participants conducted computer-assisted communication: the first circumstance is when participants talked with each other while constantly referring to some components on the computer screen, where a software interface can be displayed or a specific audio or video file was open; and the second circumstance is where participants taking to each other whilst interacting with the floor pad and observing the changes in the interface on the big screen.

- The coded data of the *Drawing-assisted* node shows that, during the drawing-assisted communication, participants either drew something on paper or on the white board. Within the coded data under this node, in terms of the frequency, it has been found that the technologists conducted drawing more often than the artist did and most of the drawings were related to the design of the interface and the layout of the whole artefact.
- The coded data of the *Object-assisted* node shows that, during the object-assisted communication, participants mainly used one external object, which is a printed version of the proposal where the detailed description about the design of the interface was listed.

The category *Non-assisted* in TableA3.2 was used to differentiate the mediated communication as discussed previously from non-mediated communication. During the non-assisted communication, participants mainly talked with each other face to face where eye contacts between participants constantly happened.

In summary, the above discussion about the *Communication* master node was carried out for analysing the GEO data from four perspectives: verbal, non-verbal, assisted and non-assisted. In the next section, a summary about the last master node *Behaviour* is presented.

Behaviour Master Node

The summary of each node under the *Behaviour* master node, made based on the related coded data from the GEO case, is presented in the following table.

Table A3.3: *Behavior* master node summary

Category	Node	Results
Cognitive Styles of Collaboration	Leadership	The artist was the leader of the whole team throughout the collaboration process and the rest of the team members (two technologists) were equal with each other.
	Learning	The learning process of two technologists is more obvious compared with the learning process of the artist.
Cognitive Styles of Participants	Goal-Driven	The last two months was more of a goal-driven style of collaboration than the exploratory style. During that period, all participants focused on very specific goals, such as the quality of the sound, the sensitivity level of the floor pad.
	Exploratory	The first three months was more of an exploratory type of collaboration than the goal-driven style. During this period, technologists helped the artist to shape his ideas and explore the possibilities about the design of the interface, the design of the interactive system and the quality of the video sequence.
	Flexibility	The artist and technologists showed less interest to each other's field. The technologist T_a and the technologist T_b showed more interest to each other's field.
Emotional States	Evaluation	The evaluation of the artefact by all the participants was pretty positive.
	Expression of Emotion	The technologist T_b expressed the feeling that he had learnt a great deal from the residency, particularly related to software Max/MSP application. The artist felt pretty frustrated that he couldn't dictate the process. The technologist T_a felt frustrated that the meetings were kept a bit long.

The results in relation to the category *Cognitive Style of Participants* in Table A3.3 are summarized as follows.

- The data coded from the *Leadership* node shows that artist led the collaboration through out the whole project and both of the technologists were working as equals with each other. Furthermore, it was observed that the technologists controlled some technical issues, such as the choice of software, or one particular function of the software, but the artist controlled the outcomes of the technologists' choice, the design of the artefact and the outcome and contribution of the project and other related issues, such as time allocation, budget etc.
- The data coded from the *Learning* node shows that both technologists expressed that they learnt a great deal through collaboration, particularly related how software applications can be applied in a complicated interactive art project. For example, the technologist T_b said in the interview that he had learnt about how to use Max/MSP, how to reduce the CPU power by using a Java program and he also learnt a new function of Java-the "spring" mode. In contrast, the artist mentioned his learning process was mainly related how to manage the quality of the panorama structure he shot.

The results in relation to the category *Cognitive Styles of Collaboration* in Table A3.3 are summarized as follows.

- In comparing the results between the *Goal-driven* node and the *Exploratory* node, it was found that: during the five months of collaboration, in the first three months, participants conducted a more exploratory type of collaboration than a goal-driven style. During this period, the technologists helped the artist to shape his ideas and explore the possibilities about the design of the interface, the design of the interactive system and the quality of the video sequence. In contrast, in the last two months, the collaboration style participants conducted was more of a goal-driven style than an exploratory style. During that period, all participants focused on very specific goals, such as the quality of the sound, the sensitivity level of the floor pad etc.
- The results of the *Flexibility* node shows that participants exhibited different level of interests to each other's field: the artist and the technologists showed less interests in each other's field compared with the interests shared between technologist T_a and technologist T_b. It was also found that the artist showed less interest to the technological issues compared with the interest the technologists showed to the aesthetic issue.

The results in relation to the category *Emotional States* in Table A3.3 are summarized as follow:

- From the coded data of the *Evaluation* node, which mainly comes from the in-depth interviews conducted at the end of the project, all three participants gave some quite positive feedback resulting from this collaboration process and the final product of the collaboration.
- The positive feedback includes:
    - The artist was quite happy with the final product of the collaboration, which realized most of the fundamental requirements he needs;
    - Both of the technologists expressed that they learnt a great deal about the Max/MSP software application, particularly the functionality of combing object-oriented software applications, such as Java, or handling large amount of video and audio data.
- The negative feedback or suggestions raised by the participants include:
    - The technologist T_b wished to have a more flexible working time;
    - The technologist T_a would like to shorten the weekly meeting time;
    - The artist wished that they can resolve a way of stitching together the images in a better quality and to reduce the jerkiness of the panorama when it paned right or left. Moreover, the artist would have liked to improve the scalability of the images that software Max/MSP offered. In the future, he would like to try other potential possibilities, such as a

flash based environment and JavaScript, to decrease the capacity of the CPU and increase the mobility of the system.

In summary, the above discussion about the *Behaviour* master node analyzed the participants' behaviour in the GEO case study in terms of the types of collaboration, such as leadership, learning process, and the collaboration styles the participants had, such as goal-driven or exploratory, verbal or non-verbal, assisted or non-assisted. The summary of this master node also covers the evaluation participants made to the project, where positive and negative feedbacks from participants were identified.

A3.2 Interaction Graphs

The following figures are the interaction graphs drawn from each meeting across eighteen meetings.

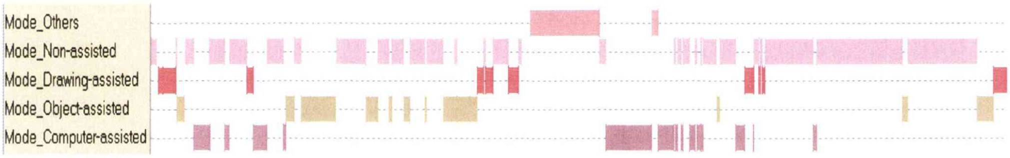

Figure A3.1: Interaction graph for the 1st meeting (13th of July, 2007)

Figure A3.3: Interaction graph for the 2nd meeting (21st of July, 2007)

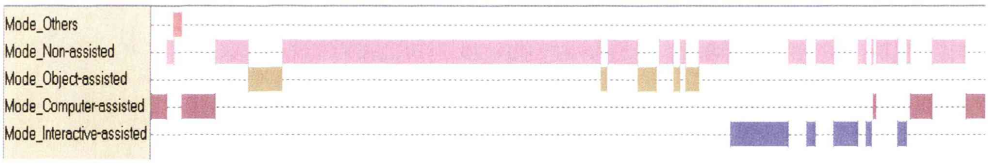

Figure A3.4: Interaction graph for the 3rd meeting (1st of August, 2007)

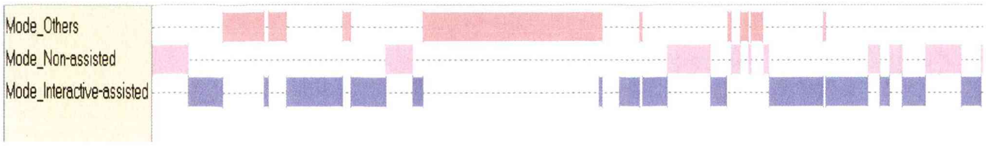

Figure A3.5: Interaction graph for the 4th meeting (16th of August, 2007)

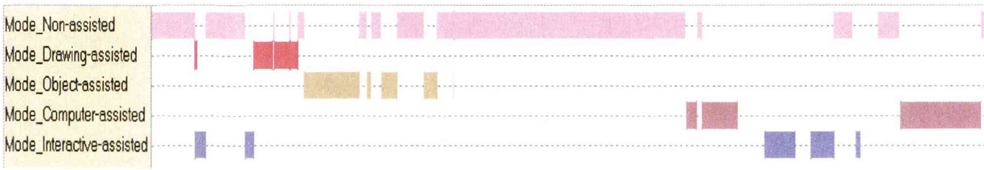

Figure A3.6: Interaction graph for the 5th meeting (23rd of August, 2007)

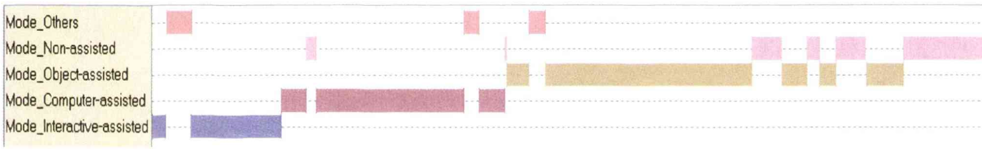

Figure A3.7: Interaction Graph for the 6th meeting (30th of August, 2007)

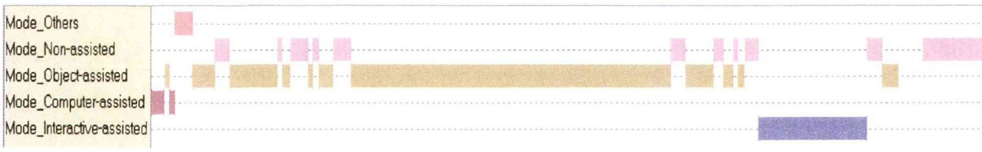

Figure A3.8: Interaction Graph for the 7th meeting (6th of September, 2007)

Figure A3.9: Interaction Graph for the 8th meeting (13th of September, 2007)

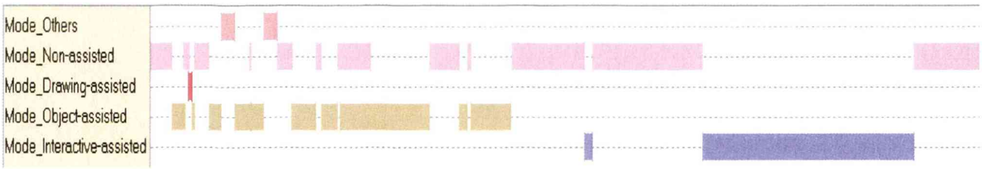

Figure A3.10: Interaction Graph for the 9th meeting (18th of September, 2007)

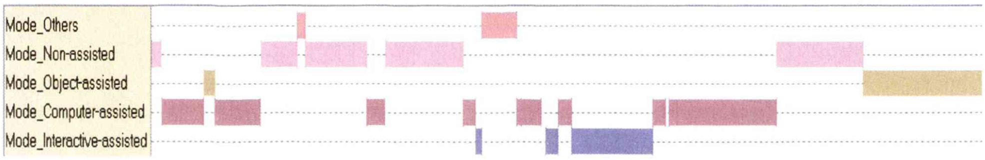

Figure A3.11: Interaction Graph for the 10th meeting (26th of September, 2007)

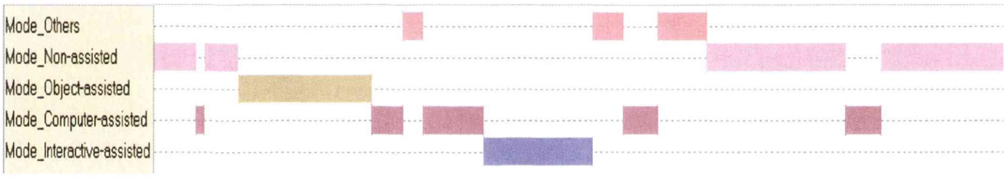

Figure A3.12: Interaction Graph for the 11th meeting (11th of October, 2007)

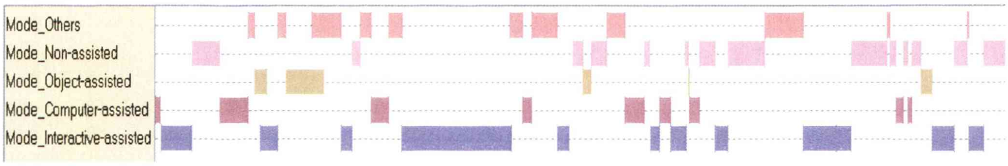

Figure A3.13: Interaction Graph for the 12th meeting (18th of October, 2007)

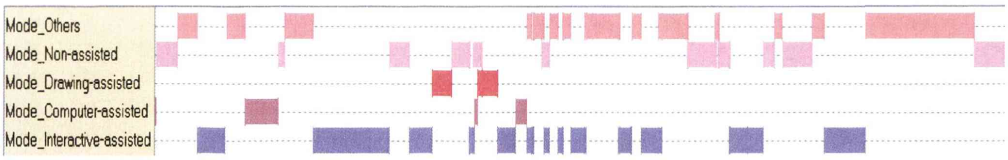

Figure A3.14: Interaction Graph for the 13th meeting (27th of October, 2007)

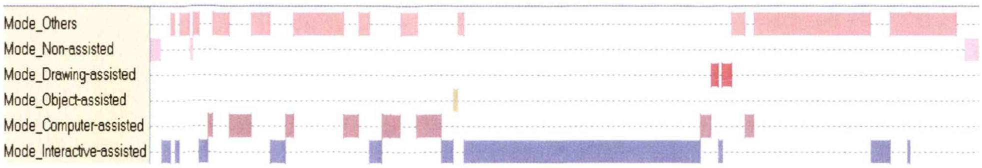

Figure A3.15: Interaction Graph for the 14th meeting (2nd of November: AM, 2007)

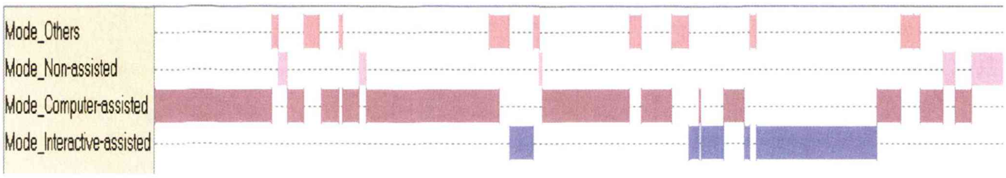

Figure A3.16: Interaction Graph for the 15th meeting (2nd of November: PM, 2007)

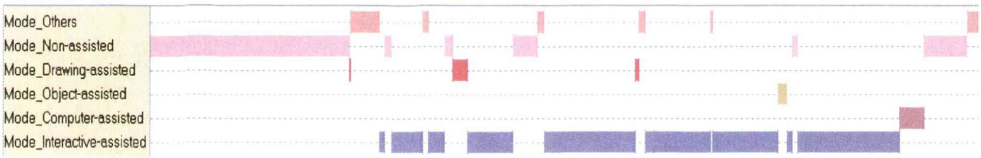

Figure A3.17: Interaction Graph for the 16th meeting (6th of November, 2007)

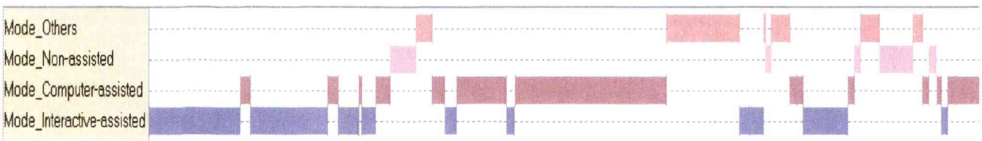

Figure A3.18: Interaction Graph for the 17th meeting (15th of November, 2007)

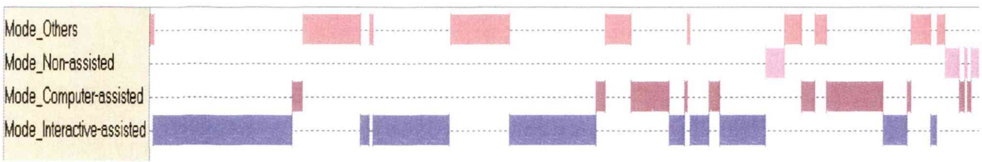

Figure A3.19: Interaction Graph for the 18th meeting (6th of December, 2007)

A4 Publications

1. Zhang, Y. and L. Candy. *An In-depth Case Study of Art-Technology Collaboration* in *Proceedings of the Sixth International Conference on Creativity & Cognition*, 2007, Washington DC, US: ACM, pp. 53-62.

   Abstract: This paper presents an in-depth case study of the creative process of an art-technology collaboration project. We begin by providing a brief description of art-technology collaboration research and go on to describe a particular art-technology collaboration project called "GEO Narrative Landscapes". This is followed by an account of a novel method for the analysis of the interaction between artists and technologists based on five communication modes. Findings include common types of conversation topics of communication modes, how these modes interacted with each other and how they were distributed in terms of frequencies and duration across meetings during the collaborative process. Finally, we discuss the contribution of this work to our understanding of art-technology collaboration.

2. Zhang, Y. and L. Candy. *A communicative behaviour analysis of art-technology collaboration* in M.J. Smith & G. Salvendy (eds), *Proceedings of the 12th International Conference on Human-Computer Interaction*, 2007, Beijing, China: Springer, pp. 212-221.

   Abstract: This paper presents an approach to investigating interdisciplinary collaboration between an artist and a technologist based on case study methods. The aim of the research is to understand how artists and technologists communicate with each other during a collaborative process. The paper begins with a brief account of the art-technology context, and goes on to describe how the data was collected and how the analysis framework was developed specifically for this context. At the end of this paper, we discuss the preliminary findings which illustrate the characteristics of participants' communication behaviour in art-technology collaboration.

3. Zhang, Y., A. Weakley, and E. Edmonds. *Resolving assumptions in art-technology collaboration as a means of extending shared understanding* in M.J. Smith & G. Salvendy (eds), *Proceedings of the 12th International Conference on Human-Computer Interaction*, 2007, Beijing, China: Springer, pp. 204-211.

Abstract: This paper extends the knowledge and understanding of art-technology collaboration. It reports upon a close empirical study of how computer programmers interacted with a digital artist to develop a computer-based interactive artwork. Analysis of the data collected showed that the joint uncovering and resolving of assumptions made by each party led to increased shared understanding. The contribution of this paper is to provide a better understanding of creative collaboration, particularly focusing on how developing the artefact increased the understanding between the artist and technologists.

4. Zhang, Y. and L. Candy, *Investigating collaboration in art and technology*, Co-Design: International Journal of Co-Creation in Design and the Arts, 2006, 2(4): pp. 239 – 248.

Abstract: In order to understand how collaboration between people from different disciplines takes place, research is being undertaken in the area of art and technology. The present paper describes three studies of collaboration between artists and technologists drawn from the COSTART (Computer SupporT for ARTists) project, an artist-in-residency programme that provided a platform for studying the creative process. The paper describes how case studies were carried out and, in particular, how the data analysis was conducted using a coding framework developed specifically for this art-technology context and what the preliminary findings that have emerged were.

5. Zhang, Y. and L. Candy. *A Study of Interdisciplinary Collaboration in Art and Technology* in *Proceedings of CCS/ACID Symposium: Engage: Interaction, Art & Audience Experience*, 2006, Creativity and Cognition Studio, University of Technology, Sydney, Australia: Creativity and Cognition Studio Press, pp. 282-290.

Abstract: This paper describes a method based on protocol analysis to study interdisciplinary collaborative activities between an artist and a technologist. The data was collected during an artist-in-residency project COSTART (COmputer SupporT for ARTists). The aim of the research is to understand how artists and technologists communicate with each other during a collaborative process. The paper describes how the research was carried out and, in particular, how the data analysis was conducted using coding schemes developed specifically for this context. At the end of the paper, preliminary findings are presented and future works are indicated.

6. Zhang, Y. and L. Candy. *Investigating Interdisciplinary Collaboration: Case Studies in Art and Technology* in *The third international conference on Qualitative Research in IT & IT in Qualitative Research*, 2006, Institute for Integrated and Intelligent Systems, Griffith University, Brisbane, Australia: Griffith University Press, pp. 173-183.

Abstract: In order to understand how collaboration between people from different disciplines takes place, research is being undertaken in the area of art and technology. The paper describes two studies of collaboration between artists and technologists drawn from the COSTART (COmputer SupporT for ARTists) project, an artist-in-residency programme that provided a platform for studying the creative process. The paper describes how the research was carried out and, in particular, how the data analysis was conducted using a coding scheme developed specifically for this context. Finally, the preliminary findings are discussed and future work is proposed.

7. Turner, G., Weakley, A., Zhang, Y., & Edmonds, E. (2005). *A Social Study of Creative Collaborations, with Implications for Supportive Technology*, Paper presented at the *Apple University Consortium Conference*, Hobart, Australia.

Abstract: This paper presents findings from a grounded theory study of the social and technical roles of programmers, as quintessential digital technology workers, in their collaborations with artists, as quintessential creative workers. Combined with a review of the roles of technology with respect to helping artists engage with the computing medium, we show that programmers can play several roles in such collaborations, both supportive of and obstructive to the requirements of artists, beyond merely 'doing the programming'. Of central importance is the process of 'attuning' between the actors and artefacts involved, and this can show us ways of making programming systems more comprehensible to creative practitioners, and ways of making computing systems better suited to creative innovation.

8. Turner, G., Weakley, A., Zhang, Y. & Edmonds, E. 2005, *Attuning: A Social and Technical Study of Artist Programmer Collaborations*, In *Proceedings of the work shop on Psychology of Programming Interest Group (PPIG)*, University of Sussex, Brighton, UK, pp. 106-119.

Abstract: This paper presents findings from a grounded theory study of the social and technical roles of programmers in art-technology collaborations. Combined with a review of the roles of technology with respect to helping artists engage with the computing medium, we show that programmers can play several roles in such collaborations, both supportive of and obstructive to the requirements of artists, beyond merely 'doing the programming'. Of central importance is the process of 'attuning' between the actors and artefacts involved, and this can show us ways of making programming systems more comprehensible to artists.

9. Turner, G., Weakley, A., Zhang, Y. & Edmonds, E. 2005, *A Grounded Theory Study of Programming in Artist-Programmer Collaborations*, in H. Fujita & M. Mejri (eds), *The New Trends in Software Methodologies, Tools and Techniques: proceedings of the Fourth International Conference on SoMeT_W05*, IOS Press, Tokyo, Japan, pp. 388-400.

Abstract: This paper presents findings from a grounded theory study of the social and technical roles of programmers in art-technology collaborations. The process of 'attuning' between the actors and artefacts involved is a recurring theme in our study and one that we think is central to trans-disciplinary collaboration and for non programmer-focussed software development. We reflect on the use of grounded theory to study software engineering social processes and conclude that the methodology can bring designers and researchers rich theoretical understandings that can be used to develop new tools to support different types of software engineering.