Understanding Creative Interaction:
A Conceptual Framework for Use in the Design
of Interactive Systems for Creative Activities

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Abstract

This thesis explores the possibility of a theoretical basis for the design of interactive systems that support creative activities, and – through theoretical, empirical and design-based research – develops a conceptual framework for the support of this process. The thesis begins by describing our current understanding of creativity, the notion of supporting creativity, and the relationships between creativity and interactive systems. It argues that an understanding of creative interaction could be of use in the design of systems for the support of creative activities. The method of enquiry employed to develop this understanding is for observations, a questionnaire and participatory task modelling approaches to be analysed, and the findings used to inform three prototype design and evaluation studies. Through this process, a conceptual framework consisting of three perspectives on creative interactions: Productive, Structural and Longitudinal is developed, with an example prototype system developed and evaluated from each perspective. As the conceptual framework generalises from the wide scope of activities that can be considered creative, the effects of some important contextual factors on instances of creativity are also analysed using the model. These comprise the Domain, the Interpersonal context, and the Expertise of those involved. Generic requirements, and questions for eliciting context-specific needs for the design of interactive systems are presented. Conclusions are drawn on both the utility of the conceptual framework to design, and the possibilities for extending this work in the future.
Part 1: Introduction
1.1: Overview

This thesis presents an analysis of the interaction of humans with external artefacts, and with each other, in creative activities. The understanding built through this exploration is developed into a conceptual framework for use in the design of interactive systems for creative purposes.

Human creativity has been said to distinguish us from other animals and to be essential to our ability to adapt and survive as a species (Csikszentmihalyi, 1996). In modern times creativity is argued to be the driving force behind our economic and social development (Florida, 2002). At its heart, creativity involves mental processes that lead to outcomes in the external world. The interactions between people and external artefacts are therefore central to creative processes, and a better understanding of these should be valuable in the design of interactive systems for creative activities. In order to achieve this goal, the thesis begins with a review of existing research on creativity, interaction and the design of interactive systems. A combination of empirical and design research methods are then used to explore the nature of creative interaction, and its existing or possible relationships with interactive systems design. The major contribution of this thesis is a conceptual framework for the designers of interactive systems, along with concrete examples of prototype tools based on the findings. In a wider context, this thesis also contributes to the field of Human-Computer Interaction as an example of the application of an understanding of complex human processes to interactive systems design.

A wide range of influences on creative processes have been identified, ranging from the qualities of a tool (Terry et al, 2004, Tanaka, 2006), to serendipitous encounters (Simonton, 1989, Gelernter, 1994), to the effects of a socio-cultural context (Becker, 1982, Amabile, 1993, Csikszenmtihalyi, 1996). The complexity of the system that supports and evaluates a creative act is therefore high. The use of computers in creative activities has become pervasive, but the effects and opportunities presented by this are still poorly understood. In many cases the computer has caused controversy, with its influence on our imagination, and its effects on creative domains, being derided as often as they are praised. This thesis is inclusive of the wider context of creative activities, considering interactive systems as a special class of tools that offer distinct possibilities for support, but that – in their current forms – often fail to replicate the characteristics of the tools and systems that have evolved to support creativity over much longer periods of time.

Creativity is both pervasive and hard to bound – we can identify activities that typify an ideal of what it is to be creative, but cannot find many activities that do not periodically require some creative thought to be applied. Romer argues that: “An ant will go through its life without ever coming up with even a slightly different idea about how to gather food. But people are almost incapable of this kind of rote adherence to instruction. We are incurable experimenters and problem solvers” (from Florida 2002, p 36). As a response to this, the thesis is not bounded to a specific set of tasks for which the findings are expected to
be useful, instead, it aims to define generic concepts and forms of creative interaction, then explore how contextual factors affect these in instances of creative activities. The studies described in this thesis are of activities that can be considered to inherently involve a high degree of creativity, such as musical composition and filmmaking. The people studied have shown an interest, and generally have some level of experience, in the related activity. In this way they are representative of a wide population of users that designers could support through new systems.

The conceptual framework that embodies the findings of this thesis combines a representation of the generic interaction processes that occur between humans and tools in creative activities, and a consideration of how several essential contextual factors affect these processes. This thesis presents the argument that creative interaction can be usefully viewed from three generic perspectives: **Productive Interaction** – focused engagement on the development of a creative outcome, **Structural Interaction** – the development of the structures in which production occurs, and **Longitudinal Interaction** – the long-term development of resources and relationships that increase creative potential. Over the course of performing the research presented in this thesis, it has become apparent that these perspectives and the relationships between them provide the most succinct basis for a holistic conceptualisation of interaction in creative activities.

While there are a wide range of contextual factors that can affect these interactions, three important factors are explored in this thesis with reference to the perspectives described above: Being central to our modern understanding of creativity, the **interpersonal** aspects of creative interaction – particularly collaboration and social interaction - are integral to variations in creative processes. In much the same way as a single human seems to focus their creativity in only one or a few domains, yet we can identify a general notion of creativity, many software tools need to provide specialised, **domain-specific** support for the generic types of interactions identified in the perspectives. Finally, the notion of **expertise** is considered in terms of the ways in which experience, learning and skills affect creative interaction from each perspective.

Empirical research methods are employed in this thesis to understand current creative practice, and design research methods are used to analyse how the design of systems affects creative processes, and to explore how design can be performed. The research includes observational studies in the domains of musical composition and filmmaking, an open questionnaire study, and Participatory Task Modelling. Three iterative prototype design and evaluation studies are used to understand both user needs and the design process itself. Evaluations of prototypes create a dialogue with creative practitioners, and are used to explore the interactions that can occur in the design process. User participation in the design process is explored through Participatory Design sessions, and also in the utilisation of an End-User Development approach to software development. Both the empirical and design studies are used in the development of the conceptual framework.
For the purposes of this thesis it is necessary to find evidence concerning how creativity can be supported or prevented through the design of computer environments. As in many of the complex domains of study relating humans and technology, a difficult task is to define an effective notion of what it is that constitutes suitable or improved support. Whereas more constrained studies of human-computer interaction use measurements such as efficiency or accuracy, no simple measure exists that is effective in comparing instances of creativity, or the effectiveness of tools. Qualitative data forms the backbone of this thesis, with quantitative measures used in tandem with this where appropriate.

Understanding support for creativity is an important and complex challenge for Human-Computer Interaction as a discipline, highlighting a more general need to understand and design for a range of complex human processes. Emerging unpredictably from a system of practitioners, tools and contexts, designing for creativity must leave scope for serendipitous encounters, allow users to challenge boundaries and explore ambiguous possibilities. As the development of theory lags design, and designers are capable of intuitive reasoning in the development of systems, examples that realise many of the findings of this thesis are apparent in the tools that already support creative practice. However, by producing a conceptual framework, it is hoped that a wider audience can effectively understand these processes and needs, and that deeper discussion and analysis are supported in future work.
1.1.1: Research Contribution

Firstly, this thesis contributes a conceptual framework with which to understand creative interaction. This is intended to be of use to the designers of interactive systems for creative activities. It could also be of utility to other researchers, or those in roles that require an understanding of creativity that can be practically observed and applied to decision-making and design.

Secondly, this thesis contributes three prototype systems, and - through the evaluations - further suggestions for improvements to these. These exemplify the translation of the findings in to designed systems. They include novel interface functionality that could be applied across a range of systems, and have been refined through an iterative design and evaluation process.

Finally, in this thesis, research methodologies have been adopted and developed in novel ways: For example, Participatory Task Modelling is applied in a novel domain, and with a novel method of analysis (section 4.1.3.2). Also, usage statistics from prototype evaluations are collected and analysed in novel ways to produce understanding of user behaviour (particularly in section 4.3.5.1).

The contribution of the work described in this thesis has been recognised through the peer-reviewed publication of sub-sections of it in the following journals and conferences: ACM CHI 2006 (Coughlan & Johnson 2006), ACM Creativity and Cognition 2007 (Coughlan & Johnson 2007), the International Journal of Human Computer Interaction (Coughlan & Johnson 2008a), ACM CHI 2008 (Coughlan & Johnson 2008b), ACM Creativity and Cognition 2009 (Coughlan & Johnson 2009a), and the Journal of Digital Information (Coughlan & Johnson 2009b). Three workshop papers at CHI 2006, 2007 and 2008 have also been peer-reviewed, accepted and presented based on this work, on the topics of Sketching, HCI and New Media Arts, and Personal Information Management.
1.1.2: Thesis Outline

Part 2 of this thesis contains a review of literature and research related to creativity, interaction and design, converging towards the specific focus of this thesis. The first chapter of this section: 2.1: Understanding Creativity and Creative Processes, provides a general overview of how creativity is understood. Following this, chapter 2.2: Human – Human Interaction and Creativity considers how the interaction between people is integral in creative activities. In chapter 2.3: How Creativity is Supported, the interaction between people and the external artefacts that support creative interaction is explored, with reference to research from a range of disciplines. Chapter 2.4: Human – Computer Interaction and Creativity takes the focus further towards interactive systems, describing research relating to the characteristics of computers as a support tool for creative activities. Finally, chapter 2.5: Designing Interactive Systems provides a background on design processes, in order that the findings that can be understood in this context.

Part 3 describes the research performed for this thesis, and the reasons for the methods of study and analysis used. The section begins with chapter 3.1: Issues with the Study of Creativity and Support for Creativity. Creativity is a difficult phenomenon to effectively study, and this chapter presents a critical analysis of methods and issues raised in existing research. These issues provide a context for the next chapter: 3.2: Methods Used and Instances, which describes and explains the methods used in the research performed for this thesis.

Part 4 describes the findings of this research. It begins with chapter 4.1: Overview of Research Findings. This describes the structure of the findings, the process of reasoning through which this framework emerged, and overall evidence for its validity. The following chapters (4.2: Productive Interaction, 4.3: Structural Interaction, and 4.4: Longitudinal Interaction) describe the three perspectives on creative interaction in a common form, utilising the empirical studies throughout, and describing a prototype design and evaluation study in each case.

Part 5 brings together the findings, and considers how they can be applied in chapter 5.1: Utilising the Findings as a Framework for the Design of Interactive Systems. Chapter 5.2: Conclusions then critiques the findings and the general issues that the process of performing this research has highlighted.
1.2: Research Questions and Objectives

The following sections define the questions and objectives that constitute the aims of this thesis, and the outcomes produced through it.

1.2.1: Research Questions

1: What are the essential processes in the interaction of humans with external artefacts, and with other humans, that characterise creative activities?

This encapsulates the topic of this thesis – understanding the interactions that occur in creative activities. These interactions are considered to include those with external artefacts – such as tools, media and the environment, and those with other people – such as collaborators, peers or the designers of support tools.

2: How can an understanding of these interactions be usefully applied, supporting the design and development of interactive systems for creative activities?

This considers that an understanding of creative interaction can be utilised by designers, but that the nature of the design of interactive systems needs to be explored and reflected upon for an effective tool to be produced that can achieve this.

1.2.2: Research Objectives

1: Build an understanding of the interaction that occurs both between humans and with humans and external artefacts in creative activities, combining a range of research methodologies to develop this understanding.

The thesis begins with a review of relevant research from a range of disciplines. Building upon this, the findings of the empirical studies are utilised and an understanding of creative interactions is presented.

2: Iteratively design, implement and evaluate prototype systems to support creative activities based on the findings of objective 1.

In order to develop an understanding of creative activities and needs suitable for designers, it is necessary that the relationships between tools and creative activities are explored. This occurs through the design and evaluation of prototype tools in response to identified needs in creative interaction from the empirical studies. The utility, deficiencies and phenomena caused by the introduction of these tools is then analysed, leading to further understanding of the effects of design in this complex area. A design and evaluation study is presented in relation to each of the identified perspectives on creative interaction.
3: Develop a conceptual framework and guidance for the design process, that takes the findings of objective 1, refined through the understanding of designing for creative activities built through objective 2, and provides a useful tool for designers of interactive systems for creative activities.

A conceptual framework is developed, consisting of three perspectives that when combined, present a holistic representation of interaction in creative activities. The final chapter of this thesis presents a distillation of the findings as guidance to the designers of interactive systems for creative activities.
Part 2: Background
2.1: Understanding Creativity and Creative Processes

This chapter gives an overview of existing research that has shaped our understanding of what creativity is and how it occurs. Firstly, definitions and forms of creativity are explored, highlighting the central concepts of ideas, outcomes, novelty and value. This is followed by a review of conceptions of the creative process. The rest of the chapter then builds a picture of the common themes that appear throughout creativity research.

2.1.1: Defining Creativity

Creativity is seen as an essential human trait, and as such it has concerned thinkers and researchers from many disciplines and in many contexts. There has been a chronological movement from attributing creativity to external forces working upon man – the muses or divine inspiration (Claxton, 2005, Sawyer, 2006), through conceptions of creativity as an individual trait, requiring either rational thinking and skill, or a harnessing of the irrational unconscious mind (Sawyer, 2006), towards modern conceptions of creativity as a socio-cultural phenomenon, to be understood in terms of the context of the interaction between people and social structures (Amabile 1993, Csikszentmihalyi 1996).

As with many complex phenomena, creativity has proved difficult to satisfactorily define and bound. Despite concerted efforts at definition from a range of perspectives, there exists variation amongst researchers, practitioners, and also amongst the general population (Glück et al, 2002). There are however recurring themes that support consensus upon aspects of a definition:

Whilst creativity is generally conceived as a process (e.g. Wallas, 1926, Sawyer, 2006), it is the nature of the outcome that is commonly used to define it. Whilst to create is defined simply as “to bring in to existence” (Oxford English Dictionary), it is widely felt that to be creative, a process should result in an outcome that is both novel and appropriate to the situation (Amabile, 1993). From an economics perspective, Florida (2002) considers the creative class to be those who “create meaningful new forms” (pg. 68) From a sociological perspective Csikszentmihalyi (1996) describes one definition of creativity as involving “an idea or action that is new or valuable” (pg. 23). From a cognitive psychology perspective, Johnson-Laird (1993) gives three properties of an act of creation: That the result is formed from existing elements but in a combination that is novel for the individual and perhaps for society, that it satisfies some pre-existing criteria, and that it is not constructed by rote or deterministic procedure.

Taking an inclusive approach, the definition of creativity used in this thesis amalgamates and aligns with these existing perspectives. Creativity is defined here as:
A process resulting in the production of outcomes that have some level of both novelty and value.

Breaking down the definition, we find that creativity is a process by which a person or persons produce some form of outcome. The process therefore involves the externalisation of ideas from the minds of those involved. Sarmiento and Stahl (2007) summarise that creativity “involves extended efforts to articulate, critically consider, and communicate notions that are not already part of the taken-for-granted life-world” (pg. 44). A creative outcome can therefore be seen as the product of processes acting on numerous externalised ideas, so ideas that may hold novelty and value are therefore central elements of creative work.

Ideas are defined in the dictionary as “a thought or suggestion of a possible course of action” (OED), in the rest of this thesis, the term idea is used in a creative sense – in that some degree of novelty and value should exist in the “course of action”. Finke (1995) describes two dimensions on which ideas can be placed. These are from Creative to Conservative, and from Idealism to Realism. Conservative ideas tie in closely to existing ideas, and due to this can be expressed unambiguously and are likely to be easily accepted by others. Creative ideas are on the other hand more novel and difficult to define and encourage people to adopt. At its extreme, idealism defines ideas that have no basis or utility in reality because they are unrealistic or arbitrary. A level of realism, on the other hand, means that an idea has relevance to an existing issue, building upon something that is either useful or interesting. Finke sees Creative Realism as being of the highest value, as it effectively combines novelty and value.

Novelty and value are therefore essential concepts that creative practitioners are conscious of in their work. However, both are dynamic, context dependent qualities. For example, once an outcome has been created, replicating that outcome no longer holds any novelty, if a need has been met, the value in an alternative solution diminishes. Csikszentmihalyi (1996) uses this dynamic nature of novelty and value to argue that creativity occurs in “the interaction between a persons thoughts and a sociocultural context” (pg. 23). Specific instances of creativity can only be defined in response to specific conceptions of novelty and value, which are subject to dynamic individual and cultural variation.

Novelty need not be – some would argue could never be - total, and in most creative acts obvious aspects of the outcome are pre-existing, and are built upon or combined into a ‘novel’ outcome (Boden 1993, Simonton 1989). This need for novelty does however give us some further understanding of the nature of creative work. Creativity contrasts with conformity and ordinariness (Torrance, 1988). The drive towards producing novelty casts the creative practitioner in an exploratory role (Sawyer, 2003). It requires an extraordinary step outside existing logic or known possibilities, as Johnson-Laird (1993) suggests when he finds creative acts not to be constructed by deterministic
The novelty characteristic of creative outcomes makes it necessary for creative practitioners to express and realise concepts that may have limited precedent or definition in language or other form (Sarmiento & Stahl, 2007).

It is logical that the requirement for value requires evaluation by practitioners to occur in the course of creative activities, although the criteria used could range from individual aesthetic preference, suitability as a solution to a known problem, or an internalisation of what the responses of an audience or field of experts may be (Csikszentmihalyi, 1996). The nature of value in creativity is related to the aims of the practitioner and the context in which the outcome is to be produced. Simonton (2000) notes that the study of creativity has commonly differentiated between little ‘c’ creativity in everyday problem solving, learning and leisure – of value to the individual and perhaps to an immediate circle of others - and big ‘C’ creativity of high value to a society, prompting the labels of ‘genius’ or at least ‘professional’. Similarly, Boden (1993) distinguishes ‘P’ (psychological) creative ideas that are novel and valuable to the person who thought them, from ‘H’ (historical) creativity that is novel and valuable to the world. From an employment perspective, Florida (2002) differentiates between the “Core” of the “Creative Class” who engages fully in the creative process and aim to create products that are widely used, and the “Creative Professional” who engages in creative problem solving as a major part of their work, but is not expected to create outcomes of more general value to society. The first class would include artists, professors and scientists, while the second includes lawyers and managers.

On a similar topic, Taylor described five levels of creativity in 1959 (cited in Torrance 1988):

1. **Expressive Creativity**: as in the spontaneous drawings and utterances of children.
2. **Productive Creativity**: as in artistic or scientific products where there are restrictions and controlled free play.
3. **Inventive Creativity**: where ingenuity is displayed with materials, methods, and techniques.
4. **Innovative Creativity**: where there is improvement through modification involving conceptualising skills.
5. **“Emergenative” Creativity**: where there is an entirely new principle or assumption around which new schools movements and the like can flourish.

Although these distinctions are important, Craft (2001) argues that the mental processes involved in writing a report or making a meal out of the ingredients left in the fridge are essentially no different from those that were employed by Mozart or Einstein. All of these forms mentioned are of interest to interaction designers, and it can be expected that there are some variations and similarities in process and support needs due to differences in the notion of outcome value.
2.1.2: Understanding Creative Processes

Models and descriptions of the creative process have been a preoccupation of many researchers. As the creative process varies to some extent across practitioners, domains and cultures, all these representations are abstract generalisations, but they attempt to define actions, patterns and relationships that are repeated across creative activities. Shneiderman (2003) categorises descriptions of creativity as ‘Inspirationalist’ – considering how ideas occur, ‘Structuralist’ - focused on systematic exploration of conceptual spaces, and ‘Situationalist’ – taking social and environmental context as paramount.

Wallas’s four stage model - originally published in 1926 - is a particularly well referenced example of a creative process model (e.g. Gabora 2002, Jim Eales 2005, Warr & O’Neill 2005). The model consists of:

- **Preparation**: Sensing a need or deficiency leads to an exploration of a topic, where reading, discussing and formulating and analysing possible solutions occurs.
- **Incubation**: A period in which the topic is not consciously considered, but unconscious processes continue to work upon it.
- **Illumination**: An insight or idea occurs that could possibly provide a breakthrough on the topic.
- **Revision**: Experimentation evaluates the idea(s) and possible implementations.

Torrance (1988) describes Wallas’s model it as the basis for a great deal of the creativity research that follows. For example, through a questionnaire survey of inventors in 1931, Rossman (1931) expanded Wallas’s model to add more detail related to his findings. Rossman's model contains:

- Observation of a need or difficulty
- Analysis of the need
- A survey of all available information
- A formulation of all objective solutions
- A critical analysis of these solutions for their advantages and disadvantages
- The birth of the new idea -- the invention
- Experimentation to test out the most promising solution, and the selection and perfection of the final embodiment

The specific detail given in this model belies its roots in a dialogue with inventors. A bias towards engineering or scientific approaches is apparent, and a lack of resonance with the processes of artists in statements such as “A formulation of all objective solutions”. Differences in creative processes are explored later in this chapter, and in the findings of this thesis. At this point it is important to note that the abstract, widely applicable nature of Wallas’s model may explain its pervasiveness.
Plsek (1996) presents a review of major creative process models developed over the last century, including Wallas’s and Rossman’s. He identifies many similarities, but also variations, particularly in the degree to which they represent the involvement of the chance events and the unconscious.

Simonton (1988, 1989) in particular has argued that chance is central to creativity, developing the ‘Chance-Configuration Theory’ of creativity, based on an application of evolutionary theories to situated mental processes. Through a range of empirical research utilising introspective reporting, personality correlates and anecdotes from those considered ‘geniuses’, Simonton’s research builds a theory of three key ideas:

1. The Chance Permutation of Mental Elements
2. The Formation of Configurations
3. The Communication and Social Acceptance of those Configurations

The theory begins with the premise that the creative process entails operations on mental elements, such as images or mathematical formulae. Simonton suggests that permutations of these mental elements occur in the mind with some degree of unpredictability, that “a large number of potential permutations exist, all with comparably low but nonzero probabilities” (Simonton 1988, pg 7). A chance linking of permutations results in a new configuration, which may – through a selection process – be retained in some stable form as a novel configuration of mental elements. A novel idea now exists at a personal level, and the final step in this evolutionary model of creativity is the communication of this configuration to others, which may lead to its selection and acceptance at a social level.

Simonton’s theory of the mental processes involved in the production of novelty has similar properties to other theories that define association or ‘bisociation’ as the mental process that results in novel ideas. This associative process can be considered responsible for novelty, but a balancing process – as suggested by Simonton’s selection – is necessary to consider the value of these ideas. Research by Gerlenter (1994), Koestler (1964) and Gabora (2002) suggests that creative processes can be described in terms the generation and evaluation of ideas. This reflects two cognitive modes or forms of thought process: ‘Associative’ – revealing subtle or remote connections between items in memory, and ‘Analytic’ – focused on evaluating cause and effect relationships. It is the combination of these modes of thought that provide a platform for novel and valuable ideas to emerge and be identified from associations between disparate items in memory.

The models presented above are seen in an inclusive light in this thesis – Wallas’s (1926) model and others like it generalise longer-term processes involved in creative activities, whilst the concepts of associative and analytic thought can be used to characterise focused engagement with ideas.
Simonton (1988) poses a useful theory with which to view both micro and macro components of creativity.

The remainder of this chapter utilises further creativity research to present a thematic overview of components that are widely considered to be central to creative processes.

### 2.1.3: General Characteristics of the Creative Process

#### 2.1.3.1: Iterative Ideation and Evaluation in an Ill-Structured Context

One of the most universally reported aspects of creative processes is their iterative, ill-structured nature (e.g. Schön 1987, Carroll, 1991, Simon 1996, Amitani & Hori 2002). Describing the process of painting, Simon (1996) states that “every new spot of pigment laid on the canvas creates some kind of pattern that provides a continuing source of new ideas to the painter. The painting process is a process of cyclical interaction between the painter and canvas” (pg 163). The requirements for novelty and value are realised through the generation of novel ideas – for which the term ‘ideation’ will be used in this thesis – and the judgement of the value of generated ideas – for which the term ‘evaluation’ will be used. These can be seen as two essential mental processes involved in the creative process, reflecting the associative and analytical thought processes described above. The terms ‘divergent’ and ‘convergent’ thinking (Baer 2003) are also commonly used, making a distinction between exploratory acts to find suitable ideas and reductive acts that decide which ones to use and then realise them.

Ideas can therefore be seen as the atomic elements in creative processes. In terms of creative ideation, Briggs and Reinig (2007) define an idea as “an actionable object-verb phrase that is presented as a potential solution to the task at hand”. This definition however, reflects a focus on ideas that are verbally represented. Ideas begin as mental constructs, but must be externalised in some form to be used.

Amitani & Hori (2002) note that a tension in creative work is between ‘mental fixation’ – inappropriately converging on a solution too early - and a continual divergence of thought that does not converge upon a solution. Another similar, commonly used description is that creative processes involve ‘problem finding’ and ‘problem solving’ behaviours (e.g. Runco & Dow 1999, Mayer 1999). Problem solving is a well-studied human process that shares some parallels with creativity (Jonassen 1997). In particular the notion of an ill-structured problem is relevant. This term has been described as a situation where the exact nature of the outcome is not known as the activity proceeds, and a ‘best’ path to a suitable outcome is not clear. These are distinct from constrained, well-understood tasks such as completing a puzzle (Schön 1983, Schön 1987, Jonassen 1997). Terminology such as finding a ‘solution’ is commonly adopted in creativity research, but caution should be applied when
considering creativity solely as a combination of problem finding and solving. Creative processes - particularly in the arts - are inherently less constrained as a bounded problem is not obvious, and therefore the notion of a solution is only an approximation of what the outcome really means. ‘Problem’ often inappropriately connotes a specific, bounded issue that needs to be addressed. Equally ‘solution’ connotes the inappropriate meaning of a single correct answer. The compatibility of creative activities with a problem based approach may be related to the level of constraint enforced upon the practitioner, Glück et al (2002) found that practitioners in more constrained creative roles (e.g. architects and graphic designers rather than sculptors or painters) were more likely to emphasise problem solving in their individual definitions of creativity.

Ideation and evaluation occur in cycles, preferably moving towards an outcome, but in reality exploring contrasting directions, finding new difficulties and reversing previous decisions. Because they operate in an ill-structured situation, creative practitioners develop strategies or schemas through experience to proceed through to an outcome in an effective way. Schön (1983, 1987) described the strategies employed by professionals as ‘reflection-in-action’ and ‘reflection-on-action’. In performing ill-structured problem solving, the practitioner performs experiments and reflects on the results to inform the course of her / his work (‘reflection-in-action’). After the event they also reflect on their actions to explore and question their approach (‘reflection-on-action’). Schön argued that this reflection forms the basis for learning and development in complex domains.

There are of course, variations in the time available to practitioners to reflect and iterate as they produce outcomes. Johnson-Laird (1993) argued that real-time creativity without chance for evaluation requires the internalisation of sufficient criteria to guarantee that the results are at least acceptable. Sawyer (2003) focuses his research on improvisation as it offers an opportunity to observe creativity in action, also noting the need for previous learning of structures and development of a set of “ready-made” ideas to draw upon, so that improvisation can proceed with a likelihood of producing something valuable. In essence, a reduction in the ability to iterate in response to reflection in action requires the practitioner to rely on their internalised understanding of the domain and their ability to predict which ideas will have value in the current context. This could result in more structured outcomes with less novelty, but the ability of practitioners to be creative in more constrained spaces is often highly valued. The scope for iteration is explored further in findings chapter 4.2: Productive Interaction.

2.1.3.2: Structures: Domains, Conceptual Spaces and Constraints

Although they are ill-structured, creative tasks do not occur in a vacuum. A range of structures exists in, and through, which creative activities are performed. However, the development of these structures is an essential part of being creative. This topic is explored further in findings chapter 4.3:
Structural Interactions, to which this section provides an initial background. Concepts related to structure that are used extensively in creativity research are the domain, the conceptual space, and the constraints imposed on a creative task.

The nature of a domain is explored in Csikszentmihalyi’s (1996) sociocultural model of creativity, which is explained in detail the next chapter. A domain consists of a set of created products, language, symbols, specialised tools and evaluative criteria that provide a platform for creativity in a discipline. Although the granularity of domains could be considered in a variety of ways, examples of creative domains could include architecture, jazz or interactive art. For the practitioner, the domain provides structures of various types. For example they will be aware of the works that are evaluated as important and consider their work in the context of existing pieces, they will also be able to use existing tools and methods, though they may feel the need to appropriate them in order to create novelty.

With some exceptions, professional creative practitioners are generally successful – in terms of societal recognition and reward - in only one domain. There is however evidence to suggest that experience and ability in other creative domains is common amongst successful practitioners and may have a positive influence or point to a common aptitude for creativity. Root-Bernstein & Root-Bernstein (2004) found over 400 instances of well-known scientists who had considered an artistic career, and of 55 documented winners of the Nobel Prize for Literature, at least 20 had trained or immersed themselves in a scientific subject. Accepting that there is a general phenomenon of creativity, polymaths appear to have developed generic skills such as abstraction, pattern recognition and empathy. The main barrier to contributing to multiple domains may be that knowledge and skills require extensive development in each case. Plucker & Beghetto (2004) consider creativity to involve the interplay between ability and process. Practitioners with a wide, shallow set of skills and knowledge cannot achieve any real contribution, while individuals or groups with little background outside a single domain will be too fixed in their approach. They argue that successful creative practitioners value the perspectives that can be utilised from other domains, whilst acknowledging the need for extensive domain experience and commitment. In essence, an understanding of the structure of a domain is essential to making highly creative contributions, but a distinction can be drawn between the domain structure and creativity in general. In this thesis, the domain is considered as an essential contextual factor that needs to be understood in tandem with a generic understanding of creativity in order that effective support can be designed.

A ‘conceptual space’ can be used to explain the internal process of creating and developing novel, valuable ideas. Boden (1993) argues that ideation occurs through the exploration of a mental space that internalises our knowledge of the domain and other information, and allows us to understand the boundaries within which suitable actions may lie. These boundaries are only ever partially explored, as the range of possible actions are greater than 26
it would be possible to test. The practitioners’ knowledge and experience constrains the choices made to those they believe are most likely to be novel and valuable. The internalisation of experiences and knowledge that results in the development of conceptual spaces is central to the contextual factor of expertise that is explored in the findings.

As creative tasks are ‘ill-structured’ (Boden 1993, Johnson-Laird, 1993), there is a need for constraint to be imposed to limit the vast range of possible actions in any context in which creativity occurs. Although it may seem paradoxical that constraints are essential to creativity, the blank canvas is difficult to overcome, and constraints are often sought or introduced in order to gain focus. Stokes (2005) argues that useful constraints for creativity preclude tried and tested responses or promote and direct practitioners towards novel responses. She refers to the constraints provided by the domain as ‘first choruses’, as they provide the starting point from which the practitioner departs from or improvises with as they create. It is important to remember that practitioners are as likely to work against first choruses as with them. On top of this, practitioners develop or adopt their own ‘task’ constraints - materials or tools, ‘subject’ constraints – the topic of their work, and ‘goal’ constraints – conceptual aims that are poorly defined but which the direction taken in producing the work defines as it progresses.

Constraints on the creative process have been explored in a number of domains: Pérez y Pérez and Sharples (2001) classify constraints in creative writing either as external factors - tools and resources existing in the world, or mental constraints that reflect requirements for content or rhetorical issues of how best to compose for the audience. Writing involves periods of engagement and reflection. Engagement entails realising ideas that are expected to comply with constraints. Constraints “drive the production of material during engagement” (pg. 122), but writers also enter periods of reflection when they run low on ideas or feel compelled to depart from current constraints due to divergent thinking. In modelling the process of musical composition, Pearce and Wiggins (2002) identify three types of constraints on the composer: ‘Internal’ - the requirement to fit with existing ideas in the composition, ‘external’ - the limitations on what it is possible to create, given current skills, tools and knowledge, and ‘stylistic’ - constraints relating to the intended outcomes and genre.

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An interesting distinction can be drawn between externally imposed constraints and those imposed by the practitioner. In the above research, artistic domains were analysed. By contrast in design processes, constraints are commonly identified as a basis for bounding the design space in which solutions must fit. A range of constraints from cost or available materials to the functions required of the design can be identified and used to frame the process. Chandrasekaran (1990) notes that “all design can be thought of as constraint satisfaction” (pg. 65) but in design tasks of any complexity the space satisfying constraints that can be formally defined remains large, with many ‘correct’ solutions. Creativity in scientific or engineering processes can be seen to be even more externally constrained – based on the need to
create a solution that meets pre-existing constraints, either to construct a
theory from empirical data, or to engineer the best solution to a problem.

2.1.3.3: Associations and the Involvement of Conscious and Unconscious Processes

The nature of the mental processes that lead to novel ideas arising remains
somewhat mysterious, although several well-argued theories have been
produced to explain it. In literature on this issue, the intertwining of conscious
and unconscious processes forms a common theme. Bindeman (1998)
summarises that “Something has to break down in our old pattern-making or
pattern-recognising activities, and we have to experience this breakdown in
some way both consciously and unconsciously for the creative process to find
its impetus” (pg. 76). Claxton (2005) notes that “in creativity, consciousness
functions as the grateful, bemused beneficiary of a high form of intelligence
that, self-evidently, is operating unseen by the minds eye” (pg. 218).

Koestler (1964), Simonton (1989) and others have argued that the most
logical explanation of novel ideation – for which Koestler coined the term
‘bisociation’ - is that some kinds of associative processes connect multiple
thought matrices in the brain, and that novel ideas arise through the
association of these existing items in memory. Gerlenter (1994) takes these
theories and considers not only how it is possible for us to have novel ideas,
but also how these processes utilise our emotions and physiology. He
proposes a spectrum of thought from metaphoric low-focus to analytical high-
focus, affected by our physiology and context. While we can associate
disparate items in memory when we lack mental focus, emotional responses
triggered by an interest in a particular subject are required to alert us to the
possibly interesting ideas that emerge from our subconscious. Analytical
processes are then needed to evaluate an idea and assess its potential to be
realised. An emotional interest in a problem is therefore key to ideation, and
the use of the spectrum of consciousness in an effective way is essential to
creativity. This comprises of an ability to make use of low levels of mental
focus for ideation, whilst retaining the ability to identify ideas with potential,
and equally the ability to evaluate and realise these ideas at higher levels of
focus. This research reflects a need to understand creative lives outside of the
focused production of creative outcomes, and is explored further in the next
section and in findings chapter 4.4: Longitudinal Interaction.

2.1.3.4: Motivation and Life Involvement

A common perception is that creative practitioners are more intensely
involved in what they do than is normal in other tasks or activities. For the
serious practitioner, creative activities often define them as a person and
encompass a large portion of their lives and thinking. In the previous section
the strength of emotional interest in the topic was seen as essential to
bisociation using unconscious processes. Amabile (1993) argues that intrinsic
motivation is central to creative ability, with challenge, satisfaction and
enjoyment indicative of successful creativity, while external motivations such
as money can have a negative effect. In the same vein, Csikszentmihalyi
(1996) argues that creative practice is characterised by ‘flow’, a situation in which the practitioner is engaged by a challenge that effectively utilises their skills. Flow is a positive mental state characterised by phenomena such as high focus, a sense of personal control over the situation and a distorted sense of time.

Florida (2002) notes that while creative practitioners commonly demand autonomy in their employment, set their own hours and adopt a more casual attitude than is accepted in many other occupations, they are “never truly not at work” (pg 13). Work and life are blended because “creativity cannot be switched on and off at predetermined times, and is itself an odd mixture of work and play” (pg. 14). This wider perspective on creative processes is explored in findings chapter 4.4: Longitudinal Interaction.

2.1.3.5: Social, Collaborative and Contextual Influences

Whilst the next chapter will discuss human-human interaction in creative activities, a brief introduction is given here to highlight it as a further common theme. Not only is inter-domain communication and collaboration important to creativity, the domains that form basic structures for creative tasks are socially defined and continually developing. Amabile (1993) proposed a ‘consensual definition’ of creativity, through which outcomes are socially assessed for appropriateness in a given context. Sawyer (2006) notes that: “If creativity can’t be defined without appropriateness, and appropriateness can only be defined by the people working in a domain, then the definition of creativity is fundamentally and unavoidably social” (pg 122).

2.1.4: Conclusions

Through the research presented above, it is clear that there are a number of perspectives from which the creative process can be viewed, and a range of general characteristics that can be identified. The question that presents itself in the light of this thesis topic is: ‘How are these models, theories and concepts relevant to an understanding of the interaction that occurs in creative activities?’ Several assertions can be made in this regard:

• Whilst interaction with other people is apparent in many of the models, and further detail on this is described in the next chapter, these models of creative processes rarely focus on, or make reference to, the interaction between humans and the tools they use in creative processes. Interaction with tools and systems is however, necessary in the development of creative outcomes. As such there is a perceived need to translate and develop the understanding reviewed in this chapter towards the purposes of this thesis: To develop an understanding of creative interaction that can guide the design of interactive systems.

• A level of abstraction can be achieved that constitutes a generic model of creative processes. However, models are often biased towards the domain in which research has been performed. Creative processes do
vary, and scope should exist for factors that provoke these variations to be considered in the context of a generic understanding of creative interaction.

- Most perspectives on creativity can be understood in an inclusive light, and there is often overlap between them. Different perspectives highlight different aspects of the process, and can therefore provide different insights into the needs of creative practitioners. As such, this thesis will explore creative interaction from several perspectives, and consider the overlap(s) between them.
2.2: Human – Human Interaction and Creativity

The perceived importance of interpersonal aspects of creativity has shifted in recent times from being implicit – creativity was advantageous for society, therefore worth understanding, but could be understood through the study of individuals (e.g. Guilford, 1950) – to being explicit in the work of Amabile (1993), John-Steiner (2000), Csikszentmihalyi (1996) and Sawyer (2003) amongst others, who argue convincingly that creativity should be studied as a social and collaborative phenomenon. This follows a wider movement in the social sciences that argues for the analytic primacy of society over the individual in human studies (Wertsch, 1998). There are however, specific reasons for the study of creativity as a social and collaborative phenomenon:

Sawyer (2003) and John-Steiner (2000) both argue that collaboration is essential in most highly creative endeavours, while research by Amabile (1993), Csikszentmihalyi (1996) and Becker (1982) considers how creative activities occur within a social structure, and how creativity is culturally defined. Sawyer (2006) describes how the expectations of behaviour by creative practitioners varies across cultures. Art is quite clearly a social phenomena with a variety of cultural roles, but designers, engineers and scientists not only work within a social structure, the value of their work only exists in the context of the needs of the society.

Returning to the Koestler’s (1964) notion of bisociation, and Simonton’s (1989) chance configuration theory, social interaction provides one of the most obvious ways for novel ideas to develop, although conversely, groups and societies often expect adherence to norms of behaviour, which may instead lead to a lack of risk taking and the stifling of creativity. Whether through intentional discussion or chance overhearing, the possibility that novel ideas will emerge through human interaction are high as the depth of experiences and the critical capacities of multiple human beings are clearly greater. The experiences and ideas of people from other disciplines, cultures and places can often provide the required inspiration for a person who has found and explored a problem but cannot see the solution in their own experiences. Picasso and Matisse were among a number of artists whose innovative styles were highly influenced by an appreciation of African sculpture, which they viewed in stark contrast to the European aesthetics of the day (Sawyer, 2006).

A more pragmatic reason to study the human interaction that occurs in creative work is that it offers a visible insight in to the workings of the creative process. Perkins (1981) suggests that think-aloud techniques are necessary to understand creative processes, and that studies of created artefacts or post-hoc descriptions by practitioners are open to misinterpretation. Whilst a useful method, it is likely that think-aloud techniques have an impact on the activity studied. In contrast, practitioners engaging in collaborative creativity naturally and actively communicate some of their thoughts as part of the need
to share, evaluate and reflect on ideas, and to maintain awareness of their current focus. Sarmiento and Stahl (2007) propose that the actions of a group present a visible externalisation that parallels internal creative processes. What is clear is that the interactions that occur in collaborative creativity provide useful data for study, without interfering with the activity itself.

### 2.2.1: The Social Nature of Creativity

Csikszentmihalyi (1996) has developed the most widely referenced model of creativity as a social process, known as the ‘Sociocultural’ model of creativity. The three components are a domain, a field, and an individual creative practitioner situated within this. The *domain*, explained in the previous chapter as a set of created products, language, symbols, specialised tools and evaluative criteria that provide a platform for creativity in a discipline. The domain provides scope for practitioners to 'stand on the shoulders of giants', utilising previous creative contributions as a basis for their own creativity. The *field* is a set of recognised intermediaries who play the role of gatekeepers in a domain, forming a collective judging panel that steers the domain and assesses potential contributions. A *person* internalises existing domain knowledge, then creates novel contributions, which are evaluated by the field. If accepted they are added to the domain, they are internalised by other people as part of their domain knowledge.

![Figure 1: Sociocultural Model of Creativity (Csikszentmihalyi, 1996)](image)

As with all useful models of complex phenomena, this is a simplification of essential principles that have wide ramifications: The definition of creativity used in the socio-cultural model reflects a focus on big-C rather than little-c creative acts – a field is unlikely to judge everyday or little-c create acts - but even the casual amateur is influenced by their surrounding culture and inspired by others in a domain. The nature of the field is also open to wide variation across domains and contexts. For example the Internet has removed some of the barriers to disseminating creative outcomes online, so there is at least the possibility of practitioners effectively adding to the domain without
explicit interaction with critics, industry or experts. However the power to decide which novels get published or widely advertised, which scientific theories are given credence, who wins awards or who is commissioned to design a building, is still in the hands of people who have reached influential positions – ideally based on their expertise. Creative value is socially constructed, but there are a range of forms that the field can take, and a range of structures through which creative people interact with it.

As they require knowledge and skills beyond that of a single person, social networks are often necessary for complex creative outcomes to occur. Research by Kijkuit & van den Ende (2007) has analysed how ideas and innovations develop through social networks in product development. Using social network analysis techniques to represent relationships in product development processes, they suggest that the benefits of many ‘weak ties’ are that they form bridges that link social groups and support the wide diffusion of ideas, but also that ‘strong ties’ are important - closer relationships that support effective, deeper transfer of knowledge and skills. Greve (2004) studied nested networks of industries, organisations and individuals in the development of innovative technologies for the oil industry. Career paths with an element of mobility allowed individuals to build heterogeneous networks of relationships across disciplines, putting those individuals in a better position to be innovators. Greve argues that for innovation to be supported, it is necessary for individuals to be able to build social networks that span organisations, that they can communicate with professionals in other disciplines, and understand the implications of breakthroughs in these disciplines. Fischer (2005) argues that spatial, temporal and technological distances, and diversity, are important sources for social creativity. Boundary objects are necessary to support communication across these distances. Relationship building and the development of structures for social creative interaction are considered further in the findings chapter 4.4: Longitudinal Interactions.

2.2.2: Forms of Human Interaction in Creative Activities

A cursory glance at any creative domain would lead us to understand that a range of human interactions occur in every case. As with other aspects of creativity, novel processes lead to novel outcomes, and new roles and structures for human interaction in creative activities develop over time, often with their roots in technological shifts: a current example of this being the development of Wikipedia through a novel structure for cooperation. There are however general archetypes of interaction that are pervasive across history and domains, and a wide body of research exploring various types of human interaction that are highly relevant to this study.

2.2.2.1: Producer and Audience

It is generally accepted that valuable creative acts have a large audience, or at least, that they influence an eminent audience that act as conduits to a
wider audience. Csikszentmihalyi’s (1996) notion of the field relates to the role of expert practitioners themselves as important audience members, acting as gatekeepers to judge the value of contributions to a domain. Taking a narrow view, the audience only sees the completed outcome, and plays no explicit role in the process that leads to the outcome. From a sociological perspective, practitioners are aware and influenced by the prospective audience for their work, and it is clear that problem finding and evaluation occur with reference to the perceived value to the field and audience for most forms of creative work. Potts et al (2008) argue that in the creative industries “the choices about both production and consumption are predominately shaped by feedback from social networks” (pg 170). They contend that because the value of a creative outcome is uncertain due to its novelty, the individual in the process – whether producer or consumer - is heavily influenced by social networks in their value judgements.

Theatre metaphors are commonly used in discussions of creativity (e.g. Sutton & Kelley, 1997), because the notions of audience and the distinction between visible acts on the stage and unseen backstage activities can be applied effectively across domains. For example: The audience for an innovative electronics device are not party to all the design work that occurs backstage, but may be told some details as part of the promotion of the device’s innovative nature. The accepted means of interaction from the audience are limited, domain-specific structures: in a theatre interaction is often limited to formal gestures such as applause, although this barrier is less well observed in certain cases such as improvisational theatre or stand up comedy (Sawyer, 2003). For the designer, audience response can be gauged through product reviews, complaints or sales.

2.2.2.2: Produsage
The distinction between producer and audience is important, but in some creative interactions the roles are interchangeable. Producers can often be expected to be audience members, but the opposite is less common. The notion of ‘Produsage’ has been coined by Bruns (2007) to define the forms of interaction commonly seen in modern web-based publishing systems such as Wikipedia or Flickr, where barriers to production are few and the gate-keeping role of a select field is largely removed, being replaced by a structure where all users can play this role. While Produsage has possible limitations in terms of quality and the expertise or accountability of producers, it exhibits the power of technology to provoke new forms of creativity and has affected the production and consumption of widely used media.

2.2.2.3: Cooperation and Community
Cooperative work was defined by Marx (1867, cited in Schmidt & Bannon, 1992, pg. 7) as “multiple individuals working together in a conscious way in the same production process or in different but connected production processes.” Schmidt & Bannon (1992) find that key to most use of the term cooperation is the notion of “interdependence in work”. In this thesis, cooperation is distinguished from collaboration (discussed in the next section)
in that whilst there is interdependence in the work performed towards producing a creative outcome, the goal of producing the outcome, and the decisions concerning the nature of this outcome, are not shared by all parties. Becker (1982) argues that the cooperation of people with a wide range of goals is often necessary to produce creative outcomes. Cooperative social interaction is also key to creativity at a number of levels: Centres, networks, schools or events focused on specific practices or interests support the exchange of ideas, the forming of new collaborations and the development of domains.

In his sociological analysis of ‘Art Worlds’ Becker (1982) takes the perspective that “artistic work, like all human activity, involves the joint activity of a number, often a large number, of people. Through their cooperation, the art work we eventually see or hear comes to be and continues to be” (pg. 1). The nature of the creative outcome is influenced by people performing a range of tasks, some of which are considered to form the creative ‘core’ while others roles are supportive but no less necessary. Even in the case of an artist who could be said to produce work as an individual there are commonly constraints imposed by cooperating parties. Becker gives the example of a sculptor who relies on lithographic printers to add colour to his stone designs, and analyses a discussion in which the printer is unwilling to produce certain designs for the sculptor, because they feel they would look poor to the eyes of others in their profession. In a variety of ways, cooperative links - while necessary – affect or constrain the process of realising the creative practitioners intentions.

In addition to analysing closely integrated collaborations, John-Steiner defines the notion of ‘Thought Communities’ in which the “objectives are to develop a shared vision as well as achieve jointly negotiated outcomes” (pg. 196). Two distinct types of these communities are ‘communities of practice’ (CoPs) and ‘communities of interest’ (CIs), concepts that were applied to social creativity by Fischer (2005). CoPs bring together individuals with a degree of homogeneity in their domain of practice, although there are individuals with specific or greater levels of expertise. Communities such as these support situated learning and develop shared concepts and language with which to communicate. Whilst members of CoPs do collaborate on specific projects, the community benefits from the sharing of ideas and solutions in a wider manner.

CIs on the other hand, bring together individuals from heterogeneous domains to work on shared problems. As Greve (2004) described in analysing the social networks required for innovation, these communities often bring together representatives from various CoPs for a particular purpose, and interdisciplinary communication and understanding is necessary to cross domain boundaries in these communities.

A relationship that is typically cooperative, and is central to this thesis is that between tool designers and creative users. There is a shared goal of making creative outcomes, and tool designers make decisions that afford and
constrain what users can achieve, but the decisions made leading to a particular creative outcome – the goals, the ideas chosen to be implemented and the choice of tools to use – are the product of the intentions of the user. Although tightly collaborative relationships between developers and creative practitioners from other domains can exist and be fruitful (Candy & Edmonds, 2002), the designer of support for creativity is generally a distanced, cooperative party. Understanding and improving these relationships is linked to the aims of this thesis, and a background to this is described in the chapters that follow: 2.3: Supporting Creativity, 2.4: Human-Computer Interaction and Creativity, and 2.5: Designing Interactive Systems.

2.2.2.4: Collaboration

Distinctions between cooperation and collaboration have been made in various ways, and for some researchers, the words are used interchangeably. A common distinction can be found in the development of the goals of the activity. Whilst both involve a collective effort to achieve something, for the purposes of this thesis it is only in collaborative creativity that the specific goals of a project are collectively developed and negotiated. Creativity is considered to be collaborative in this thesis when the outcome represents decisions made by all those who took part. Whilst the process may not necessarily be entirely democratic, each collaborator has a voice in the direction taken.

John-Steiner (2000) and Sawyer (2003) both argue effectively that collaboration is essential to most highly creative activities, but that there is a difficulty in establishing effective collaborations. Sawyer’s work describes improvisational collaborations such as jazz groups and theatre ensembles, building on Csikszentmihalyi’s (1996) notion of ‘flow’ – optimal experience where challenges and skills are balanced - by exploring the notion of ‘group flow’ in creative collaboration. In contrast, John-Steiner focuses on effective long-term partnerships such as that between Marie and Pierre Curie. Both researchers emphasise that collaboration enables creativity that would not otherwise have been possible, whether because the result emerges from the collective skills, knowledge and personalities, or because it is impossible for a single person to achieve a certain outcome (for example creating a musical or theatrical performance involving multiple roles).

Collaboration is often essential to creative breakthroughs. John-Steiner (2000) notes that collaboration is a means to overcome biology, given that one person can only realise “a subset of the human potential that can be achieved at a particular historical period” (pg. 189). Successful collaborators often have contrasting yet complementary personalities and working styles that develop over time in to an effective system for the discussion, evaluation and realisation of ideas. In agreement with this, Sawyer (2003) argues that the outcomes of group creativity are emergent properties, more than any individual would be able to achieve. However, both John-Steiner and Sawyer find collaboration to be a difficult and sometimes short-lived phenomenon. Creative work in all fields is emotionally charged, and the atmosphere in which ideas can be exchanged and critiqued, and risks taken with the
likelihood of some failures, without negative sentiments developing, is not easy to find, build or maintain. John-Steiner (2000) finds that building an effective collaboration is often a long process, and can often grow from cooperation when the party in control of the project realises the value of the other party as a decision-maker and offers them a fuller role in the process.

The interdependent work of various parties is especially important to the realisation and acceptance of innovative creative processes that cannot be fulfilled using current tools and conventions. In this sense, there is a need for collaboration (i.e. sharing of goals) for innovative creative processes to be feasible. To show this Becker (1982) gives the example of Partch’s musical compositions that make use of 42 tones rather than the standard 12 in an octave. A performance of his composition generally involved eight months of work to build the instruments that could play the tones (see figure 2), and the learning of both how to play these instruments, and a new system of notation by the performers. Professional musicians could have learnt a more conventional composition to an acceptable standard in eight hours rather than eight months. This example shows that relationships and the social norms that accompany creative domains not only support but also shape creative activities, affecting the outcomes that can be produced, or requiring collaboration in order to change these norms.

Figure 2: Instruments Designed and Built to Play the Compositions of Harry Partch. The ‘Diamond Marimba’ (left) and the ‘Harmonic Cannon II’ (right). Photos by Fred Lyon.

As the closest form of creative human-human interaction, collaboration has particular importance as a focus for support and is considered in depth in this thesis. Understanding the nature of interaction in creative collaborations is therefore essential. Group interactions have been a topic of research in a wide variety of contexts and tasks. Barnes & Todd (1977) analysed exploratory talk in secondary school project groups, and found the following general characteristics: Hesitations and changes of direction, tentativeness shown in intonation, assertions and questions in the hypothetical modality, inviting modification and surmise, self-monitoring and reflexivity.
Sawyer (2003) defines two forms of human interaction in creative activities, ‘synchronic’ – occurring immediately in a shared time and space - and ‘diachronic’ – occurring through artefacts as a dialogue over an extended period of time. He extends Csikszentmihalyi’s (1996) notion of ‘flow’ to explore the ‘group flow’ that occurs in successful creative interaction. Through observations of improvisational jazz and theatre groups and finds the following general characteristics of creative groups:

- **Process**: Group creativity is a process and needs to be studied as such, an end product gives little information about how the group operates. In the case of improvised art forms, the product is the process.
- **Unpredictability**: The group creative process is very unpredictable. No individual knows what ideas another will have, and the effect his or her actions will have on the process.
- **Intersubjectivity**: The dependence of an action on subsequent actions makes it difficult for the group to create identical mental representations of what is going on.
- **Complex Communication**: Collaborators are both performing, and at the same time negotiating intersubjectivity indirectly or implicitly.
- **Emergence**: Group creators with a good dynamic produce a whole greater than the sum of their individual abilities.

Both Sawyer (2003) and Sarmiento & Stahl (2007) describe the importance of ‘indexicals’ to creative collaborations. In this definition, indexicals are references to elements or ideas related to the project, particularly those for which symbols are created by the group and therefore the meaning does not exist outside of it. This “shared meaning-making” is at the centre of interaction in creative groups (Sarmiento & Stahl, 2007). It defines an extreme or highly focused instance of the process of ‘grounding’ described by Clark & Brennan (1991) as central to everyday human interaction. Grounding is the process by which two or more people develop and establish that they share common ground in order to communicate or coordinate activity. Shared meaning making could be considered a more active process than grounding, involving the development and labelling of concepts, and is necessary for novelty to develop as a shared product of collaboration.

Creative collaborations are of most value where complementary skills, knowledge and personalities exist between the collaborators, however conceptual distances between collaborators can be difficult to overcome (Fischer, 2005). Interdisciplinary collaborations can be highly creative and are essential to large or highly innovative creative projects. For example, many of the problems inherent in the use of computers in creative activities relate to the overhead of understanding the computer’s potential and having the skills to utilise it. Candy & Edmonds (2002) studied co-creativity in partnerships between artists and technologists, finding that the development of a common language was key to successful partnerships. It was also important that a common understanding of the vision or goals for the project was achieved, that exploratory “what if” sessions occurred and that the relationship was
allowed to develop over a long period of time. In contrast to the more common, less interactive relationships between tool designers and creative practitioners, collaborative partnerships between artists and technologists can utilise more effectively the possibilities new technologies offer, but these are currently rare, requiring organisations that support the effective development of relationships between disparate individuals. They organised case studies of this type of collaboration in a digital art context as part of the COSTART project. They identified three types of relationships that emerged: The technologist as an assistant to the artist, an equal partnership, or a partnership with the artist in control, taking responsibility for evaluating the work. They conclude that organisations are necessary that foster and sustain relationships between those with appropriate interests, who can converge around shared projects (Edmonds et al, 2005).

2.2.3: Conclusions

This chapter has shown that a range of human interactions are necessary in creative activities. In chapters 2.4: Human-Computer Interaction and Creativity and 2.5: Designing Interactive Systems, this thesis explores the relationships between interactive systems, their designers, and creative users. Firstly though, it is necessary to explore what the notion of ‘support’ for creativity entails.
2.3: How Creativity is Supported

“We shape our tools and are shaped by them”
Vera John-Steiner, 1997

This chapter is an exploration of what can be meant by support for creativity, and the relationships between cognitive functioning and the external world in creative activities. At the heart of creativity is the notion of externalisation, of mental processes resulting in novel and valuable actions and outcomes. The creative actions of the human body are in general augmented or mediated by tools of various kinds, supporting activities that the body alone would be incapable of. There are of course art forms such as dance or theatre where a creative outcome can be realised by the body alone, but even in such cases, the creative process is supported by an array of conceptual and tangible tools. As such, exploring the interaction between mental processes and external artefacts is essential to understanding the phenomena of creativity, and to the aims of this thesis.

At its most general, a tool is defined as a device or implement, used to carry out a particular function. A tool need not be a physical object, it can equally be a virtual entity existing in software, or a language or form of notation. Physical, virtual and conceptual tools are in certain ways very different, for example their malleability and interconnectedness is an important theme later in this thesis, however at an abstract level they all ‘afford’ particular uses (Norman 1988, Gibson 1979) which constrain and direct human activity. Tools provide structure, affect the processes through which creative outcomes are developed, and play a determining role in the scope of possible outcomes. Tools supporting creative activities range from conceptual frameworks such as ‘TRIZ’ (Orloff, 2003) – which provides a structure through which to explore possible innovative solutions, or ‘Group Brainstorming’ (Osborn 1957, Diehl & Strode, 1987) – which suggests a process for idea generation, to physical artefacts such as a paintbrush or piano. In this thesis it is argued that most interactive systems occupy a large design space in between these conceptual and physical extremes. This is further explored in findings chapter 4.3: Structural Interaction.

In the rest of this chapter, essential themes in the support of creative activities are explored with reference to a range of literature. Firstly however, an example of how technological shifts resulting from design have changed the domain of music is given to give a concrete initial platform for this discussion.

2.3.1: A Brief History of the Effects of Technological Shifts in Music Creation

A detailed, general history of the relationship between technological developments and creative endeavours would amount to a large thesis in its own right, but a brief consideration of how the design and adoption of new
support tools has deeply affected music creation follows, both for its resonance with the topic of study, and as a background to the domain used in much of the empirical research performed for this thesis.

Although it is thought that music was first made using the body as an instrument, early man soon realised that tools or objects from the environment have their own distinct sonic properties that could be used to add emotional intensity to ritual and dancing. Rattles and various kinds of drums, built using entire tree trunks or pits dug in the ground and covered with bark, were most likely to have been the earliest instruments. Excavations of Neolithic sites have found wind instruments that could be used to play different tones, precursors to the modern flute and trumpet (Sachs, 1977).

In addition to the development of instruments for realising creative outcomes, forms of symbolic idea representation have impacted upon the development and dissemination of music in complex ways. Classical Western musical notation visualises discrete pitch / time arrangements, which is not the case in other representations such as the Tibetan example in figure 3. Wishart (2002) argues that the influence of this system on composition in our culture has been the elevation in importance of melody (variation in pitch) above rhythm, timbre and other elements that must exist in music, but are not formally represented in this notation. Since the melody is the only part of the music that is accurately represented and communicated, the other elements are open to interpretation by the performers (Shaffer & Todd, 1994), and creating a melody is therefore the major objective of composition. This can be compared to Asian or African musical traditions, where rhythm is often considered primary and pitch is less often constrained to the discrete notes of the octave (Wishart, 2002). This aspect of the influence of tools relates to the concept of representational determinism (Zhang, 1997), discussed later in this chapter.

![Figure 3: Western (above) and Tibetan (below) Musical Notation](image-url)
Stepping forward many millennia, further ground shifts occurred with the first audio recording and playback devices – again, changing the creative process through the availability of new forms of representation. Beginning with Edison's Phonograph, the ability to retain, distribute and review music has changed almost every aspect of musical creation and consumption. Composition no longer relies upon symbolic systems as its only form of retention and communication. Recording technology offers preservation in sonic form and has resulted in a movement away from the classical notion of composition and the primacy of melody, combined with a growth in the intercultural exchange of musical styles and ideas. Recorded music follows us everywhere, yet many of us still enjoy the experience of live musical performance where amplification technology supports concerts attended by thousands, retaining the original purpose of music as a social experience. Others would argue however, that recording technology has reduced participation in the creation of music from a common activity to the preserve of the expert, and that technology is needed that supports and encourages informal musical interactions beyond passive listening (e.g. Bryan-Kinns & Healey 2006, Tanaka 2006).

Ground-shifting technological steps have effects on creative domains that take many years to become stable and understandable (McCloud, 2006). Entire musical genres rely on particular technologies, combinations of instruments or techniques. A thirst for novelty drives many musicians to look to new technology as the means to find their own unique sounds. These can be seen as new structures that modify the constraints on the creative process, and their effects are wide ranging. Of particular interest in recent times is the transformation of formerly technical roles such as sound mixing from simply capturing the sound of a band, to a common source of what is recognisably novel in new music. Because of the increased importance of recorded music as a realised creative outcome, and the development of new functionality in tools with which to interact with recorded sound, these technologies have been appropriated as instruments in their own right, and creative production is seen as essential and much more valuable than was the case in the past (Becker, 1982).

Having already begun to dominate music promotion and commerce, several projects have highlighted the emerging opportunities of the Internet as a platform for creative interaction between musicians. The collaborative writing of Wikipedia shares many commonalities with the production and remixing of music between musicians on sites such as ccMixter (ccmixter.org) and MacJams (macjams.com). Taking a markedly different approach, Ninjam (ninjam.com) supports nearly synchronous jamming by factoring in the latency of the network with standardised time delays, and Tjoon (tjoon.com) supports asynchronous net-based jamming by combining clips created with web cams and microphones (see figure 4). Commercial software tools such as Sony's ACIDPro have also begun to integrate collaboration features in to their environments, seeing the value in allowing users to interact in richer ways.
The development of music, and the processes through which it is created and disseminated continue to occur through a platform of technological innovation.

Figure 4: Online Jamming with Tjoon (left) and Ninjam (right)

This history mirrors that of many domains, where new technological structures have shifted the nature of the production of creative outcomes, and also the surrounding contexts in which creativity occurs. These themes are central to the presentation of the findings and the framework presented in this thesis.

2.3.2: Idea Representation

The externalisation of ideas in creative activities leads to their representation, and the representation of ideas is key to our understanding of tool use in creative processes. Some representations form a realisation - a creative outcome in a form and at a level of completeness in which it is intended to be disseminated. However creative processes generally require a great deal of representation before a realisation is produced. These are perhaps best described as sketches, although in this case the definition of this term is not restricted to visual representations (Nakakoji et al, 2006). The obvious importance of sketching to creative tasks has led to behaviours associated with it being examined in several domains, particularly in design and architecture.

A sketch can be ambiguous, may ignore details or focus only on specific aspects. The utility of sketching to complex creative or problem solving tasks was described in detail by Donald Schön (1983, 1987), whose concepts of Reflection in, and Reflection on, action are widely referenced in relation to creativity (e.g. Goldschmidt 1999, Nakakoji & Yamamoto 2001, Century 2007). He described professionals as reflective practitioners, using and developing their skills in ill-structured tasks by working in conversation with materials and analysing the impact of their actions. A sketchpad and pencil supports this conversation in a ‘virtual world’, where possible actions can be evaluated without real-world constraints. For example, Schön (1987) describes how, in the resolution of an architecture problem, a teacher and student can explore the problem without considering materials or actually expending the resources required to build anything. These representations provide ‘talk back’ that supports the development of, and reflection on, ideas in the process of producing a creative outcome.
Studying the process of representation in design, Oxman (1997) developed a model of re-representation to describe the process of adapting a design to new constraints. She argues that representations of declarative – rather than procedural - knowledge support innovation because they externalise the underlying structure of the domain, supporting the manipulation of the represented problem. Again, representation is defined as a process involving initial constraints, a design move, evaluation of that move and reflection on the changing constraints on the solution.

Research has explored and provided support for the notion of ‘representational determinism’, that the information visible in a representation directly affects the actions people take in response. Zhang (1997) provides experimental evidence for this effect in games based in problem solving such as Tic Tac Toe. The ramifications of this are that representational form affects feedback, affordances and therefore the development of creative outcomes. In the brief history of technology and musical creativity that opened this chapter, the effects of representational determinism were evident in the arguments that Western, African and Asian musical traditions were heavily influenced by the standard representational forms used. The concept provides a perspective from which to consider how provision for feedback in the design of technologies for the representation of ideas could make a difference for practitioners, for example through visualising material in novel ways or providing useful overviews of a composition. John-Steiner (1997) argues that the differing characteristics of various forms of thinking are a powerful platform that provides bridges for exploring complex or ambiguous notions, for example through the ambiguity of a visual sketch or the utility of shared language to verbal communication. Representational forms with new affordances, as well as the ability to combine or manipulate forms in new ways, can provide a catalyst for breakthroughs that would not otherwise occur.

The above research suggests that the creation and review of representations is central to creative processes, and that the nature of the representation is central to the value of it. By necessity, idea representation tools and styles vary across contexts, and there is also wide variation between practitioners in style. There is however, consistency in process and needs between contexts where the creative outcomes are disparate in form, the notion of sketching being a clear example.

From a semiotics perspective, an idea representation is a collection of signs. It communicates properties of the idea back to the person who created it, and also communicates properties to other persons if seen or heard. Returning to the differentiation between realisations and other representations made at the start of this chapter, and using Pierce’s semiotic model (Fiske, 1990). It can be suggested that the elements of idea representations that ‘talk back’ to their creators are iconic, representing something of the character of the idea in its realised form. However, not all ideas can be represented as required in an
iconic manner. Arbitrary Symbols are important to retain and communicate ideas, as guitarist Joe Satriani states:

“I can look at a musician and say "I need a minor 6th there and I need it in a triplet eighth note" and that's the language that we use and then I can communicate the sound in my head to that musician so they understand it. There's just this huge vocabulary that you have to learn in order to interpret what's going on inside of you and can understand and translate all the music coming at you from other musicians.” (Satriani & Jones, 2003)

As visual and verbal forms of representation lack an obvious iconic relationship with music, a wide range of codes and languages exist, incorporating various iconic and arbitrary elements. Symbolic representation is necessary, but can be difficult and less rewarding in terms of talk back. As is apparent in this quote, collaborating practitioners learn and share common language in order to communicate ideas and knowledge. It is only after a process of mental translation that the nature of the idea is apparent from the symbol, so the utility of symbolic representation as a means of understanding the idea is likely to be less. The notion of 'indexicals' - Pierce's third form of sign – was discussed in the previous chapter with reference to group creativity (Sawyer 2003, Sarmiento & Stahl 2007). Sarmiento & Stahl (2007) describe creativity as a process of developing novel meanings for symbols, from which it can be derived that there is a need for representational tools that support the expression of new concepts.

Through the research above, it has been shown that idea representations are not only necessary to individual creativity, they are essential to the collaborative and social aspects of creative processes. However, it is also clear that these representations are created utilising various forms of structure, such as languages and tools. These structures are considered in the following section.

2.3.3: Structure and Constraint

Creativity involves a tension between constraining structures and novel actions that practitioners explore throughout their creative lives. Scientific theories are created as possible solutions within a set of observed constraints. Designers are generally presented with initial constraints required of any solution, such as health and safety laws or limited budgets. Artistic work is less constrained by external prescription, but in its place practitioners have to focus their activity, for example by concentrating on a single subject matter or restricting the materials with which they work. Instruments are commonly chosen for the actions they make possible, rather than for their ease of use. Analysing the approaches of successful practitioners across a range of domains, Stokes (2005) argues that each practitioner aimed to preclude conformist, tried and tested responses and promote novelty by finding or developing demanding constraints on the task and subject matter, that partially defined an overall goal of interest. Analysing collaboration, Middup &
Johnson (2007) found that the adoption of artefacts by a group influences the division of labour, and directs the actions performed to complete tasks.

Norman (1988) describes all tools as holding ‘perceived affordances’ – they can be used for a bounded range of actions that the user of the tool is aware of. The brief history of technology in music creation at the beginning of this chapter suggests various ways in which tools structure and constrain creative processes. The selection and development of tangible and conceptual tools, in order that desired actions are afforded, is a topic essential to findings chapter 4.3: Structural Interactions. Forms of constraint on the creative process were discussed in chapter 2.1: Understanding Creativity, and the relationship between idea representation and structure was described in the previous section (2.3.2).

2.3.4: Experiential Needs

Noting that the term ‘tool’ has taken some precedence over ‘instrument’ in computer music, Tanaka (2006) argues that there is a distinction between the tools used in artistic creativity and those used in other activities. Limitations or imperfections that would be considered negatively in other contexts are often an important part of the voice or ‘personality’ of a musical instrument. The sound produced and the characteristics of playing that affect the output combine to form the ‘idiomatic’ of the instrument. Understanding an instrument’s idiomatic is essential to using it in the right contexts and ways.

As well as showing how artists value aesthetic properties over other factors, the constraints imposed by an instrument or medium and the skill and practice required to use it effectively have important roles in structuring creative domains. Of course, creative practitioners make use of many supporting tools for which usability and efficiency are key, but it is important to remember that the value of tools for creative activities may depend on other factors, such as the experience of using them, and the unusual affordances they present or the processes they provoke.

In contrast to the common user-centred design practice of designing a tool based on an understanding of human tasks, a more recent research direction in HCI has defined the more holistic notion of ‘User Experience’, including aspects of our interaction with tools that go beyond “the purely cognitive and task-orientated” (Hassenzahl & Tractinsky, 2006). This has included for example the consideration of ambient displays of information (Mankoff et al, 2003), and the abdication of choice in music consumption through shuffling (Leong et al 2008). Two avenues for experiential interactions are explored in the design research performed in this thesis. Firstly, support for peripheral awareness of the actions of others, with scope for practitioners to see what their peers or collaborators are doing (considered in both the Music Builder and Associative Scrapbook design projects in chapters 4.3 and 4.4 respectively). Secondly: serendipitous inspiration, where the computer provides scope for chance encounters with information and ideas, and to
encounter the work of other practitioners who may have relevant skills or ideas (considered in the Associative Scrapbook design project in chapter 4.4).

2.3.5: Conclusions

This chapter has developed an understanding of the close relationship between mental processes from which ideas emerge, and the external world to which creative outcomes are translated. A range of needs that can be defined as supporting creative processes emerge, central to these is the need to represent ideas, both in realising a creative outcome, and in representing ideas in the course of developing a conception of this outcome. Major themes include the need for tools with which to represent ideas and receive feedback on these, the need to apply structure to inherently ill-structured creative tasks, and the need for tools and systems that provide new experiences and provoke new processes. The next chapter considers the themes presented here in relation to research that links interactive systems with creative activities.
2.4: Human-Computer Interaction and Creativity

“The digital world is closer to the world of ideas than the world of things.”

Lawrence Lessig, 2002

Computers and the way we interact with them continue to evolve and branch off to new territory. Computers have taken a prominent role in almost all creative activities. This makes both the aims of this thesis important, and the central focal point - the nature of the computer's role – somewhat dynamic. This chapter is a reflection on the roles that can be observed or envisaged for the computer in the creative process and an exploration of where computers categorically differ from other tools.

2.4.1: Characteristics of Computers as Tools for Creativity

In his influential book ‘Mindstorms’, Papert (1993) argues that the introduction of new technologies can act as a catalyst for new ideas and can also extend the reach of them. Technological change results in instabilities in the status quo that often provoke or allow real changes in process, from individual interactions, up to society as a whole. Papert is writing about the use of computers in education, but his comments resonate with an analysis of paradigm shifts in creative domains. His argument is that computers can provoke innovation by supporting people to use new processes and spread new ways of thinking. Turkle (2005) also argues that computers can have an important impact on our thought processes, noting that: “the computer’s chameleonlike quality, the fact that when you program it, it becomes your creature, makes it an ideal medium for the construction of a wide variety of private worlds” (pg. 6). The connection of this description with Schön’s (1987) notion of a virtual world, distributed between the practitioner’s mind and a medium, points at one of the paths through which computers can be seen to support creativity uniquely.

Although extremely relevant to this discussion, Turkle’s original comments are now over 20 years old. Looking back on her original work, she notes that: “increasingly, we stand on the boundary between worlds we understand through transparent algorithm and worlds we understand by manipulating opaque simulation” (prologue). The vast majority of computer users no longer program, and the transparent mechanisms of cause and effect that existed for the users of LOGO observed by Papert and Turkle are less clear in the complexity of modern software for creative activities, such as Adobe Photoshop, or Ableton Live. Creative practitioners work at the boundaries between control and exploration, but if the workings of the tool are opaque or
unpredictable, it may follow that the tool is less of an aid to purposeful creative interaction or exploration.

Whilst the malleability of the virtual can be positive, physical tools have properties that creative practitioners often find integral to their work. Physical interaction with materials and media is essential to practitioners in many domains even where computers are heavily used. Treadaway (2007) notes that “connections between vision, touch and cognition inevitably impact on perception of physical experience and influence imaginative thought” (pg. 67). Whilst specialist hardware instruments such as graphics tablets and midi keyboards can integrate the physical and the virtual for some applications, these commonly fail to replicate important tactile feedback from the tools they are intended to replace. Physical objects can also be arranged, compared and manipulated with an ease and transparency of affordance that does not exist in computer interfaces despite decades of research and development. Jim Eales (2005) notes that a marked contrast between virtual and physical mediums is one of reproducibility or authenticity. Both are exploited in the visual art creation he analyses: reproducibility as an affordance for experimentation that supports the conservation of previous versions of the work, and the authenticity of a physical canvas for the presentation of the final piece to showcase valuable painting skills. Few painters would ruin a canvas they valued just to explore an alternative idea, but with computers the cost of repairing a mistake has commonly been reduced to a keyboard shortcut (Terry & Mynatt, 2002).

Another central characteristic of computers is their digital nature. Making use of the power of computers requires the objectification, definition and division of information in order to process it according to rules and procedures. Defining and objectifying elements in idea representations is a process somewhat at odds with the ambiguity seen in sketching behaviours across creative domains. Johnson and Carruthers (2006) note that the “creator’s need for imprecision and the computers need for precision” is a common tension in the use of computers for creative activities. The previous section described a strength of paper and other representational forms that supports sketching behaviours in the ability to leave elements ambiguous and to work with incomplete structures. This is not impossible to support with computer tools, but it does work against the obvious strengths of the computer and therefore is often compromised in order to offer functionality. However, the processing power of interactive systems also provides scope for new forms of creative interaction, examples of which are described in the section on Practical Research later in this chapter.

In comparing musical composition performed with and without computer tools, research performed for my MSc dissertation found that software tools commonly enforced both representational form and process upon users. The representational forms are structured in order to provide a clear structure through which the computer could ‘understand’ users input and afford scope for manipulating it. Processes are enforced because the interface offers rigid functionality and limited options to automate particular tasks where human
effort would previously have left scope for varying the way a task was performed. The designers of software tools can therefore prevent creativity as easily as supporting it (Coughlan, 2004). However - as was mentioned in the preceding sections - creative activities do require some level of structure, and in collaborative creativity shared structures are particularly important to facilitate coordination and provide common ground for communicating and developing ideas. Dillon (2004) describes how a software tool for musical composition ‘scaffolds’ the interactions between students in collaborative composition tasks, providing a shared technological context that led to similar patterns of interactions between students across the differing physical contexts of formal school lessons or in a community centre youth group. The practical utilisation of this concept of scaffolding is considered in the Music Builder design study described in chapter 4.3.

In addition to strengths as a constructive medium, computers are increasingly becoming a standard tool for the communication and the proliferation of information and ideas. Fischer (2005) argues that computers can reduce spatial and temporal distances, but can also introduce technological distances between people using different tools and with differing knowledge and understanding of technology. Conceptual distances also exist that need to be overcome in collaborations between those from different disciplines. These four distances are useful concepts when designing systems for interaction between members of creative communities.

The research presented above provides a wealth of characteristics and description of how computers differ from, or extend, the affordances of other kinds of tools. They are a malleable platform for construction, offering more scope for the nature of the tool itself to be manipulated or for new tools to be developed and shared. They enforce structure and processes in ways that other tools do not, but also provide support for novel or more efficient processes and human-human interactions. By being multifunctional, they can remove or blur the seams between tools and therefore between previously bounded tasks. However, physical interactions are richer in tactile feedback than most interactions with computers. The essence of the computer is digital, so the quantification of user input is an important part of interaction, even if this may not be in the practitioner’s interest. In addition to this, as a processor of data, the computer can automate or aid in many tasks that otherwise require greater human skill and / or effort, there are however limitations and tensions with this use of computers in this way in creative activities.

2.4.2: Paradigms for Technological Support in Creative Activities

In this section, existing ways in which technologists and interactive systems provide support for creative activities are discussed. This begins with a consideration of the roles interactive systems can and should play in the creative process, followed by a discussion of the extent to which computers can play an active role in the creative process. Finally, tighter collaborations between technologists and creative practitioners are explored.
In order to understand how software could make people more creative, Shneiderman (2003) defines activities that computers can support in his GENEX framework. The phases and corresponding activities are:

- **Collect**: Learn from previous works stored in libraries, on the Web and in other places.
- **Relate**: Consult with peers and mentors at early, middle and late stages.
- **Create**: Explore, compose and evaluate possible solutions.
- **Donate**: Disseminate the results and contribute to libraries, the Web and other places.

Shneiderman also makes clear that the integration of support for these needs is central to successful support, and that smooth transitions and communication are fundamental elements of creativity that computers can make more efficient.

Lubart (2005) identifies four lines of thought upon which the role of computers to enhance creativity could be considered. These are as ‘Nanny’ – encouraging, organising and monitoring progress. ‘Pen-pal’ – aiding idea exchange and development. ‘Coach’ – providing help or materials for relevant tasks such as divergent thinking, and ‘Colleague’ – a collaborative partnership where the computer’s input is to some degree creative. Lubart accepts however, that these types of interaction may suit some users whilst hindering others, and that each person has particular needs to support their existing skills and aims.

Though these distinctions Lubart also provides a platform to consider the issue of computer agency in the creative process. As creativity is seen as an essential human trait, the vision of creative computers has been a subject of research in the artificial intelligence and cognitive science research communities. The example Lubart uses for a computer ‘colleague’ is Johnson-Laird’s jazz improvisation program, and both Johnson-Laird (1993) and Boden (1993) have written extensive reviews of A.I experiments with creative software. This work has improved our understanding of creativity from philosophical and cognitive perspectives, but also highlights the limitations of designing computer tools to act creatively. Although Harold Cohen’s AARON system – responsible for the picture in figure 5 and further images of human figures from a range of perspectives - is often considered as a prime example of computational creativity, it’s author denies that it has agency in the creative process, closing however with the caveat that “if it is not thinking, then what is it doing?” (Cohen, 1994).
The limitations of computers as colleagues or creative agents should be considered with reference to Dreyfus & Dreyfus’s (1986) work on the limits of a problem-solving model of intelligence. In analysing how thought processes in performing tasks change with proficiency, they argue that “Competent performance is rational; proficiency is transitional; experts act arationally.” In explanation they state that: “The conscious use of calculative rationality (by an expert) produces regression to the skill of a novice or at best, the competent performer. To think rationally in that sense is to forsake know-how and is not usually desirable” (pg. 36). Expertise in any complex task – and work in any creative domain must be considered as such – makes use of processes outside of the rational, rule-based processing that computers are built to perform. In essence, AARON utilises declarative and procedural knowledge about the human body and the process of making a picture, with some arbitrary decision-making that affects the future procedure (Cohen, 2000). Dreyfus & Dreyfus’s position would suggest that this rational behaviour is insufficient to produce expert creative performance.

Whether AARON is seen as creative or not, it is clear that a creative outcome is being produced in some way, and that the affordances of the computer are a significant part of the structure that produces it. The structure of AARON’s rational behaviour is – at a high level - directed by Cohen, and through the interaction of human and computer, creativity does occur. Boden & Edmonds (2009) describe how the discipline of Generative Art has developed through the utilisation of computers since the 1950s, and existed in other forms before then. They define Generative Art as being that where “The artwork is generated, at least in part, by some process that is not under the artist’s direct control” (pg. 29). Amongst a range of defined computer-based approaches to art, AARON is defined as a form of ‘Computer Generated Art’; a special case where the computer program is being “left to run by itself, with minimal or zero
interference from the human artist” (pg. 31). They argue that the computer can in such cases be given some ‘Authorial Responsibility’.

Simonton (1989) describes creativity as stochastic, characterised by conjecture and non-deterministic processes. In a similar vain Gerlenter (1994) argues that computers in their current form are not capable of the creative thought humans find natural because they lack our rich life experiences, a complex physiology that affects the functioning of our brain, and the unconscious bisociative processes that effectively combine items in memory. Johnson-Laird (1993) notes that while “Purely random techniques are easy for machines. Without the exercise of judgement… they do not yield memorable works of art” (pg. 120).

Computers are tools that question our notions of what it is to think and create, and are capable of supporting highly novel forms of creativity. However, it is important to question whether machines could ever replicate the intuitive, contextual judgement of novelty and value used to evaluate ideas from a human perspective, and whether attempting to replace human creativity has any great value when human resources are plentiful and creative activity is generally seen as an enjoyable and meaningful occupation. Therefore, while modelling the creative process through computational methods has proved valuable to understanding the phenomena, this thesis focuses on a notion of support that assumes the primacy of human creative agency in the interaction with the computer and seeks to augment and expand it. The scope for computers to play novel roles in creative processes is central to their utility, but the interface with the human in this process is seen as the focal point in this thesis. This is in keeping with other HCI perspectives on the issue (e.g. Shneiderman 2003, Fischer 2005).

This section has described several perspectives on the way creative practitioners interact with technology. It has shown that there are various paradigms of interaction, and roles for humans and computers to take in creative processes. The next section introduces a range of practical examples of research linking creativity and interactive systems.

2.4.3: Practical Research in the Design of Computer Tools for Creative Interaction

As was previously noted, the range of perspectives from which creativity research has taken means that only a portion of the material is of use in understanding the design of interactive systems to support creative activities. Even this work needs translation towards an operational purpose. Research such as Shneiderman’s GENEX and Lubart’s classifications are valuable tools for thinking about high level support needs, but it is an equally important task to explore and prescribe how to support creativity practically in interaction design. The studies described below have taken a practical approach of designing and evaluating systems to explore aspects of creative interaction with computers:
Several researchers have taken Schön’s (1983, 1987) exploration of reflective thinking through sketching activities as a basis for exploring what constitutes useful feedback from a representation, and how interactive tools can improve reflection. Nakakoji & Yamamoto (2001) defined the notion of ‘Amplifying Reflective Talkback’ (ART) and have explored possibilities through prototypes in a range of domains. One common design feature of the ART systems is support for the free positioning of objects in a two-dimensional space. The authors argue that this supports reflection by allowing the representation of intermediate situations without requiring preciseness or commitment, describing the representations as ‘indices for thoughts’. This again relates the representation of creative ideas to Pierce’s notion of indexicals (Fiske, 1990), explored in the preceding chapter (2.3: How Creativity is Supported).

Also with reference to Schön (1983, 1987) and to Oxman (1997), Sedivy & Johnson (1999) performed empirical studies of sketching, producing requirements that led to the development and evaluation of a support tool: ‘Speak ’n Sketch’. Requirements included the need to allow access to functionality as quickly as possible due to the quick nature of the sketching process, and to provide as much space as possible on the screen for the sketching, rather than for functionality. In response to this, the system utilised voice control over functions such as increasing the thickness of the pen, and used pop up radial menus for other functions.

Terry et al (2002, 2004) explored support for the creative process by considering how aspects of the process such as variation and iteration could be better supported in tools. They make the argument that creativity generally involves the exploration of multiple possible solutions, so tools should support users to develop and compare multiple instances of a piece of work. They developed a design approach called ‘Parallel Paths’ and apply this in an image manipulation tool, supporting the comparison of multiple instances through ‘Parallel Pies’ that show a set of variations in one representation.

Computers can also provide novel forms of feedback that support evaluation processes: Johnston et al (2005) have created and evaluated tools that produce a visual representations that interprets a performer’s play, promoting reflection. Through the ‘Spheres of Influence’ system, they aim to support the development of musical skill. They suggest such systems have value if they can provide visualisations that the musician can intuitively understand.

A further topic that systems to support creativity have aimed to support is the discovery and collection of information and ideas relevant to a topic of interest. Koh et al (2006) developed and evaluated ‘combinFormation’, a mixed-initiative system in which users compose pages of images and text based on searches performed by the system. Users can for example position, resize and remove elements from the pages, while the search agent adds material based on an evolving understanding of the user’s interests. They produced qualitative and quantitative evidence that their system better supports information discovery tasks than the same tasks performed with
standard Google search and Microsoft Word. Although closer to Lubart’s (2005) notion of computer as a ‘colleague’ in the creative process, this work follows Lieberman’s (1997) argument that autonomous agents should “suggest rather than act”. The human’s primacy in the creative process is maintained, but the computer’s strengths as an information processing system are utilised to support exposure to relevant information. This topic is explored further in the **Associative Scrapbook** design study discussed in findings chapter 4.4: *Longitudinal Interaction*.

Creativity is a process utilising experiences and reflections from throughout practitioners’ lives, and the development of ideas often occurs over long periods of time, but Shibata & Hori (2002) note that few creativity support systems consider the importance of long-term idea generation. They developed a prototype system to support creative thinking in everyday life, consisting of an ‘**IdeaManager**’ that supports the representation of problems and ideas, and a ‘**iBox**’ that stores personal information and relates this to the problems and ideas represented in the IdeaManager. Nakakoji et al (2002) explore a similar area but consider how systems can support collective creativity in design processes – the use of design knowledge constructed by other designers to identify and retrieve useful information. Their development of two systems to support this raises important issues, such as how information can be delivered that is neither too obviously related (and therefore trivial or leads to a lack of innovation) or so loosely related it is highly unlikely to be useful. This work shows the important bridges between creativity support and the personal information management research discussed in the next section.

Music has been a focus for several projects developing experimental creativity support tools. Abrams et al (2002) developed and described ‘**QSketcher**’, an environment for composing music for film that aims to support the early stages of creative workflow, arguing that most software to date are geared towards realising preconceived ideas and are also detached from intuitive musical concepts. The environment allows users to place “anything anywhere” and develop a visual layout that persists when they return to the environment. The system also allows content to be viewed in or out of temporal context, so that related sections can be *pinned* to each other even if not sequentially attached. This sort of interaction could be important if trying to produce music for two parts of a film with similar themes or contexts. Fluid movements are also supported between content, so for example a video can be viewed whilst written notes are made simultaneously. More recently, Phalip et al (2008) have explored in depth the support required for online, asynchronous collaboration in film scoring. This project aims to understand how musical ideas can be communicated clearly and precisely across remote contexts, avoiding the ambiguities that were evident in their analysis of current practices. Advantages were also apparent in the ability of stakeholders to evaluate each others work in advance of meetings, a phenomena with some similar features to the ‘**Call and Response**’ interaction described in the findings chapter 4.2: *Productive Interaction*. 

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Amitani and Hori (2002) developed another musical composition system ‘MACSS’, focused on supporting externalisation of the composer’s mental space. As with the ART systems (Nakakoji & Yamamoto, 2001), a 2 dimensional space is utilised, but in this case it provides a representation of computationally recognisable similarities between recorded phrases. The authors found evidence that this reduces mental fixation and helps users understand and develop the relationships between their ideas.

A specialised community has emerged focused on the design and analysis of new instruments for musical creativity. Research has included a focus on collaboration, in particular Bryan-Kinns & Healey (2006) developed ‘Daisyphone’, an application for group music making that has been used as a platform to study effects such as the effects of decay or persistence of contributions. When user’s musical phrases persisted indefinitely, groups could become bored quickly, but when they decayed there was an additional level of anxiety and need to continuously add new work that changed the interaction significantly. The authors link this to Csikszentmihalyi’s (1996) flow theory of matching skills to challenges. Gurevich (2006) developed ‘JamSpace’, an environment for novice musical collaboration over a local network. A spatial metaphor is infused in the design in the form of private, personal, shared and public spaces, and the system supports a variety of musical interactions. Research has also explored the notion of an instrument in the computer age. Hunt et al (2000) define the basis of all musical instruments as a means of gesture-based input mapped to a sonic output, and Magnusson (2006) developed a range of screen-based musical interfaces to explore the differences between physical and virtual materials.

Resnick et al (2006) produced a set of principles that capture many of the findings of design research for creative activities. They are:

1. **Support Exploration**: Users must be encouraged to explore the space and systems should have ‘low-viscosity’ that supports changing the design of the space.
2. **Low Threshold, High Ceiling, and Wide Walls**: Support a wide range of explorations and projects. In evaluation, diversity of outcomes is an indicator of successful design.
3. **Support Many Paths and Many Styles**: People have very different styles of playing, designing and thinking. Accessibility to ‘hard’ and ‘soft’ thinkers is important.
4. **Support Collaboration**: Creative work is most often done in teams, and computers can also support new forms of collaboration through collaboratories and through the web.
5. **Support Open Interchange**: The process is not usually supported by a single tool, so creativity support tools need seamless integration and extensibility.
6. **Make It As Simple As Possible – and Maybe Even Simpler**: Technology-based products are complex and are some are becoming even more so. But a simple user experience can be beneficial.
7. **Choose Black Boxes Carefully**: One of the most important decisions is the choice of “primitive elements” that users can manipulate. The higher level the primitives, the easier they are to use but the less they can do.

8. **Invent Things That You Would Want To Use Yourself**: Tools cannot succeed without communities of interested users, and designers work better creating tools they will use themselves.

9. **Balance User Suggestions, with Observation and Participatory Processes**: Each has utility.

10. **Iterate, Iterate – Then Iterate Again**: Iterative design with prototypes rather than just storyboards. Prototypes also support discussions between designers and users.

11. **Design for Designers**: Make tools that enable others to design themselves.

12. **Evaluation of Tools**: Evaluating a tool for creativity is not easy as how to measure creativity is an open question, but evaluation is important. We can assume that tools that are not effective or efficient will hinder creativity, even if we cannot assume the reverse will hold.

These principles reveal some of the similarities and contrasts between interaction design for creative use, and for more general aims such as usability, efficiency and learnability. They also highlight the importance of the design process in developing tools for creative tasks. In the wider scope of this thesis, it is important to compare the utility of these principles with the GENEX framework or Lubart’s roles, in order to consider the best form that the findings of this research can take. These principles prescribe ways of thinking about the design of tools at a practical interaction level, whereas the previous conceptual frameworks described high-level user needs, which can direct the designer towards aims in the development of systems. A combination of the practicality of these principles in tandem with the holistic view provided by GENEX and Lubart’s roles appears as an attractive goal for this thesis.

While HCI research with an explicit focus on creativity is a growing area, a large range of existing research has strong relevance to the design of support for creative tasks. The next sections describe highly relevant research in the fields of **Personal Information Management (PIM)**, **Computer-Supported Cooperative Work (CSCW)** and **End-User Development (EUD)**.

### 2.4.4: Personal Information Management

PIM is relevant to creativity support because many forms of information are managed and used in creative processes. Represented ideas, feedback, messages, plans, context, visualisations and inspirational materials are just some of these. It is essential that the right information be retained, that it can be viewed or compared effectively, and that relevant information is available at the time to use or communicate to others. Computers can provide a powerful means of storing and manipulating information, but because they
increase the amount of information that can be stored and accessed, they also provoke information overload and organisational difficulties. Jones and Teevan (2007) argue that: "In a vision of better and better PIM, we spend less time with the burdensome and error-prone activities of managing information and more time making creative, intelligent use of the information at hand to get things done".

A further related area is that of Knowledge Management, related to PIM by research on the topic of Personal Knowledge Management. Knowledge is defined by Wilson (2002) as involving “the mental processes of comprehension, understanding and learning that go on in the mind and only in the mind, however much involve interaction with the world outside the mind, and interaction with others.” Whilst there is clearly value in the sharing of knowledge, Apshvalka & Wendorff (2005) note that “knowledge transmitted from the mind becomes information for an outside observer”. Similarly, knowledge creation occurs when perceived information is understood by an individual. Knowledge and learning are particularly relevant to the development of a creative practitioner’s ability to make decisions in an ill-structured space (Schön, 1984,1987). Wilson (2002) however, is critical of the idea of managing knowledge, seeing it as the equivalent of saying that the mind itself can be captured or downloaded. A focus on information management is therefore a more feasible endeavour, but knowledge is an important concept within the aims of this.

Erickson (1996) explored his own personal development and use of an electronic notepad as an aid to information management. In keeping with earlier analysis of the affordances of paper, he argues that the formality and rigid structure of many computer systems hinders the personalised capture, management and transformation of information. His system has developed through self-imposed structures, such as ‘dog-ears’ that mirror the folding over of a page in a book, or topic-specific ‘stamps’. He also describes the importance of the tool to support writing as “my way of thinking about things”. This echoes back to Schön (1983, 1987) and John-Steiner’s (1997) analysis of the interaction between creative practitioners and media.

Three PIM activities can be distinguished (Jones & Teevan, 2007): ‘Finding’, ‘Keeping’ and ‘Organising’. Finding and keeping information are activities triggered by events (i.e. the need to know a particular piece of information, or discovering information that may be important in the future. A particularly important and distinctive class of finding is ‘re-finding’, that is the process of finding information that has been seen before. In re-finding activities, the person already has some knowledge about what or where the information is, but keeping information to be effectively re-found is difficult because it requires the person to predict the value of the information and the future context in which it will be valuable. Conscious efforts at organisation are also difficult, both because developing and maintaining an effective structure for information involves predicting the forms future information will take, and also because of the fragmentation of information across media, devices and locations.
Keeping information often relies on effective capture. Brown et al (2000) explored information capture in working through a diary study, finding that capture was goal orientated, but that capture technologies were generally aimed at supporting the capture, rather than the goal of using the captured information – for example cameras do not support the sharing of photos well. The capture of ideas and inspirational material by practitioners is analysed in this thesis, particularly through an open questionnaire study, and the design study reported in findings chapter 4.4: Longitudinal Interaction.

In a study of the organisation of information in offices and on desktops, Malone (1983) describes ‘filing’ and ‘piling’ as two distinct strategies employed by office workers. Jones (2007) notes that each approach has its uses and limitations: Filing is cognitively difficult and can result in information becoming invisible and forgotten, but provides a structure through which information can be re-found and the process of organising material in to categories can help us make sense of information and represent plans. Piling offers higher visibility and aids memory until piles become too large, however our ability to know where information is can be restricted to physical location because there is no defined organisational structure. An interesting parallel can be drawn between filing or piling and the defined or ambiguous structures that are a tension in creative activities. Computers in their current form are much better at helping us file than pile. Teevan et al (2007) found that our strategies for finding information are also complex, and often based on ‘orienteering’ - finding a piece of information by stepping through the related context towards it – rather than through automated search.

The fragmentation and unification of documents and information is another area of PIM that has direct relevance to creativity support. Our interaction with computers is application-centric, and despite our aims and use of information often crossing application boundaries, the integration between these is often lacking. In our everyday lives we may interact with emails, pictures, address books, web pages, word-processed documents, printouts and many other digital and physical objects. In creative activities, a variety of media and tools are also used and need to be integrated to provide support for activities such as the composition of a film with its soundtrack, or collaboration between users working with different tools (discussed further in the following sections on CSCW and EUD). Karger (2007) identifies three approaches to unification, each affording different types of interaction between the integrated objects. Firstly ‘visual unification’ aims to allow the viewing of disparate items side by side. This supports relationship building and orienteering, but leaves the management and manipulation of object to the specific application. Secondly, there is the use of ‘standard data types’ with undemanding semantics that can be supported by a wide range of applications. The simple text file or set of comma-separated values can make sense to multiple tools and therefore allow data to be shared between them and manipulated or managed by either. Finally, ‘metadatata’ can be used to annotate objects and manage them independent of content and related application.
While PIM research focuses on personal information spaces, it is not ignorant of the fact that most of our interactions with information and documents are intertwined with those of other people. Some of the research most relevant to this thesis crosses boundaries between PIM and CSCW. Landay & Davis (1999) found that computer support to share notes taken in meetings or seminars is feasible and could be useful if structured effectively, but could also be disruptive if note creation became the focus of individual’s efforts. In defining the problems that face designers of support for group information management, Lutters et al (2007) find that people’s information sharing is heavily contextualised and situated (we may wish to share information with friends that we would not with work colleagues, or only decide to share on a case by case basis) that individual strategies for organising and finding information do not work for groups (we all pile and file in our own ways for our own purposes), and that as Grudin (1994) has previously argued, incentives to cooperate or adopt group solutions to information sharing often vary between users (others would like to know when we have ‘free time’, but we may prefer them not to know). Greenberg et al (1999) explored relations between individual and group work with PDAs and shared displays, finding that the notions of public and private that exist in most groupware systems are both overly simplistic and complicate work for users when compared to the subtle and implicit transitions that occur in the physical world. In the physical world people perform individual tasks in public places, and artefacts can exist in a public space without necessarily being advertised or available to everyone present. They suggest that groupware tools “that will let people fluidly shift their artefacts from personal to public and the many gradations between in subtle and lightweight ways” are needed.

2.4.5: Computer-Supported Cooperative Work

Chapter 3 of this thesis has already discussed the connections between creativity and human-human interaction, and the use of computers as communication, cooperation and collaboration tools has been explored for over two decades in the CSCW community. According to Carstensen and Schmidt (1999), CSCW “addresses how collaborative activities and their coordination can be supported by means of computer systems.” They continue by stating that: “A series of questions becomes central, for example: What characterizes cooperative work?; How can we model cooperative work?; Which computer based facilities should be provided?; And what are the basic characteristics of useful platforms for CSCW-systems?”.

Some particularly relevant CSCW work has direct links with creative collaboration and idea representation: Prante et al (2002) tested the utility of three software tools for collaborative idea finding. They found the ability of users to structure the shared space collaboratively was valued, and that the ability to formalise ideas incrementally was needed. Difficulties were reported where multiple users could not use the system synchronously, and where the process was constrained by formal techniques such as Osborn’s (1957) brainstorming rules. The authors use their requirements to design a set of tools including a system for mobile idea representation by individual group
members and a system for co-located idea representations and structuring. Fono and Counts (2006) developed the ‘Sandboxes’ system, which allows collaborative multimedia composition on mobile phones and focuses on how little-c creative interactions can be facilitated in social networks. By breaking the rigid structures currently supported by mobile devices where only a single media artefact can be sent in a message, and there is no scope for arrangement or connections between artefacts, their system provokes users to interact through their media in more complex ways.

The integration of informational and architectural spaces has been the focus of research that has explored support for creative work by co-located groups. Examples include the ‘i-LAND’ environment, which was developed by Streitz et al (1999) with the aim of breaking the ‘bottleneck’ of using standard desktop computers designed for individual users in creative groups. The developers achieve this through the development of reconfigurable components that support individual, sub-group and full group interaction with simple transfer of media across these spaces.

A common issue explored in connection with creativity and CSCW is group brainstorming. Initially prescribed in the 1950s, variations on the technique have been popular ever since, despite a lack of empirical evidence for its value. While Osborn (1957) argued that producing more unique ideas means that higher quality ideas will emerge, other researchers would argue that this is not necessarily the case (e.g. Rickards, 1999). The logic has proven popular, particularly so in research because it provides a simple metric that can arguably represent an important aspect of creativity. This thesis however, takes the view that idea generation represents only a fraction of the creative process that requires support. Diehl and Strobe (1987) amongst others have studied brainstorming groups and found that nominal groups (individuals generating ideas in isolation) consistently outperform co-located real groups at idea generation. They suggest the phenomena of ‘Production Blocking’, ‘Evaluation Apprehension’ and ‘Free Riding’ can be used to explain this. Systems have been developed that attempt to reduce these effects, and the effects of interactive systems in general on group creativity have been considered: Olson et al (1992) found that the introduction of a shared editing tool to a co-located group undertaking a design task encouraged focus but led to less exploration of possible solutions.

A CSCW approach of interest to this thesis is support for the collaborative use of software designed for single-users. The adoption of group tools commonly requires users to drop their software of choice and learn a new tool that may lack the functionality and interface they are used to. This can be a serious detrimental factor in the uptake of groupware solutions and in the case of creative collaboration, heterogeneous tool use may be a requirement for practitioners with different roles and skills. While commercial groupware packages such as Microsoft’s NetMeeting support generic application sharing and allow a distanced user to take control, they still retain a single user paradigm in that only one user can interact with the application - and therefore the work - at a time (Sun et al, 2006). Li & Lu (2006) developed a system that
synchronise files and provides awareness information about the text editing performed between heterogeneous text editors such as Microsoft Word and Latex. As the freedom to choose and develop tools and structures is essential in creative activities, it is particularly important that groupware solutions for creative collaborations can be extended and heterogeneous tools integrated.

Awareness of others has been a central research theme in CSCW, and this has an underexplored relevance to creativity support. Two examples of this are the value of studios or laboratories in which a range of practitioners interact socially, learning and being inspired by an awareness of each others activities, and the acute awareness required for collaboration in creative activities such as Jazz improvisation (Sawyer, 2003). Hindmarsh et al (2000) analysed the difficulties found in object-focused human interaction in virtual environments, finding that awareness of the peripheral actions and perspectives of others was often impaired. Dourish and Bellotti (1992) define awareness as “an understanding of the activities of others, which provides a context for your own activity”. The problems of supporting awareness in distributed groups are particularly acute and often require additional effort on the part of group members. Mechanisms that support the passive generation of awareness information (requiring no user effort to convey) offer the possibility of improving awareness over distances without creating overheads. As with other aspects of CSCW, awareness support has often required that users follow rigid structures - such as adopting set roles - that can interfere with natural styles of group interaction and performance. The use of video and screen sharing technologies is being explored as means to passive awareness that can reduce the impact of distances and improve interaction. Tee et al (2006) note that desktop video conferencing tools have utilised screen sharing for focused interaction, while they developed and evaluated a system that can display miniaturised screen shots of multiple users' desktops to each other, aiming to support opportunistic interactions between distributed groups. In the Music Builder design study described in chapter 4.3: Structural Interaction, screen sharing is used in a focused way, to support detailed awareness of the actions of two collaborators.

2.4.6: End-User Development

Although the previous section considered the adaptation of individual tools to collaborative use, a further research theme has explored ways of supporting the development or modification of the computer environment by users themselves. The promotion of this behaviour fits with Turkle's (2005) view of the computer as a tool for exploration and projection through construction. End-user development (EUD) is an umbrella term for design efforts to support the user to manipulate the computer environment. Whilst it is an important area of ongoing research, EUD is already pervasive in computing: The users of spreadsheets and databases develop structures within the software environment that leverages the power of the computer to perform user-specified tasks and organise or present information in user-defined ways, and the development aspects of these applications have contributed to them being among the most well-used software tools (Nardi & Miller, 1990).
Users will only adopt development processes where their motivations exceed their perceptions of the costs involved. There can be high costs involved in setting up and learning to use the environment, in addition to the cost of development itself (Sutcliffe, 2005). Creative users may be considered a special case with differing motivational factors from the norm: Whilst the clerical worker may be motivated by improving efficiency, the scientist, artist or designer may be moved to develop the environment because of the chance of creating novel outputs or insights that were previously not possible to achieve.

Even in the early days of mass computing, it was clear to some researchers that programming with abstract language statements was not the best method with which to engage users in developing tools. People are - in general - better at working with real examples than abstract rules, but abstract rules and procedures are the strength of computers (Lieberman, 1993). Programming by demonstration is one method devised to overcome the abstract symbolism of coding. First developed in 1975, Smith's Pygmalion system introduced both the concept of visual icons to hold behaviour and data, and the demonstrating of instructions to a computer through concrete examples that were then generalised into a program (Smith, 1993). Observing the difficulties that students had making use of Logo, Lieberman (1993) developed Tinker, which supports the demonstration of examples in order to produce complex procedures including elements such as conditional statements. One complex aspect of programming by demonstration is the mechanisms by which the computer infers meaning. These can be simple – ask the user when anything is ambiguous – or complicated pattern finding algorithms that attempt to guess what a user wants to achieve.

Where standard programming languages provide a general set of concepts that relate to computational procedures, users may be better served by domain-specific languages (DSL) that map better to their expertise and to the tasks the environment is aimed at performing. DSLs should embody domain knowledge at a level that supports development for tasks in the domain (Deursen, 2000). Domain orientated design environments can represent the level of discourse relevant for the user rather than the level of discourse developed for / by the computer scientist (Fischer et al 1992). Scoping DSLs is difficult, with a tension between keeping the system open by providing general constructs and employing concepts that the user will be familiar with, particularly when creative use is the aim. These are not mutually exclusive - DSLs can be built on top of general programming environments and provide access to them for extendibility - but reverting to the underlying language positions the user back in the environment of the computer programmer.

Of particular interest to this thesis are the social and collaborative aspects of users developing structures and constraints for shared use. Pipek & Kahler (2006) explore what they define as the “collaborative tailoring” of software environments. They describe three levels of linkage related to tailoring: Firstly, shared use implies that the same tools are used, but individuals can tailor the
tool to their personal needs and work independently. Their relationship with other users may only exist through discussion forums, as there are no dependencies between them in the context of software use. **Shared context** occurs where collaboration requires that the tools used be standardised between the users and therefore agreements reached. Interdependencies increase dramatically and standardisation is often a major issue. The most integrated and therefore socially demanding level is **shared tool**, where the actual workspace is singular and shared between the collaborators. Workspaces in this can are built collaboratively by necessity to take in to account needs. Across all of these forms of socio-technical interaction, platforms to exchange adaptations and experiences can be useful.

Taking in to consideration the cultural and technical landscape that surrounds the design and use of technological environments, **meta-design** is a conceptual framework used to consider the infrastructures through which designers and users can interact to find requirements and design support in more appropriate ways. Fischer & Giaccardi (2004) state that “**The importance of meta-design rests on the fundamental belief that humans (not all of them, not at all times, not in all contexts) want to be and act as designers in personally meaningful activities.**” The approach considers that support environments for creative activities often exist at two equally inappropriate ends of a spectrum: Either they are environments where anything is possible but nothing is easy (e.g. a standard programming environment), or they are domain-specialised environments where operations are easy but little of interest is possible. In response, a meta-design approach considers that systems should be designed to be flexible enough to evolve in the hands of users. Developer guidance and intervention will occur but should not be necessary for users to adapt the system to their needs. Although **design time** and **use time** are distinct in the development lifecycle, designs need to evolve during use time as needs cannot be predicted accurately during design time. As important as designing the system is **designing the design process** in order to encourage participation, both through establishing conditions for user engagement, and supporting the development of social networks of those with a shared interest in the system.

There are of course many different aspects of, and methods through which users affect the computer platforms they interact with. At the heart of the notion of ‘Web 2.0’ is the participation of users in developing both content and structure (O’Reilly, 2005). Vander Wal (2007) noted the rise of the user-generation of categorical structures through activities such as tagging, and for this he coined the term ‘**folksonomy**’. In a more technically advanced example, tools such as Greasemonkey (http://www.greasespot.net/) and generic information formats such as RSS allow end users to alter the way information is presented to them from the web and integrate information from various sources to develop their own tools utilising powerful information sources such as Google Maps.

For the purposes of this thesis, end-user development and similar concepts present some of the most interesting and complex facets of the relationship
between computers and creativity. Environments that are open to manipulation mirror the creative mind by allowing users to question and explore boundaries (Smith, 1993). The computer “enhances freedom for exploration, but also contains within it the potential tyranny of continual choice” (Haworth et al., 2005). Conversely, well-designed software environments can aid the development and use of constraints by promoting reflection and ensuring that constraints are satisfied. Candy (1997) noted that a tool for scientific visualisation “presents the existing constraints, the human revises them and the resources of both are employed in the process of considering and negotiating plausible revisions.” (pg. 7–8) Creative practitioners have always explored and developed the structures surrounding their practice, but computers make structures more rigid in the instance (less open to ambiguity and bending) but more malleable in the long term. An exploration of the processes and interaction that occur when practitioners develop both structure and ideas in the same environment is central to the findings on Structural Interaction presented in part 4, chapter 11.

2.4.7: Conclusions

The research reviewed in this section presents a body of concepts, example systems and findings that we can build upon in order to understand the design of computer support for creative practitioners. Several major themes emerge: The first is the types of interaction that the computer affords that are of aid to the representation of ideas and the development of structures within which creativity occurs. Secondly, that creative practitioners can be supported by computers to retain and organise ideas and inspirations as a basis for their work in the long-term. Thirdly, that computers offer a platform for a variety of human interactions in creative activities that can be designed and offer different affordances to those available in the physical world. Design research to date provides strong evidence that computer tools can be developed that take in to account a theoretical understanding of the creative process and the factors that can encourage or prevent creativity.
2.5: Designing Interactive Systems

This chapter explores the design of interactive systems, and how the findings of this thesis can contribute practically in this context. As the objective of this thesis is to produce an understanding of creativity that can be utilised in the process of designing interactive systems, it is necessary to consider how these processes occur, and how the findings can be presented and used effectively.

The previous two chapters have shown how creative activities are influenced by the tools used in support of them. These range from tools that are directly used in the production of creative outcomes, to those that allow access to resources and support communication, social interaction and the dissemination of creative outcomes. In chapter How Creativity is Supported, it was shown that the idea representation processes that are central to creative interaction are commonly reliant on tools, and can be structured and constrained by the characteristics of these tools. In chapter 2.4: Human-Computer Interaction and Creativity, the specific nature of interactive systems as a platform for creative interaction was discussed. Major points included: That the malleability of interactive systems shows promise as a basis for new forms of designer-user relationships such as End-User Development and tailorability, which can be suited to creative activities. The common need to define and quantify input can be at odds with the need for ambiguity and user-defined structure in creative interaction, but this also underpins new forms of information processing and manipulation that lead to new creative possibilities. Computers and networks have also radically changed the way in which we both share and consume information, which should affect ideation, collaboration, and dissemination processes.

Interactive Systems are designed through socio-technical processes, and they themselves provide some of the most complex examples of human creativity. These design processes themselves combine formal methods with creative thinking (Wolf et al, 2006). However, our focus is the design of interactive systems for creative activities in general, rather than in understanding the creative component of this specific design process. The focus in this chapter is therefore on the formal methods and concepts that exist to support design, and how the findings of this thesis can best be made applicable to the context of designing interactive systems to support creative activities.

2.5.1: Software Engineering

The discipline of Software Engineering is central to understanding the formal development of interactive systems. In response to the increasing complexity of development, which involves vast quantities of time, people and money, approaches to formalising methods towards a rigorous basis for producing interactive systems have been devised. These include models of the development process, such as the waterfall or iterative models, and the implementation of processes such as requirements analysis as a basis for
maintaining a solid understanding of what a software project aims to produce and the process followed to achieve and maintain this (Sommerville, 2006).

The notion of Software Engineering is important, as the complexity of software development requires organisation, structure and processes that can be regulated and analysed. Although these techniques are commonly taught and used, there are issues and criticisms that have been raised at the current approaches to development. McCarthy & Wright (2004) note that the software industry often approaches design from technical-rationalist goals of more efficient software production, that can be inappropriate to the design of many applications, and that they take only a limited interest in understanding actual user experiences. As was argued in chapter 2.4: Human-Computer Interaction and Creativity, End-User Development is an important factor in creative activities. The fixed notions of design time and use time that are common in Software Engineering may be restrictive in conceptualising such systems, that should instead continually evolve with the input of users, as a basis for provoking novelty.

For integration with a Software Engineering approach, a set of requirements is developed as part of the findings. To provide scope for a more open, creative approach to design, a set of questions are also developed to provoke and guide designer’s thinking in developing ideas for systems. These requirements and questions include a consideration of the scope for End-User Development in a system. An iterative approach is used in the design studies performed in this thesis, both as this allows the development of the prototype systems as a dialogue between the designer and user, and because through cycles of evaluation there is greater scope to understand user needs and to test the practical implementation of findings.

2.5.2: Task-Artefact Cycle

Carroll et al describe how tasks and designed artefacts co-evolve over time in a dynamic system. This presents challenges to software engineering approaches that suggest the ability to produce a fixed set of requirements. The process, depicted below, describes the current state of an artefact and task, and the evolution of this over time. Designers respond to understood user requirements by developing artefacts that present possibilities to users. These in turn provoke changes to, or new opportunities for, performing tasks, which become the baseline for future artefact design.
The task artefact cycle suggests that the development of scenarios and prototypes of novel systems can aid forward thinking in terms of a dialogue with users on the possibilities for, and direction of new system designs. In this thesis, the task artefact cycle is taken as an inspiration for an action research approach. It is observed that evaluations with users expand their scope for thinking about novel systems, so as well as analysing the interaction of users with prototypes, a dialogue with participants is encouraged during and after these sessions, to explore how their understanding of the possibilities of interactive systems has developed. Future improvements to the systems presented are discussed in the design studies of each chapter of findings.

**2.5.3: User-Centred Interaction Design**

Understanding users has been central to the methodologies adopted in this thesis and to the framework produced. In particular, the notion of integrating contextual factors with a generic understanding of creative interaction is key to utilising the framework in design. We also present and utilise methods such as analysing the forms of idea representation used in a domain as a basis for integrating an understanding of specific user groups with the framework.

Interaction Design can be defined as “designing interactive products to support people in their everyday and working lives” (Preece et al, 2002, preface). Analysing the interaction design processes that have occurred in the ART project to develop support for creative tasks, Nakakoji et al (2002) describe an effective way of viewing the process as seeking for compromises between desirable outcomes expressed by designers, and possible outcomes expressed by programmers. These compromises were developed through demonstrations of fragments of applications, a form of representation that supported the collaboration. In the case of this thesis, the role of designer and programmer is taken by one person, however, prototypes still form a basis for reflection on what is possible and – through evaluation with users – what is desirable.

Interaction design can be seen as the application of HCI research with a User-Centred approach, to design with an understanding of how users experience their interactions with technology. In addition to the empirical studies,
participatory design and the iterative design and evaluation of prototypes were used as research methods in this thesis.

2.5.3.1: Participatory Design
Participatory Design involves prospective users actively in the development of new designs. Various techniques have been developed through which users develop low-fidelity prototypes (Schuler & Namioka, 1993) and models of their processes (O’Neill & Johnson, 2004) as part of the design process. Proponents see participatory approaches as key to user-centred design, while others are more cautious. Buxton (2007) argues that the professional designer has skills and knowledge that cannot be replicated in the user. Whilst user’s opinions and input are important, he argues against the idea that users can effectively perform the role of a designer.

In conjunction with Participatory Design, Participatory Task Modelling was applied as a basis for understanding how users view their creative processes. This approach was inspired by previous work by O’Neill and Johnson (2004) that involved users in developing models that represent their tasks and domains. In this instance models were produced by individuals and then by groups of these individuals, and these were used as a tool in the Participatory Design process, for example by identifying areas of the models where computers provided, or could provide, useful support. Further detail on this is described in chapter 3.2 Studies Performed and Methods Used. As this is a research project, the approach to participatory design was focused on producing greater understanding of creative practitioner’s needs, and paradigms for their possible involvement in the design process. These are discussed in chapter 5.1: Utilising the Findings as a Framework for Designing Interactive Systems.

2.5.3.2: Prototype Design and Evaluation
The evaluation of prototype systems with users, with the goal of building understanding that can be applied in new design work is central to interaction design. This approach has been central in providing a practical impetus to this thesis, in which effective ways to understand creative use of software tools have been explored and applied.

In exploring the term ‘design research’, Zimmerman et al. (2007) state that most HCI practitioners consider the term to denote “the upfront research practitioners do to ground, inform, and inspire their product development process”. In contrast, they find that in the wider design research community, the term is used to denote “an inquiry focused on producing a contribution of knowledge”, rather than “the work to more immediately inform the development of a commercial product”. They describe tensions between a design research approach and reductionist, science and engineering based approach to design, but also note that some researchers consider a harmonious relationship between the two possible. In this thesis the design studies are used to complement and extend the empirical and theoretical research performed. Wolf et al describe how the design of prototypes is an
effective method for communicating a research contribution. Zimmerman et al (2007) produce 4 criteria on which interaction design research contributions should be measured:

- **Process**: Unlike scientific or engineering approaches, there is no expectation that design research processes lead to reproducible results. However, the rationale behind methods and a documentation of the process is important to the contribution.
- **Invention**: The process should produce a novel integration of subject matters to address a specific situation
- **Relevance**: Rather than a scientific validity, effective design research should make an impact in the real world.
- **Extensibility**: It should be possible to employ the process and knowledge gained through the design research in future projects.

These criteria are important in bridging the gap between design research and practical interactive systems design, and are therefore considered in the development and analysis of the design studies.

### 2.5.4: Conclusions: Developing Usable Findings for the Design of Interactive Systems

If we consider the design of interactive systems as a creative activity, it requires structures in which it can occur, but for those structures to be open to further development and appropriation for use in particular contexts. Through this, novel, valuable interactive systems for creativity can be developed with the findings of this research as a basis. At the same time, the understanding built through the design and evaluation of these further systems can be formalised for research purposes as an expansion of this structure.

A review of formalisms of interactive behaviour by Harrison and Duke (1995) concluded that there is a substantial gulf between what computer scientists do, and what behavioural scientists do. This is reflected in a great deal of behavioural research that, whilst relevant, is misunderstood or unused in computer science. They suggest that neutral frameworks are required that draw from both perspectives equally. In this thesis, building a theoretical understanding of behaviour in tandem with the development of interactive systems is seen as the best approach to bridging this gulf. The models produced describe the interaction between human processes and external artefacts. Through this understanding the generic actions that will be performed through interfaces for systems used in creative activities, and the results of these, are identified.

Informing design processes requires an assessment of the degree to which findings in one context are generally applicable, or reflect the specific context of the task and artefact studied. To differentiate these where possible in the research performed, the findings of this thesis are presented in terms of generic models and explorations of how contextual factors cause changes to
processes and needs. Together this forms a framework that best represents the findings, and can be utilised in a predictive manner to understand needs or conceptually explore possibilities for novel support tools. Chapter 5.1: *Utilising the Findings as a Framework for Designing Interactive Systems* discusses a range of ways in which these generic and contextual considerations can be applied.
Part 3: Research Performed
3.1: Issues in the Study of Creativity and Support for Creativity

Creativity research - like that of many complex human phenomena - has undergone historical paradigm shifts, and has taken different starting points across various disciplines. Whilst it is important to review and make use of some of the findings of this body of work, it is essential that the specific aims of this thesis be used continuously as a critical lens through which to evaluate the utility of particular findings and arguments. It is also essential to provide a rationale for the methods of study used in the development of this thesis.

From the body of literature written on creativity, particular issues come to light that pose difficulties for research in this area. In this section the most relevant of these are described and discussed. These issues shed light on the nature of creativity, and through them understanding can be gained for the process of designing support for creative activities.

3.1.1: Understanding and Measuring Creativity

One of the major problems that any study of creativity faces is that the components of novelty and value that make up the definition of a creative outcome are both subjective, being related to the perspective they are evaluated from, and the context they occur in. The notion of measuring creative outcomes – and therefore quantifying the creativity of a particular instance of activity – is a problem that researchers have wrestled with, but have not produced an entirely satisfactory outcome to. Metrics for creativity have been produced and used in abundance, but in each case there are arguments against their validity and limits to their ability to be employed.

Studies of creativity - particularly those focused on group brainstorming - have measured the number of ideas produced in a session (e.g. Diehl & Strobe 1987, Warr & O'Neill 2005), but ideas are difficult to separate and quantify in domains such as visual art or music. Although in this thesis the concept of an idea is central, the identification of ideas as distinct entities – particularly as they develop and are integrated in a wider piece of work – is not always easy or necessarily effective. It is easier to identify instances of idea representation and their development as external artefacts, and to observe the development of ideas through these. Ideas are clearly central to creativity; Glück et al (2002) found that having “many ideas” was the only common notion in conceptions of creativity across a range of artists and students. But not only is idea generation only one facet of a creative process, the development of an outcome will rarely implement a large number of ideas from one particular focus. Such metrics are therefore considered unsuitable in light of the aims of this thesis.

A more promising approach may be to use human judges to consider the creativity of outcomes as a representation of the field in Csikszentmihalyi’s (1996) Socio-cultural model, but again this poses many difficult questions
(Kasof, 1999). For example: How can those who judge be considered representative? What realistic criteria do we ask them to judge on? A more naturalistic metric for creativity is success of the outcomes in the real world. This metric is higher in validity, but is mostly appropriate to longitudinal studies and historical analysis. It has been used in the CoSTART project (Edmonds et al, 2005), and in historical studies which focus on the activities of those considered to be highly creative (e.g. John-Steiner, 2000) For the purposes of this thesis, it may be difficult to establish a causal relationship using such methods due to the number of extraneous factors and comparability of instances of creative activity: One person may be more successful because they are using particular tools, but it is just as likely that they are more enthusiastic or skilled than others, or that they met the right people to collaborate with, inspire or promote them.

It is clear that quantifying creativity is itself complex, but the focus of this thesis adds further complexity - the design of interactive systems to support creativity. Tanaka (2006) argues that tools for creativity cannot be evaluated solely through reference to commonly held notions of usability or efficiency. He takes the position that artistic tools such as musical instruments or oil paint do not make creativity ‘easy’ but provide desired character, constraint and aesthetic nuance to the work, by design they are not as ‘efficient’ or ‘usable’ as they could conceivably be.

Creativity is a process occurring within a complex system, and the measurement of outcomes - however performed - is not likely to give us insight into the nature of the process (Sawyer, 2003), neither can it necessarily identify a high quality of user experience in support tools. Shneiderman (2007) argues that rigorous research methods in creativity support should not be equated with controlled experimental studies, and that “the complex nature of human discovery and innovation cannot be studied like pendulums or solid-state materials”. From a design perspective we must accept that qualitative methods and observation are the tools most likely to gain us the in-depth understanding we need. Naturalistic settings for observation and the evaluation of systems should be aimed for, along with the involvement of those with a range of experiences as creative practitioners. Candy et al (2006) argue for a practice-led strategy towards research in interactive art, where qualitative and quantitative methods are combined to study the co-evolution of creative acts and the knowledge gained through research.

For the reasons stated above, the studies performed in this thesis do not attempt to use metrics for creativity as a basis for comparison, or for evidence of improved support. Some comparative analysis of the activities and opinions of users is quantified where deemed appropriate. These provide examples of the ability to quantify certain aspects of creative interaction. Future work could make further use of this in comparing instances of creativity support, but a definitive metric for creativity is yet to be developed, and due to the nature of the phenomena, may not be possible. Instead, it is the understanding of the
processes of interaction through qualitative analysis that form the bulk of the findings in this thesis.

3.1.2: The General and Specific Nature of Creativity

An essential issue in the study of creativity is the abstraction of general creative interaction processes and needs from those of specific contexts.

Plucker & Beghetto (2004) argue that creativity is both domain-specific – because performance assessments do not correlate across domains – and domain-general – because valid general descriptions and process models have been produced. Components of creative activities such as judgements of novelty and value and useful skills and knowledge have both domain-specific and domain general aspects. Researchers such as Simonton (2000) have considered how domains differ, for example arguing that a major difference between scientists and artists is the greater amount of constraint forced upon the scientist, with this constraint developed and self imposed by the artist.

Aside from the context provided by a domain, different forms of creativity were described in chapter 2.1: Understanding Creativity and Creative Processes. Big C and little c creativity require different understandings of the concepts of novelty and value, and the levels of expertise involved will affect the kind of functionality and level of guidance to the creative process that is required. The participants in the studies that constitute this thesis have a range of backgrounds from professionals in their domain, to those with little or no experience who expressed an interest in taking part.

Human-human interaction has been identified in the previous chapters as a central factor in creative activities, and the interpersonal context varies greatly across instances of creative activities. Many creative acts require practitioners from a range of domains, and this interdisciplinary creativity is another complex notion that should be considered in the design of support (Fischer, 2005). Various interpersonal contexts are studied in the observational studies, and in the evaluation of prototypes. Collaboration and social interaction are a major theme of the questionnaire study.

The major question for this thesis is how an understanding of creativity that is useful to designers across contexts can highlight rather than overlook differences, and integrate them in the design process. Clearly the designer should elicit specific knowledge about the users and tasks they are aiming to support, but it will be beneficial if this can be achieved through a structured approach that captures the general needs of creative interaction. It is also important not to consider contexts as fixed, independent structures. For example: The evolution of domains and the connections made between them are essential in groundbreaking creative acts. Many technological advances impact on creativity across a range of domains, and new domains such as film
or video games make extensive use of existing domains such as music and visual art. To be useful, an interactive system will be capable of adapting to use in a range of contexts, but the understanding of these contextual factors is considered throughout the findings and conclusions of this thesis, as a basis for focusing the abstract models of creativity towards concrete contexts of use.

3.1.3: Bounding Creativity

In addition to considering creativity across a range of contexts, it has already been stated that it is difficult to bound creativity, as in some senses it pervades most human activities. The definition of creativity used in this thesis – if applied with inclusive definitions of novelty and value - could be considered to include a large range of actions, such as conversations. McCarthy & Wright (2004) argue that all experience is itself creative. Whilst this can be viewed as an indication of the importance of creativity and therefore the aims of this thesis, it is also necessary to effectively bound what is being studied and why.

The notion of a creative practitioner is used extensively in this thesis, as it reflects a focus on people and activities that are explicitly considered to be creative. The term is not used to restrict the focus of study to professionals, but it is used because it denotes an explicit interest in being creative. The focus of the majority of this thesis is artistic domains of creativity, though contextual issues that relate this to creativity in science, design or engineering are included. This is chosen because artistic domains more consistently require an explicit intention to be creative (Simonton, 2000).

Whilst the findings of this thesis may be relevant to a range of applications, the focus is on the interactions that are considered part of the creative process, and the needs of these. In performing the design and evaluation studies, a range of general usability problems were identified and resolved as a standard part of the design process, however, the focus is on issues that appear relevant to creativity in particular, as oppose to general issues that could be expected to arise in other interactive systems.

3.1.4: Myths and Image Creation by Creative Practitioners

An obvious data source available to creativity researchers is the recorded words of practitioners themselves. After all, successful practitioners in any important domain are commonly interviewed in the modern era, and the processes of artists, scientists or inventors of note have always intrigued people. However there is reason to be highly sceptical of biographical sources.

In order to further their image, successful practitioners are often very creative in descriptions of their creative processes. Perkins (1981) dissects this
phenomenon with reference to the writers Edgar Allen Poe and Samuel Taylor Coleridge, finding in both cases that their public descriptions of the process of creating the poems ‘The Raven’ and ‘Kubla Khan’ contrasts greatly with collected evidence that provided a fuller view of the development of each piece. The phenomenon sheds light on socio-cultural aspects of creative work, whereby practitioners often feel compelled to present their talent as mystical or unique. Ultimately success requires more than talent, hard work and the right tools, it is often reflective of a strong personality and a capacity for imaginative self-promotion.

Although this issue must lead us to be critical of historical sources, including popular examples used in past explanations of creative processes, the words and opinions of practitioners are central to a user-centred understanding of design. It is however important to compare observed and described behaviours. The thesis therefore uses a range of empirical methods, and the chapters presenting the findings (chapters 4.1 - 4.4) triangulate the findings of these methods to build a more complete picture of creative interaction.

The next chapter describes the methods used in this thesis, devised in response to the issues described here.
3.2: Studies Performed and Methods Used

A range of methods were used in the research performed for this thesis. This represents both an effort to explore the possible means of understanding a complex area of study, and the recognised need to compare and triangulate findings across methods in order to effectively show the validity of the conclusions drawn. The thesis draws from both empirical and design research methods, as a basis to both understand, and to contribute to, support for creative interaction. As the last chapter argued, due to the complex, subjective nature of the topic, the majority of the analysis is qualitative, with quantitative analysis used where appropriate.

This chapter provides information about the nature of the studies performed, the resulting artefacts, and the analysis performed on them. The basis for the decisions made in relation to these is also described, utilising the understanding of issues in studying creativity from the previous chapter. The empirical studies utilised across the findings chapters are described in detail here. As the design studies reflect a particular perspective on creative interaction, the methodology and instances are introduced here, but they are described in detail in the relevant chapters of the findings (chapters 4.2 – 4.4).

3.2.1: Overview of Studies Performed

The studies performed for this thesis comprise:

- **Observational Studies** of filmmaking, and the review and reanalysis of previously performed observations of musical composition.
- An **Open Questionnaire Study** with responses elicited from creative practitioners across a range of domains.
- **Participatory Task Modelling and Design Sessions** with groups of musicians.
- **3 Prototype Design and Evaluation Studies**, involving the iterative development and evaluation of prototypes with prospective users.

3.2.2: Observational Studies

The research began with **observational studies**, initially of **musical composition**. For comparison, observations were later performed of groups performing a **filmmaking** task. According to the dichotomy presented by Preece et al (2002), the observational studies performed were ‘outsider’ studies, where the role of the researcher was as observer, as opposed to the ‘insider’ studies where the researcher becomes involved in the activities being studied. This was chosen so as not to affect or steer those involved from a natural course of action, particularly as the studies occurred with small groups to which the addition of an active person with a research agenda could have had strong effects.
Studies were performed in two domains in order to have data from which comparisons and contrasts can be drawn, leading to a generic understanding of creative interaction with scope for consideration of the effects of contextual factors. In choosing domains, the following aspects were considered key:

In light of the discussion of the bounding of creativity in this thesis in the last chapter, studies should be performed of domains in which creative acts are common and can be observed easily. This first criterion was considered with reference to Simonton’s described artistic disciplines as less externally constrained and structured. The less structured a task, or the more space in which solutions could possibly exist, the greater need for creative action and the greater time spent performing creative act (2000). This is not to say that creativity within tight constraints is not important – as Finke’s (1995) Creative Realism suggests, these could be considered more valuable - but it does mean we are likely to observe a greater quantity of creative acts in domains that are less externally constrained. An artistic domain is therefore a highly suitable candidate for study.

Secondly, collaboration should be key in the studies performed, as this is both a major theme of the thesis and makes observation more fruitful, as collaborators externalise their creative processes through their need to communicate with each other (Sarmiento & Stahl, 2007). There are various types and forms of collaboration in artistic endeavours, and therefore a wealth of possible choices when we aim to study a highly collaborative domain. Certain domains seem less obvious choices – for example fiction writing and many visual arts are not domains where tight collaborations are comparatively common – but domains including filmmaking, music creation and performing arts are collaborative in the majority of cases.

It was also assessed that it would be most fruitful to explore domains where computer technology is common, but exists in addition to an array of tools and media with which to compare the impact of computer tools on the process. Music and film are both domains where technology has pervaded in a variety of support roles. However music creation has a greater history prior to computers, and could be seen as less essentially dependent on technology than film making, which is a more recent domain that could not exist without video recording technology. The domain of musical creativity is therefore highly suitable for analysis of the technological effects of computing technologies.

Finally, it was deemed useful that studies would be performed in a domain of which the author has an existing level of understanding, allowing common ground in discussions with practitioners and more effective analysis of the data in the time available. I have been an amateur musician for over ten years now, recording and composing using various tools. I have played and created music collaboratively in various situations, and have had a strong interest in music in general. Musical composition was therefore chosen as the primary domain of study. Filmmaking was chosen as a second domain, as although I have only minor understanding of film creation, it fits the other criteria well.
3.2.2.1: Characteristics of Musical Composition and Filmmaking

In order to consider how musical composition and filmmaking can be studied in developing a generic understanding of creativity, this section considers the specific characteristics of these two domains. It has already been established that these are artistic domains where collaboration is common. A further shared quality is that the outcomes produced have a temporal nature. In general both domains could be said to involve the composition of smaller pieces of material in to a larger sequential structure, although there is great variation in how this process occurs and the ways in which the act of creation combines planning and performance. In addition to the temporal dimension both generally contain a further dimension by combining simultaneous channels. In the case of film this commonly comprises video images, related audio and soundtrack. In music, there may be any number of instruments, musicians or singers involved in a single outcome.

Both activities involve a particular combination of planning and improvised action, with collaboration requiring both the sequential and diachronic interaction defined by Sawyer (2003). Film creation is related to, but distinct from theatre in that the outcome is a recorded artefact developed from performance and manipulation rather than a temporal performance itself. Musical creation and performance are perhaps more closely related, particularly in highly improvisational forms where only a loose structure of ‘ready-mades’ exists before performance, rather than a refined, well-understood composition (Sawyer, 2003).

As has already been mentioned, music is often an important aspect of film. A narrow view of music would suggest that visual elements are not part of the domain outcomes, but they are of major importance in a wider sense in terms of live performance before an audience, in terms of interaction between musicians who maintain awareness through the visibility of actions and communicate through gesture, and in terms of the visual representations of compositions.

3.2.2.2: Studies of Musical Composition

The field studies that formed part of the MSc dissertation ‘Designing Software for Creativity Support and Idea Representation’ (Coughlan, 2004), were revisited and reanalysed as a starting point for the research that constitutes this thesis. These field studies were used to gain a naturalistic understanding of creative practice in the musical domain. Informal interviews and questionnaires were also used to gain more detail from the participants. In addition to the field observations of these two groups, individuals and pairs were observed using existing computer tools for musical composition. These were not further developed in this thesis, so are cited as (Coughlan, 2004) where mentioned.
3.2.2.2.1: Results

The musical composition observations involved two separate groups of experienced musicians (nine people in total), who were observed composing together. The first of which were the Bath University Musical Production Society (BUMPS), who were observed in three of their regular meetings on the university campus, where they met to compose together and discuss various aspects of music creation and performance (see figure 7). For comparison, a session was spent observing a further group of musicians (referred to as ‘2nd Group’ composing and practicing at one of the participants’ homes. Sessions lasted between 1 and 2 hours, in total producing 6 hours of material across 4 sessions. Table 1 describes the participants and their involvement.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Involvement</th>
<th>Relevant Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5 hours (BUMPS)</td>
<td>Writing, singing, composing &amp; playing guitar solo and in groups for many years</td>
</tr>
<tr>
<td>B</td>
<td>2 hours (BUMPS)</td>
<td>Singing for 3 years, mostly with other people’s material but some original work.</td>
</tr>
<tr>
<td>C</td>
<td>5 hours (BUMPS)</td>
<td>Playing keyboards, drums and singing since childhood. Writing original material for keyboard. Writing and performing music in small theatrical productions</td>
</tr>
<tr>
<td>D</td>
<td>4 hours (BUMPS)</td>
<td>Singing and playing various instruments. Teaching and working with choirs and other university musical groups.</td>
</tr>
<tr>
<td>E</td>
<td>1 hour (2nd Group)</td>
<td>Playing guitar for 6 years, previously composing and performing with a band.</td>
</tr>
<tr>
<td>F</td>
<td>1/2 hour (2nd Group)</td>
<td>Playing drums and percussion instruments for about 2 years as well as keyboards.</td>
</tr>
<tr>
<td>G</td>
<td>1 hour (2nd Group)</td>
<td>Played guitar and keyboards for 3 years. Some experience of jamming</td>
</tr>
<tr>
<td>H</td>
<td>1 hour (2nd Group)</td>
<td>Playing guitar for 8 years, keyboards for 2 years. Jamming with friends and composing.</td>
</tr>
<tr>
<td>I</td>
<td>1 hour (2nd Group)</td>
<td>Used to sing regularly with a choir, plays piano occasionally</td>
</tr>
</tbody>
</table>

Table 1: Participants in the Observations of Musical Composition
A description of each of the observed sessions follows:

**BUMPS Session 1:**
The session was attended by A, B, C and D, instruments used were an electric piano, guitar, voice and a drum. Participants A (guitar) and B (vocals) collaborated on improving an incomplete piece composed by A. A had created a written representation of the piece comprising chords and words, as this was the first time B had seen this it was studied and used frequently in order to perform the piece together. After achieving a level of shared understanding a coherent performance was produced. A and B then manipulated the structure of the piece. After this a discussion ensued on the way to improve the “relationship between music and lyrics” (D). This included the use of adjectives and phrases to explain the intended emotional content of the piece such as “shady” and “soul mate”. During this time sections of the composition were played repeatedly with different dramatic structure. A and D also used their voices to express how they felt the piece should be sung by B. An improvised jam occurred using the song ‘Sitting on the dock of the Bay’ as a basis. All four participants played and attempted to allow each other space to sing and improvise. After this the participants discussed how such a jam can work, needing each member to understand what the others are doing and “find space” to join in (D).

**BUMPS Session 2:**
A, C and D attended this session, instruments used were a guitar and drum. A song entitled ‘Firefly’ developed previously by A and C was performed several times, with a focus on improving the vocals. Some lyrics and guitar had been composed but the pitch and manner of the vocals was developed. Sections of the piece were replayed (e.g. the chorus) to evaluate alternative ideas. Discussion occurred between the performances, with input from all three participants. A and C created a composition using lyrics written by A. C on guitar was told by A to use a 12 Bar blues structure in the key of G. The guitar piece was developed to suit the verse-chorus structure of the lyrics. This took several replays and D informed the players that the original structure was flawed because the guitar chords did not complement changes in the pitch of the vocals. This was rectified and the piece was developed successfully to a 2-3 minute song.

**BUMPS Session 3:**
The session was attended by A and C. Whilst there was some play the session was short and offered the chance for me to discuss composition with the participants. Both had computers set up as part of a home studio, which also included several instruments and for C a multitrack recorder. Software they used and recommended included Cakewalk as a software recording studio and Cubase for composing MIDI scores. A stated that one of the most annoying aspects of using a computer for composition was the way in which some software added aspects without any direction from the user. It could also be difficult to achieve the intended timing when using some computer composition tools, as they were too ‘mechanical’ when compared to playing real instruments in a band.
2nd Group Session:
Five musicians participated (E – I). They were well known to each other and some had played together before, however the group as a whole had never composed together, providing an interesting comparison with the BUMPS group. The group created two sections of a composition in the session, in both cases based on chord structures developed by the guitarists (E and H). From this the other participants playing keyboards (G) and drums (F and I) developed their own parts to fit. The first section was represented on paper after 12 minutes of play and discussion, the explicit purpose of this being to solve confusion between the two guitarists. The representation consisted of chord names on paper, and was subject to various revisions. G (playing a keyboard) used the chord representation to develop a melody, however she continually felt that her play wasn’t suited to the piece, resulting in discussion with the group. The drum players developed parts by listening to the rhythm of the guitars and each other, never using the paper representation.

3.2.2.2.2: Analysis
In the MSc thesis, the observations were analysed through the following means: Sessions were transcribed and evidence for existing models of creativity – such as reflection-in action (Schön, 1983,1987) – was identified as an initial basis for understanding the data. A Hierarchical Task Analysis was produced (Dix et al, 1998), along with a taxonomy of the forms of idea representation that could be observed, or were discussed, in the sessions. This is reanalysed in chapter Productive Interaction. Further analysis focused on the interactions with technology that were observed, and the questionnaires filled in by participants, which discussed what had occurred in the sessions, the participants opinions on technology and creativity, and the wider context of the activity.

For this thesis, all the captured material was reviewed, and a session was coded using the Transana environment (see figure 8) for qualitative data analysis (www.transana.org). This supported a more detailed and structured approach to analysis, that involved using and refining the concepts identified in each perspective of the framework as codes. The coding process involved splitting the video in to clips separated by time codes, and labelling these clips according to the concepts represented in them. A similar process was applied to the analysis of an art - technology collaboration in the COSTART project by Zhang & Candy (2007), to understand the use of communication modes in the creative collaboration. Initially, the session was transcribed based on, and in the process of refining, the concepts present in the Productive Interaction perspective – building on the previous work performed for my MSc thesis (Coughlan, 2004). The coded session was returned to, and additional codes added in the process of reflecting and refining the Structural and Longitudinal Interaction perspectives. A similar process was applied to analyse other video recordings in the studies performed for this thesis (see sections 3.2.2.3 and 3.2.5.3).
The overall analysis of this session is presented in section 4.1.3, and the transcription is included in appendix 6.3.1, along with a transcription of the 2nd group’s session which was also reviewed as part of this data set. The analysis and examples from this study are used across the findings chapters (4.1 – 4.4).

3.2.2.3: Studies of Filmmaking

A group project to create an informational film was devised as a means to study group creativity in an alternative domain, and to study the utility and effectiveness of existing technologies to supporting collaborative creativity. The observational nature of this study followed the form of the original field studies, with the difference that the task and groups were arranged rather than natural, and that the groups were provided with technological support (although not restricted to using the support provided). This support included a PC with a large screen attached for use in meetings, and individual HP IpaQ Smartphones, for use in capturing ideas and other materials at any time.

The task given was to “create a public information film, encouraging people who frequent the university to be active in making the campus more eco friendly” (see appendix 6.4.1). Group members arranged their own meeting times and were given a lab setting to use for this. The project was to be completed over the course of three weeks. Groups were asked to arrange as many meetings as they needed – with a minimum of one a week - in a room where we observed their interaction with technologies and each other. Experience of filmmaking was not a prerequisite for participation.

At the end of each meeting, the groups were asked to summarise their progress, providing further scope to analyse their understanding of how the task developed. The participants were also asked to describe the other tools
they had used in the process of developing the film. Questionnaires were given to the participants at the beginning and end of the task. These provided useful data about the processes of creating the film, and descriptions and opinions of the technologies used (see appendix 6.4.3).

3.2.2.3.1: Results:
Two groups of four took part in the filmmaking study. Both groups produced a short film as an outcome. In the case of the first group, this could be seen as a complete piece. The second group produced several short skits, which they saw as being prototypical of the film they would produce given more time and resources.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Involvement</th>
<th>Relevant Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1st Group</td>
<td>No practical experience of filmmaking.</td>
</tr>
<tr>
<td>B</td>
<td>1st Group</td>
<td>Writes, directs and edits short films. Owns a camcorder, and has filmed and edited on numerous special occasions (e.g. weddings).</td>
</tr>
<tr>
<td>C</td>
<td>1st Group</td>
<td>Some video editing experience.</td>
</tr>
<tr>
<td>D</td>
<td>1st Group</td>
<td>Used video camera and DV for family videos since childhood. Previous experience of simply editing videos, like cutting and add music etc.</td>
</tr>
<tr>
<td>E</td>
<td>2nd Group</td>
<td>Experience of filming and editing as a hobby. Also uses DVD authoring and video capture software.</td>
</tr>
<tr>
<td>F</td>
<td>2nd Group</td>
<td>Some experiences of filming using a video camera.</td>
</tr>
<tr>
<td>G</td>
<td>2nd Group</td>
<td>Familiar with recording videos, editing and creating films. Also has strong experience in recording and producing audio.</td>
</tr>
<tr>
<td>H</td>
<td>2nd Group</td>
<td>Directed and edited a 15 minute documentary for Cable TV.</td>
</tr>
</tbody>
</table>

Table 2: Participants Involved in the Filmmaking Study

A description of each groups’ progression through the task follows:

Group 1:
The group held four meetings over the three-week period. In the first meeting, the members took roles. D was to work on an introduction, whilst A B and C were each to take a theme from the concepts of Reduce, Reuse and Recycle, and work towards producing a short skit based around this concept. In the second meeting, members took turns to present their ideas and concepts, which they had developed between the meetings. The themes given to each member in the previous meeting had not been stuck to, but they still provided concepts for discussion. In the third meeting, storyboard images were used by participants B and C to explain their ideas, whilst A and D only presented their ideas verbally. A plan was developed for actions to be performed by each member before the fourth meeting. A collected footage from the Internet, B and C filmed footage using B’s video camera for use in their skits, and D produced an introduction using facts about recycling. The fourth meeting was used to edit together the footage and produce the final film.
Group 2:
The group held five meetings over the three-week period. In the first meeting they suggested and discussed a range of ideas, culminating in the accepted structure of creating a set of short films involving celebrity impersonators recycling. They also discussed various ideas related to the audience, and how they could be encouraged to recycle through the correct placing of screens showing the films. The second meeting involved initial attempts to refine the ideas into a script. The third session was only attended by two of the members (F and H), they produced a script based on the ideas agreed upon in the previous sessions, and emailed this to all four group members. The fourth session was used to record footage on campus, which required agreement on who was acting in which role, and the gathering of props, before members of the group (E, G, and H) acted in three separate pieces impersonating Indiana Jones, James Bond and The Terminator. Film was recorded using the Smartphones provided as part of the study. In a fifth meeting, two group members (F and H) edited the footage together and produced the final film.

3.2.2.3.2: Analysis:
The meetings of the groups were recorded and analysed for common themes and processes. As with the musical composition observations, a taxonomy of the types of idea representations observed was developed, and is described in chapter *Productive Interaction*. Individual use of the Smartphones was captured through a log of user’s interactions with the software installed, and the syncing of the devices with the meeting room PC allowed us to capture the files used by participants.

A representative sample of the video recordings of the group meetings was coded using Transana in order to achieve a more in depth analysis of the interactions that occurred. This was performed in a similar way to that described in section 3.2.2.2.2. As groups performed the task over multiple meetings, it was felt that the best approach to achieving a representative sample was to analyse and code approximately 30-minute segments of two of the meetings of each group. One segment from the observations of each group was taken and analysed from early in the process of completing the task, and one towards the end. For group one, segments were taken from the second and third meetings (out of four meetings in total). For group two, the segments were taken from the first and fourth meetings (out of five meetings in total).

The segments chosen for coding reflect the best approximation of comparable sessions of activity, given the different ways that the groups performed the task. It is interesting to note that designing a study that involves performing an ill-structured task inevitably leads to differences in data that makes comparable analysis more difficult to achieve. For example: The groups had different numbers of meetings, in the final meeting of group two, only two of the group members were present, and group one’s first meeting was very short, so was not considered suitable for this analysis. The results of the
The overall analysis of the coded sessions are discussed in section 4.1.3, and transcriptions are included in appendix 6.4.2.

The process of coding involved an initial transcription of the discussions and other actions of the participants. This was then coded with reference to, and involved in the refinement of, the concepts of the Productive and Structural Interaction perspectives. Later, the sessions were returned to in order that elements related to the Longitudinal Interaction perspective could be identified and these elements refined (see figure 12 in section 3.2.6 for a full representation of the wider analysis process that led to the findings of this thesis). The analysis and excerpts from the studies are used across the findings chapters (4.1 – 4.4).

3.2.3: Open Questionnaire Study

An open questionnaire study was devised to gain greater detail of idea representation practices – particularly those that occur away from observable practice. This study led on from the realisation that some of the creative process occurs away from intentional practice in a studio or other place of work. Again the study provided scope to explore commonalities and contrasts across domains.

3.2.3.1: Method

The questionnaire was produced as an online form, and advertised to creative practitioners known to the author, participants involved in the previous studies, the university notice board, and through online forums for a range of creative domains. The questions used in the study were as follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What tools do you use to record ideas and inspirational material? (e.g. a notepad, diary, dictaphone, PDA, Post It notes, mobile phone, laptop or anything else) Please describe when you have these tools with you and how you make use of them:</td>
</tr>
<tr>
<td>2</td>
<td>Describe how you represent ideas and inspirational material using the tool(s). What form do they take? (e.g. written text, sketches, photos, video, voice recordings, scraps cut from magazines etc):</td>
</tr>
<tr>
<td>3</td>
<td>How do you integrate the tool or tools with the rest of your work? When and why do you refer to it?</td>
</tr>
<tr>
<td>4</td>
<td>Can you recall ever having a good idea at an unexpected or inappropriate time? Examples of this would include when you were travelling, in bed, shopping or doing any other activity away from your work or practice. Does this happen often?</td>
</tr>
<tr>
<td>5</td>
<td>If you can, please describe a situation like this and what you did about it:</td>
</tr>
<tr>
<td>6</td>
<td>Do you feel that you have forgotten good ideas in the past because they occurred at an unexpected time and you could not record them?</td>
</tr>
<tr>
<td>7</td>
<td>Other than as part of a completed piece of work, do you share your ideas with others in any way? Please describe how and why:</td>
</tr>
<tr>
<td>8</td>
<td>Do you ever show the tool(s) mentioned earlier to other people? If so, when and why?</td>
</tr>
<tr>
<td>9</td>
<td>Apart from using the tool(s) mentioned earlier, how do you present your ideas to other people?</td>
</tr>
<tr>
<td>10</td>
<td>If you collaborate with other people, how do you come to decisions about what to do next as a group? What tools, if any, do you use as part of this (e.g. paper and pen, a computer etc) and how are they used?</td>
</tr>
</tbody>
</table>

Table 3: Open Questionnaire Study Questions
The questionnaire study was designed to complement the observational studies to provide a more complete empirical picture of creative activities. Table 3 shows the set of questions used. These were developed from themes that were apparent, but difficult to understand, through the observational studies. They also draw upon the understanding of creativity built through the literature review. Questions 1-3 explore the holistic use of tools to represent ideas across creative activities, questions 4 – 6 are inspired by Gelernter’s (1994) assertion that ideas commonly occur away from intentional periods of creative work, and questions 7 – 10 explore how communication and collaboration occur through the use of idea representations.

3.2.3.2: Results

27 practitioners from a wide range of domains completed the questionnaire online. 17 of these described themselves as professionals while 10 described themselves as amateurs. Most respondents listed multiple creative occupations or hobbies (an average of 2.6), with 13 describing themselves as musicians, 10 creative writers and 6 painters. Further domains represented included web designers (5), researchers (5) and filmmakers (3). Respondents were found through local arts groups, university notice boards and web forums for creative domains. The full responses are included in appendix 6.1.1.

3.2.3.3: Analysis

All of the questionnaire responses were analysed and coded using the Weft Qualitative Data Analysis environment (http://www.pressure.to/qda/). The analysis performed included specific foci of identifying and quantifying the tools used by each respondent and identifying the contexts in which ideas occurred and where it was difficult to capture them. In addition, a coding of elements in the responses was used to identify common themes and issues, which are referred to where appropriate in the findings chapters. Table 9 in section 4.1.3.3 lists the codes and the frequency of their occurrence in the data. The analysis is then used across the findings chapters (4.1 – 4.4).

3.2.4: Participatory Task Modelling / Participatory Design Sessions

Participatory Design (PD) is an approach that aims to engage prospective users and stakeholders in the design process Namioka & Schuler (1992). It is a development that has occurred outside the HCl community, but it links well with the notion of user-centred design and its consideration application is therefore becoming common. Participatory Task Modelling (PTM) is an approach that combines the notions of user participation with Task analysis, guiding users to produce models describing their current and envisaged tasks. It is an attempt to push user participation “upstream” in to the modelling and analysis activities more commonly performed by analysts alone (O’Neill & Johnson, 2004).
The application of PD and PTM in this project stems from two needs: Firstly the aim is to understand how to inform design processes and as part of this designer-user relationships in creative activities, PD presents a user-centred approach that may be effective in developing for creative activities where novel processes and affordances are key. Secondly, modelling work by users can be used as one method to assess the validity of the model of creative activities that was developed through observation and a review of literature, and is key to this thesis.

Unlike the focus of much of the PD and PTM literature, this project is not aimed at designing bespoke systems for large organisations. In contrast, the aim is to focus on identifying the related needs of a range of prospective users, and the scope for designing new technologies that improve support for their activities in general. In addition, the aim is to support a range of collaborative interactions rather than to understand a specific set of roles that exist in one case. PTM focuses on the notions of current and envisaged task models and the roles of system users and it is worth noting that technological shifts often support new kinds of collaborative interaction. As part of the sessions we therefore asked participants how they could conceive of collaborating with each other and asked them to develop a model of their collaboration with reference to a model they had created of their current creative process.

3.2.4.1: Method

Participants were recruited through University notice boards and music societies, for sessions that combined Participatory Task Modelling and Participatory Design. The format of these sessions was as follows:

1) Each participant filled in a questionnaire describing their background
2) Individuals were asked to produce a model of their creative process
3) The groups were divided in to two sub-groups, and individuals were asked to explain their model to the other people they were assigned with.
4) The sub-groups produced a model of how they collaborate together if they had previously done this, or how they could conceivably collaborate together if they had not.
5) Participants were asked to define and discuss where and how computers could be useful or problematic in their creative process, using the models they had produced.
6) Participants were asked to produce paper prototypes of new systems they felt would be useful to them. They were asked to utilise their models in this process, and given two themes to focus on: Systems for collaboration, and for capturing and organising ideas.

The presentation slides used to guide these sessions can be found in appendix 6.2.1.
3.2.4.2: Results

Two sessions were performed, one with a group of 5 participants, and the other with a group of 6 participants, all of whom had experience of playing and composing music, as described in table 4.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Involvement</th>
<th>Relevant Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1st Group (PTM model A)</td>
<td>Plays guitar in a band, composing for two years. Some computer music experience e.g. Guitar Pro 5.</td>
</tr>
<tr>
<td>C</td>
<td>1st Group (PTM model A)</td>
<td>Plays guitar, bass and drums. Has been in 4 bands since aged 17. Uses Garageband for producing own music. Has previously recorded an EP in a studio.</td>
</tr>
<tr>
<td>D</td>
<td>1st Group (PTM model B)</td>
<td>Pianist for 17 years, also plays guitar. In a band since start of university with some original material. Some limited use of computers to create tabulature.</td>
</tr>
<tr>
<td>E</td>
<td>1st Group (PTM model B)</td>
<td>Has been in 3 bands and a percussion ensemble. Very little experience of computers in music.</td>
</tr>
<tr>
<td>F</td>
<td>1st Group (PTM model B)</td>
<td>Writes compositions for violin, and takes part in informal jamming sessions, improvising with other musicians.</td>
</tr>
<tr>
<td>H</td>
<td>2nd Group (PTM model C)</td>
<td>Creates music for theatre shows and in two bands. Extensive experience in composing on computers, and in recording bands as a sound engineer / producer.</td>
</tr>
<tr>
<td>I</td>
<td>2nd Group (PTM model C)</td>
<td>Extensive experience of composing using computers. Plays clarinet and saxophone in bands.</td>
</tr>
<tr>
<td>J</td>
<td>2nd Group (PTM model D)</td>
<td>Has composed music in bands and individually, uses Linux audio tools extensively.</td>
</tr>
<tr>
<td>K</td>
<td>2nd Group (PTM model D)</td>
<td>DJing for 10 years, and now starting to compose own tracks using Linux audio tools.</td>
</tr>
</tbody>
</table>

Table 4: Participants in the Participatory Task Modelling / Design Sessions

The Participatory Task Models produced in collaborative groups follow here in figures 9 - 12.
3.2.4.3: Analysis

The main analysis performed of the Participatory Task Models was to identify the individual components, and the links between these in each instance, then to group these thematically. The discussions between participants when developing their models were also recorded and reviewed where they could provide addition clarity on the models the participants had produced.

An analysis of the collaboratively produced Participatory Task Models shown in figures 9 – 12 was performed using the following process:

1) Identify the individual elements in the models
2) Identify whether they represent existing concepts of the framework, if not, highlight and analyse what they do represent, then refine framework to include this.
3) Identify the relationships between elements by identifying all the elements to which this element is connected

For example, the analysis of PTM model A (figure 9) is the shown below in table 5.

<table>
<thead>
<tr>
<th>Element No.</th>
<th>Description</th>
<th>Framework Concept(s)</th>
<th>Connected to Element(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Start Point (Riff, Brief, Art, sound)</td>
<td>Ideation, Idea representation</td>
<td>2(out), 5 (O), 7 (in)</td>
</tr>
<tr>
<td>2</td>
<td>Library / Scrapbook of sounds in head or on computer</td>
<td>Idea Representation, Retention, Organisation, Using</td>
<td>2 (in), 3 (out), 7(in), 8 (O)</td>
</tr>
<tr>
<td>3</td>
<td>Elements of music / sounds</td>
<td>Idea representation</td>
<td>2 (in), 4 (out), 7 (in)</td>
</tr>
<tr>
<td>4</td>
<td>Arranging</td>
<td>Idea represented in context, Internal Structure</td>
<td>3 (in), 5 (O), 6 (out), 7 (in), 8 (out)</td>
</tr>
<tr>
<td>5</td>
<td>Final Production</td>
<td>Idea represented in context, evaluation, decision making.</td>
<td>2 (O), 4 (O), 7 (in)</td>
</tr>
<tr>
<td>6</td>
<td>Elements not working discarded / tweaked</td>
<td>Evaluation, Decision Making, Change Conception of the outcome,</td>
<td>4 (in)</td>
</tr>
<tr>
<td>7</td>
<td>Other People (suggestions, new sounds / chunks of music, expertise)</td>
<td>Collaborative productive interaction</td>
<td>1 (in), 2 (in), 3 (in), 4 (in), 5 (in)</td>
</tr>
<tr>
<td>8</td>
<td>Suggest new sounds</td>
<td>Ideation, Idea Representation</td>
<td>4 (out), 2 (in)</td>
</tr>
<tr>
<td>9</td>
<td>Production / Tweaking things</td>
<td>Idea represented in context, evaluation, decision making.</td>
<td>Connected loosely to whole model</td>
</tr>
</tbody>
</table>

Table 5: Analysis of Elements in PTM Collaborative Model A

The full set of tables, representing the analysis of each of the four models in this way, are included in appendix 6.2.2. The framework concepts represented in the full set of four PTM models were then tabulated. This tabulation is presented in table 8, in chapter 4.1: Overview of the Research Findings.
The major use of the participatory task models is to refine and provide evidence to validate the models of each perspective on creative interaction. As such, the themes used reflect the concepts that comprise the models. The validation occurs in finding a theme that fits each element of the Participatory Task Models, so that no spurious elements exist that cannot be categorised. In such cases, the models were refined to reflect this. It was also important to consider in this analysis, whether all the elements of the models were apparent, and if not, to reason why this may be the case.

The analysis of the Participatory Task Models is represented in the findings chapters in tables, taking two forms: Firstly, tables are used to identify all the elements related to a particular theme, in order to explore the characteristics of that theme. Secondly, tables are produced that identify elements and the subsequent elements they are connected to, in order that the relationships between elements of the creative process can be explored. The analysis is used across the findings chapters, but particularly in chapters 4.2: Productive Interaction, and 4.3: Structural Interaction, as these are more related to the focus of the participants (discussed further in section 4.1.3.2).

The paper prototypes produced by participants were also analysed and the design ideas inherent in these – along with the discussions between participants that occurred as they were developed – provided further data with which to understand practitioners’ opinions of support tools and ideas for new technologies. However, it is the participatory task modelling that was found to be exceptionally useful in providing a further avenue through which to refine and validate the theoretical aspects of this thesis. The experience of using Participatory Design in developing support for creative activities is discussed in chapter 5.1: Utilising the Findings as a Framework for Designing Interactive Systems.

### 3.2.5: Prototype Design and Evaluation Studies

As the focus of this research is the use of empirical understanding to inform design, the design and evaluation of prototypes was the method of research that took up the majority of the time and effort during this project. The work presented in this thesis included three prototype design projects, each including two iterations of design and evaluation.

Carroll et al’s (1991) task-artefact cycle and Zimmerman et al’s (2007) principles of design research – introduced in chapter 2.5: Designing Interactive Systems - are also essential to the aims of these design and evaluation projects. Through introducing new artefacts that affect the tasks that users perform we can better understand the dynamic relationship between artefacts and creative processes. Simultaneously, exposure to new technologies provokes understanding amongst users of the possibilities for new technologies to affect and support them in their creative activities. This understanding was captured through questionnaires and interviews after the evaluations took place.
Initial aims and requirements for the design projects were established through the analysis of empirical research described above. This analysis led to the models of creative interaction from each perspective, which highlighted actions in creative activities that need support, and their relationships to each other. These are presented in the Model sections of chapters 4.2 - 4.4. Also, throughout the analysis of the data on the current use of, and opinions on, interactive systems, further direction for design were defined. Both these aspects were distilled in to the aims and requirements presented in the ‘Design Study’ sections of chapters 4.2 – 4.4. Some element of design always remains a creative process in an ill-structured space, but the findings chapters aim to justify the major design decisions through reference to the data and analysis.

Design and evaluation were performed in two iterations in order that conclusions and design ideas drawn from the evaluation of the existing design could be implemented and evaluated in an additional cycle.

3.2.5.1: Issues in Performing Prototype Design and Evaluation Studies

It is important to note that utilising prototype development and evaluation in research is a complex process, and that some of the most important lessons learnt in the course of writing this thesis have been on this topic. The 1st study performed: Sonic Sketchpad, should be seen as a pilot study as it highlighted many of the difficulties in using prototypes to effectively elicit findings. In particular, these issues include:

- The balance of developing high-fidelity, usable prototypes that are feature rich but reliable enough for evaluation, in a limited time scale.
- The need to support users to learn to use the system in a naturalistic way, and reach competency without being guided towards using the system by the nature of the learning support given (e.g. tutorials).
- Utilising the system itself to produce quantitative data on system use through logging, and knowing in advance what data it would be useful to have in this regard.
- Effectively recording the interaction between users and the system for useful analysis.
- Evaluating systems in a naturalistic way, despite their limitations as prototypes.

The lessons learnt in this regard are apparent in the development of the methodologies used to evaluate Music Builder and Associative Scrapbook. In particular, the analysis of Music Builder makes effective use of system logs to provide a picture of user types (see section 4.3.5.1), and in the case of Associative Scrapbook, case studies were successfully performed with users installing the prototype on their own computers and using it over a period of at least three weeks (see section 4.4.5.1).
3.2.5.2: Studies Performed

Central to the understanding of creative interaction built in this thesis are three design projects. In each case two iterations of design and evaluation were performed, resulting in the production of a prototype tool and data from evaluations. The projects were:

1. **Sonic Sketchpad** – A tool to support the representation of musical ideas, individually and collaboratively, initially for co-located use but developed for networked use in the second iteration.
2. **Music Builder** – An environment for developing screen-based musical instruments and using these to create compositions. In addition the system supported collaborative composition through a modified version of the Sonic Sketchpad prototype.
3. **Associative Scrapbook** – A tool based on a scrapbook metaphor, supporting the collection and organisation of various media. The system is aimed at supporting a wide range of creative practitioners and the development of their work over the long term.

Whereas the analysis of the other studies is referred to where relevant in all three of the findings chapters, the prototype design and evaluation studies are each specifically linked with a perspective and therefore a chapter of the findings. The nature of the evaluations also varied, dependent on the context in which use of the tool was envisaged. Detailed descriptions of the evaluations performed can therefore be found in the relevant chapter and only a short overview is given here.

3 highly experienced musicians were involved in evaluations of **Sonic Sketchpad** in 3 individual and 2 collaborative sessions. 12 participants with varied musical experience were involved in evaluations of **Music Builder** in 2 individual and 6 collaborative sessions. **Associative Scrapbook** has been the subject of 4 in-depth case studies in different domains, and usage statistics have been received from more than 60 users, along with comments and email discussions about the software.

3.2.5.3: Overview of Methods and Analysis for the Evaluations

The evaluations were filmed where possible, with notes taken during the sessions. In the case of Music Builder and Associative Scrapbook, usage statistics were logged by the software, providing a picture of the functions used by participants in each session. In all the evaluations, open questionnaires were used to collect opinions of the software, descriptions of how the participants had used it, and ideas for improvements. Each of the design studies has included two iterations of evaluation, so that modifications could be made to the designs and then evaluated.

As the design studies were used to investigate different perspectives on creative interaction, and to develop an understanding of the design process itself, evaluations were performed in different ways. The Sonic Sketchpad
evaluations were used to explore support for a range of types of productive interaction, so were evaluated for individual use, co-located collaborative use with one or two terminals, and distanced collaborative use. It also functioned as a pilot study for exploring the possibilities for developing and evaluating prototypes as a research method. The Music Builder evaluations considered various aspects of structural interactions, and the utility of the visibility of collaborators’ tangible structures was explored in lab-based evaluations with three experimental conditions. The Associative Scrapbook was developed as a tool for long-term use, so case studies were performed in a naturalistic fashion, with participants installing the prototype on their personal computers and being observed on multiple occasions over several weeks.

Using the same method applied with the observations of musical composition and filmmaking (see section 3.2.2.2.2), representative sessions of the Music Builder and Associative Scrapbook evaluations were also analysed using Transana and coded according to, and in the process of refining, the concepts that form the framework. This is discussed where appropriate in the findings chapters (4.3 – 4.4).

3.2.6: Critical Review of the Analysis and Presentation of this Research

3.2.6.1: Development of Findings

The major outcomes of the analysis are three perspectives on creative interaction, which are used as a structure with which to present the findings over the following chapters (4.2 – 4.4). The development of these perspectives, and their refinement through the reanalysis of the pre-existing study data, is represented in figure 13. This diagram shows how specific studies led to the definition of a particular perspective, and then other studies were returned to for reanalysis with the new perspective in mind.
As figure 13 shows, the overall findings of this thesis rely upon the analysis of data from several studies, utilising a range of methods, some of which are novel. Many of the findings presented from the qualitative data are presently unquantifiable, whilst in other cases, they are only supported by quantification from a small set of data. This is considered appropriate as the thesis is exploratory in nature, aiming to define and understand the essential concepts and processes that exist and the relationships of these with the design of interactive systems. It does however, lead to complexities in establishing the validity of the findings. Silverman (2005) notes the common question of how those engaged in qualitative research are to “convince themselves (and their audience) that their ‘findings’ are genuinely based on critical investigation of all their data and do not depend on a few well chosen examples” (pg 211).

Two of the approaches Silverman suggests in response to this ‘Anecdotalism’ are utilised here to strengthen the arguments given. Firstly, tabulation of a wide set of data is used where appropriate to back up a particular example. Secondly, triangulation of the data from multiple studies is utilised as much as possible, giving multiple examples where significant aspects of the framework are defined. In addition, an overall analysis of all the studies is used to present a case for the existence of the concepts presented in the framework (See section 4.1.3).
3.2.6.2: Scope and Validity of Findings

The data on which the findings are based is an important factor in considering the scope to which they can be considered valid. An effort has been made to sample a range of contexts in which creativity can occur, but this data does not provide a full, or entirely representative, sample of all the activities that could be considered creative, or all the types of people who are involved in these activities. This would have been difficult to achieve within the constraints of a PhD project, or indeed in any research project, due to the vast scope of what could be considered creative.

The observational studies focused on the two domains of filmmaking and musical composition. Respondents to the questionnaire study were from a wide range of domains. This provides scope for comparison of creativity across different domains. A range of interpersonal contexts have been observed or reported across the studies, including individual work in a collaborative and social context discussed in the questionnaire study, collaborations between pairs in the musical composition observations, Sonic Sketchpad and Music Builder evaluations, and collaborations between groups of four in the filmmaking studies.

The level of expertise of the participants in the studies is an issue of importance, as creativity can be observed across a spectrum of people with different concepts of novelty and value. The thesis targets a wide middle band of potential users for interactive systems. It is not focused on geniuses or children. The questionnaire study respondents were a mixture of professional and amateur creative practitioners (see section 3.2.3.2). Whilst none of those involved in the observational studies were professionals, there was a mixture of levels of expertise, from dedicated amateurs with years of experience in the activity, to those who expressed an interest but had little relevant experience. The evaluations of the prototypes mostly involved a similar population with a range of expertise levels, with a professional animator and researcher involved in the Associative Scrapbook case studies.

The data therefore covers only some of the possible levels of expertise, some of the possible configurations of interpersonal interactions, and some of the domains that can be considered creative. In order to make for the most useful findings, the aim is to cover a wide middle ground of common activities and people, and to actively consider how variations in creative activities occur outside of this data. Confidence in the applicability of the findings has to decrease outside of the studied space. To bolster the wider validity of the work, the findings from the data are supplemented by, and compared to, existing research, which can be used to consider other domains, types of collaboration, and expertise levels. Future work could expand the understanding of the contextual factors that affect creative processes, and in particular could consider more extreme cases, rather than the middle ground aimed for here.

3.2.6.3: Conclusions

The conceptual framework presented here was developed through the analysis of the studies performed, and – as it developed - informed the next
studies so that they focused on aspects of creative interaction that could be perceived, but not well understood. For example, the open questionnaire study was developed as the data up to that point covered only focused work on the production of creative outcomes. This symbiotic relationship between data collection, analysis, and the direction of further studies could be considered to lead the researcher to find only what they want to find. As there are many more contexts in which creativity occur, it is difficult to argue that the findings represent a ‘complete’ picture of creative interaction, but it can be well argued that the framework represents a useful picture of creative interaction that can inform design, as each perspective was utilised in a design process, leading to useful understanding of the needs of prospective users. The framework can also be utilised as a basis for future research, as discussed in the concluding chapters of this thesis (5.1 and 5.2). Whilst this thesis maps out a framework, future work that explores aspects of it in more depth, analyses more data, and utilises it in the design of interactive systems would add important refinement and further validation.
Part 4: Findings
4.1: Overview of the Research Findings

4.1.1: Introduction to the Findings

This thesis aims to advance the current theoretical understanding of creative interaction that can be utilised in the design of computer systems to support creative activities. As the research presented in chapter 2.1: Understanding Creativity and Creative Processes shows, creativity can be understood from many perspectives, and current theoretical understandings of creativity have not been developed from the perspective of the design of tools, or with a focus on computer technologies and the particular opportunities and characteristics they present. As argued in chapter 2.4: Human-Computer Interaction and Creativity, computers present a number of characteristics that challenge existing norms with respect to tools, and present opportunities for new forms of creative interaction both with tools and between people. The understanding built through this research is presented as a conceptual framework with which to guide designers in this context, which has become quickly integrated in to creative activities, but remains poorly understood and under-explored.

The studies and analysis described in the previous chapter provide a set of data elicited and analysed through different methods, and covering different contexts of creative activity. In order to form a coherent picture of the phenomena, triangulation between the analysis of each study is required. As such, rather than presenting the analysis of each study individually, the following chapters make use of combinations of data to back up the arguments presented. The findings of the studies described in the previous chapter are therefore presented thematically across the following three chapters. Each chapter presents a perspective on creative interaction, so called because whilst they offer distinct points from which to understand the creative process, they also overlap and co-exist. Due to the complexity and recursive nature of some aspects of creative interaction this was found to be the best paradigm for understanding the whole. For each perspective, findings from the empirical studies were used to produce a model of interaction, and to inform a design and evaluation study. To conclude each chapter, requirements and questions designed to elicit context-specific understanding are presented for use in the design of interactive systems for creative activities.

The three perspectives: Productive Interaction, Structural Interaction and Longitudinal Interaction integrate with each other hierarchically, as each forms a sub-part of the higher level. There are however recursive elements and overlap between the processes that occur. This is explored in chapter 5.1: Utilising the Findings as a Framework for Designing Interactive Systems.

From each perspective, the effects of important contextual factors are considered in terms of the generic model. Although they are not considered to
be exhaustive, in this thesis we consider three contextual factors that are highlighted in the literature and can be shown to affect creative interactions through the empirical and design studies. These are the ‘Interpersonal’, ‘Domain’ and ‘Expertise’ contexts in which the creative activity occurs.

4.1.2: Development of the Framework

4.1.2.1: Generic Perspectives

The findings are presented as three perspectives as, through the process of performing and analysing this research, this has been found to be the most natural way of distinguishing the processes of creative interaction. As this interaction is complex, occurring both in the moment and over the course of a lifetime, a single perspective was found to be an inadequate basis for understanding this interaction and providing a useful framework for design. This section briefly charts the development of these perspectives, from studying the low-level interactions that occur when producing and evaluating ideas, to the development of the structures that support and bound this production, to the surrounding context and long-term development that occurs over the course of a lifetime.

4.1.2.1.1: Productive Interaction

This research began by studying and analysing the interactions that occurs as creative outcomes are produced, and the support required for this. Creativity by definition involves the creation of an outcome, so the interaction that occurs when engaged in the production of a creative outcome is an obvious starting point for understanding the phenomenon. This led to an understanding of Productive Interaction, defined as the generation, externalisation and evaluation of ideas towards the explicit goal of producing a particular creative outcome. The tools that support this are often the most visible tools involved in the creative process, even defining the creative domains they are used in. The video camera, musical instrument and paintbrush are the most obvious symbols of the related craft. Support in computer tools for the production of creative outcomes is also highly visible and common. Graphics or music software and word processors are used pervasively in production. Chapter 4.2 explores in detail the nature of Productive Interaction, and its support through interactive systems.

4.1.2.1.2: Structural Interaction

As the studies and analysis progressed, two important concepts were identified that expanded the range of the theoretical understanding required towards a second perspective: Firstly, the productive interaction always occurs in a context that determines and bounds the space in which it occurs. Secondly, this context is variable and is developed by the actions of the people involved. Productive Interaction describes a low-level set of interactions that occur in focused creative tasks, however it does not consider the development of the structure in which this production occurs.
So a second perspective to consider is the structuring of the creative process, including practices such as selecting or modifying tools, building conceptual goals or constraints or developing methods. Integrating an understanding of this Structural Interaction into the framework is important because creativity inherently includes a self-reflective component, evaluating the effectiveness of structures that influence production. It is logical that novel outcomes will be produced from novel processes, and as creative tasks lack a clear path to an outcome, they require additional structuring to support a path to completion. From this perspective, the malleability of tools and their ability to be used in a range of ways, as well as their support for defining concepts and constraints is key. The relationships between creativity and interactive systems are particularly interesting because they provide a unique malleability amongst the tools that can be used in creative practice. Chapter 4.3 explores in detail the nature of Structural Interaction, and its relationships with the design of interactive systems.

4.1.2.1.3: Longitudinal Interaction

The previous two perspectives bounded the understanding of creative interaction to instances of creative tasks. An implicit assumption is that creative activities can be effectively considered in terms of these individual instances. Whilst most of the research highlighted above considers that these tasks are influenced by previous events and influence future events, the focus is an intentional, explicit act of creation, leading to an outcome. This is useful as a reductionist method for understanding the complex phenomena of creative interaction, but to complete the picture a third perspective is needed, because the creative practitioner does more than produce creative outcomes, and activities outside of this are perhaps the least visible or well defined. From the initial analysis of the musical composition observations it was obvious that the previous actions of those observed performing creative tasks was highly influential on their potential to be creative in the current context (e.g. in the description of the sessions given in section 3.2.2.2). A first example of this was composers bringing in partially developed ideas and mentioning their influences in the sessions of musical composition. It was however, only later that a significant amount of data on the activities that occur outside focused creative interaction was collected (through the Open Questionnaire study and the Associative Scrapbook design and evaluation study).

So finally, creativity must be considered beyond the performance of focused, individual tasks. An understanding of Longitudinal Interaction is essential because ideas, inspirations, experiences and relationships occur and develop over long periods of time, affecting processes and outcomes and requiring distinct forms of support. Our creative capability in a specific instance of a task is based in previous actions and remembered experiences that have occurred over the course of our lives. Collected resources form available possibilities, and experiences inform decision-making processes in the productive and structural interactions described above. When we visit an inspirational place, browse through divergent materials on the web, or attend social gatherings, we are shaping our future creativity. Associating ideas and inspirations for later use in the correct context, retaining structures and
outcomes, and building and maintaining collaborative and social relationships requires a range of support over the long term. Chapter 4.4 explores in detail the nature of Longitudinal Interaction, and its support through interactive systems.

4.1.2.1.4: Common Structure of Generic Models from Each Perspective

In order to provide a consistent understanding of each perspective and the connections between them, a model in a consistent form is presented in each section. Each model contains two components: Human processes are represented in the inner circle, and the external artefacts that are affected or produced through interaction with them are represented by the outer circle. As such they represent the interaction between people and the external world. In particular the model can be used to understand how tools are used, can provide a language with which to discuss how they could be designed, and can provide scope for predicting needs or problem areas in the design of tools.

4.1.2.2: Contextual Factors

The three perspectives of Productive, Structural and Longitudinal Interaction provide a set of useful generic lenses through which to view creative interaction. There are however, in addition, important contextual factors with which creative activities vary. In this thesis three important contextual factors that vary across activities are analysed in relation to each of the perspectives. It is important to note that these three are not exhaustive - there are likely to be other factors that influence creative interactions. However these three have been identified in previous literature and were apparent across the studies. Comparing various contexts also provides necessary examples of how the generic understanding represented in the perspectives can be utilised in the context of a particular design project that aims to provide support for creative activities.

4.1.2.2.1: Interpersonal

Creativity occurs across a range of interpersonal contexts. It can be tightly collaborative, or performed individually but aimed at satisfying another person. Equally it can be reliant on the abilities of others in various ways, even if these people are not explicitly defined as collaborators (Becker, 1982). Structures for mediating human-human interaction in creative activities are based on the needs of a specific context: Novelty and value are socially constructed concepts (Amabile, 1993), creative processes contain collaborative or co-operative elements (Sawyer, 2003), and the social context of a practitioner is an important element of what it is possible to achieve or disseminate.

In this thesis, various interpersonal contexts occurred in the observational studies. For example the observations of musical composition included groups of different sizes, and the filmmaking study included the natural adoption of sub-groups for particular tasks and meetings where only some members of the group attended. Interpersonal interactions were a theme of
several questions in the open questionnaire study. Similarly, varied interpersonal contexts were set up in the evaluations of the prototype systems. In particular, Sonic Sketchpad was evaluated with individual users and with pairs in distanced and co-located settings (see chapter 4.2) and in the evaluations of Music Builder, the visibility of collaborators to each other was explored (see chapter 4.3).

4.1.2.2.2: Domain

There are also domain-specific components that affect creative interaction. Whilst we define a concept called creativity, and identify a set of concepts and processes that characterise it, there are variations between the work of the scientist, engineer or artist, and within the sub-disciplines of those. When designing for creative interaction, the activity needs to be understood alongside its adherence to an abstract understanding of creativity.

Some of the understanding of domain-specific differences used here was gained through an exploration of literature describing creative processes in varied domains, in addition, studies were conducted in a second domain and a general survey of practitioners is included. It is important to note that almost all of the research performed concerns creative processes in domains that explore ‘what could be’ – encompassing art and design - rather than the explanation of ‘what is’ – encompassing science (Simonton, 2000). Therefore it must be said that it is in artistic domains where these findings hold the most validity. However, by understanding this distinction we can hypothesis what the differences in support needs are, and research is presented through which these hypotheses can be justified. Domain-specific issues are explored in this thesis through the following methods:

1) Review of existing research on domain commonalities and contrasts, and comparison of existing research in disparate domains.
2) Development of a domain-general support tool (The Associative Scrapbook) and consideration of adoption of tools and features of the tools to other domains.
3) Comparison of field studies of filmmaking and music creation
4) Comparison of responses from practitioners across different domains in the Open Questionnaire Study

4.1.2.2.3: Expertise

Finally, the expertise of those involved in the creative activity is an important factor. Creativity is a common human trait, present across a broad range of human activities. However some obvious distinctions and consequences can be identified between the processes of the beginner, in response to everyday creative demands, and the expert in a domain: The professional creative worker hones skills and understanding of a domain, and simultaneously must strive for a high level of novelty and value, closer to Boden’s (1993) notion of ‘historically’ unique creativity. Everyday creativity is more likely to be ‘psychological’ – novel to the mind of the person. Its value can often be
related to a specific issue that has arisen for the person, e.g. making a gift for a friend or writing a speech for a social occasion.

The participants in the studies that comprise this thesis had a wide range of backgrounds and levels of experience. In particular, in the filmmaking study and the evaluations of Music Builder, no requirement for previous experience with the domain was made of participants. In other cases, such as the evaluations of the Associative Scrapbook, those with higher levels of expertise were seen as a more appropriate user group.

Overall, the three generic perspectives, and the analysis of the effects of the three contextual factors on these perspectives, forms the most effective basis that could be identified for a conceptual framework to inform the design of interactive systems for creative activities.

### 4.1.3: Overall Summary of the Analyses

Whilst chapters 4.2 – 4.4 present detailed findings related to each perspective and each concept in the model of that perspective, this section presents representations of the overall analyses from the participatory, questionnaire and observational studies performed. This is used to explore the occurrence of the concepts presented in the framework. For the purposes of this section it is sufficient to describe the framework as a set of three perspectives which contain a total of 22 major concepts. These are shown in table 6:

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Interaction:</td>
<td>Internal Structure, Tangible Structure, Conceptual Structure, Development of Structure, Change Conception of the Outcome</td>
</tr>
<tr>
<td>Longitudinal Interaction:</td>
<td>Retaining, Organising, Using, Sharing, Learning, Experiencing, Bisociation, Relationship Building, Social Development</td>
</tr>
</tbody>
</table>

Table 6: The Three Perspectives and 22 Concepts that Constitute the Framework

These concepts will be defined and explored in chapters 4.2 – 4.4. In the following sections, representations of the overall analyses of each of the studies are presented.

#### 4.1.3.1: Observational Studies

This section presents overall analyses from the observational studies of filmmaking and musical composition.

##### 4.1.3.1.1: Filmmaking

All of the meetings that occurred during the filmmaking study were observed and reviewed (see section 3.2.2.3). Four segments from these meetings, approximately 30 minutes in duration (two from each group) were analysed and coded in depth using the Transana software. Figures 14 - 17 present
keyword maps from each of these sessions. Transcriptions of these sessions are included in appendix 6.4.2.

Figure 14: Keyword Map from Coding of Filmmaking Study (Group 1, Meeting 2)

Figure 15: Keyword Map from Coding of Filmmaking Study (Group 1, Meeting 3)

Figure 16: Keyword Map from Coding of Filmmaking Study (Group 2, Meeting 1)
Figure 17: Keyword Map from Coding of Filmmaking Study (Group 2, Meeting 4)

Whilst these keyword maps do not represent the depth of analysis necessary to understand the processes of creative interaction, they do represent the breadth of data analysed, and the existence of the concepts that form the framework across the coded sessions. The coding process provided a structure through which concepts are developed and refined, and the outcome is a large quantity of identified examples for each concept, some of which are described in the findings chapters (4.2 – 4.4).

Table 7 presents a tabulation of the number of instances of each type of code in the four sessions analysed using Transana (gathered from summaries produced by Transana, included in appendix 6.4.2.5). This describes the instances of framework concepts that are apparent in the coded sessions, and the number of sessions in which they are present.
### Framework Concept

<table>
<thead>
<tr>
<th>Framework Concept</th>
<th>Total Instances of Related Codes</th>
<th>Number of Sessions with Related Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideation (Idea Externalised, Idea Represented in Context)</td>
<td>55</td>
<td>4/4</td>
</tr>
<tr>
<td>Evaluation (Evaluation Represented)</td>
<td>45</td>
<td>4/4</td>
</tr>
<tr>
<td>Productive: Idea Externalised</td>
<td>29</td>
<td>4/4</td>
</tr>
<tr>
<td>Productive: Idea Represented in Context</td>
<td>26</td>
<td>4/4</td>
</tr>
<tr>
<td>Productive: Evaluation Represented</td>
<td>45</td>
<td>4/4</td>
</tr>
<tr>
<td>Productive: Decision Making</td>
<td>15</td>
<td>3/4</td>
</tr>
<tr>
<td>Productive: Iteration (Convergence + Divergence)</td>
<td>24</td>
<td>4/4</td>
</tr>
<tr>
<td>Productive: Scope for Iteration</td>
<td>13</td>
<td>3/4</td>
</tr>
<tr>
<td>Structural: Internal Structure</td>
<td>18</td>
<td>3/4</td>
</tr>
<tr>
<td>Structural: Tangible Structure</td>
<td>12</td>
<td>3/4</td>
</tr>
<tr>
<td>Structural: Conceptual Structure</td>
<td>21</td>
<td>4/4</td>
</tr>
<tr>
<td>Structural: Development of Structure (Structure Adopted, Explored, Dropped or Produced)</td>
<td>8</td>
<td>4/4</td>
</tr>
<tr>
<td>Structural: Change Conception of the Outcome (Divergence)</td>
<td>3</td>
<td>2/4</td>
</tr>
<tr>
<td>Longitudinal: Retaining ( Artefact Representation: Storyboards, Audio / Visual Recordings, and Written Representations)</td>
<td>23</td>
<td>2/4</td>
</tr>
<tr>
<td>Longitudinal: Organising</td>
<td>0</td>
<td>0/4</td>
</tr>
<tr>
<td>Longitudinal: Using (Using and Using Experiences)</td>
<td>20</td>
<td>4/4</td>
</tr>
<tr>
<td>Longitudinal: Sharing</td>
<td>0</td>
<td>0/4</td>
</tr>
<tr>
<td>Longitudinal: Learning</td>
<td>0</td>
<td>0/4</td>
</tr>
<tr>
<td>Longitudinal: Experiencing</td>
<td>0</td>
<td>0/4</td>
</tr>
<tr>
<td>Longitudinal: Bisociation</td>
<td>0</td>
<td>0/4</td>
</tr>
<tr>
<td>Longitudinal: Relationship Building</td>
<td>0</td>
<td>0/4</td>
</tr>
<tr>
<td>Longitudinal: Social Development</td>
<td>0</td>
<td>0/4</td>
</tr>
</tbody>
</table>

---

**Table 7: Tabulation of Code Usage in Filmmaking Study Analysis (From Summary Reports in Appendix 6.4.2.5)**

All of the concepts of the Productive and Structural Interaction perspectives are apparent in the coded sessions, although in some cases, different codes have been used in the analysis to describe aspects of a concept (these are shown in italics in the Framework Concept column). For example, codes 'Iteration: Divergence’ and ‘Iteration: Convergence’ are aspects of the concept ‘Focus of Iteration’ (see section 4.2.2.1). Also, ‘Ideation’ and ‘Evaluation’ are internal processes, only recognisable through their externalisations (represented in the codes As these are an analysis of sessions that focus on the production of creative outcomes, many of the concepts of the Longitudinal Interaction perspective are not present, but ‘Using’ previous ideas and experiences is present across all of the sessions, representing the input of longitudinal experiences in to instances of create activities. This is explored in detail in section 4.4.2.

**4.1.3.1.2: Musical Composition**

To give scope for some comparison of processes between the two domains, a session of the Musical Composition observations was reanalysed after the
formation of each perspective, and codes were added according to the concepts present in each of the perspectives. Figure 18 presents a keyword map showing the codes that occurred from all three perspectives in this session. A transcription of this session is included in appendix 6.3.1.1.

Again, all of the concepts from the Productive and Structural Interaction perspectives are all present (taking the adoption of structure as a an example of ‘Development of Structure’, and the conceptual structuring as an example of ‘Changing the Conception of the Outcome’). Further aspects from the Longitudinal Interaction perspective that are represented include the ‘Sharing’ of ideas from previous sessions, and ‘Learning’ is apparent in instances where participant D teaches participant A about song structuring and the correct use of microphones in performance.

4.1.3.2: Participatory Task Models

Table 8 presents a tabulation of the identifiable occurrences of elements of the conceptual framework across the 4 collaboratively produced Participatory Task Models. The method for producing this analysis was presented in section 3.2.4.
A major reason for performing the Participatory Task Modelling sessions was to explore whether creative practitioners held the same perceptions of their creative processes as the analysis performed for this thesis suggested.

Taking the tabulation presented in table 8, it can be identified that 18 of the 22 major concepts present in the framework were represented in the collaborative PTM models. The four concepts that do not exist: ‘Experiencing’, ‘Bisociation’, ‘Relationship Building’, and ‘Social Development’, are all related to the Longitudinal Interaction perspective, and as such relate to activities that occur ‘beyond focused effort on a specific creative task’ (Definition of Longitudinal Interaction from section 4.4.1). An argument for the non-appearance of these would be that they are external to the focused instances of musical composition that the participants modelled. It is interesting to note from the totals that the Productive Interaction concepts are by far the most common in the models. When asked to produce a model of their creative process, it appears that it is the production of outcomes is the major focus, rather than structuring and longitudinal development.

### 4.1.3.3: Open Questionnaire Study

This study provided more depth on the practice of individuals than the PTM models, therefore a different coding scheme developed, much of which is based around support needs and the use of tools in creative interactions. In this section these codes are related back to the concepts of the framework.
Whilst the *Longitudinal Interaction* concepts of ‘Experiencing’, and ‘Bisociation’ are not represented in the PTM models, they are a common theme in the Open Questionnaire Study. Table 9 tabulates the number of responses and instances where the codes developed to describe the questionnaire data, and can be used to show the validity of these concepts:
<table>
<thead>
<tr>
<th>Code</th>
<th>Responses</th>
<th>Instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium: Visual</td>
<td>14</td>
<td>34</td>
</tr>
<tr>
<td>Medium: Verbal</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Medium: Text</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>Medium: Aural</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Device: Paper &amp; Pen</td>
<td>26</td>
<td>64</td>
</tr>
<tr>
<td>Device: Mobile Phone</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Device: PDA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Device: Audio Recorder</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Device: Camera</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Device: Computer</td>
<td>21</td>
<td>43</td>
</tr>
<tr>
<td>Device: Video Camera</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Device: Whiteboard</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Sketching</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Improvisation</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Availability: In Bed</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Availability: Travelling</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Availability: Ubiquitous</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Ideas occur through Interaction with others</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Ideas occur through stimuli from environment</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Ideas occur through stimuli from media</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Ideas occur unexpectedly</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Ideas occur when performing activities other than creative ones</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>Ideas occur through interaction with the medium</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Evaluation and deciding which ideas to use is more difficult than ideation</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Collaboration involves presentation and shared evaluation of ideas</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Collaboration involves roles</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Conceptual tools / processes are used for ideation (e.g. brainstorming)</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Understanding of Internal structures</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Transitions across media</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Organisation of ideas</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Searching ideas</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Idea loss is important</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Idea loss is not important</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Ideas are accumulated, then used in new projects</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Ideation occurs across projects</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Idea Representations are used to retain ideas</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Idea Representations are used to communicate ideas</td>
<td>18</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 9: Codes and the frequency of their use in the Analysis of the Open Questionnaire Study (Responses = Number of responses that the code occurs in. Instances = number of instances where the code is used across all of the responses)

The concept of ‘Experiencing’ includes the phenomena described by the codes: ‘Ideas occur through interaction with others’, ‘Ideas occur through stimuli from the environment’ and ‘Ideas occur through stimuli from Media’. Together there are 12 responses where one or more of these codes occurs.
The concept of ‘Bisociation’ away from the focused production of creative outcomes draws together the codes ‘Ideas occur Unexpectedly’ and ‘Ideas occur when performing activities other than creative ones’. Together, there are 15 responses in which one or both of these codes occurs.

Further concepts from the framework that are apparent in the questionnaire study codes are described in Table 10 below:

<table>
<thead>
<tr>
<th>Framework Concept</th>
<th>Relevant Open Questionnaire Study Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productive: Ideation</td>
<td>Ideas occur through Interaction with others, Ideas occur through stimuli from environment, Ideas occur through stimuli from media, Ideas occur unexpectedly, Ideas occur when performing activities other than creative ones, Ideas occur through interaction with the medium</td>
</tr>
<tr>
<td>Productive: Evaluation</td>
<td>Sketching, Collaboration involves presentation and shared evaluation of ideas, Evaluation and deciding which ideas to use is more difficult than ideation</td>
</tr>
<tr>
<td>Productive: Idea Externalised</td>
<td>Ideas occur through interaction with the medium, Sketching</td>
</tr>
<tr>
<td>Productive: Idea Represented in Context</td>
<td>Understanding of Internal structures</td>
</tr>
<tr>
<td>Productive: Evaluation Represented</td>
<td>Collaboration involves presentation and shared evaluation of ideas</td>
</tr>
<tr>
<td>Productive: Decision Making</td>
<td>Evaluation and deciding which ideas to use is more difficult than ideation</td>
</tr>
<tr>
<td>Productive: Focus of Iteration</td>
<td>Ideas occur through interaction with the medium</td>
</tr>
<tr>
<td>Productive: Scope for Iteration</td>
<td>Improvisation</td>
</tr>
<tr>
<td>Structural: Internal Structure</td>
<td>Understanding of Internal structures</td>
</tr>
<tr>
<td>Structural: Conceptual Structure</td>
<td>Conceptual tools / processes are used for ideation (e.g. brainstorming)</td>
</tr>
<tr>
<td>Structural: Development of Structure</td>
<td></td>
</tr>
<tr>
<td>Structural: Change of the Outcome</td>
<td></td>
</tr>
<tr>
<td>Longitudinal: Retaining</td>
<td>Idea Representations are used to retain ideas, Idea loss is important, Availability: In Bed, Availability: Travelling, Availability: Ubiquitous</td>
</tr>
<tr>
<td>Longitudinal: Organising</td>
<td>Organisation of ideas, Searching ideas</td>
</tr>
<tr>
<td>Longitudinal: Using</td>
<td>Ideas are accumulated, then used in new projects</td>
</tr>
<tr>
<td>Longitudinal: Sharing</td>
<td>Idea Representations are used to communicate ideas, Ideas occur through Interaction with others, Collaboration involves presentation and shared evaluation of ideas</td>
</tr>
<tr>
<td>Longitudinal: Learning</td>
<td></td>
</tr>
<tr>
<td>Longitudinal: Experiencing</td>
<td>Ideas occur through stimuli from media, Ideas occur through stimuli from environment</td>
</tr>
<tr>
<td>Longitudinal: Bisociation</td>
<td>Ideas occur unexpectedly, Ideas occur when performing activities other than creative ones</td>
</tr>
<tr>
<td>Longitudinal: Relationship Building</td>
<td></td>
</tr>
<tr>
<td>Longitudinal: Social Development</td>
<td></td>
</tr>
</tbody>
</table>

Table 10: Framework Concepts and Relevant Open Questionnaire Study Codes
In conclusion, the Open Questionnaire Study coding provides significant evidence for two of the concepts (‘Experiencing’ and ‘Bisocation’) that were not represented in the Participatory Task Models. Overall it provides explicit evidence for 17 of the 22 concepts. The codes themselves provide some more detail on the nature of each concept, which will be explored along with relevant examples from the data itself as the concepts are introduced in chapters 4.2 – 4.4.

4.1.3.4: Conclusions

This overview of the analyses shows evidence for 20 of the 22 concepts of the framework in total. The final two concepts, ‘Relationship Building’ and ‘Social Development’ are both from the Longitudinal Interaction perspective, and the evidence for their existence is described in section 4.4.2.3. The complexities of understanding Longitudinal Interaction are described in chapter 4.4, and these important interpersonal interactions are identified as a direction for further work in chapter 5.2.

4.1.4: Common Structure of the Findings Chapters

The following structure is used in each chapter of the findings to provide continuity and a comparable set of results:

1) The scope of the perspective is defined and described
2) Data from the empirical studies is introduced and analysed to provide a detailed understanding of the perspective
3) A model of this form of interaction and its components are introduced
4) The effects of contextual dimensions are described (Interpersonal, Expertise and Domain-Specific aspects)
5) The prototype design and evaluation project is described
6) Conclusions on the design of support for this form of interaction are given, including requirements and essential questions for understanding the context in which it is envisaged a system will be used.

The findings are presented in this way so that the arguments for the components and relationships that form the model of each perspective can be justified through the data. The produced model is then utilised in explaining the prototype design process and evaluation data, leading to the development of conclusions that utilise both the model and examples from the prototype study.

After the three perspectives have been presented and discussed, the final chapters of the thesis ties the findings together and considers how they can be usefully employed by designers of support for creative practitioners.
4.2: Productive Interaction

“Creativity is a type of learning process where the teacher and pupil are located in the same individual.”
Arthur Koestler, 1964

4.2.1: Definition and Scope

This first perspective on creative interaction focuses on the processes that are explicitly involved in the production of a creative outcome. This involves the generation, representation and evaluation of ideas, which are developed and combined with the aim of producing a novel and valuable outcome. In this chapter, an understanding is built of creative interaction from this perspective, and this is then used to consider how interactive systems can be designed to support the production of effective idea representations, the evaluation of these ideas, and decisions-making leading to the production of a creative outcome by individuals and collaborative groups.

Productive Interaction is defined in this thesis as:

The generation, externalisation and evaluation of ideas, working towards the explicit goal of realising a creative outcome.

The theoretical platform for this perspective includes research on the nature of idea representation processes, such as that by Schön (1983, 1987) and Oxman (1997) described in chapters 2.1 and 2.3. Additionally, Csikszentmihalyi and Sawyer’s descriptions of the way in which individuals and groups flow as they create effectively together (chapters 2.1 and 2.2) provide further background. The next section describes relevant findings and analysis from the empirical studies introduced in chapter 3.2: Studies Performed and Methods Used, leading to the development of a model of Productive Interaction. The purpose of this model is to describe the generic interaction between creative practitioners and representations of their ideas in the process of producing a creative outcome. This provides a set of generic concepts and defined relationships, in the context of which, the effects of contextual factors are considered. Following this, the iterative design and evaluation of ‘Sonic Sketchpad’ – an interactive system for musical composition - is described and used to develop practical understanding of how to apply the findings and model in a design process.

4.2.2: Findings from the Empirical Studies

As it is central to creative activities, all of the empirical studies provide data from which an understanding of productive interaction can be built. In particular the forms of idea representation used in the observational studies of musical composition and filmmaking are analysed, along with the characteristics of the processes that occur during these observations. These
are compared with the models produced in the participatory task modelling sessions, and informed by responses to the open questionnaire. Findings and examples from the studies are introduced where appropriate in an exploration of three facets of creative interaction that are apparent in the literature and directly relate to the production of creative outcomes: Iterative development, the representation of ideas, and evaluation and decision-making.

4.2.2.1: Iterative Development

An aspect that is central to almost all understandings of creative processes is that they contain forms of iteration in the development of an outcome. As this is a pervasive phenomenon, it is used here as a starting point for the analysis of productive interaction. The question explored here and expanded upon in the following sections is: What is it that occurs in these iterative cycles, and how do iterations evolve as the process continues?

Iteration is defined as the repetition of a process. The concept also includes the notion of applying the results of a previous application of the process as a means of moving closer to a solution (OED). Iterations of productive interaction are clearly linked to the development of ideas through interactions with external artefacts that provide opportunities to represent them. A professional composer and writer responded to question 3 in the open questionnaire study by saying that:

“I keep writing and re-writing and re-sketching the structures and number lists until they look good. By then I don’t actually need to refer to my notebooks because my idea is clear enough to be entirely memorized - and often by that time, the piece is more or less finished”.

(Response 11, Question 3)

5 of the questionnaire responses were coded as explicitly describing how ‘ideas occur through interaction with the medium’ in a similar way to this (from table 9 in section 4.1.3.3). The excerpt above exemplifies the progression that occurs as iterative cycles continue, and the interaction between internal and external processes that develop what will be referred to in this thesis as a conception of the outcome. This conception is the evolving composition of adopted ideas and concepts that together form a mental representation of the outcome that the practitioner intends to realise. The tools used often change during this progression toward producing an outcome, as the further excerpt from another respondent to the open questionnaire study shows below:

“The tools I use become more sophisticated as the process evolves. For a painting, I'll start with an original sketch (as an example), I will compose a more well-thought out image, do a photo shoot with models, compose an image using photoshop, re-draw the image working out lights and darks, use the computer for color experimentation, grid up a canvas and redraw the image scaled up, then begin working with paint (oil) and react to what’s happening on the linen as the image develops.” (Response 26, Question 3)

Iterative cycles were apparent across all of the observational study sessions (see table 7 in section 4.1.3.1.1 and figure 18 in section 4.1.3.1.2), and a more in-depth look at the iterative nature of productive interaction can be
gained through studying excerpts from these sessions. The following two excerpts have the related codes shown in italics. The first is from the filmmaking study (table 11), while the second is drawn from the musical composition observations (table 12):

**The use of sound in the film is discussed, as C is interested in presenting some facts and advice to viewers. B and A are interested in how this may be done, and suggest the possibility of reading the facts out audibly. C then suggests that sound may not always be audible, and the group adopt the concept that the sound used in the film will only be complementary.**

C is explaining some of the advice he feels the film should get across.

B: How do you want to do that? I mean do you just want someone reading out these facts or some pictures... *(Idea Externalised)*

C: No I have to admit I haven’t worked on that.

A: I would think it could be pictures and then you reading the facts, which relate to the pictures... *(Idea Externalised + Decision Making)*

C: Umm, I’m thinking if that is to be played in the Parade *(a bar)* or in the public streets, maybe sound is not an option. *(Evaluation Represented + Decision Making)*

A: That’s true. *(Evaluation Represented)*

C: Or maybe we should have sound only as a complementary channel, and we should have the facts bring it out. So we have a quote displayed. You can have voice on top, but not dependent on it. *(Decision Making, Convergence, Idea Externalised)*

A: Yeah true. *(Evaluation Represented)*

C: We can have sketches that are without dialogue, and have some nice music on top, if its not being played its not necessary. *(Idea Externalised)*

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**Table 11: Excerpt from Filmmaking Study Group 1, Meeting 2 with Related Codes**

The above excerpt from the filmmaking studies shows an example of the type of iterations common in creative processes. The dialogue can be understood as cycles involving the representation of ideas, their evaluation, and decision-making based on this process.

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**Table 12: Excerpt from Observations of Musical Composition (BUMPS session 2) with Related Codes**

In the above excerpt from the observations of musical composition, it is clearer that iterations develop and add to a set of ideas that form the conception of the outcome. A and C repeatedly play their partially developed
composition, keeping much of it the same but making changes based on evaluations. D provides much of the evaluation from an external viewpoint, as she is not involved in play and is free from the cognitive load involved in this.

In the longer term, collaboration adds layers to this process, in that there can be individual iterations feeding into and from collaborative ones. In both the excerpts above, individual productive interaction has been performed previously (resulting in C’s ideas about the film and A’s lyrics), that is then shared with the group. In the excerpt from the open questionnaire study below, a professional fiction writer describes individual and collaborative iteration in the process of writing books collaboratively:

“what we did was have lunch and talk about where we wanted the story to go next. In one of the cases, the other writer was very much a talk-about-it writer, so we had lots of lunches and did lots of talking; in the other case, my collaborator was the sort of writer who can’t discuss her work-in-process, so we had very few lunches and very circumspect conversations, and mostly each made up our own parts of the plot and then fixed them up in revisions. In both cases, we each took occasional notes during lunch so we wouldn’t forget particular plot points we’d agreed on, but they were extremely minimal -- on the order of “Don’t kill subvillain for two more chapters; J. needs him for plotpoint,” not anything elaborate. My colleagues both made notes in paper notebooks; I used my PDA. Maybe three or four cryptic sentences per lunch, tops.” (Response 13, Question 10)

These layers and the issues they raise are explored further in the interpersonal contextual factors section, and through the evaluations in the Sonic Sketchpad design study.

Iterative loops are apparent in all four of the collaboratively produced Participatory Task Models (see table 8 in section 3.2.4.3). The example of Participatory Task Model B shown in figure 19 shows how iteration in the form of feedback loops is clearly present. These loops commonly make explicit the need for idea representation – “play it” in Model B, evaluation, “is it good?” in Model B, and decision-making “elements not working discarded or tweaked” in Model A as part of these loops. The starting point for these loops relates to the generation of ideas e.g. – “idea” in Model B – or the consideration of previously developed and retained ideas, e.g. “library/scrapbook of sounds in head or on computer” in Model B.
However, the focus of these iterations – the type of ideas that are being considered - can vary substantially, with different tools used and directions being explored. In model B, the participants consider the play of instruments to provide the basis for iterative interaction. When the play is evaluated positively ("is it good? > yes"), it is continued. If evaluated negatively ("No, new ideas, alterations"), new influences, musical knowledge, people or instruments can be used to improve the idea. In model A however (figure 20), a pair of computer-orientated musicians describe a somewhat different process, with several iterative aspects. A "library / scrapbook of sounds" that is "in head or on computer" is drawn upon for "elements of music / sounds". Three iterative aspects can be identified in this model: Firstly between arranging and getting the final production, secondly, between finding sounds from the library and arranging, and thirdly, between the final production and finding sounds from the library.
Two aspects of the context of productive interactions can be identified have a clear impact on the iteration that occurs. These are defined in this thesis as the focus of iterations and the scope for iterations:

The focus of iterations in the observational studies changed over time. In the filmmaking studies, identified foci included sound effects, music, individual sections of the film, and the context in which the film would be shown. In the observations of musical composition, singing, lyrics, individual parts and overall structure were discussed and developed in cycles. Thus while an understanding of the domain leads us to an important understanding of the likely foci, practitioners focus their productive interaction in different ways within this space as the task progresses, and also due to their personal interests and processes. As the iterations continue, the conception of the outcome develops, and the focus of the iterations can change to consider various aspects of this outcome. ‘Divergence’ away from existing ideas towards new ones, and ‘Convergence’ in fleshing out and adding to ideas, are both apparent across the observational study sessions (see table 7 in section 4.1.3.1.1 and figure 18 in section 4.1.3.1.2), leading to differences in the type of iterations that occur. These will be considered in more detail in the section on evaluation and decision-making.

It must be noted at this stage that the scope for iteration in productive interaction is often limited by various contextual factors, and that the improvisational creativity studied by Sawyer (2003) builds upon the previous experiences of the creative practitioner, but focuses on producing novelty in the moment, rather than upon multiple iterations of ideation and evaluation in the production of a single outcome. In the excerpt below a musician describes this tension between rehearsal and novel, spontaneous production:

“Before the actual performance, musical ideas are "shared" by rehearsing them away from the audience. In order to get a good element of spontaneity in a jazz performance it's best not to over rehearse the music.” (Response 16, Question 7)

Each improvisational performance therefore contains single instances where ideas are represented without iteration, but with decisions made through reference to past experiences – rehearsals and performances. While this is a very different creative process in terms of iteration, it still contains the same basic elements of ideation, representation, evaluation and decision-making. The effects of the scope for iteration and the focus of iteration are considered further in the contextual factors section of this chapter.

Contextual factors may also move iterations towards convergence on adopting ideas and defining a specific conception of the outcome, or allow scope for further divergence as outcomes are continuously modified. A major difference between the filmmaking and musical composition observations was that a single, ‘final’ outcome was produced in the case of the filmmaking, whereas a musical composition is often defined partially, and whilst a recording may be made, it is expected to be performed – and perhaps modified through iteration – without ever being considered entirely ‘final’. In
the musical composition observations, a composition that had been performed live several times was developed further, showing that whilst it could be considered a complete creative outcome, iterative development of it was still occurring (evident in BUMPS session 2, see appendix 6.3.1.1). The filmmaking study could be said to cover an entire production process, whereas the musical composition studies were more naturalistic and therefore open to influence by previous events and consideration of future events, but the notion of a complete creative outcome and its openness to further iteration varies considerably across domains and due to other contextual factors.

In response to the question posed at the beginning of this section; ‘What is it that occurs in these iterative cycles?’ The combination of data from the observations, participatory task models, and questionnaire study described above show that cycles include the externalisation of ideas, interaction with the representations created through this process, the evaluation of ideas through these representations, and a developing conception of the outcome through decision-making processes. Idea representation is therefore central to the process and is the topic of the next section.

4.2.2.2: Idea Representation
A central aspect of productive interaction is the representation of ideas. An idea is defined as a thought or suggestion as to a possible course of action (OED). So an idea representation is defined as the externalisation of this in some form. These representations are the crossover points between mental processes and the external world that result in creative outcomes being produced. Idea representations range from the initial and simple - a verbal utterance or rough sketch, to a realised creative outcome that is disseminated to others, for example a performance, book or painting.
Discussion of what to do: A mentions some lyrics he would like to try to create a melody for.

A: “Well just play anything to start”
A: “Umm, this tempo”
A clicks his fingers to define tempo
C begins to play at defined tempo
A watches C and listens to guitar play
A begins to sing lyrics from memory
After a period of play, D interrupts with “Stop there”
A and C stop playing
“Are you changing the chords at the right time?”
“Possibly not”
“I don’t know”
“Are you singing ‘mmm, sure you look fine’ and all of that bit is on one chord, and then you change afterwards”
A: “Yeah that needs a change of chord”
D: “You’re changing for the ‘and I saw you baby and you sure look fine’”
C: “Right”
C begins to play again
D: “Do you want to play it a bit faster as well?”
A: “Yeah a tiny bit faster”
C speeds up play
A watches C for a time, then begins to sing again
D: “Okay, you defiantly haven’t got enough bars there”
C: “Have I not?”
A: “That’s where you need to keep going on the same chord” (points at C)
A and C stop
D mimics the guitar play with her voice, “dee duh dee duh dee duh de”
A: “So another one of those”
A: Taps foot to define tempo

Table 13: Excerpt from Musical Composition Observations (BUMPS session 2, appendix)

The excerpt above shows the use of various forms of representation in order to externalise and communicate aspects of musical ideas. Evaluations and modifications to the idea are also represented. Verbal communications and play (of instruments and singing) are clearly essential to this process. Gestures are also used on several occasions as a representation of timing (see figure 18 in section 4.1.3.1.2 and the transcript of BUMPS session 2 in appendix 6.3.1.1).
Figure 21 depicts the use of storyboard images and verbal communication in the observations of filmmaking. The images - produced individually and brought in to this meeting, are used as a basis to communicate an ideas for a short part of the film in which a person is told off for binning rather than recycling paper by a disembodied voice (See transcription in table 14).

B: So it starts off with a character reading a letter, its an upsetting letter ‘Dear John’ or whatever, rejection letter from some whatever and he’s not happy. So he crumples up the letter and throws it away (moves to next storyboard image). Suddenly, a disembodied voice tells him (all laugh at picture of B looking shocked as it is rotated) ‘What are you doing!’

A: It would be good if it did spin around like that, zoom in to the screen (laughs)

B: Like ‘Whose that? whose talking?’ and he says ‘What are you doing throwing that paper away’ and he says ‘Well I dont want it anymore’, then he says ‘Why dont you recycle it?’ Then the guy says (switches image) ‘Well, there are no recycling bins around here, what am I supposed to do?’ (all laugh) So we pan out to reveal (switches image) a recycling bin right behind him. He says (switches image) ‘Wait a minute, thats just one recycling bin thats just coincidence that we had a recycling bin there there could have been... you know theres no other recycling bin anywhere else. So then the disembodied voice (switches image) takes us on a little tour, showing us all the places on campus where we have recycling. So I figure,

A: Ahh thats good.

B: people know why they should recycle, but they don’t do it cos they figure its too much effort, so if we point out everywhere on campus where we actually have little recycling bins Here! Here! Here! Here (switches images) And by the end, our little character (switches image) is no longer able to say anything and he apologise profusely to the disembodied voice. Thats my little storyboard.

C: Wow, yeah thats cool. Yeah I guess it needs sounds at least for the disembodied voice

B: mmm

Table 14: Dialogue from Filmmaking Study Related to Storyboard Use (Group 1, Meeting 2)

Through the above examples, it is clear that multiple representation styles and methods are used within and across creative domains, and that these representations afford different possibilities for sharing, exploring and evaluating ideas. Below is a table representing the types of idea representation found through coding of the observational studies of musical
composition and of filmmaking (gathered from table 7, figure 18 and appendicies 6.3.1 and 6.4.2):

<table>
<thead>
<tr>
<th>Musical Composition</th>
<th>Filmmaking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument Play</strong></td>
<td><strong>Acting</strong></td>
</tr>
<tr>
<td>A full performance is the realisation of the composition, but play is also the primary method used to realise and evaluate ideas. It was observed that play of instruments put a cognitive load on the composer that can lead to an inability to evaluate satisfactorily. Observed examples of this include failure to realise structural mistakes during play until pointed out by observers, and the expressed need to review performances or get feedback from observers. It was also observed that participants would repeatedly perform small parts of the composition, evaluating variations on an idea without playing the whole.</td>
<td>Acting formed part of the production of an outcome in creating the film. Although some elements of acting can be seen in the production of the storyboards, and in representing ideas in the meetings, the members of the group mainly acted once a script had been largely devised, rather than as an initial basis for representing ideas.</td>
</tr>
<tr>
<td><strong>Play Gesture</strong></td>
<td><strong>Storyboard</strong></td>
</tr>
<tr>
<td>Gestures were used to communicate parts of the composition where play made verbal communication inappropriate. This type of gesture was not observed in the software tool observations so is considered to be a method for coordinating instrument play.</td>
<td>Visual representations that sequentially represent aspects of an idea for the films were used. Figure ? shows the use of a sequence of images, along with verbal commentary, used as a basis for explaining the idea for a piece which was later filmed and included in the produced film. In this study, the storyboards produced were based on photos produced using the Smartphones, but storyboards can often be sketched as well.</td>
</tr>
<tr>
<td><strong>Verbal Communication</strong></td>
<td><strong>Verbal Communication</strong></td>
</tr>
<tr>
<td>Verbal representations of ideas and evaluative opinions were commonly observed, often full of adjective use and reference to musical rules or the work of other composers. As reflected in the model (Figure 1), discussions of ideas occurred before play to generate necessary shared understanding and reflected opinions and further ideas after play, aiding the negotiation of a decision on the next move to make.</td>
<td>Discussion of ideas, concepts and means of realising them were central to the meetings. As other forms of representation are generally only created outside of meetings, verbal communication provides the initial form of representation through which ideas are introduced and evaluated. If some level of positive evaluation occurs, the individual or group may take the idea forward by producing a representation in another form (i.e. storyboard).</td>
</tr>
<tr>
<td><strong>Artefact Gesture</strong></td>
<td><strong>Artefact Gesture</strong></td>
</tr>
<tr>
<td>Discussions were also observed that used gestures aimed at representation artefacts to represent new ideas. The creation of shared understanding of an idea was the perceived reason for these actions, which occurred in both types of observed collaborative composition.</td>
<td>Gestures towards artefacts were seen to draw attention. These could be physical, such as pointing at sections of a piece of paper, or virtual, such as the use of the mouse to point at sections of the screen.</td>
</tr>
<tr>
<td><strong>Vocalisation</strong></td>
<td><strong>Video Recording</strong></td>
</tr>
<tr>
<td>The voice was used to communicate musical ideas as an alternative to performance. Unlike singing – which is considered a form of play – vocalisation was observed as use of</td>
<td>Video recordings were made and edited together to produce the final outcome, and some trial recordings were made beforehand. Videos were also taken from the Internet,</td>
</tr>
</tbody>
</table>
voice to communicate ideas that would normally be played using another instrument by mimicking instrument output. Use was most apparent where the vocalising participant had no access to the instrument/software tool and attempted to communicate an idea to the controller of the tool. Verbal descriptions of tempo ("1,2,3,4") were also considered as a form of vocalisation.

shown in the meetings and once evaluated positively, used where the group did not feel able to produce adequate footage themselves (e.g. the felling of a large tree and its transport on a lorry).

<table>
<thead>
<tr>
<th>Audio Recording</th>
<th>Audio Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td>A recording retains the composition in an almost natural form and participants stated that they used software tools, Dictaphones and other recording devices for evaluation and to make a record of raw ideas for later review and revision.</td>
<td>Audio was taken from the Internet in a similar way to video recordings, evaluated by the groups in meetings, and used as background music and sound effects for the film. Video recordings produced by the group generally included audio as an additional channel.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visual / Written Representations</th>
<th>Written Representations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sketches of compositions were observed being created, manipulated and reviewed to provide an externalisation and record of the composition. The interaction method of both software tools involved manipulating visual representations. Despite music being a non-visual art, the universal utility of visual representation is evident through its common use in this as in other domains. Representations commonly form instructions for the play of a composition in a sequential manner, but it is evident that composers have differing methods, and adapt representations to suit the instruments and people involved.</td>
<td>Various written or typed representations were brought in to, and produced in the meetings. These included a list of facts on the use and waste of paper at work that were found and used in the film, notes on the distribution of tasks (which were typed and emailed to the group members), and scripted segments used to define roles and lines during acting.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 15: Idea Representation Types and Uses in Musical Composition and Filmmaking</th>
</tr>
</thead>
<tbody>
<tr>
<td>The comparison of these forms suggests generic needs and contextual differences. These differences are particularly apparent in their relation to the nature of the outcome to be produced, but are also related to the communication of ideas required in these collaborations.</td>
</tr>
</tbody>
</table>

A clear example of the differences in the use of these idea representation forms between domains is evident between instrument play and verbal communication in the coded sessions from the filmmaking and musical composition studies. In the filmmaking study meetings, verbal communication occurred consistently throughout, whereas in the musical composition session coded above, large sections have no verbal communication, as instrument play was essential in the representation of ideas (see section 4.1.3.1, figures 14 - 18). Differences such as these are explored further in the domain contextual factor section of this chapter (4.2.4.2).

The Participatory Task Models provide useful data to back up the argument that the externalisation of ideas is a starting point for productive interaction. Table 16 shows that the component identified as a starting point in all four models of collaborative composition contains the notion of an idea, and/or conception of the outcome. The subsequent component in each case contains
the notions of a process of externalisation, development, or interactions with existing externalised materials.

<table>
<thead>
<tr>
<th>Model</th>
<th>First Component</th>
<th>Subsequent Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>“Start Point - “Riff, Brief, Art, Sound”</td>
<td>“Library / Scrapbook of Sounds - In Head or on Computer”</td>
</tr>
<tr>
<td>B</td>
<td>“Idea”</td>
<td>“Give it a bit of Structure”</td>
</tr>
<tr>
<td>C</td>
<td>“Initial Idea - (Individual). Chords / Melody - Structure”</td>
<td>“Discussion, Refinement - (Group)”</td>
</tr>
<tr>
<td>D</td>
<td>“Idea - What do I want to do?, Vision, Outcome”</td>
<td>“Tools - Synths, Wave Editors, Samples”</td>
</tr>
</tbody>
</table>

Table 16: First and Second Elements of Collaborative Participatory Task Models (Gathered from Appendix 6.2.2)

There are also further elements in each model that form descriptions of idea representation processes. These elements are presented in Table 17, and give more detail of the ways in which idea representation plays a role in each of the groups’ creative processes. In particular, PTM model D shows how software tools structure the process of representation in to discrete sections. (Full analyses of each model are included in appendix 6.2.2)

<table>
<thead>
<tr>
<th>Model</th>
<th>Further Components Related to Idea Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>“Elements of Music / Sounds”, “Arranging”, “Final Production”</td>
</tr>
<tr>
<td>B</td>
<td>“Play It!”, “Don’t forget it, Record / Write”</td>
</tr>
<tr>
<td>C</td>
<td>“Documentation of Ideas – Notation, Rough Recordings”, “Performance”, “Output – Live Performance, MP3, CD, Tab / Score Printout”</td>
</tr>
<tr>
<td>D</td>
<td>“Sound Library – Samples Edited to fit the Attitude of the Idea”, “Mastering – Wrt Idea”, “Sequencer – Stick it together”</td>
</tr>
</tbody>
</table>

Table 17: Further Elements of Collaborative Participatory Task Models Related to Idea Representation (Gathered from Appendix 6.2.2)

To achieve both of the objectives of this thesis, it is important to understand the characteristics of the tools utilised in representing ideas, and how these are used. Turning to the open questionnaire study, it is clear that idea representation tools often share common characteristics, including the ability to bring together various media forms together, and to be free to arrange these elements as part of the reflective process. In response to question 3 of the open questionnaire study (“How do you integrate the tool or tools with the rest of your work? When and why do you refer to it?”), a visual artist respondent stated that:

“The sketchbook is key to idea development as it brings together ideas and images. The physical act of cutting and pasting and moving the images around in physical space is also important...also because it takes time to reflect on new and emerging ideas.” (Response 1, Question 3)

The concept of sketching has been identified as important to creative activities (Schön 1983, 1987, Oxman 1997, Buxton, 2007), and in the empirical studies described here, sketching-type behaviours are exhibited through various representational means. Sketching interactions are described in 14 of the questionnaire responses (See table 9 in section 4.1.3). The essential characteristics of these interactions are low-cost externalisations with little
enforced structure upon the act of representation. Representational forms from vocalisations to storyboards share these qualities along with pen and paper sketches. The empirical studies present a wealth of evidence to suggest that these characteristics need to be captured in the design of interactive systems for productive interactions, but is currently often lacking.

Representations are often made or used specifically for the purposes of communicating ideas. A filmmaker described using a scrapbook as a tool with which to communicate ideas to others with images:

“if i am working on a film and i want to convey an idea about the particular colours and tones of a scene then i use a scrap book. This scrap book contains many clippings from newspapers, magazines etc. This is because it is difficult to describe an exact colour or tone. If i say blue to the cameraman he may have one idea of blue and i may have another.”
(Response 17, Question 2)

18 of the questionnaire responses contained reference to the use of idea representations for communication with others (table 9 in section 4.1.3). This particular example shows that in aspects of some domains, verbal language does not exist that can effectively represent ideas for communication. Some specific representational forms relate to the form the outcome takes in a particular creative activity. For example, as filmmaking produces a visual, temporal outcome, storyboards and the scrapbook of colours mentioned above fulfil important needs in representing ideas. In musical composition the outcome is still temporal but purely audio, so a written score provides a similar type of consistent representation.

Through these examples, it can be argued that an important characteristic in defining the utility of idea representations is the degree of medium-semblance – defined as their commonality with the medium of the intended outcome. An idea representation with a high medium-semblance in a musical domain would be an audible one such as the play of an instrument or a recording. Alternatively, a written score can present useful alternative forms of information - such as timing, or a holistic overview of a composition, that would be less apparent from play or listening to a recording. Representations capable of conveying the temporal nature of music like gestures could also be considered to have a degree of medium-semblance. In filmmaking, storyboards combine a strong visual resemblance to film with scope for representing temporal change through which ideas were represented and communicated to others without producing a final form.

As they are the medium, the highest end of the spectrum of medium-semblence contains the representation forms used in the realisation of a creative outcome. Instrument play and acting are representational forms central to creating outcomes in music and filmmaking respectively. These are temporal forms of representation, retained through audio and video recordings. Both acting and instrument play can be realisations (a concert or theatrical production, or representations of partially developed ideas, as can their persistent counterparts of video and audio recording. Persistent
representations present other qualities however: They can also be used to evaluate externalised ideas without the cognitive load of externalisation, and can be retained and reused as a memory aid, or for communication.

It is clear that the persistence of these recordings is a characteristic that affords important qualities. Related to persistence are characteristics of reproducibility and malleability: Whether the representation can be easily replicated or altered. These are important to the iterative development of the idea through interaction with the representation. Temporal representation forms such as verbal communication or instrument play often have a lower cost, and are also essential to developing ideas. It is, however, important to consider that this cost is incurred every time the idea is externalised. Much of what is said or played is not retained, but this is not necessary if ideas can be represented in persistent forms where needed. Decisions made with respect to temporal representations can be seen as more tenuous, and open to change, as they have no persistent representation that symbolises their adoption to the conception of the outcome.

An idea representation has a level of detail, representing either an individual idea such as a musical phrase or piece of dialogue, or a more complete conception of the outcome such as a full script. In the observational studies, ideas are often represented both distinct from the conception of the entire outcome, and then in the context of the current conception of this outcome, for example in the excerpts shown in tables 11 and 12, and in the codes ‘Idea Externalised’ and ‘Idea Represented in Context’ which are present across all the coded observations (see table 7 and figure 18 in section 4.1.3.1).

Providing support for both representing ideas as distinct entities and within the context of other ideas is essential to processes of evaluation as the value of an idea is somewhat dependent on its context of use. The detail and granularity of each representation is an element that defines the type of feedback it presents.

The costs of producing an idea representation can take various forms, and in designing representational forms in software tools reducing costs could be seen as an obvious means of improving creativity support, so will be explored in the design study. There is likely to be some relationship between the cost of production and the level of detail in a representation, and a cost assessment in the decisions made to represent in one form or another. The filmmaking groups did not produce any film until they had well defined and accepted representations of what was to be produced (for group 1, film was produced only after their third meeting, and for group 2, film was produced as part of their fourth meeting). Both groups progressed from verbal communication of initial ideas, through storyboards and / or written representations, before producing footage and choosing the additional material (e.g. background sounds) that were required. Finally they edited the material together in to the complete outcome (see section 3.2.2.3 and appendix 6.4.2).

The ability to communicate using idea representations is also an important consideration in their creation and the use of representation forms in
combination with each other. Visible throughout the observational studies is the phenomena of idea representations being brought in to a collaborative context after being developed individually. Earlier in this section, figure 21 and table 14 showed how storyboards produced on the Smartphones and imported to a PC, combined with verbal communication, provided an effective means of sharing ideas. This marks an area where there is scope for computers to provide features that are useful to communication in creative groups: Idea representations produced for individual use such as on a small mobile device, can be scaled up and presented to a group, with modification and annotation where necessary.

4.2.2.3: Evaluation and Decision-Making
Research by Schön (1983, 1987) and Oxman (1997) argues that a major purpose for idea representation is the evaluative feedback it can produce. Through the observations and Participatory Task Models, it is clear that this evaluation leads to decision-making processes on whether and / or how to use an idea. In collaboration, these processes may require that the evaluations of group members are articulated, and that some form of negotiation may occur in choosing that path that is taken. It is rare for an idea to arrive fully formed, although - as shown in the previous section - ideas may be brought in to a productive situation that have been developed previously. In many cases, evaluations lead to ideas for modifications or developments that are externalised and evaluated through further iterative cycles. It is therefore important to understand the effects of evaluation as a factor in subsequent iterations. This section presents evidence from the empirical studies related to these aspects of evaluation and decision-making.

Although they were not directly asked about it, 8 of the respondents of the questionnaire study stated explicitly that ideation was the easier part of creative work, while evaluation and decision-making were considered the difficult and time consuming aspects of the process (table 9, section 4.1.3.3). ‘Evaluation Represented’ is also the most common code across the analysed sessions of Filmmaking (see table 7 in section 4.1.3.1.1). Discussing the process of developing marketing campaigns for large corporations, a former CEO stated that:

“Effective brainstorming was essential but more essential was the ability to discern good/great ideas from mediocre ones.” (Response 26, Question 4)

Therefore whilst some previous studies have implicitly or explicitly considered creativity to be analogous to brainstorming, it could be argued that this focus misses the more difficult and valuable side of the production of creative outcomes. Providing effective support for evaluation, and for further developing ideas based on evaluations, is clearly an important area for research that is often overlooked in favour of the more quantifiable aspects of the creative process, such as counting the number of ideas produced.
The observational studies showed that representations of evaluations can range from simple or subtle communications, to extensive dissections of how ideas could be used or modified. Looking back to the excerpts from the observational studies given in tables 11 and 12, the range of representations of evaluations is apparent between comments from the filmmaking study. These range from minimal affirmations such as “Yeah True” to detailed descriptions such as “Umm, I’m thinking if that is to be played in the Parade (a bar) or in the public streets, maybe sound is not an option”. More extensive evaluations such as the later one generally lead to further convergent cycles where the idea is modified, according to descriptions of what is positive and/or negative about the idea in its current form.

In the following excerpt, the idea representation used takes the form of a video clip, which has been produced earlier by C. After this the group members A, B and D represent their evaluations and consider how to proceed. D and A produce simple positive evaluations of C’s representation overall, then B and A represent more detailed evaluations of the timing. Next A brings their attention to a further concept, having music in the piece, which will form a further iterative cycle. Decisions have been made (note though that they are somewhat implicit and tentative) to use C’s idea, but also to modify it (change the timing) and to adopt the concept of having music, for which ideas are produced and modified through further cycles.

One of the group members – C – copies a video clip that he has prepared onto the desktop computer. It is suggested that he starts the meeting by showing this to the group. As the group members watch the video clip, they ask questions and offer suggestions on how C could develop this idea further.

A – Maybe C should start, cos you’re doing the first bit
C – Yeah. He takes the desktop mouse and starts the clip.
They all watch the video for a few seconds, then S asks:
B – Do you have sound on this one?
C – No
B – Ok
They watch the remainder of the clip in silence; at the end, the discussion of it begins again.
D – That’s good
A - Yes, very nice
B – I think we need a bit longer for the messages
A – I think the messages are ok, if it’s playing on a loop
B – Some of them I didn’t have time to read
A – I think we should … well (he looks at C) have you got any music to go with it?
C – No, I haven’t

<table>
<thead>
<tr>
<th>One of the group members – C – copies a video clip that he has prepared onto the desktop computer. It is suggested that he starts the meeting by showing this to the group. As the group members watch the video clip, they ask questions and offer suggestions on how C could develop this idea further.</th>
</tr>
</thead>
</table>

Table 18: Excerpt from the Filmmaking Study (Group 1, Meeting 4)

Below, a similar exchange occurs in musical composition. In this case, a new musical idea is played by G and receives positive evaluation by H and E. I then suggests that the idea should be used, but that other members of the group need to find something complementary to play. Having developed the idea for use by the entire group, they return to playing the composition together.
The group have developed parts of a composition, but are looking for further pieces that will fit with the existing conception of the outcome.

G: “Shall I try…” (plays new phrase)
H: “That sounds really good”
E: “Yeah”
E: “So shall we keep working on this”
I: “Yeah I thought that sounded quite good, but it needs more to it”
E and I play individually for a minute.
E plays a new set of chords
E: “If I play this, can you start backing up…”
The group return to playing the composition.

Table 19: Excerpt from the Observations of Musical Composition (2nd Group)

As Schön (1987) described, both excerpts above show how the ‘talkback’ from viewing an idea representation provokes evaluations. Two components of this process can be identified: A perception of the qualities of an idea representation, which triggers an evaluative mental process, and an externalisation of some of the results of this process. This externalised evaluation can contain both an opinion of the merit of the idea, and the proposal of decisions of what to do next.

In the group models produced through the Participatory Task Modelling sessions, evaluation and decision-making can be seen to form the analytical counterpart to ideation and idea representation. Table 20 shows the components in the models that represent evaluation and decision making, and the subsequent components. These reflect a decision between further idea generation, or towards development and acceptance of some element of the outcome.

<table>
<thead>
<tr>
<th>Model</th>
<th>Evaluation / Decision-Making Components</th>
<th>Subsequent Component(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>“Elements not working discarded / tweaked”</td>
<td>Iteration Loop: Suggest New Sounds</td>
</tr>
<tr>
<td>B</td>
<td>“Is it good?”</td>
<td>Iteration Loop: “No &gt; New Ideas and Alterations”, “Yes &gt; Go yay!”</td>
</tr>
<tr>
<td>C</td>
<td>“Agreement”</td>
<td>“Documentation of Ideas”, “Practice, Finalisation”</td>
</tr>
<tr>
<td>D</td>
<td>“This is dynamically evolving”</td>
<td>No further components</td>
</tr>
</tbody>
</table>

Table 20: Components Representing Evaluation in the Collaborative Participatory Task Models (Gathered from Appendix 6.2.2)

This evaluation is partly based on the conception of the outcome, and it in turn affects this conception. Based on evidence from the empirical studies, the decisions made can be categorised as follows: Ideas can be accepted for use, or retained for later but without a decision made on whether or how to use them. Otherwise, a decision to modify the idea in some way leads to convergent cycles, which focus on improving the idea or defining an effective way in which it can be used. Finally, discarding an idea can lead to divergence as a new idea could be introduced in the next cycle.
The feedback produced from representations is used to assess the suitability of the idea as both novel and valuable. In the observational studies, evaluation and decision-making were tightly linked, with input from multiple group members often contributing their opinions of represented ideas in tandem with suggestions of what to do next.

The conception of value upon which evaluation and decision-making is based is a highly contextual notion. In both sets of observations aesthetic and practical considerations were externalised. It was also common to see some empathy with a conceived audience for the outcome as a basis for evaluation. For example in the excerpt shown in table 14, participant B states that: “people know why they should recycle, but they don’t do it cos they figure its too much effort, so if we point out everywhere on campus where we actually have little recycling bins…” Using the perspective of a prospective audience member makes sense as a means to evaluate how the outcome might be received. This relates to Finke’s (1995) notion of ‘Creative Realism’ as the most valuable form of creative outcome, because this value is drawn from an understanding of its audience. 9 references to the potential audience were coded in the analysis of the filmmaking studies, occurring in 3 of the 4 sessions (tabulated from appendix 6.4.2.5).

Respondents to the questionnaire study also considered that interpersonal interactions resulted in useful evaluative material, as they provided responses from a perspective other than that of the person from whom the idea originated: A professional writer noted that:

“other people ask questions I wouldn’t have thought of, or make assumptions that let me see where I’m being too predictable” (Response 13, Question 7)

7 of the open questionnaire study respondents described collaborations involving the sharing and evaluation of ideas (see table 9 in section 4.1.3.3). John-Steiner (2000) noted that these multiple perspectives are one of the positive features of creative collaborations. In the observational studies, the democratic nature of evaluations in meetings can be seen as another example of the desire for input from as many perspectives as possible. Evaluation and decision-making also serve to negotiate a shared conception of the outcome. For example in a cohesive group, it could be expected that ideas that are evaluated positively shape the direction of future ideation, as the individual group members use this as an example of the characteristics of an idea the group accepts. This is explored further through the notion of internal structures in the next chapter (section 4.3.2.1).

The effects of decision-making are a change to the conception of the outcome, and a choice of whether to continue focusing on the same aspect or introduce entirely new ideas. The results of these choices lead to paths that have parallels with descriptions of creativity involving convergence and divergence (Baer, 2003), with creative practitioners either converging around an idea that has been evaluated positively and refining it, or diverging away from a previous idea. A final response to an iteration of productive interaction
is that the individual or group break from the externalisation of ideas, and consider changes to the structures in which they are producing creative outcomes, such as their adopted tools and goals. This forms another link between Productive Interactions and the Structural Interactions explored in the next chapter (4.3).

4.2.3: Model of Productive Interaction

An initial model of musical composition was developed as part of my MSc thesis (see figure 22). Through reference to the research described above, aspects of this model have been taken and revised to form a generic model of productive interaction. The model contains two major elements, the creative practitioner’s mental processes, and their interaction with representations of ideas. An instance of the model could include one or many practitioners who engage with representations as a basis for externalising and getting feedback on ideas and the use of them in a wider context. Initially an individual instantiation of the model is presented, and further instances are described in the contextual factors section.

![Figure 22: Model of Collaborative Musical Composition from Coughlan (2004)](image)

4.2.3.1: Model Definitions

Creative Practitioner: The model represents creative practitioners processes in performing productive interaction. A practitioner is defined here as a person with the explicit goal of developing a creative outcome. The practitioner is modelled performing internal processes of ideation and evaluation, and holding a conception of the outcome, which develops over time. The inner circle of the model represents a practitioner’s mental processes, while the outer circle represents their interaction with the external environment.

Conception of the Outcome: Productive interaction aims at producing a creative outcome. As described in the Iteration section earlier in this chapter,
when practitioners decide to adopt an idea it becomes part of their current conception of what this outcome will be. Each individual has their own mental conception of what the outcome should be, and in collaboration it is to be expected that conceptions should be similar or be brought closer together as work proceeds.

*Ideation:* The mental process of ideation is that which produces ideas. The value of these ideas is evaluated internally before a decision is made whether to externalise or communicate them. Theories of ideation and evaluation are described in chapter 2.1, were expanded upon in sections 4.2.2.1 and 4.2.2.2, and a further exploration of how ideas occur to creative practitioners from a Longitudinal Interaction perspective is included in section 4.4.2.

*Evaluation:* Ideas are evaluated through an analytical thought process. This can be applied to both personal ideas and those communicated by others to the person. The findings above suggest that the conception of the outcome is used as a context to these evaluative processes, along with previous experiences and an empathy with the audience (from section 4.2.2.3).

*Idea Representation:* An idea representation is an embodiment of a particular idea or a collection of ideas in an external form. Representations are used to communicate and evaluate the ideas that form the outcome and to understand the effects of changes made (from section 4.2.2.2).

*Externalised Idea:* The externalisation of an idea in a cycle of productive interaction. Depending on the form of the idea and the stage of the project, this may represent the idea in an initial form, or a development to it based on the results of previous cycles (from section 4.2.2.2).

*Idea Represented in Context of Use:* In this step, the idea is represented in a context of use in the current conception of the outcome. At times this step can be combined with the previous one or bypassed, where the internal conception of the outcome is used as a basis for evaluating how the idea fits in context (from section 4.2.2.2)

*Represented Evaluation:* The evaluation of an idea may need to be communicated to any collaborating practitioners, or may be represented for personal use. These evaluations are based on feedback from the representations and are necessary to form a conclusion upon how to proceed (from section 4.2.2.3).

*Used, Retained, Modified or Discarded:* A decision must be made on how to proceed with the idea. This can be made individually or as a negotiation between collaborators. This decision then informs the practitioners' conceptions of the outcome. Decisions to use ideas as part of the outcome also result in internal structures that constrain the space for further ideas, described in the next chapter (from section 4.2.2.3)
4.2.3.2: Explanation of Model

The model instance presented in figure 23 represents the focused engagement of an individual in the production of a creative outcome. Further versions of the model are presented in the contextual factors section, representing instantiations of the model in particular interpersonal, domain and expertise contexts.

The first step of each cycle occurs when internal ideation processes lead to the externalisation of an idea. The result of using this idea may be represented in the context of the current conception of the outcome, in order to support an evaluation of the idea and its possible use. This evaluation may then be represented in some form, and a decision to use, use, retain, modify or discard the idea is taken. This changes the individual’s conception of what the outcome will be, and provokes further convergent or divergent cycles, or a move to structural interactions, which are explained in chapter 4.2.

The next cycle can be convergent if a decision is made to continue with the modification of the idea, or to represent it in further forms. In a convergent cycle, the externalised idea will be some development or derivative of the one used in a previous cycle. Divergence occurs where the decision regarding an idea is complete (it is either used, retained for possible later use, or discarded). The next cycle therefore diverges with the introduction of a new idea.

4.2.4: Contextual Factors

4.2.4.1: Interpersonal

This section draws together some of the issues raised earlier in this chapter to consider how interpersonal factors affect the generic process of productive interaction described in the model.
Collaborative productive interactions revolve around communication through the representation of ideas, evaluations and decisions in temporal and persistent forms. The instance of the model shown below describes collaborative productive interaction where both practitioners are involved in the interaction in a synchronous manner - i.e. representations made are shared by both parties such as in the excepts from the observational studies in tables 11, 12, 13, 14, 18 and 19. In this case one of the practitioners externalises an idea, making it visible to both parties. The idea is again represented in a possible context of use, and is evaluated by both practitioners, who can then represent their evaluations to each other. Negotiation may then be necessary to decide how to proceed, with this influencing each practitioner’s conception of the outcome.

Figure 24: A Model of Collaborative Production

Figure 24 represents a cycle of productive interaction, started by the externalisation of an idea by Collaborator 1. The collaborators develop individual understandings of the idea, which function as a basis for evaluation by both of them. A period of discussion follows, where the individual evaluations of both collaborators can be externalised through further representation. As before, a decision must be reached as to how to proceed, but in this case negotiation may be necessary between the collaborators.

Comparing this instance of the model with the individual instance presented in figure 23, it is clear that the complexity of the interactions increases as more collaborators are added. When an individual works alone the element of discussion is removed, leaving feedback from representations as the only method of evaluation. This simplifies representational needs, allowing the individual to focus on their ideas without needing to create shared understanding, however at some point external evaluation may be required to explore the potential value of ideas with others, as the previous quote from the questionnaire study suggested. Adding further collaborators to the model, the number of inputs and outputs to the discussion / feedback element increase. Questions arise about the tools required and communicative processes used to deal with this: How can each collaborator have an equal
ability to create, manipulate and view representations? How can numerous evaluative contributions be represented to and understood by each individual? How is a shared conception of the outcome maintained?

This complexity can be used to explain phenomena surrounding interpersonal productive interactions, such as the integration of individual productive interaction with collaboration, the small size of many effective creative groups, despite the logical argument that more people would bring more diverse ideas and knowledge, and the focus on structured approaches to creative collaboration such as group brainstorming (Osborne 1957, Diehl & Strobe, 1987). The limits of the attention of any person along with the increased overhead of teamwork may make larger creative collaborations difficult and smaller ones favourable, or lead to what Pinelle & Gutwin (2002) termed ‘loosely-coupled’ collaborations in many creative activities.

The quote from questionnaire study response 13 in section 4.2.2.1 shows how collaboration does not always occur with this consistent close connection between the collaborators, in many cases it is more appropriate to perform individual productive interaction cycles with occasional collaborative ones to agree on a shared conception of the outcome. Below is another example of a description of integration between individual and collaborative productive interaction in a collaboration:

“I have one collaborator, we usually brainstorm with pen and paper (and maybe a few beers). The core idea will be typed and we will each receive a copy, then we work independently on the idea( on computers) until we meet again and the process is repeated until it is time to write the whole script. Then one of us will write it (on computer), and they other will edit it and offer feedback.” (Response 17, Question 10)

This was repeated in both the filmmaking and musical composition observational studies, where individually produced ideas were brought in to group meetings (see sections 3.2.2.2.1 and 3.2.2.3.1). Figure 25 uses the model to describe this style of collaboration, where individual idea representation and evaluation cycles occur, leading to occasions where used or retained ideas are shared with a collaborator, when a cycle of collaborative productive interaction occurs based around this shared idea.
The importance of decision-making and negotiation are also apparent in the model and can be the cause of tensions that make creative collaboration difficult or impossible where personalities and opinions are incompatible. Systems that support creative collaboration need space not only for the representation of ideas, but also for representing the evaluation of those ideas in refined and subtle ways. They may also need to provide scope for negotiation to occur where opinions differ. The distances between collaborators are likely to lead to a reduced ability to hold a shared conception of the outcome when compared to the tighter collaborations represented in figure 24.

A wide range of further interpersonal interactions occur in the course of productive interactions: For example, the producer and audience, or a cooperative supporting relationships such as those defined by Becker (1982) and discussed in chapter 2.2: Human-Human Interaction and Creativity. A more thorough exploration of these is beyond the scope of this thesis but the models produced could be applied to examine many of these relationships in future work.

4.2.4.2: Domain
The domain and the medium that the outcome is to take are essential aspects in productive interaction. Each stage of the model described above is influenced by the nature of the outcome to be produced. This includes the nature of ideas, the forms through which they are represented and the criteria through which they are evaluated. In the following instances (figures 26 and 27), the model is used to represent specific productive interaction cycles from the excerpts in tables 12 and 18, taken from the musical composition and filmmaking studies respectively.
An analysis using this method to compare multiple cycles across instances of productive interaction can be used to explore differences in process. Even though many of the forms of representation used are the same, comparisons show the extent to which the domain of creativity affects the use of representations in the process, and it should be noted that as these are both temporal art forms, there are other forms of creative activity between which greater contrasts would exist. The large amount of verbal discussion that occurred before any film was produced by the groups in the filmmaking observations contrasted greatly with the immediate play of instruments that pervaded the musical composition observations. The feasibility of language as a means to explain ideas for plot or dialogue in the production of film contrasts here with the qualities of music which can only be represented and evaluated effectively through play.
Where the representation takes the outcome form, the evaluation is based on a real experience of what the outcome could be like. Where representations lack medium-semblance, an internal conceptualisation of the idea forms the basis for evaluation. In some domains it is more successful or convenient than in others to externalise ideas directly into the outcome media. It could be hypothesised that it is both more difficult to conceive of a piece of music based only on a verbal description, than to conceive of an idea for a film. A musician can also play ideas and explore possibilities with an immediacy that is lacking in film due to overheads. It is however, clear that if interactive systems are correctly designed, they are capable of reducing the costs involved with producing representations – for example in C.A.D/C.A.M, or providing new forms of representation – for example the visualisations of music in response to play of instruments developed by Johnston et al (2005).

The form of the outcome is also an essential variant in productive interaction. Variation was already noted between the musical composition observations, in which compositions were produced and performed, but could never be considered ‘finished’, and the filmmaking study, in which an artefact outcome – a short film – formed a finished outcome. These can be contrasted with improvised production, and with other creative work such as an advertising campaign to be produced to a specific deadline. In differing contexts, the time and space to iterate is different, and the notion of ‘finishing’ the task changes. Such variations affect process deeply, not just through the number of iterations, but through the tendency to diverge or converge over ideas after iterations.

The notions of Focus of Iteration and Scope for Iteration were identified as having domain-specific properties in the Iterations section earlier in this chapter. In the musical composition excerpt modelled in figure 26, the focus of the iteration is the structure of the song, which is being developed through the combination of verses and chorus. In the filmmaking study excerpt modelled in figure 27, the focus of iteration is a video clip produced by one of the group members, which is evaluated for use in the wider film. In both cases, the scope for iterations is wide, but in the case of the filmmaking observations, there is a deadline for the project, which pushes the team forward towards producing their final outcome quickly. In the musical composition observations, the conception of the outcome has been performed to an audience previously, but is still subject to development in the sessions.

4.2.4.3: Expertise

The participants in the observational studies ranged from expert musicians and experienced filmmakers to those with only minor experience in each domain. As many aspects of expertise are more clearly explained with reference to structural and longitudinal interactions, those sections describe expertise issues and reflect upon the links with productive interaction in each case.
One aspect of developing expertise clearly apparent from a productive interaction perspective is the ability to internalise the space in which usable ideas can be produced in the current context, based on prior experience and understanding. Figure 28 shows that from a productive perspective, expertise alters the ideation processes, with an internalised conception filtering ideas before they are represented. Without experience, initial productive interactions are often exploratory, taking the form of externalised ‘can it be done?’ or ‘what can it do?’ questions with respect to tools. A lack of experience in using the tool also affects the evaluation process if the idea has been represented in a form other than the outcome medium. For example it is necessary to evaluate whether a musical idea described verbally is actually possible to produce using the available instruments and skill.

Figure 28: Affect of Expertise on Productive Interaction Processes

This issue was apparent in the filmmaking studies as both groups produced ideas that were not feasible given the available technologies such as editing software and cameras. More experienced participants (particularly participant B in group 1) had stronger existing experience of filmmaking and therefore flagged up ideas as unfeasible, and directed the group towards those that could be achieved. This issue is explored further with reference to structural interactions in the next chapter (particularly in section 4.3.2.2 with reference to the reuse and exploration of structures). The development of expertise over time is also explored in chapter 4.4, as further concepts with which to understand these phenomena will be introduced by that point in the thesis.

4.2.5: Design Study: Sonic Sketchpad

The empirical studies suggest that support for productive interaction should provide effective affordances for representing ideas – both individually and in the context of the conception of the outcome, and for evaluation and decision-making. In collaborative interactions, additional needs are to provide platforms
through which ideas, evaluations and the conception of the outcome can be better understood, and that negotiation and decision-making can occur.

The design study performed to explore support for productive interaction resulted in the development of ‘Sonic Sketchpad’, an interactive system to support individual and collaborative musical composition through idea representation, evaluation and decision-making.

Persistent representations provide scope for representing ideas and for perceiving information that is important to evaluation, and to progressing the task through modifying ideas and developing the overall outcome. In developing Sonic Sketchpad, the aim was to produce a tool enabling composers to represent, record and share ideas, whilst keeping the environment flexible and open-ended.

As well as considering how the generic model of productive interaction can inform design, it is essential to consider contextual factors related to the prospective user group of the system. An understanding of musical composition was built through the empirical studies that can be applied here, and the nature of applying this knowledge to design is an important factor in achieving the 3rd objective of this thesis – developing the knowledge gathered in to a tool for designers across contexts. The adaptation of the forms of idea representation observed in the domain for use in the design of new systems is considered central to this. Further information considered includes the foci of iterations that will be supported, and the scope for iterations it is expected users will have. These factors were refined and formalised through their use in this design study, and are presented in section 4.2.6 at the end of this chapter.

As instrument play is seen as the central form of representation used in creating outcomes, the relationship of Sonic Sketchpad to this representational form was an initial focus for design. The musicians observed had expertise in using various existing instruments in productive interaction, so it was decided that the system would augment instrument play, rather than provide instruments to the user. This reflected a perceived lack of systems in this design space, and also kept the focus of this design study on productive, rather than structural interactions. As the focus of the design study performed in the next chapter is on structural interactions, the alternative approach is taken there, and a means to develop instruments for play using the system is designed.

Inspired by the foci of iterations observed in the studies of musical composition, Sonic Sketchpad supports a focus on individual recordings of ideas, and a further focus on understanding of the structure of a composition created from recordings linked together in sequence. Although Sonic Sketchpad can be used to produce an effective composition of recordings that could be considered as a realised outcome, the primary aim is to support earlier stages of productive interaction, where initial idea representations are created and evaluated individually and in the context of the composition. It is
therefore assumed that the users have scope for iterations, and the design was developed with this in mind, rather than providing specific support for improvisation or performance. It was observed in Coughlan (2004), as well as being highlighted by Abrahms et al (2002) and Phalip et al (2008), that sketching-style behaviours and free form annotations are common in musical composition, yet are often poorly supported by interactive systems for composition. There were also instances of written / visual representations of compositions in the Musical Composition observations (see section 3.2.2.2.1), but these do not follow a specific form across the instances of composition observed. An attractive solution is to give users control over a flexible, freeform space, which can be utilised according to users’ own working methods and current project.

As this was the first design study performed, knowledge of how to use prototype design and evaluation in the study of support for creative interaction was also gained. Although the evaluations and analysis of Sonic Sketchpad are largely informal, and only a small number of participants used the system, useful experience was gained that is utilised in the development of the more advanced methodologies used in the Music Builder and Associative Scrapbook studies.

4.2.5.1: First Design Iteration

Sonic Sketchpad was developed through scenarios and storyboards utilising the model and the contextual factors concepts described above, in tandem with concrete examples of musical composition from the empirical studies. The following functionality was developed and included in the initial version of the prototype:

![Figure 29: Sonic Sketchpad](image)

**Minimal Idea Input Costs:**
As the first step of a productive interaction cycle is the externalisation of an idea, an effort was made to reduce the cost of recording ideas from
instrument play. A foot pedal was provided as a method to control recording, or alternatively a single mouse click. Minimal system dialog was used in the recording process, descriptions could be added later or left blank at the user’s discretion.

**Free Representation Space:**
Whilst the majority of existing interactive systems for composition are aimed at realising pre-existing ideas (Abrahms et al, 2002), Sonic Sketchpad aims to support the representation and evaluation of partial composition ideas, and to avoid constraints on visual representation style where possible. Users can create recordings that are added to a free-form 2D space, where these can then be reviewed, combined and manipulated. Notes or diagrams can be added anywhere in the space using a stylus.

**Icon Sketching:**
When an idea is recorded, the user is given the opportunity to create a visual sketch using the stylus along with providing a text description. The sketch then forms an icon for the recording which can be positioned anywhere in the representation space. A user may for example choose to sketch notation, a picture or a description of the content. The pictures in figure 29 are examples of these sketched icons. Since composers have been found to use both visual and audio representations of their ideas the aim is to link these representations in a suitable manner and create a connection between sketched information and a recording, even if it is repositioned or re-used.

**Sequencer Functionality without Representation Constraints:**
In order to support a focus of iteration on the structure of a composition, Sonic Sketchpad allows users to combine the play of recordings simultaneously or sequentially to build longer compositions. Playback can also be looped. This functionality aids the review and modification of a composition without instrument play, and allows the development of a composition from multiple phrases. Such functionality exists in the software tested, but in the prototype users remain free to use recordings of any length, and position the linked recordings anywhere within the space. To allow users to edit recordings access to an external audio editor was provided through Sonic Sketchpad.

**Use Flexibility / Portability:**
The system was designed with a variety of interpersonal contexts in mind. These included individual use, asynchronous and synchronous collaboration. The second iteration described below included functionality to support collaborative, networked use on multiple machines. Sonic Sketchpad was coded in Java for portability across systems, and evaluated using portable tablet PCs, giving the option of pen input, and allowing the user flexibility in positioning the system in their workspace.
4.2.5.2: Evaluations and Redesign of Sonic Sketchpad

Iterations of design and evaluation are essential both in terms of developing a usable design, and in being able to learn from the results of evaluations through designing and testing answers to the issues raised. An initial version of Sonic Sketchpad was evaluated in a pilot study, with changes resulting in a 1st design iteration (discussed in section 4.2.5.3). Individual and collaborative evaluations resulted in changes leading to the 2nd design iteration being produced (discussed in section 4.2.5.4). This iteration was then evaluated in a range of collaborative contexts (discussed in section 4.2.5.5). Table 21 describes the participants.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Involvement</th>
<th>Relevant Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Individual pilot evaluation, individual and collaborative evaluation of 1st iteration. Evaluations of 2nd iteration</td>
<td>12 years of experience playing the guitar, 5 years of bass guitar. Composing and jamming in various bands. Has tried using a range of computer music software.</td>
</tr>
<tr>
<td>B</td>
<td>Individual and collaborative evaluation of 1st iteration.</td>
<td>16 years of experience playing the keyboard and composing.</td>
</tr>
<tr>
<td>C</td>
<td>Evaluations of 2nd iteration</td>
<td>10 years playing the bass guitar, also mandolin, guitar and harmonica. Extensive experience with software tools for musical composition.</td>
</tr>
</tbody>
</table>

Table 21: Participants Involved in the Evaluations of Sonic Sketchpad

4.2.5.3: First Iteration Evaluations

The individual pilot evaluation was performed with participant A, lasting 49 minutes. Basic usability issues were highlighted through this, such as a lack of obvious feedback to tell the user that recording had been started with the pedal. In response to this the system was redesigned so that the whole representation space - around 80% of the screen - turned red, providing an obvious sign that a recording was being made. Additionally the removal of unwanted silence at the beginning and end of recordings was found to be a commonly performed task and a distraction from evaluating combinations of recordings, functionality was added to semi-automate this process. After this redesign participants A and B both used the tool in individual sessions for 35 and 38 minutes respectively followed by a collaborative session for 36 minutes. The composers had not collaborated with each other before, so musical common ground had to be found.
Most of the issues raised by participants in the evaluations were focused on reducing input costs and automating processes that translated recordings into usable representations for evaluation. Both participants praised the utility of the pedal as a method to start recording. In the collaborative evaluation the introduction of the pedal also provided a means by which both users had some control over the system, as participant B sat in front of the keyboard and participant A had the pedal at his feet. Participant A also felt that the highly visible feedback for recording introduced after the initial evaluation was useful as they did not have to attend to the screen and could concentrate on their instruments. The participants both felt that the main frustration in using the software was in synchronizing recordings correctly, a process that involved the use of the editor to correct timing issues and distracted from the evaluation of combinations of ideas. Participants felt this activity would be made easier if they could be given some kind of visual information on timing in the representation space.

Use of the icon sketching functionality was limited in this evaluation. Figure 29 shows three examples of the shapes produced by participant A as icons and a single case where incomplete notation was sketched. When questioned about this functionality participant A stated that he was “not a visual person” and felt little need to sketch notation when a recording had been made. However he also stated that he found the ability to “hold” recording icons and move them around the space helpful, suggesting that the direct manipulation of visual-spatial representations of relationships between elements of a composition aided his creative process.

The participants explained their collaborative creative process as making recordings and trying to link them. Clearly defined idea representation and evaluation / decision-making stages were observed involving different methods of using the tool. During an idea representation stage the participants attended to their instruments and represented ideas to each other using verbal communication, gesture and play. After making a recording,
participants then moved to evaluate it. They attended to the screen, combined and played recordings and negotiated a next move. This involved further verbal communication and gestures towards the on screen representation.

4.2.5.4: Second Design Iteration
The first evaluations showed that collaborative use of the tool could benefit from individual controls and views of a shared space for collaboration. Therefore further functionality was included to support this. The system was also expanded to support its use in a distanced context, and to respond to needs raised through the previous evaluations. Details of the major changes made follow:

Networked Space
The second iteration of Sonic Sketchpad functions as a networked, shared space with a client for each individual user. This supported both the use of multiple terminals in a co-located or distanced context. Files recorded by one user were added to a shared space.

Voice Communication Channel
A voice channel was provided to support verbal communication between users when physically distanced from each other.

Awareness Mechanisms
Given the use of multiple instances of the system by collaborators, it was considered important to signify who was the creator of a recording through a tag added to the visual representation. This provided a means of automatically identifying recordings that was more specific than the unique colour or number applied in each case. A visual alert showed other users if a collaborator was making a recording, or if they were listening to a recording that existed in the system.

Recording / Sketch Library
Rather than adding recordings directly to the sketch, new recordings are added to a library. Users can also start a new page and access any page quickly from a library of sketches. The library system allows recordings to be used in multiple sketches and edited whilst retaining an original copy. Experimentation is also possible without losing the original version, and alternatives can be compared.

Overdubbing (Recording over Play)
An essential function of the software is to allow users to combine recordings in order to collaborate and evaluate contributions in context. This version of Sonic Sketchpad provided a simple interface for users to record over a playing idea and link the new recording to play simultaneously with its companion piece. Recording over play could also be triggered through pressing a pedal in the same way as normal recording.
Length Representation of Recordings
As participants have been far more interested in fitting recordings together than providing sketch annotations, this iteration uses a modified visual representation that clearly represents the comparative lengths of recordings. Where as in the previous iteration a small bar represented length as part of the larger representation, in this case the bar is the entire visual representation.

Count in
In response to user feedback in the previous evaluation, a visual count in was added to the recording process. This supported musicians in timing the beginning of their play correctly.

4.2.5.5: Second Iteration Evaluations
The second iteration of Sonic Sketchpad was evaluated as a collaborative composition support tool with two experienced musicians (A and C) in a naturalistic context. After an initial session of composition was observed without the tool, several configurations were tested: Firstly, a single instance of the system was provided for use between the two collaborators. Secondly, the users were co-located but had individual terminals (figure 31), thirdly, the users were distanced from each other, using the system as the sole basis for communication as the developed a composition (figure 32). In each case, the participants were asked to create a short composition with no time limit imposed.

There was no editing of recordings by the participants in these evaluations, compared to several cases in the first evaluation where users needed to use the editor when trying to combine recordings. Both the introduction of a countdown and the automated removal of silence appeared to aid the user's ability to effectively time recording so that recordings could be combined for evaluation. In several cases, it was visible that the awareness of who
authored each recording provided useful information to the collaborative process.

Several changes to the creative process were perceived after the introduction of the tool. Firstly the tool provided a shared means of creating persistent representations. Focus was therefore on working with the existing represented ideas as these were recorded and building upon them. In comparison the unsupported session involved a less focused approach where ideas were explored but very quickly forgotten. This mirrors the finding of Olson et al (1992), who noted that the introduction of a groupware tool increased the focus of collaborators towards building a solution.

The productive interaction process that occurred in the co-located evaluation of the tool was similar to those in the first evaluations: Participants played together in a form of exploratory play or jamming for a period of time, decided on an idea they would like to record, reviewed the recording after making it and then worked to add to this recording. However in the case of the distanced evaluations, a looser approach prevailed due to the distances between the users. Individual recordings were made and evaluated by the individual, who on several occasions deleted them after evaluation. Their collaborator would listen to these contributions and come up with responses. Creativity therefore proceeded in a ‘call and response’ manner – diachronic interaction involving recordings - even where participants were using the system synchronously. Call and response patterns are a common structure that is upheld in various forms of human communication, particularly in African cultures, where public meetings and music are performed in a turn-taking manner, in which an initial statement (the ‘call’) is followed by a ‘response’ that affirms or completes the sentence or musical phrase (Smitherton, 1977). In the case of these evaluations, the response is often as complex as the call, but it has a similar function, to evaluate, represent this evaluation, and to extend or accompany the initial communication.

The lag that exists both in terms of the audio link and the time spent sending recordings meant that participants were not capable of working in the manner they could whilst co-located. However the audio link did provide an awareness
of what the other participant was thinking and doing in distanced synchronous use. The instantiation of the model describing individual productive interaction in a collaborative context (figure 25) was representative of this call and response structure. Individual cycles occurred in which initial ideas were represented and evaluated, before a recording was produced of positively evaluated ideas. This was then shared as part of a collaborative cycle, in which evaluations of the idea could be shared through the voice channel. The other collaborator would then perform further individual cycles, followed by a sharing of the response. In this sense, each call or response contains multiple individual cycles, which are connected by a set of collaborative cycles when an idea is shared.

The main attraction of Sonic Sketchpad to users is the ability to evaluate recorded ideas quickly and evaluate them in context using a combination of aural and visual representations. When participants recorded an idea they took the time to review and evaluate it individually and where possible with collaborators. On several occasions participants deleted their idea from the shared space on the basis of this review and recorded a new or modified idea. The same activity occurred when recording a response or additional piece for an existing idea, participants would evaluate their response by linking it to the existing recordings and playing the combined piece, they would then keep the recording in place or record a new response whilst either retaining the existing idea separately or removing it from the space. When physically distanced the collaborating user was aware of this process through the audio link, but could choose to intervene, stay passive or work individually on ideas.

Call and Response working is a collaborative scaffold employed by users to structure contributions when the distance felt by participants disrupts simultaneous working. In the processes seen in the distanced evaluation, it does not require action without reflection. This is in contrast to jamming or real time collaboration, in which the scope for individual iterations is limited because of the presence of a collaborator. In the Sonic Sketchpad evaluations, users distanced in space worked in an environment where individual and collaborative productive cycles co-existed. This exemplifies the different contexts of interpersonal productive interaction represented previously in section 4.2.4.1.

Evaluations provoked thought on how this can be properly supported to provide an ideal environment for the composition process. The sonic environment is a great consideration in this, and whilst an audio link between participants had obvious benefits for awareness, and supported communication of the audible temporal idea representation types, it could also invade the personal space in which individual ideas were developed. The latency in any audio link caused by the network lag in these evaluations makes simultaneous play a practical impossibility, however the link provided participants with a high level of awareness about each other’s activities.
4.2.6: Designing Support for Productive Interaction

The essence of support for productive interaction is an ability to develop creative outcomes through cycles of externalising ideas, evaluating them and deciding whether and how to use them. This section draws together findings on the design of support for productive interaction from both the empirical and design studies. These findings then feed in to the final chapter of the thesis, which draws together these specific issues in to a holistic understanding of design for the support of creative interaction.

4.2.6.1: Interactive Systems and Productive Interaction in the Empirical Studies

Interactive Systems were used in the observations of filmmaking and discussed in the observations of musical composition. The questionnaire study responses gave a wide range of views on computer tools and parts of the participatory design studies focused on computer use in creative activities. This section builds upon chapter 2.4: Human-Computer Interaction and Creativity to explore some of the issues presented by the use of interactive systems in productive interaction.

Existing computer tools are used for the creation of idea representations and outcomes, and also as a basis for communication and collaboration amongst collaborators in creative groups. In representing ideas and creating outcomes, users have different foci for their cycles of iteration. Tools are often useful in supporting different aspects of the process – for example editing film or arranging audio – and the transitions between these tools are often difficult and restrictive.

A negative opinion of the use of interactive systems in several aspects of productive interaction was apparent through the participatory sessions and the open questionnaire study. Opinions of computers as tools for ideation and initial representation were often low. Computers were considered more useful to combine, edit and manipulate idea representations. It is clear that computers commonly provide scope for actions that would otherwise not be performed, or be performed very differently, for example by automating or quickly performing tasks that would otherwise be difficult or impossible in video editing and composition. The affordances of tools are central to the outcome that is produced – a topic covered in further detail in the next chapter.

As interactive systems often fail to support early sketching processes and other needs, such as providing physically movable and comparable objects, most creative processes utilise a mixture of computers and other tools such as paper and pen. The integration between these is often lacking, but can provoke a separation between the initial development of a conception of the outcome, and the actual production of it in the medium form.
Interactive systems can provide effective tools for the communication of ideas with collaborators in creative groups. The filmmaking study showed the effectiveness of a PC with a large screen as a basis for a variety of idea representations by members, including storyboards, video clips, text files and audio. The utility of a computer to scale up and modify idea representations for the needs of communication were apparent.

4.2.6.2: Findings from the Design and Evaluation of Sonic Sketchpad

The evaluation of Sonic Sketchpad suggested that lowering idea capture costs and automating or simplifying tasks that distract from evaluation would improve the usability of the tool. Simple design interventions were often the most successful, such as the pedal to start recording, and the automation of removing silence from recordings. These made it easier for users to focus on ideas, rather than the interface. As the system aims to record idea representations rather than provide instruments itself, a simple, paper-like interface offered an effective basis for users to gain feedback on their ideas and develop compositions.

The Sonic Sketchpad evaluations raised several interesting aspects to consider when supporting both individual and collaborative creative processes. As we have assessed that both types of creativity should be supported as co-existent processes, we have developed a system by which individuals can collaborate over physical and temporal distances. An individual’s ability to evaluate ideas before communicating them to the group should improve the quality of their contributions. By externalising ideas individually they are engaging in a middle level of evaluation – between individual internal and group external. The instantiation of the model developed previously represented a synchronous co-located collaboration and further representations should consider the ability of the individual to externalise and evaluate ideas individually whilst still working within a collaborative context. By providing awareness through an audio link, composers could to some degree work collaboratively.

A further important aspect of the Sonic Sketchpad design and evaluation study was the experience and knowledge gained in the development and testing of prototypes as a research method for this topic. Sonic Sketchpad can be considered as a required pilot study for the more complex prototypes and evaluations described in the following two chapters.

4.2.6.3: Understanding Contextual Factors in the Design Process

The research described in this chapter (particularly in section 4.2.4: Contextual Factors) highlights a number of contextual issues that should be considered in the design process as they can be influential to needs, and provoke reflection on how a system could be used. The following summarise these in the form of questions that designers should consider:
A) What are the main forms of idea representation currently used in producing outcomes in the domain?

B) What are the forms of idea representation currently used in sketching processes in the domain?

The forms of idea representation currently used should provide the basis for understanding needs, input methods, useful feedback, and the nature of expected outcomes. A key distinction is between representations that constitute outcomes, and others that are for initial sketching purposes. The later can fulfil different needs and are often overlooked in existing systems. The following questions explore idea representation further:

C) What persistent or temporal forms of representation should the system support?

Interactive systems commonly produce representations that persist because they can easily achieve this, but temporal representations have a role in productive interaction processes, allowing the distinction between ideas that form part of the conception of the outcome, and those that are being considered in current cycles or have been discarded. Systems should support these distinctions in some form.

D) How will the system integrate with existing forms?

E) How will it improve these forms?

As Sonic Sketchpad shows, tools need not reproduce all of the idea representation methods found. The possibilities for augmenting or improving them may be key. By allowing instrument play to be easily recorded, and for recordings to be represented visually and linked together in a free form environment, Sonic Sketchpad integrates with instrument play, and improves the link between recordings and visual representations.

The foci of, and scope for, iterations are important in deciding the functionality the system requires. The final questions provoke a consideration of this:

F) What foci of iterations can be expected / supported by the system?

G) Is there expected to be scope for iterations in the use of the system? Is there scope for individual and / or collaborative iterations? What bridges these?

In Sonic Sketchpad, the expected foci were individual musical ideas and considerations of the composition of these ideas together. A scope for iteration is expected – the system is not designed for performing an outcome,
but rather for ideas to be developed and reflected upon. In the 2nd iteration, scope for individual and collaborative iterations existed, but the integration of these could be improved further.

As designing interactive systems is an ill-structured, creative task, there is no single correct answer to these questions. For other systems – even in the domain of music – alternative, but equally valid answers could be developed, as they relate to an open design space. The point is to focus attention and structure the process of design, whilst leaving space for novelty to emerge in design processes.

4.2.6.4: Requirements

In addition to the questions above, the research highlighted a number of practical requirements for usable tools for productive interaction:

1.) Productive interaction requires tools for the early representation of ideas through sketching-type interactions, as well as the realisation of creative outcomes. Interactive systems need to better support the capture of raw ideas, providing a flexible medium for manipulation and support communication and negotiation with collaborators. Given the centrality of ideation / evaluation cycles to the process (from section 4.2.2), effort must be made to reduce the costs of idea capture, modification and removal to a minimum.

2.) Even in non-visual domains like music, visual representations and interfaces can play an important role in allowing creative practitioners to evaluate ideas and structure their conception of the outcome. In addition to defined elements of an interface (such as a recording), systems should allow users to add textual and graphical descriptions to any part of the representation. These can be notes for the individual, or communicate ideas to collaborators and build shared understanding.

3.) It was observed that the process of representing ideas in some forms (for example instrument play or filming) can create a cognitive load or other cost that makes evaluation difficult as the representation is created. The ability to review ideas without this load is important (from section 4.2.2.3).

4.) Interactive systems should provide mechanisms for evaluating ideas and the development of the outcome. In particular this could support a consideration of how a prospective audience would view the outcome, and support the evaluation of alternative ideas or uses of ideas (from section 4.2.2.3).

5.) Productive interaction integrates previous work, and it is rare that the production of an outcome occurs entirely in one location or session. New ideas occurring within collaborative meetings need to be recorded, and an individual’s previous ideas need to be presented and used as shared
artefacts. This links with the longitudinal interaction perspective presented in chapter 4.4, where ideas are retained for use in productive interaction.

6.) Various forms of interpersonal interactions occur in productive interactions, and the design of interactive systems often leads to the development and adoption of particular structures to occur. The studies included observations of tight collaboration, individual, and loose collaborations such as the call and response interaction identified. These forms have various characteristics and advantages and an ideal system should support various structures for collaboration. A consideration of the kinds of collaborative interaction that may be most useful in a context should inform the design of systems.

4.2.7: Conclusions

This first chapter of findings has introduced and explored the interaction that occurs in the production of creative outcomes. A detailed understanding of central concepts, such as iteration, idea representation and evaluation has been produced, and the first design study has been presented, providing an example of support for sketching processes in musical composition, as well as providing a pilot for the more complex prototype design and evaluation studies that are described in the next 2 chapters.

This perspective alone can provide an understanding of issues that are central to creative interaction, but is most useful when considered in tandem with the concepts of structural and longitudinal interaction, which are introduced in the following chapters.
4.3: Structural Interaction

I must Create a System, or be enslav’d by another Man’s.
William Blake, 1820

4.3.1: Definition and Scope

This chapter describes a set of interactions on the platform used in the productive interactions described in the previous chapter. The establishment of this second perspective stems from previous research that argues that reflection on, and development of, the structures applied to a creative task, is essential to successful creative practice (e.g. Stokes 2005, Pearce & Wiggins 2002, Pérez y Pérez & Sharples 2001, Johnson-Laird 1993).

A ubiquitous property of creative work is that constraining motivations, tools and conceptual structures are necessary to direct and support creative activities, but that the ongoing questioning and development of these structures is central to the process. Distinct from engaging in the production of creative outcomes, practitioners reflect upon the structures that support and bound this production (Johnson-Laird 1993, Pérez y Pérez & Sharples 2001). This is a response to the ill-structured nature of creative work that requires a consideration of both how to constrain a vast space of possible actions, and how to provoke novel, valuable actions rather than mundane responses.

Chapter 2.3: How Creativity is Supported described relationships between creativity and the external world, showing that tools play an integral role in structuring creative interactions. Chapter 2.4: Human-Computer Interaction and Creativity presented an initial discussion of the nature of interactive systems as tools for creativity. From this background, it is clear that the malleability of interactive systems is a key characteristic that differentiates their utility in creative activities. It was however, observed in the empirical studies, and through previous studies of composition using computer tools (Coughlan, 2004), that existing interactive systems often constrain productive interaction processes to a greater extent than other tools – such as pen and paper. An aim of this chapter is to explore how users can be empowered to effectively develop these constraining structures.

This chapter also provides further understanding of what ideas and creative outcomes are, by considering what is necessary to produce them, and differentiating them from the surrounding concepts and artefacts utilised in producing them. Through this, it is hoped that creative interaction can be viewed with greater clarity. Structural interaction is an essential concept in terms of the objectives of this thesis, because in developing interactive systems, designers produce structures within which creative interaction occurs, and in which users – when allowed to - can perform further structural interactions themselves.
Structural Interaction is defined as:

A meta-level reflection on the process of Productive Interaction, resulting in the development of structural elements that affect this process, by supporting and constraining the actions through which ideas are generated, represented and evaluated, and through which outcomes are realised.

Following the structure of the last chapter, the empirical studies are used to provide a general understanding of creative interaction from this perspective. Following this, a model of structural interaction is presented, with contextual factors are considered in light of this model. A design and evaluation study – producing the prototype system ‘Music Builder’ is then described. Finally, conclusions on the guidance that can be provided to designers from this perspective are given.

4.3.2: Findings from the Empirical Studies

In this section findings from the empirical studies are drawn upon to explore the nature of the structures that support creative interactions. The structures through which productive interaction occurs both provide affordances and constrain the space of possible, or useful ideas. Firstly, types of structure are identified and analysed. Secondly, forms of interaction with these structures are analysed, including exploration, reuse and development.

4.3.2.1: Types of Structure in Productive Interactions

In this section, existing research on structures and constraint in creative activities is combined with examples from the empirical studies to define three forms of structure from the perspective of designing technological support. The theoretical background to these is described in the section on ‘Structures’ in chapter 2.1: Understanding Creativity and Creative Processes, and in relation to tools in the section on ‘Structure and Constraint’ in chapter 2.3: How Creativity is Supported.

Taking the discussions of structure and constraint in creative practice described in chapters 2.1-2.4, it is clear that structures for creative activities are essential, but can be viewed in various ways. As the focus here is on the design of interactive systems, distinctions between types of structure were identified that are relevant from the literature review, and then these classifications were explored and refined through analysis of the data from the empirical studies performed for this thesis.

Tangibility is the essence of the external constraints of Pearce and Wiggins (2002) and the task constraints of Stokes (2006). For this thesis, ‘Tangible Structures’ are defined as properties in the virtual or physical environment that have defined qualities and limitations, such as a painter’s palette or the range of a piano. Subject and goal constraints in Stokes’s definition are, like Pearce and Wiggins’s stylistic constraints and Pérez y Pérez & Sharples’s (2001)
mental constraints, conceptual notions that have no defined form. ‘Conceptual Structures’ are therefore defined as those constraints that exist in the minds of practitioners, such as aiming to create a painting in an impressionist style. Finally, Pearce and Wiggins’s notion of internal constraints is an essential factor in the process of composing creative outcomes. ‘Internal Structures’ are defined in this thesis as accepted ideas that constrain the space in which further ideas should fit. Examples of this include a drumbeat that a collaborating musician should play to or a figure in a painting that additional features must fit around.

Table 22 presents examples of each kind of structure from the observational studies. These forms of structure are now explored in more detail through these, and further data from the empirical studies.

<table>
<thead>
<tr>
<th>Type of Structure</th>
<th>Examples: Filmmaking</th>
<th>Examples: Musical Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangible</td>
<td>Camera, Smartphone, PC, Video Editing Software</td>
<td>Guitar, Keyboard, Drums, Microphone, Paper and Pen.</td>
</tr>
<tr>
<td>Internal</td>
<td>Fitting the individual film ideas together coherently (group 1), Using multiple action heroes for continuity (group 2)</td>
<td>Relationship between Verses and Chorus, Ordering of Verses, Timing of Changes.</td>
</tr>
</tbody>
</table>

Table 22: Examples of Structure from the Observational Studies (Gathered from transcripts in Appendices 6.3.1 and 6.4.2 and Exit Questionnaires in Appendix 6.4.3.2)

4.3.2.1.1: Tangible Structures

In essence, the tangible structures utilised in productive interactions provide a means to perform actions. They are defined, external objects that are interacted with in the course of representing ideas and producing outcomes. Obvious examples include a paintbrush and paint, a pencil and paper, or a piano. However, in this case, tangible is used in terms of the definition ‘clear and definite; real’ (OED), rather than to denote only physical objects. The reason for this is that the interfaces of interactive systems present similar defined properties. All tangible structures, be they physical or virtual, have perceived affordances, which are actions that a person understands that they can perform through this artefacts (Norman, 1988). This is not to say that there are not differences to be explored between physical and virtual structures – this is a major focus of this chapter, and has already been introduced in chapter HCI through the work of Turkle (2005) and Treadaway (2007) – but to say that a physical and virtual interface share the same essential properties of a defined tool for interaction with the external world.
The group have met with the intention of filming footage based on their ideas. A was expected to bring a camera but due to bad weather assumed it would not be needed. C suggests that filming is still possible and that a Smartphone (referred to as PDA by the group) can be used to record, the adoption of which is supported by D.

E – ‘My camera’s in the car. I thought with this rain we wouldn’t be bothering with much.’
G – ‘We can film in the rain.’
F – ‘Well, er, A just said…’
E – ‘The camera’s in the car’
G – ‘We can film with the PDA’
H – ‘Yeah, we can film with the PDA’

Table 23: Excerpt from Filmmaking Study (Group 2, Meeting 4)

The excerpt in table 23 gives a simple example of the use of tangible structures in a creative activity, in this case filmmaking. It is clear to the group that a device is required with which to film. However the expected video camera is not available, so a device with similar affordances (one of the Smartphones provided) is used for filming instead. This does however force changes to the outcome produced, and group members were unhappy with the quality of the film produced (see exit questionnaire responses in appendix 6.4.3.2). Similar explicit references to the adoption, dismissal or production of tangible structures were found in 12 cases across 3 of the 4 coded sessions of the filmmaking study (table 7, section 4.1.3.1.1). Interestingly, the session in which tangible structures were not explicitly mentioned was group 2, meeting 1. In this meeting, the group produced and evaluated ideas but did not consider the structures necessary to realise their creative outcome. When they came to realising the outcome in sessions 4 and 5, they faced a range of issues related to tangible structures, - such as not having a video camera or effective editing software - that group 1 had discussed earlier in the process (see transcripts and exit questionnaires in section 6.2, and also section 3.2.2.2.1). Much of this discussion of tangible structures was started in group 1 by participant B, who had strong previous experience of all aspects of filmmaking (see section 3.2.2.2.1).

4.3.2.1.2: Conceptual Structures

Rather than artefacts in the external world, conceptual structures are the abstract notions that are used as a mental platform for ideation and evaluation. Concepts can be shared through examples and represented symbolically, but unlike tangible structures, their boundaries remain fuzzy. Examples include a genre or movement such as jazz music or cubism or a goal or abstract need such as that used in the filmmaking study of improving awareness of environmental issues. Conceptual structures provide foci for producing creative outcomes, means to think with and to share abstract notions and to describe ideas.

As they are mental constructs, and hard to bound, it can be difficult to differentiate conceptual structures from each other, and from ideas. Boden (1993) makes a distinction between Conceptual Spaces and the ideas produced through them – for which the conceptual space provides a platform. In this thesis, a differentiation between concepts and ideas is made, by using
the definition of ideas: “a thought or suggestion of a possible course of action” (OED). A course of action denotes a concrete description of something that can be done in the real world. A conceptual structure is, in contrast, abstract in nature. It does not denote a specific course of action, but an underlying purpose or principle from which an action can be built or justified. A simple distinction is that ideas represent a concrete ‘what’, whereas conceptual structures are often the ‘why’, and tangible structures as a means to act: the ‘how’.

Table 24 shows dialogue from the filmmaking study, through which this distinction can be presented. In this case, conceptual structures used include the notion that the film is “a reminder”, could use the abstract notion of a “silly animal trick” and that the film should not “make them crazy”. On the other hand, the examples used for these concepts – “So a cow”, “Ducks… whats that duck doing there?” – can be classed as ideas as they are concrete instantiations of possible actions, used in this case to explore the introduced concepts. Such relationships between conceptual structures and ideas are commonly seen in creative interactions. 21 explicit references to conceptual structure could be identified across all 4 coded sessions of the filmmaking study (table 7, section 4.1.3.1.1). It was also an identifiable concept in 3 of the 4 participatory task models analysed (table 8, section 4.1.3.2).

It is important to note that conceptual structures commonly require some form of symbolic representation to be externalised and shared. Building on Sawyer’s research, Sarmiento and Stahl describe how indexicals – symbols for novel concepts - are developed as a necessary aspect of building shared understanding of novel concepts in a group (Sawyer 2003, Sarmiento & Stahl,
2007). In the filmmaking study, group 1 discussed and adopted the concepts of “reduce, reuse and recycle” as three themes that focused their productive interactions, and repeatedly returned to these as they developed their outcome. In the example above, the “silly animal trick” provides a similar example of an indexical for a conceptual structure. Returning to the quote from Satriani & Jones in chapter 2.3, we can see how musical concepts need symbolic representation to be used on an interpersonal basis.

4.3.2.1.3: Internal Structures

Internal structures form a final group of components that bound productive interaction cycles. Through these cycles, ideas that are expected to be used in the conception of an outcome are collected, forming the conception of the outcome. This produces another form of structure, as further new ideas need to combine with these existing ideas in the conception of the outcome, and reflection upon these relationships is central as the production of a creative outcome progresses and ideas are positively evaluated for use. The following excerpt from a respondent to the questionnaire study exemplifies this issue:

“Once I'm working on a book about, oh, colonizing Mars in the 22nd century, it's not going to be any use at all to get good ideas about stories set in 3rd century Rome, or about dragons -- no matter how good those ideas are, they won't fit into my book on Mars.” (Response 13, Question 6)

The accepted existing ideas – in this case, that the setting is Mars and the time period is the future - provide a structure that bounds the space in which new ideas are valuable. It is however, interesting that this structure only applies to the current juxtaposition of ideas forming the conception of this outcome, and an idea about 3rd century Rome could be valuable in a different conception of the outcome. The value of ideas are therefore linked to the context in which they are presented. This point is expanded upon in chapter 4.4, where a Longitudinal perspective on the use of ideas is adopted. For the purposes of this perspective, it is essential to consider that productive interaction is bound by these internal structures. 18 references to conceptual structures were coded across all 4 of the coded sessions in the filmmaking study (table 7, section 4.1.3.1.1). Internal Structures were also an identifiable concept in 3 of the 4 analysed participatory task models (table 8, section 4.1.3.2).

4.3.2.2: Structural Determinism of the Conception of the Outcome

In this section, the ways in which structures affect productive interaction processes are discussed. In particular, the notion of a conception of the outcome is used, and changes to this due to structural issues are analysed. Table 25 gives an introductory example of how the conception of the outcome can be determined by an understanding of adopted structures from the filmmaking study.
Group members discuss conceptual structures and ideas, how they could be implemented, and the affordances of editing software in relation to these ideas. A has produced several concepts, including speeding up the film, that will require suitable technologies to perform. C is supportive of these ideas until B highlights that the software he was expecting to adopt is unlikely to be able to perform these functions.

A: So for reuse (one of the adopted thematic concepts) … the movie takes someone through the process of making paper, but funny, maybe Benny Hill-esque… We could intersperse ourselves with footage we can get… and so it could maybe be kind of speeded up as well.”

C: “Yeah definitely”

A: “Cos it need to be short, and that would make it entertaining if it was sped up”…

B: “Windows Movie Maker, I’ve not found a way that it can speed up, or slow down, or reverse or anything like that… My theory would be that if we can come up with something without needing any gimmicky kind of effects, other than some editing, it would probably be better…

C: Yeah I mean, that’s an idea, if it’s easy we do it, if not… whatever.

Table 25: Dialogue from Filmmaking Study (Group 1, Meeting 2)

In this dialogue, A and C are discussing conceptual structures that may lead to concrete ideas that form part of the conception of the outcome – for example ‘being funny through speeding up the film’. However, B intercedes with a consideration that the tangible structure he expects to adopt for editing the film (Movie Maker) does not support the functions required to produce outcomes in line with the desired concepts. After this, C shows that the available structures will determine the conception of the outcome by saying “if it’s easy we do it, if not… whatever”. C’s input shows how the affordances of the editing tool significantly affect the outcome they will produce. The group have accepted that the functionality of the editing software is a constraining factor in their productive interactions.

After this excerpt B offers examples of ideas that could be implemented in a continuation of productive cycles. Later, the group do discuss adopting alternative editing software – the topic of a later section on the development of structure. Through structural interactions such as adopting software and considering its affordances and constraints, the group explored whether, and how, their ideas could possibly be realised. Almost concurrently, they evaluated the suitability of the current structures. Although it was feasible for the group to modify either the tangible structures, or their conception of the outcome, they chose the later at this point in time. Structural determinism therefore holds where the structure is not developed, and where it is the conception of the outcome that is modified.

Whilst some form of structural determinism is ubiquitous in tools use, it is of particular relevance to the design of interactive systems: When using paper or verbal communication, a person has the ability to represent ideas with a great deal of freedom to develop and manipulate the structures used. Whilst there are limited affordances (for example, audio or video representations cannot be made with paper and pen), there are few limitations on how a visual representation can be created and interacted with. When using software tools, the ability to represent is commonly constrained by the design of the representation environment and the common need for the computer to ‘understand’ or quantify the user’s input in some way (Coughlan, 2004).
Negative attitudes towards interactive systems from creative practitioners often reflect concerns with the imposition of structure, as the following quote from the questionnaire study shows:

*I have seen advertisements for creative tools, and own one myself, bundled with a scriptwriting program. I advocate against them. No tool can organize the dream. Inevitably, it will force an alien structure on the creation, cutting off creativity.* (Response 22, Comments)

In this case, the respondent is referring to tools for writers that explicitly aim to support creative thinking by providing a structure for the representation of ideas and concepts. The respondent argues that an enforced structure on the process serves to cut off creativity. This shows the perceived importance of an ability to develop a structure of one’s own, rather than work within provided structures. The quote from Blake at the beginning of the chapter also reflects this need for creative practitioners to avoid being forced to follow the structures of others. Once again, sketch-like productive interactions in environments that do not enforce adherence to structures are seen as essential to being creative. However, creativity requires a balance between the freedom to develop structure, and the need for this structure to exist in order that outcomes can be produced. A positive approach appears to be not to enforce tangible structures upon creative practitioners unnecessarily, but to allow them to easily adopt, dismiss or develop them as they progress towards an outcome, and support the making of representations that break from adopted structures.

Conceptual and internal structures also have a deterministic effect on the creative process, guiding ideation and evaluation processes as seen in table 24. In theory, conceptual structures such as goals could be easier to change or refine when compared to tangible structures, as they are mental conceptions without defined existence. However, research described in chapter 2.2: Human-Human Interaction and Creativity shows that there may be both socio-cultural and practical difficulties faced in deviating from accepted concepts in a domain. A tension is apparent here, and there may also be a negative effect from modifying the conception of the outcome to fit with existing tangible structures – the novelty and value inherent in a conceived goal might both be reduced in the course of translating the conception into a realised outcome.

### 4.3.2.3: Exploration and Reuse of Structure

Looking back at table 25, it is apparent that through externalising ideas, the group members are exploring the space in which they can produce outcomes given the current structure they have adopted. An individual or group’s understanding of a tangible structure and the actions it affords is likely to be limited, particularly if the tool is complex. Skill in using a tool is developed through experience of productive interactions using it. Similarly, an individual or group must explore the meaning of conceptual structures, developing knowledge of these abstractions and the means through which they can be used to produce concrete ideas.
As this exploration - and the understanding accrued from it - occurs inherently through productive interaction, it forms a link between productive and structural interactions that is described in the model presented later in this chapter: Exploration through productive interactions informs structural interactions, while the results of evaluating productive interactions can cause a phase of structural interaction to occur – for example when a limitation is recognised that is in contrast to the conception of the outcome.

The development of knowledge of the actions available through tangible structures is therefore essential in guiding further productive interaction, and constitutes learning that is utilised if and when structures are reused. In the following excerpt, a respondent to the open questionnaire study describes their process of musical composition in terms of the tangible structures commonly used:

"Usually I start off with manuscript paper, generally working at the piano. After a short period of time I often find that I lose track of where I am (not a very good pianist!) and then I transfer what I've done into the Finale notation software on my computer. This helps to sort out any rhythmic problems too (often my initial notes are fairly haphazard in this respect - I'll mark a value as dotted to show the rough rhythmic relationship, but whether it's a dotted quaver or crotchet can be fairly random) and determine appropriate key signatures and time signatures. After that, generally I'll compose directly in Finale without much reference to the original notes, although sometimes on a longer or more difficult piece, I'll go back to tinkering with things at the piano and start the process again from somewhere in the middle." (Response 12, Question 3)

The tangible structures (manuscript paper, piano, and Finale software) have clearly been utilised across a number of instances of productive interaction. Through this exploration and reuse, the affordances and utility of each have become apparent to the respondent, and a standardised process for production has been developed, although variations are apparent in response to variations in conceptual goals e.g. a longer or more difficult piece.

Conceptual structures are also commonly reused. The jazz improvisations discussed in the previous chapter on productive interaction require adherence to conceptual musical structures such as key and scales. These are necessary in order that a single productive cycle can produce an outcome of enough quality for a performance, but remain abstract enough that variation occurs across sessions.

Where experience of conceptual and tangible structures exists, there is scope for predictive processes that can assume that ‘doing this will work’, whereas in creative activities where less experience with the adopted structures exist – such as the filmmaking study – productive and structural interactions take a more exploratory approach, asking questions such as ‘what is possible using this structure?’. This is explored further in the Expertise section (4.3.4.3) later in this chapter.

Several conclusions can be drawn here: The development of expertise through exploration and reuse links Productive, Structural and Longitudinal
Interactions, as exploration through productive interaction leads to improved skills and knowledge of structures, resulting in learning and retained structures. From a longitudinal perspective, this learning and retention will affect practitioners’ willingness to adopt new interactive systems, and integration with these existing structures may be an important requirement if a new system is to be successful. It is also important for designers to support exploration effectively, and to provide consistency in designing tangible structures, so that reuse can take advantage of previous experiences.

4.3.2.4: Development of Structure

In this section, an alternative response to structurally-determined interactions and the reuse of structure is explored: The development of the structures used in productive interaction. Rather than allowing the structure to determine the path the creative activity takes, an essential counteraction is to adopt, dismiss, build or modify tangible or conceptual structures. It could be argued that this approach can be central to producing an outcome of real novelty – because the structures in which it is produced may hold some novelty, and value – because a conception of the outcome can be maintained, rather than adjusted to what it is easy to create through a path of least resistance.

However, research described in chapters 2.1 and 2.2 can be used to argue that this would amount to an overly-simplistic perspective on a complex issue. A counter argument would state that it is necessary to follow socially accepted structures in order to make valuable contributions, of the kind Finke (1995) describes as ‘Creative Realism’. It can be assumed that existing tangible and conceptual structures have evolved towards some characteristics of value, and that any novel production in these commonly understood structures is often valuable. Finke argues that this is because it is both difficult to produce something novel in a well-explored space, and because what is produced relies on structures that are widely understood.

From another perspective, given the basic principle that nothing is ever created in a vacuum, there is always some underlying structure upon which novel structures are developed, so the structures developed by practitioners invariably build upon structures designed by others. Processes that can be considered the development of structure include the adoption or dismissal of existing structures, and the production of structure based on the modification or building of structure using some existing primitives. A distinction can be drawn between the adoption or dismissal of externally designed structures – for example a guitar or existing software tool – and the production of structures by creative practitioners themselves utilising primitives – for example an alternative tuning of a guitar, or an end-user developed modification to a software tool. These issues highlight a highly contextualised use of structural interactions, that is explored in the Domain contextual factor section later in this chapter.

The structural interaction perspective can be used to perceive creative activities as involving the alignment of conceptual structures with tangible
structures, in order to support actions that fit conceptual goals. It is often the case that novel ideas and goals cannot be achieved using available tangible structures, and therefore some form of development is necessary to achieve them. Although it may not be appropriate in every context and in every way, it can be stated that support for the development of structure, and support for guidance and reflection on the possible structures that could be adopted, are important requirements in encouraging creativity in the use of interactive systems.

In some cases, the participatory task models represented instances of productive interaction in participant's commonly reused structures, or some abstraction of this. In others they include an understanding of the development of this structure in their model. Model D explicitly differentiates between having an initial idea or “vision”, and then choosing “tools”. Iterative cycles are described between the development of a tool structure, and the development of sounds and a composition. Model B includes “Bring in other people / instruments” as a point of structural development (full analysis in appendix 6.2.2). It is notable that in each case, the model represents that structuring occurs after the development and representation of an initial idea. Productive interaction provides a basis for exploring a structure, and it appears that in many cases (such as filmmaking group 1) development generally occurs in tandem with productive cycles. Quantified evidence for both these assertions is described later in the Music Builder evaluations (section 4.3.5.1.1).

An important factor in the scope for the production of structure in any given situation is the malleability of tangible structures, and the difficulties in modifying accepted conceptual structures. This may distinguish between structures that are adopted or dismissed, and those that are produced or modified. A simple example of malleability is the ability to tune a guitar to various configurations of notes for the open strings. Whilst there exists a ‘standard’ tuning, intermediate and advanced players will explore alternative tunings as a structural interaction that forms a basis for interesting productive interactions that would otherwise be difficult or impossible to play.

Some promising characteristics of interactive systems for the development of structure were presented in chapter 2.4: Human-Computer Interaction and Creativity, however, it is clear that this is a complex area in terms of designing interactive systems. In the excerpt shown in table 25, the next step, were they to pursue the idea of speeding up the footage, would be to dismiss use of Windows Movie Maker and adopt alternative software. There are, of course, a variety of paradigms for computers to support the adoption or development of structures. Pieces of software can be considered as standalone tools, while shared file formats can support the use of several software tools interchangeably in a production process. Alternatively, software can also be extendible through plug-ins or similar concepts of modularity, a common source for structural modification in tools for creative activities such as Photoshop or Cubase. Finally, there are the end-user development approaches to design explored in the design study below, and in existing tools
such as Max/MSP – one of several prominent programmable and extendible systems for developing structures for the production of sound. In the following sections, the processes surrounding adoption, dismissal, production and modification are explored.

4.3.2.4.1: Adoption and Dismissal of Existing Structures
The adoption and use of existing structures is key to most creative activities. These form the basis for supporting the transition and concurrent development from conceptual goals to realised ideas and outcomes. Structures may be adopted in tentative ways, or may have a history of use by the person or group as discussed above.

Where conceptual structuring and sketchy productive interaction occur, tangible structures can be adopted in a tentative way, rather than actually being used: the dialogue in table 25 shows that, without the filmmaking groups actually making use of video editing software, the Movie Maker software had been adopted in a tentative form, and the understanding of it from previous use was used as a basis for productive interaction, without the group actually interacting with it at this stage. As discussed previously in section 4.3.2.1.1 in relation to tangible structures, this tentative adoption and discussion of structures in relation to ideas is useful in directing the group towards an outcome they can realistically create.

4.3.2.4.2: Production and Modification of Structure
The production of structure can be defined as any actions that lead to the creation of structures with some level of novelty. Logically, structures produced by a creative practitioner may be more conducive of novelty, and may be better understood as they are the product of the practitioner themselves. However, they often need to reflect some existing conventions in order to integrate the produced outcomes with the existing understanding and experience of the audience.

Due to their nature, the development of tangible and conceptual structures occurs differently. The production of conceptual structures requires the development of language-based indexicals identified by Sarmiento and Stahl (2007), and may be defined through the identification of ideas that exemplify the concept. The production of tangible structure by creative practitioners occurs when they take over some of the role of the designer with respect to the space in which productive interaction occurs. As design is a creative activity, this production occurs much like any other productive interaction. Evaluation is in this case based on the function of the structure as a basis for productive interaction in the relevant domain. For example, a musician may produce an instrument – as occurs in the Music Builder system described later in this chapter – on the basis of the conceptual structures adopted or developed.

Table 24 shows how group 2 in the filmmaking study used a discussion of ideas to produce conceptual structures. The notion that the film should not
irritate people, and that it will be a reminder of the need to recyle, are
developed as the group consider the fit of ideas to their developing conceptual
structures in tandem. Conceptual structures can be influential in guiding the
development of tangible structures, which is again a subject explored in the
following design and evaluation study.

Structural development is dependent on underlying platforms or building
blocks. Most tools allow the production of idea representations, but outside of
the virtual interfaces of interactive systems, less allow the production of the
structure to any great extent. The example of tuning a guitar contrasts with the
extent of structural development that is feasibly possible – although often not
accessible – in computer tools. Although the computer holds potential as a
highly malleable platform, it is generally necessary to learn extensive
programming or other technical skills to utilise this, often with little relevance
to the domain in question. In addition, systems are often developed that
provide little access to the underlying code and with little ability to modify the
interface. The development of effective interfaces for structural development
forms the focus of the Music Builder system, produced to explore design for
the production and modification of tangible structures.

4.3.3: Model of Structural Interaction

In this section a model of Structural Interaction based on the above findings is
described. As it has been found that structural and productive interactions are
tightly integrated, this model integrates with the model presented in the
previous chapter. Productive cycles are interspersed by periods of structural
development or changes to the conception of the outcome.

In the development of structure, practitioners consider both the fit of existing
structures to this conception and how structural changes could affect the
outcome, then implements changes to the current structure, resulting in new
tangible and conceptual structures.

Changes to the conception of the outcome can occur due to structural
determinism, where the conception of the outcome is modified to suit the
affordances of adopted structures.

Finally, productive cycles where ideas are accepted for use result in internal
structures, which guide further productive interactions.

4.3.3.1: Model Definitions

\textit{Tangible Structures:} Defined, external objects that are interacted with in the
course of representing ideas and producing outcomes.

\textit{Conceptual Structures:} Abstract notions that are used as a mental platform for
ideation and evaluation, such as goals, genres or rules.
Internal Structures: Accepted existing ideas in the conception of the outcome, providing a structure that bounds the space in which new ideas are valuable.

Develop Structures: The production, adoption or dismissal of conceptual and tangible structures for phases of productive interaction.

Develop Conception of the Outcome: A change to the conception of the outcome based on the possible space of actions presented by the current structures.

![Figure 33: Model of Structural Interaction with Relationships to Productive Interaction](image)

Figure 33 describes structural interaction and its relationship to productive interaction. A starting point could be either initial development of structure – for example by adopting a piece of software, picking up an instrument or developing a concept - or exploratory ideation in a pre-existing structure that is being reused.

Each phase of productive interaction is informed by the current conceptual and internal structures, and bound by the affordances presented by tangible structures. Tangible structures and the ideas produced through them, or for use with them, are evaluated with reference to conceptual goals and internal structures. The completion of a productive interaction cycle lead to two decisions being made:

Firstly, a decision is taken on whether and how to use the idea that the cycle has externalised and evaluated. Taking and extending the definition of this
process from the model of productive interaction in the last chapter, a decision to use or modify an idea will change the conception of the outcome and add internal structures, both of which affect the space of suitable ideas for later productive cycles.

Secondly, a decision is made on whether to maintain the current structure, and continue cycles of productive interaction, or to develop the tangible and conceptual structures in which productive interaction is occurring. If a decision to develop structures is taken, conceptual or tangible structures may be adopted, dismissed or produced. Cycles of productive interaction are then used to explore this new structure, and evaluate the structural development that occurred.

For example, a group of composing musicians may begin composing by adopting tangible and conceptual structures: such as instruments, a scale, key, and/or a theme. Next they perform productive interaction, for example, through exploratory play or a verbal discussion of possible ideas. They evaluate their ideas with reference to conceptual goals and any internal structures, deciding both what they will do with the idea, and whether to further develop the structure in which they are working or change their conception of the outcome. This abstract characterisation of the production of a creative outcome fits well to each of the concrete descriptions of the musical composition and filmmaking sessions given in section 3.2.2.

The musicians may find and retain a specific musical phrase and build the rest of the composition around it, using the inherent internal structure from this to reduce the solution space. They may also develop the structure further if they feel something is missing, perhaps changing instruments or developing the conceptual structure further in between productive interaction cycles.

**4.3.4: Contextual Factors**

The previous sections have highlighted that contextual factors affect both the form of structure, and the processes of developing and evaluating it. As in the previous chapter, these effects are now explored with reference to interpersonal, domain and expertise factors.

**4.3.4.1: Interpersonal**

The empirical studies provide evidence that developing and adopting structures through shared negotiation is essential in collaborative creativity, but this has yet to be explored in detail by researchers. The analysis presented in this section, and the design study performed in this chapter, focus on the possibilities for supporting the development of shared structures through design.

In collaboration, the shared development of conceptual structures can be seen as essential to coherent progress towards defining a conception of the outcome. This is exemplified in table 24, where part of a shared conceptual
structure is developed in which further ideas will be evaluated. Building and sharing structure together leads to shared understanding of goals, and coordinates activity as shown by the instance of the model below.

The findings describe structural developments related to the performance of a creative task, but the collaboration itself also requires a structure. Collaborations may require the formulation of roles, norms of communication and shared structures for productive interaction that co-ordinate activities and represent goals (John-Steiner 2000, Middup & Johnson 2007). The call and response and jamming strategies described in the previous chapter (section 4.2.5) provide practical examples of these kind of structures in a creative context.

From a social perspective, the sharing of tangible and conceptual structures is essential to shared understanding of the production of a creative outcome. Examples of this include the ability of an audience to understand the play of a guitarist in terms of their previous experiences of seeing guitarists (or playing guitar). A similar empathetic relationship with the audience is perhaps more difficult to achieve with novel, computer-based interfaces.

Figure 34: An Instance of the Model Representing Collaborative Structural and Productive Interactions

Figure 34 represents an instance of the model of structural interaction in which two collaborators develop structures together, and share tangible and conceptual structures. In many cases not all tangible structures are shared, as tools are required for different roles and actions, i.e. musicians play different instruments to fit their roles, and filming by participants in the filmmaking study.
was performed with different cameras. By sharing tangible and conceptual structures, or having shared understanding of these, the space in which each individual’s ideation and evaluation occurs become similar, leading to more coherent productive interactions. Similarly, shared understanding of internal structures develops when decision-making on ideas occurs together.

4.3.4.2: Domain

The socio-cultural model of creativity described in chapter 2.4: Human-Human Interaction and Creativity shows that much of the structure of a creative activity is based in the collected knowledge that forms a domain. These structures define the expected form of the outcome, and the type of tangible and conceptual structures that are normally used in the process of achieving such outcomes.

In any creative activity there will be domain-specific tangible and conceptual structures that remain static. Some of these provide primitives from which developed structures are built - for example, a writer might only use the English language or a musician only a specific software environment. There may also be areas where the domain does not provide scope for producing novel structures, or where such developments would go too far against the grain of accepted practice. A good example of this is the compositions by Partch — described in chapter 2.2: Human-Human Interaction and Creativity, in which he dismissed the conceptual structure of the 12-note octave and adopted a 42-tone alternative. Without the large resources with which to produce tangible structures (instruments) that could achieve this change, and musicians willing to explore and reuse these tangible structures until they reached competence with them, realising creative outcomes in this modified structure was not possible.

By considering the static structures that constrain a given creative context, we can differentiate and analyze the areas in which practitioners consciously explore and develop structures, and the underlying structures used to frame this exploration. Designers create systems that make use of these primitives and common structures as a basis for supporting productive interaction in a domain. The focus of a designer’s productive interaction is on producing the tangible structure within which another creative practitioner will work.

Where there are roles in a creative group, or interdisciplinary creativity, the scope for productive interaction in one domain often relies upon the use of structure produced by another. For example an animator may rely on the conceptual structure given by a scriptwriter for the basis for a character they develop a visual representation of. Cooperating between roles or domains is reliant on building a shared structure in which the constraints apparent to each domain practitioner are effectively shared.

The instance of the model shown below in figure 35 splits structure in terms of static and dynamic elements. In any instance of a creative activity, there will be structural elements that provide a static platform. These often reflect the
nature of the domain, as many structural elements will be seen as essential, or common, in producing an effective outcome in a domain. For example an essential conceptual structure accepted as static in the domain of musical composition would be that the outcome is in an audible form. A commonly static structure in western music is that the accepted 12 notes of the octave will be used. These notes may then provide a primitive structure upon which further dynamic structures are adopted and used, for example a scale.

![Figure 35: Model of Structural Interaction Showing Static and Dynamic Structures](image)

These distinctions can provide the basis for a theoretical consideration of the nature of structure in a domain or other contextual factor, for example in terms of what can or cannot be changed in an interface, or what is or isn’t changed over the course of an instance of a creative process. Distinguishing structures that are currently static and the reasons why they remain so could provide inspiration for designers to add scope for structural development.

4.3.4.3: Expertise

The findings on exploration and reuse suggest that the interactions of beginners in most cases pose questions of the form ‘can it do this?’, as in table 25. Internalisations of the affordances of a tool clearly change this to include more scope for effective, complex ideation. Turkle (2005) argues that many computer tools lack an algorithm that is transparent to users, causing an increase in the likelihood of these exploratory interactions that have little conceptual basis, or conflict with conceptual structures. Finding it difficult to relate conceptual structures that should bound production to tangible structures in complex interactive systems, users are even more likely to allow
the system to direct their process and choices, rather than defining conceptual goals and realising outcomes that fit them.

Figure describes some of the effects of increasing experience on the creative practitioner’s interactions with structure. These include increased skill in using structures to represent ideas and realise outcomes, increased understanding of structures that is utilised in developing structures, an increased skill in understanding the nature of internal structures in the domain, and the ability to use understanding of the affordances of the current structure to inform internal ideation and evaluation processes.

The expertise of a creative practitioner is an amalgamation of previous explorations of structure through productive interaction, along with other learning that provides information about these structures. This understanding, coupled with a reuse of the structure, results in a deeper understanding of the possible actions that can be performed. This builds upon the understanding of expertise informing ideation and evaluation processes from the previous chapter, resulting in more complex, better-focused ideas being externalised and developed.

![Figure 36: Model of Structural Interaction with Effects of Increased Experience](image)

Extensive development of structure is often the preserve of the experienced practitioner in a domain. This is both because developmental processes often require additional knowledge or skills (for example programming, or understanding the alternative tunings of a guitar), and because it is the experience of the practitioner that supports an understanding of how structural interactions will affect the space for productive interactions. Novices are likely to adopt common existing structures, whereas experts will have already
explored these and will be interested in the possibilities for structural interaction to provide scope for greater novelty.

The productive interactions of the novice are often ‘scaffolded’ by standardised structures that support learning and exploration of the basics of a domain (Dillon, 2004). In educational research scaffolding is an accepted practice where teachers create a supporting environment for a student to learn through action, with structure provided but removed as students develop the skills required to work independently (Wood & Wood, 1996). This notion is important to support for structural interaction, and in the design study, initial structures in the form of template instruments are provided that are supportive of immediate action, but open to manipulation and removal by users when they have built an understanding of the system.

4.3.5: Design Study: Music Builder

As discussed above and in chapter 2.4: Human Computer Interaction and Creativity, interactive systems provide a malleable platform for the development of tangible structures for creative tasks. Interfaces are a crossover, they are defined and have affordances, yet they are not subject to many of the physical constraints that restrict changes to these affordances. The links between end user development / tailoring and creativity are little explored, even less so with reference to collaboration. The design study used to develop understanding of structural interaction therefore analysed the interaction between collaborating users as they develop the structure with which they create. The developed system – named Music Builder – allows users to develop musical instruments and collaborate over compositions.

In the development of Music Builder, three design aims were identified, based on the understanding built of Structural and Productive interactions to this point, and the focus of Structural Development that appeared to be a key aspect of support:

1. Provide a support environment for collaborative musical composition.

2. Be inclusive through flexibility. Support individual needs in a collaborative context, and the development of shared representations of both ideas and structures.

3. Encourage the development of constraining structures as a central part of the creative process, without forcing users to become developers.

Music Builder supports the user development of screen-based musical instruments in a networked environment for collaborative composition. Tablet computers are used, as they form a flexible physical platform that holds some appealing qualities as a musical interface: Interaction using a pen is less restrictive than with a mouse or track pad, the direct mapping between the
elements displayed on screen, and the pen supports hand–eye coordination as can be seen in Figure 37.

Music Builder consists of three spaces corresponding to elements of the model presented. The three spaces are designed to support fluid movement between creating instruments (the Build Space), playing music (the Play Space), and developing compositions (the Compose Space). With reference to the model, the support provided by the system can be described as follows:

- **Build Space**: Supporting the production, adoption and dismissal of tangible structures.
- **Play Space**: Supporting productive interactions with the focus of iterations on playing instruments and making recordings.
- **Compose Space**: Supporting further productive interactions with a different focus of iteration (composing by combining recordings), and reflection on internal structures.

In the Build Space, shown in Figure 38, users can develop their own instruments in order to manipulate the tangible structures they use for productive interactions.
The underlying structure of the building interface focuses on the essential properties of musical instruments, defined as a means of gesture-based input mapped to a sonic output (Hunt et al, 2000). Instruments are developed by adding interaction shapes to a free-form space, and defining how interactions with each shape (such as pressing, holding, or dragging) map to output values for sonic properties, such as pitch, volume, or voice.

Users link shapes to sound sources, which receive output values from the shapes, add these values to their initial settings, and produce sound. Figure 39 depicts the way in which shapes and sound sources are linked to form an instrument. To support informal representation, users can also draw anywhere on the screen, using the space as a sketchpad.

In designing a system through which users can create instruments, a trade-off is apparent: Complex environments usually involve a considerable learning process and rarely support immediate engagement with ideas, whereas simplification enforces additional static constraints on possible actions, for example, by limiting the range of functions and options available. We wished to reduce constraints by supporting the production of structure, without creating difficulties for new users. To achieve this, the metaphor of scaffolding was used as a focus in the design process.

The scaffolding in the prototype takes the form of seven template instruments, provided to engage users immediately and to make visible some of the possibilities of instrument building. These represent a cross-section of possible interaction styles and sounds, including a drum kit, a piano, and a
Theremin-style instrument where the pitch and volume vary with proximity of the pen to a shape.

**Figure 39: Building Blocks for Instruments: Sound Sources and Interaction Shapes**

These instruments can then be used to play and record musical ideas in the play space, shown in Figure 40. The system allows users to record instrument play individually or simultaneously from multiple machines. This process lets users collaborate through a variety of different structures - for example, by developing ideas individually then sharing them, or by jamming together and recording the outcome.

**Figure 40: Play Space**
Recordings made in the play space can then be replayed, combined and manipulated collaboratively in the composition space, shown in Figure 41. This supports the evaluation of ideas, with reflection upon internal structures, during composition development. To support collaborative composition using these recordings, the prototype provides a shared, networked space, based on the Sonic Sketchpad software developed to understand productive interaction. This version employs the same notion of a library of recordings and a paper-like space for composition where users can freely manipulate, arrange, and link recordings and add annotations, avoiding excess constraints on the representation of ideas.

4.3.5.1: Evaluations
An initial pilot evaluation was performed with participant A from the Sonic Sketchpad evaluations (see table 21 in section 4.2.5.2). Minor interface problems and bugs were identified through this. Once modifications had been made to deal with these, 12 participants took part in the main evaluation in six collaborating pairs. Musical experience was varied, in keeping with our notion of support for a wide range of users. Full details of the participants are included in table 29. They included a pianist with 17 years of musical experience, a guitarist and a drummer both having more than 10 years of experience, and a computer musician with 4 years of experience using the software environments Cubase and Reason. At the other extreme, several of the participants had only limited musical education, mainly from school lessons. Collaborators were in some cases unknown to each other but were generally friends who took part together.
Table 26: Participants in the Evaluations of Music Builder

<table>
<thead>
<tr>
<th>Participant</th>
<th>Involvement</th>
<th>Relevant Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1st Pair</td>
<td>Playing guitar for 14 years. Percussion, vocals and guitar in various bands for past 5 years. Some experience of Cubase and sampling as a basis for composition.</td>
</tr>
<tr>
<td>B</td>
<td>1st Pair</td>
<td>Very little experience of creating music.</td>
</tr>
<tr>
<td>C</td>
<td>2nd Pair</td>
<td>5 years of computer-based composition experience. Including Acid Pro, Cubase, Ableton Live and Reactor.</td>
</tr>
<tr>
<td>D</td>
<td>2nd Pair</td>
<td>Played drums for 3 years, bass for 3 years, guitar for 7 years. In bands, and also experience of using computer software such as Ableton Live.</td>
</tr>
<tr>
<td>E</td>
<td>3rd Pair</td>
<td>Some experiments with Garageband, keyboard lessons at school.</td>
</tr>
<tr>
<td>F</td>
<td>3rd Pair</td>
<td>Some bass guitar experience.</td>
</tr>
<tr>
<td>G</td>
<td>4th Pair</td>
<td>2 years playing the clarinet, some experience of piano.</td>
</tr>
<tr>
<td>H</td>
<td>4th Pair</td>
<td>4 years playing the piano. Sang in a choir for a year</td>
</tr>
<tr>
<td>I</td>
<td>5th Pair</td>
<td>13 years playing the piano. GCSE in music.</td>
</tr>
<tr>
<td>J</td>
<td>5th Pair</td>
<td>Brass instruments in primary school, Saxophone at secondary school, some self-taught guitar.</td>
</tr>
<tr>
<td>K</td>
<td>6th Pair</td>
<td>Played drums for 10 years, performed gigs in pubs / school. Has experimented with Cubase, and electronic drum kits.</td>
</tr>
<tr>
<td>L</td>
<td>6th Pair</td>
<td>17 years of piano, 9 years of guitar, 6/7 years of violin. Has used software including Cakewalk and Rave.</td>
</tr>
</tbody>
</table>

The studies took place in a usability lab, where screen-capture devices and cameras provided a video record. The software logged actions to provide an accurate picture of users interaction with Music Builder. Participants filled in questionnaires after each session and a final exit questionnaire.

The importance of reuse and exploration of structures for productive interaction is clear from the findings reported earlier in this chapter. As such, the evaluations involved the repeated performance of a composition task, so that the development of experience could be observed. As another aim was to explore requirements for the design of systems to support collaborative structural development, these multiple evaluations of the system were used to examine the utility of shared visual and physical space to collaboration. Participants used the system under the following three conditions in a within-participants design, balanced as a Latin Square:

1. Users co-located in the same physical space.
2. A partition separating users, with a display repeating their collaborator’s screen.
3. Users sat either side of a partition without shared screens.
Participants could talk freely and hear audio output from a shared set of speakers across the conditions. The context for the evaluations is shown in figure 42. Images of the evaluation conditions are shown in figure 43.

Figure 42: Setting for Evaluations of Music Builder, including Screen Sharing Monitors

Figure 43: Evaluations of Music Builder in Condition 1 (above) and 2 (below)
A written tutorial was provided, walking users through the features of the environment. Participants were then asked to use the environment to produce a short composition they were happy with under each condition, with the system wiped and restarted after each composition was finished. No time limits were applied.

4.3.5.1.1: Analysis of Evaluations

In analysing use of the prototype, the aim was to learn if, why, and how musicians would develop instruments in order to understand how interaction with these malleable tangible structures occurred. Evidence was gathered related to the validity and effects of support for an end user development approach, and the utility of the scaffolding template instruments, and the screen sharing, as functionality to support effective structural development. A further aim was to relate our model to observations of interaction between creators and a software environment.

Users spent between 1½ and 3 hr creating the three compositions. In many cases users were still exploring new and interesting ways to interact with sound throughout this time, and opinions of the instrument development concept were generally very positive, particularly among participants with a previous interest in computer music. Participant C described Music Builder as “A very original approach to computer-based music”.

The Transana environment was again used to analyse a sample of the evaluations. The final sessions of composition by two of the pairs (1 and 6) were transcribed and coded using the system. This coding process utilised the existing concepts of Productive Interaction, and helped to define and refine the concepts in the Structural Interaction perspective. Keyword sequence maps from these sessions are shown below in figures 44 and 45.

Figure 44: Keyword Sequence Map from Music Builder Evaluation (Pair 1, Session 3)
Over the following sections, excerpts from the data and analysis are presented thematically.

**Development of Tangible Structure:**
The data collected from the evaluations included system logs that provided an accurate record of the use of system functionality in each session (e.g. making a recording, modify a sound source etc). Figure 46 shows an example of the output of these logs in graph form. Graphs for each session are included in appendix 6.5.1.2.

The logs were used to analyse how participants had made use of the functionality provided in the prototype. In particular, they were used to distinguish instrument-building activity from playing and composing (as in figure 46). Of the 12 participants, 8 made use of instrument building in at least one of the conditions, whereas the remaining 4 used the template instruments throughout. As each participant used the system three times, there were 36 sessions. Each session was categorised in to one of four use types based on their use of instrument building and composition functionality over time:
• **Multiple Instrument Edits:** Users cycled between instrument development and play/composition (as in figure 46)

• **Multiple Templates:** Users changed templates between periods of play and composition but did not develop instruments.

• **Single Instrument Builder:** Users developed an instrument initially which they used to play/compose without further editing.

• **Single Template:** A single template was used throughout the session.

Instrument development occurred in the majority of sessions, and in almost all of these cases instruments and musical ideas were developed in cycles. The statistics presented in Figure 47 provide evidence of user interest in the development of instruments and that it is common for periods of structural development (instrument building) to occur in periods where users break away from cycles of productive interactions (play and composition). This provides evidence for the validity of the way that the model represents the relationships between productive and structural interactions.

![Figure 47: Frequency of Each Type of Use across the 36 Music Builder Evaluation Sessions](image-url)

**Figure 47: Frequency of Each Type of Use across the 36 Music Builder Evaluation Sessions**

As stated in the section on domain-specific contextual factors earlier in this chapter, the development of instruments can be seen as productive interaction in the domain of design, to develop a tangible structure in which productive interaction in a musical domain will occur. The evaluation of the instruments produced is based on its fit for the purpose of realising the conception of the outcome. Participants used the ability to develop tangible structures as a basis for defining and realising conceptual structures. A common example was the rearrangement and removal of notes on an instrument, either to constrain play to a specific scale or alternatively to constrain the instrument to allow only the notes in a musical phrase to be...
played. The ability to manipulate instruments also supported user innovation to overcome difficulties in achieving complex goals: Participant K – a highly experienced drummer - linked shapes to multiple drum Sound Sources, enabling him to play two or more drums with each tap. Through this he developed complex drum patterns, overcoming the limiting effect of single-handed input. Again, this reflects a translation of his existing knowledge into the development of tangible structures (transcribed in appendix 6.5.1.3.2).

Opinions of the instrument building concept and interface were positive, although it was those with a musical background who appreciated it more. For example participant A stated that the instrument building was “a great idea, and much simpler to do than I imagined it would be.” In contrast, his collaborator, with little musical experience, stated that “I had difficulty building instruments but this was more from a lack of music knowledge. It was easier when collaborating with someone who had more of an idea about music.” Participant F also stated that making your own instruments was “not very appealing because you had to specify a lot of things that I (non-musical) didn’t understand fully (e.g. Pitch)”. It is clear that, through support for common primitives in the domain of music, the experience of participant A could be translated into a useful background for building instruments. For participant B, collaboration with A led to more complex use of the system than would otherwise be feasible. Participant F also lacked a musical background, and his collaborator was not experienced enough to provide guidance. The excerpt below in figure 27 shows an example of this kind of leadership and guidance in instrument development.

The design of each other’s instruments was a common theme of the dialogue between collaborators. Instrument design not only affects the group’s musical capabilities but also provides a platform through which roles and intentions are explained. Qualitative analysis of approaches to development suggests that sharing tangible constraints was a successful strategy for coordinating collaborative play. Extended discussions of tonal properties and instrument structure were common. In one session a user asked if he could pass his instrument over to his collaborator. Unfortunately this was not supported here, but it could provide an interesting extension.

In the short term, the collaborative development of instruments with shared constraints provides a basis through which collaborators negotiate conceptual and tangible constraints for the intended composition. Further, instruments could evolve as tangible constraint structures passed over networks as formal social constructions for musical creativity. The excerpt shown in table 30 gives an example of collaborative development behaviour. By describing the instrument as it is built and identifying a shared concept to realise, the collaborators produce complementary instruments through which coordinated ideation is effectively constrained.
P1 and P2 discuss how to proceed

I: “Ah, shall I make a jazz scale keyboard?”
J: “Yeah go on then”
I: “Do you know jazz scale?”
J: “Um, not really, tell me the notes”
I: “OK hang on I’ll load up the piano and ...”
I and J both load the piano template
I: “That’s A, D, C ... so we need to get rid of that one”
I removes several keys from the piano, J looks at the shared screen and removes the same keys
I: (looks at Js actions on the shared screen) “Yeah, look at the screen, you can see what I’m doing”
J plays the new keyboard, I puts the notes in order across the screen, J copies this action.
I: “I think we need two octaves of these (keys)”
I and J add a second set of keys an octave higher.

Table 27: Excerpt from the Music Builder Evaluations (5th Pair)

Three reasons for the success of this behaviour are suggested here: Firstly, the externalisation of conceptual structure focuses effort on working within known constraints, rather than developing ideas solely through notions which collaborators may define differently. Secondly, shared tangible structures make a collaborator’s actions more predictable and provide a form of awareness information, narrowing the possible actions a collaborator could take and increasing the likelihood of coherent collaborative play. Finally, by restricting the instrument to notes that fit within a structure such as a scale, there is no longer the need to use cognitive resources to evaluate whether the desired constraint is being fulfilled, as it is impossible for it not to be so. These resources can instead be used to evaluate the validity of ideas in terms of conceptual constraints, to attend to a collaborator, or to generate further ideas.

**Scaffolding and Exploration through Productive Interaction:**

In 30 of the sessions, the participant’s first action was to load a template instrument, whereas in the remaining 6 sessions it was to build an instrument on a blank canvas. Once an initial structure was in place, cycles of productive interaction occurred to explore the structure, followed by further structural developments in most cases (see figure 47). Through the observations it could be identified that scaffolding fulfilled multiple user needs: Providing a starting point for instrument development, a basis for exploring the possibilities that exist in the environment, and an immediate ‘pick up and play’ structure.

The template instruments can therefore be seen as tangible structures that can be easily adopted or dismissed, but there is also scope for them to provide scaffolding for the production of structure. Users generally focused on manipulating sonic constraints such as the range of notes or voices, rather than exploring the various forms of interaction available, and the templates provided an existing structure for interaction from which these sonic properties could be quickly modified and tested, while experience from previous use could be applied because there was a consistency in the interaction required to play the instrument.
Visibility in Developing Tangible Structures

Figure 48 shows the mean of responses to three of the closed questions posed to the participants after each condition was performed. (“It was easy to communicate ideas to the other person”, “We understood what each other was doing throughout the task”, and “We made decisions together”). Whilst co-located use achieved the most agreement in response to all three questions, the screen-sharing condition performed well, and was a clear improvement over the condition without it provided. The full set of questions and response data is included in appendix 6.5.1.

![Figure 48: Mean of Responses to Questions 4, 5 and 6 by Condition (1 = Strongly Disagree, 5 = Strongly Agree)](image)

The excerpt in table 30 also shows the value of shared visibility as a basis for explanation of concepts. Collaborative developers used the shared screen when provided as a means to understand each other’s instruments, and responses to open questions provided further evidence for the value of being able to view and compare instrument developments. Further support for this process could focus on allowing collaborators to better “read” their collaborator’s instrument by making more details of instrument properties visible.

4.3.6: Designing Support for Structural Interaction

Structural interaction forms an important perspective through which to view the design of environments for creative tasks. Designers create structures within which creative activities occur, but users will adopt, dismiss and, where possible, produce further structures using them. This should be taken into account in the design of any interactive system for creative activities.
A virtual environment can often be far more malleable than a physical one, as Music Builder highlights. Therefore, the designers of interactive systems can provide scope for creative users to develop structures themselves in ways not seen in other tools. However, limitations can form useful points of reference, setting fixed structures within which creative work occurs and is understood. The interface defines a tangible constraint structure that is to some degree comparable to the physical constraints of a non-computerized environment, as the properties of the interface define the scope of possible actions. The theoretical understanding developed here suggests that it should aid users to be aware of the constraints imposed upon them by tangible structures, and to be empowered to manipulate these where feasible. The primitive building blocks provided, with which the user can produce structure in the environment, then define the static structures that constrain the user.

It is also common for environments for creative tasks to support the capture and representation of ideas. Across domains, composition requires an understanding of the internal structures inherent in the combination of ideas expected to form the outcome. As the computer understands elements of user’s ideas in more detail, it becomes more of a partner in the process by providing useful feedback and a powerful interface for manipulation, but this requires a formal structure that enforces specific processes and restricts possible forms of representation. Environments for musical composition in particular provide only a fixed set of unambiguous representations through which users can define, evaluate, and combine ideas, allowing the computer to interpret them and produce music. In contrast, composition with paper and standard instruments supports ambiguous representation and an ad-hoc process of formalization as musicians interpret, play, and develop compositions based on the representations (Coughlan, 2004).

In summation, relationships between designers and users need reassessment in light of two issues. First, computers structure creative processes to a far greater extent than other tools and demand greater formality from users. Second, computers can conceivably empower users to explore constraints and to develop and exchange not only ideas but also structures for creativity. There is great value in the artist–technologist collaboration (Edmonds et al., 2005), as creative practitioners can be stifled in explorations of technology by a lack of technical skill. Beyond these situations, designers should aim to free end users to perform more structural interactions without extensive technical expertise as a basis for novelty, but include in this a notion that the sharing of structure between practitioners is in many cases essential to producing realistic creative contributions.

4.3.6.1: Findings from the Design and Evaluation of Music Builder
Music Builder highlights the suitability of end user development approaches to environments for creative tasks. Supporting the production of tangible structures has several important benefits: Analysis of the observations suggested that a strategy of collaborative instrument development promotes
awareness and synergy and provides a structure within which successful collaborative play was significantly easier. When possible, the movement from conceptual constraints toward tangible structures promotes the formalization and evaluation of concepts as individuals and between collaborators. Creative tasks involve the realization of ideas fulfilling a set of constraints that often begin as ambiguous or intangible concepts. The user development of the environment can support the representation of these and allow new forms of reflection.

In addition, these systems can reduce the constraining influence of the designer on the user by supporting the modification of the environment. There were multiple occasions where users created instruments with properties that we as designers would never have considered ourselves, providing a valuable source of innovation and a reduction of barriers to realizing ideas. Support for the development of structure through easy adoption and dismissal or production can also overcome many of the contextual factors to provide scope for systems that support generic processes across a range of expertise, interpersonal contexts or domains. This can be important in providing for interdisciplinary interaction, or simply producing a system that can be utilised by a large audience of users.

4.3.6.2: Understanding Contextual Factors in the Design Process

As in the previous chapter, the following questions have been developed as distillations of the findings on structural interaction with reference to contextual factors (particularly the issues raised in section 4.3.4). These are for use by designers in understanding how these factors relate to the generic model of structural interaction:

A. What Conceptual and Tangible structures are commonly found in the domain?
B. How are the central Conceptual Structures represented?
C. What are the primitive concepts that underpin structures in the domain?

An understanding of the forms of structure is essential to designing for a specific domain. The symbolic representation of conceptual structures, and the primitive concepts that underpin both tangible and conceptual structures need to be inherent in the design.

D. What relationships are there between Tangible and Conceptual Structures in the domain?
E. How can users be guided, or reflect on the ramifications as they choose to adopt, dismiss or produce structures?

Tangible structures are used to represent ideas that relate to the adopted conceptual structures. The process through which this occurs needs to be
understood. In addition, users should be able to reflect on the changes they make to structures, and the guidance needed is specific to the context. This could reflect the relationship between tangible and conceptual structures, or wider socio-cultural issues (e.g. what exists in the domain and is accepted by the field)

F. What understanding of the structures used in Productive Interaction should be visible to the prospective audience of the creative outcomes produced?

G. What structures can be shared and what visibility is necessary to support collaborative development?

Structural Interactions play an important role in interpersonal processes. For an audience, some empathy with the structures used is often required, but this will reflect the particular context. In collaboration, shared development of structure is essential, and can be supported in novel ways by interactive systems, such as the development of instruments in Music Builder.

H. How can the exploration and reuse of structures occur effectively so that expertise develops across a range of structures?

Continuity is key to the development of expertise – affordances are understood and conceptual spaces mapped, leading to an effective internalisation of structures that improves ideation and evaluation processes. This however, is in tension with the need to develop novel structures in order to produce novel outcomes.

4.3.6.3: Requirements

As in the previous chapter, a set of generic requirements for systems to support creative activities is presented as a distillation of the findings

1) Support the development of tangible structures, utilising the primitives that are common to the domain as building blocks. This should provide a basis to give tangible form to conceptual structures, and therefore realise ideas based on conceptual goals. This requirement is mainly based on the findings of the Music Builder evaluations, where such development was supported and positively received.

2) Provide scaffolding to support the immediate use and exploration of the environment: Creativity support environments need structure, but structure that can be pulled apart by users at will. However the consistent availability of initial structures to adopt and explore provided inspiration and was preferred to building from a blank screen. The “tyranny of choice” identified by Haworth et al (2005) and described in chapter 2.4: Human-Computer Interaction and Creativity arises through a lack of available structure, and making tangible constraints in the environment flexible may compound these problems. This
was not apparent with Music Builder because the templates offered the required initial structure.

3) Support the sharing of developed structures and the visibility of actions in structural development: The shared screen afforded users the ability to see collaborator’s actions, aiding the communication of tangible constraints; however, alternative designs for these interactions may be more appropriate. The possibilities for sharing a single space are interesting but could be detrimental to the independence of users. Passing instruments or other constraining structures between collaborators and across networks could provide a better model for user development in creative tasks. Developed instruments form important representations of user’s intentions, so the ability to read properties of each other’s instrument and gesture toward elements in the space is key to communication.

4) Support fluid movement between productive and structural interactions: The development of structure does not occur only as an initial stage of the creative process. It is in general a reaction to the evaluation of represented ideas. As such environments should fluidly integrate the representation of ideas and of constraints and allow users to explore the interdependence of the two. Music Builder provides an example of the rich design space for software integrating the representation of ideas with the production of structures to support both engagement and reflection in creative tasks. Allowing users to easily move between production and structural interaction can improve their ability to reflect on their creative process and this reflection can encourage more creative thinking, as well as support discussion, sharing and coordination in creative collaborations. The ability to create instruments allowed users to turn the conceptual structures they had adopted in to tangible structures, as shown in the excerpt in table 30.

5) The adoption and dismissal of structures is another aspect of structural interaction that can be designed for effectively or poorly. Standardised file formats, plug-ins or similar approaches are examples of means that can allow creative users to move seamlessly between adopting a range of software structures. Through this, users are not drawn in to the fixation of needing to use a specific structure that has been adopted, but may be found to be ill-fitting to conceptual goals at a later point. This was particularly apparent in the filmmaking study, where problems with video formats and editing software were apparent in both groups, leading to changes in their conception of the outcome. (See descriptions in 3.2.2.3, and transcriptions and exit questionnaires in appendix 6.4).

4.3.7: Conclusions

From the structural interaction perspective, creative processes can be viewed as the definition of concepts, and the development of the tangible structures needed to represent ideas and realise outcomes that fit these concepts. As ideas are accepted to form part of the conception of the outcome, internal structures emerge that further constrain the space in which new ideas will fit.
The empirical studies led to a model in which the development of structure, or changes to the conception of the outcome, are processes that occur in structural interaction. The Music Builder design and evaluation study explored support for the development of tangible structure, this was found to be valuable to experienced users. Scaffolding the system with existing structures build from primitives, that could be manipulated or used immediately, satisfied novices and provided a basis for development by more musically experienced users.

Taken together, the perspectives of productive and structural interaction form a detailed model of the production of a creative outcome and the context in which this occurs. However, they define – but do not fully explain - notions that cross instances of creative interaction, such as the reuse of structures and experience. They also do not explain some very basic questions relating to creative interaction and its support. For example: Where do ideas come from? And how are collaborations or other relationships that support productive and structural interactions formed? The need to consider these questions in order to understand creative interaction holistically led to the establishment of a third perspective – Longitudinal interaction – which is the topic of the next chapter.
4.4: Longitudinal Interaction

“They could never be forced to work, yet they were never truly not at work”
Richard Florida (2002)

4.4.1: Definition and Scope
Longitudinal interaction encompasses the actions of creative practitioners that are not specific to the completion of a single instance of a creative task, but are nevertheless essential to the development of potential to be creative in these instances. Longitudinal Interaction is defined in this thesis as:

*The development of a platform from which creativity can occur, beyond focused effort on a specific creative task, but considering the activities that increase the potential of the person, group or society to be creative in these instances.*

The perceived need to study support for creativity at this level arose from a number of observations made as the research progressed. The observational studies and evaluations of Sonic Sketchpad and Music Builder presented numerous occasions where it was evident that the skills, experiences and relationships brought in to the situation were highly influential in the interactions and the resulting outcomes. It was also apparent that a study of a single, bounded task in the filmmaking study provoked behaviours in contrast to the naturalistic studies of musical composition. An expectation that the filmmaking participants would make use of a Smartphone to capture ideas ubiquitously was not fulfilled, mainly because they were only focused on completing that one particular task in conjunction with the Smartphone, whereas in a natural setting practitioners are interested in ideas and inspirations that could be of possible use in future tasks. The value of ideas and structures is highly dependent on the context of their use, therefore retention and development often occur over long periods of time.

An inspiration to the development of this perspective is the work of Florida (2002), John-Steiner (1997, 2000), Becker (1982) and Gelernter (1994), all of whom have studied creative practitioners through a holistic exploration of their lives, exploring the intrapersonal and interpersonal actions of creative practitioners over the long term. Through reference to the review of these works in chapters 2.1 and 2.2, a creative lifestyle can be identified with general themes that pervade varied personalities. In this chapter, this understanding is developed with reference to the interaction of a creative person with their environment and with others.

4.4.2: Findings from the Empirical Studies
It is difficult to observe longitudinal interactions holistically due to the lengthy nature of the processes. Therefore this chapter draws extensively on the
questionnaire study and the participatory task modelling and design sessions, as these are suited to eliciting data on aspects of creativity external to focused task instances. The questionnaire study covered aspects of creative practice in the long-term, directed by literature and the need to clarify phenomena - such as the long-term retention and revisiting of ideas - that was apparent, but not fully observable in the other studies. The participatory design and task modelling sessions also shed light on aspects of composing music that were distinct from a specific instance of the task. The observational studies are also used where appropriate – when longitudinal aspects visibly influence or result from the productive and structural interactions that occur.

In the process of studying creativity from a longitudinal perspective, a range of relevant processes became apparent. For the purposes of this thesis these were found to be best categorised as ‘Intrapersonal’ – experiences, learning and low focus bisociation, ‘Representational’ – involving the retention, and organisation of ideas, structures and inspirational materials, and ‘Interpersonal’ – the building of collaborative and supportive relationships, the sharing of ideas and involvement with the development of domains or other platforms for social creativity.

4.4.2.1: Intrapersonal

A starting point for building an understanding of intrapersonal interactions is Simonton (1989), Gelernter (1994) and Florida’s (2002) research. As described in chapter 2.1: Understanding Creativity and Creative Processes, Simonton and Gelernter focus on the mental processes that give rise to creative thinking, whereas Florida focuses on the sociology and geographic distribution of the ‘creative class’, a topic that will be considered further in the section on Interpersonal interactions. For this section it is enough to note that he argues that creative people are drawn to environments that offer diverse experiences as a platform for inspiration. Gelernter develops a theoretical understanding that can be used to extend this, arguing that experiences provide items in memory that are associated in the mind as the basis for ideation. Simonton’s Chance Configuration Theory also suggest that mental permutations of items are the starting point for creativity, and that a degree of chance is inherent in successful ideation. In both cases, ideation is seen as a complex process in which the items from which novelty arises are often unclear, but experiences also support more direct forms of inspiration, as the following Open Questionnaire Study response shows:

Top of the Empire State Building in New York...looking down from the top at the patterns of the buildings...thought about an image printed onto fabric like a patchwork of colour. Took photographs and made notes later in a sketchbook. This became a digitally printed textile artwork. (Response 1, Question 5)

7 respondents related similar experiences of ideas occurring due to stimuli in the environment (see table 9 in section 4.1.3), and it is clear from the excerpt above that such intrapersonal experiences often require some form of representation of the experience to be retained. Whilst there are parallels with the productive interaction process, an important distinction is made in that
many cases of ideation occur in a context where there is no notion of actually producing a related outcome at the time that the idea occurs. Often there is no specific plan to produce anything, only that the idea or inspiration is interesting and worth keeping in some way for future use. This is where Gelernter (1994) argues that emotion and physiology play an essential role in the creative process: An emotional response of some sort is required for ideas to be identified as interesting, as they occur where the mind is in an unfocused state. The attachment is due to a previous interest in the problem, as represented by the preparation stage in Wallas’s (1926) model of the creative process, however, Gelernter argues that the mental state in which associative thinking, and therefore effective ideation, occurs in are commonly brought on by activities that relax the person, or by tiredness, represented by the incubation and illumination stages of Wallas’s model. Along with experiences that influence creative activities, ideation often occurs outside of focused productive interaction, due to the ability of the mind to form more novel associations when in unfocused states.

An interesting facet of this is whether the process is actively guided and expected – i.e. an idea was intentionally shared between two parties, information is searched for online, or an artist travels to a specific place to experience it - or passive – experienced in the course of other activities, for example through the ‘cocktail party effect’ (Arons, 1992), or a serendipitous encounter, where no relevant issue was being specifically sought out. Reflecting on the design of interactive systems, where goals and tasks are a commonly applied conceptual framework, the focus seems firmly on the active side of this distinction. Some relevant concepts exist in HCI however, such as passive awareness mechanisms in CSCW systems (e.g. Dourish & Bellotti, 1992), and ambient computing (e.g. Mankoff, 2003).

Together with Gelernter’s (1994) description of low-focus thought, passive experiences are a key area of ideation that raises complex issues for creative interaction design. The occurrence of ideas away from focused creative activities was familiar to 26 of the 27 respondents to the open questionnaire study (see table 9 in section 4.1.3), and they related interesting details of their personal experiences:

“Virtually no creative flashes occur while looking at any organized form of the material. A walk, a shower, sitting on the toilet, washing dishes; enforced mental idleness promotes the waking dream.” (Response 22, Question 4)

Another respondent describes similar experiences, and also shows that this ideation often requires some form of retention activity through representation, which will be discussed in the next section:

“it’s an endless stream. All times, any place. My favourite time is when I lay in bed and reach that state just before falling asleep. It’s when my imagination is most lucid and my mind is beginning to review the experiences of the day. During these times, I pop myself out of bed and quickly record the thought. I am constantly seeking or always open to “good ideas” for painting, writing, music, etc.” (Response 26, Question 4)
Following the research of Koestler (1964) and Gelernter (1994), the concept of ‘Bisociation’ is used to describe this combination of items in memory to produce novel ideas away from focused creative practice. It was this phenomenon that provoked the provision of Smartphones to the participants in the Filmmaking study. However, the complexity of the issue was highlighted in the finding that these were not well used. Through analysis of the study, this can be attributed to two causes. Firstly, the devices were bulky and therefore participants were unwilling to carry them ubiquitously (See exit questionnaire responses in appendix 6.4.3.2). Secondly, as the devices were provided while participants produced a single creative outcome, rather than over a longer period, the longitudinal processes of collecting ideas that were not related to a current project did not arise. The effort needed to adopt and understand the use of the device did not meet the value of it, given that it was only available for a three-week period.

A final intrapersonal process central to creative activities is learning. This has been discussed in previous chapters in relation to the contextual factor of expertise. Throughout the observational studies, the expertise, or lack thereof, of participants is an obvious factor in the approaches taken and the outcomes produced. From a longitudinal perspective, this topic can be seen as a developmental process, rather than a single context in which a creative task is performed. This is useful as the influences on this development can be considered, including direct productive and structural experiences, teaching, and inspiration from interaction or observation of other practitioners. As with other longitudinal interactions, learning processes are harder to observe, but their effects are clearly apparent in the use of previous experiences in the observational studies, and the notion of utilising ‘influences / musical knowledge’ in Participatory Task Model B (See appendix 6.2.2).

From the previous chapters, the ability to internally evaluate ideas in productive interaction, and the experience drawn from, and utilised in, the exploration and reuse of structures, are considered from this perspective as influences on subsequent instances of productive and structural interaction. In this way, an understanding of the development of a creative practitioner is provided to inform the design of interactive systems.

From the above discussion, three intrapersonal processes that are central to longitudinal interactions are ‘Experiencing’, ‘Learning’ and ‘Bisociation’. Experiences and learning can occur through interactive systems, and while Bisociation is seen as an internal process, the utilisation of the ideas that arise from it generally requires some form of representational process, discussed in the next section.
and adopted tools with which to represent ideas and collect inspirational materials away from the environment in which creative activities normally occurred, as the following response to question 5 shows:

“Usually when travelling or at a concert. Write it down at the earliest opportunity. At concerts usually have paper” (Response 15, Question 5)

9 of the 27 respondents to the open questionnaire study worried about the potential loss of ideas and felt they had forgotten good ideas in the past, while a further 8 stated that the appearance of ideas - whilst important to their practice - did not require immediate representation and that a further level of mental distillation was important (see table 9 in section 4.1.3.3, and appendix 6.1.1). The following quotes are exemplary of these contrasting positions:

“Once or twice I’ve been caught out (say, on a walk) without my notebook. When this happens, generally I try to just keep repeating it in my head and bolt home as quickly as possible to write it down. Can be tricky though - I’ve totally lost whole chunks of music because somebody talked to me when I was trying to do this” (Response 12, Question 5)

“I have so many ideas all the time that most get forgotten. The ones that you work with are the ones that recur or contain special meaning” (Response 1, Question 6)

26 of the 27 respondents to the questionnaires study described some use of paper and pen in the representation of ideas and inspirational materials. Cameras and audio recorders were the second most frequently used devices, mentioned by 9 participants in each case. Mobile technology use was comparatively low, with only 5 respondents mentioning use of a mobile phone as a representational device and 3 using a PDA. Computers formed various parts of the creative practice of 21 of the participants (see table 9, section 4.1.3).

Although it is not a universal practice, the diligent collection of all interesting ideas and inspirations results in valued resources for many practitioners. In order that valuable ideas were not forgotten wherever they occurred, 12 respondents related that they carried a device with them ubiquitously (table 9, section 4.1.3).

A distinction can be drawn between the capture of inspirational materials from the environment, and the development of representations of ideas that occur through Bisociation. These clearly affect the type of tools used, although in many cases, it was clear that both forms of resources are collected and retained by practitioners. A further point to make is that along with these retained resources, the outcomes of previous productive and structural interactions can be retained as a useful resource for review in the future. Participatory Task Model B includes the sequence “Don’t forget it, write it down” followed by “Come back to it” (see appendix 6.2.2). The participants who produced this model stated during the session that computers can be helpful to this process as they are effective in recording their musical ideas, and that once made on a computer, these representations are less likely to be lost or degrade.
A further aspect of this retention process is how the idea can be captured effectively, a common need being the ability to capture the essence of the idea through its representation, and to provide a trigger for memory to later bring the idea or inspiration effectively back in to the person’s consciousness:

“I have learned to ALWAYS record my ideas one way or the other WHEN THEY OCCUR. Regardless of good, bad, big small, waiting a minute, an hour, day or more is VERY risky because I can "lose" the original feeling of the idea. The value of the idea can be judged later but don't stifle it. It's important to note that the recording (sketch, drawing, writing, whatever) is very rough and more about the feeling and concept than it is the imagery or precise words, etc.” (Response 26, Question 6)

“The inspirational material acts as a trigger for memory and enables ideas to be synthesised.” (Response 1, Question 3)

While individual approaches to using retained ideas and inspirational materials vary, the organisation of representations is a further common theme, as the following quote shows:

“I accumulate … dramatic events; impactful images, described in words. Unsequenced as to story. Article clippings and downloads … over an indefinite period, sometimes as much as a year, or several, allowing for rewrites. I then shuffle and cull to create a storyline.” (Response 22, Question 3)

This highlights a link with productive interaction where these ideas may eventually be used, which should be considered in the design of interactive systems for creative interaction. In participatory task model A, a “library / scrapbook of sounds” that is “in head or on computer” is drawn upon for “elements of music / sounds” when productive interactions occur (see appendix 6.2.2). It is clear that the availability of these materials as a resource for productive interaction requires that despite the distinction drawn between longitudinal interpersonal and representational processes and productive interaction, links need to exist between systems for both purposes. This integration is a theme of the design study in this chapter.

The link between the retention of this material and its use generally requires some form of organisational process to occur, such as the “shuffle and cull” described above. The following quotes are further responses to question 3, which asked respondents how they integrated tools for representing ideas and inspirational material with their work:

“I haven’t got very smooth integration systems. Generally it's a collect and collate system, and I'll work on one project for a bit, and then another, and then back to an old one. I'll look through notes and notebook on the bus and in spare time and see what happens.” (Response 7, Question 3)

This quote shows the complexity of representational processes, as multiple projects exist, developed over long periods of time, and that further mental distillation occurs through review of collected representations. The following quote from a researcher shows how interactive systems can form effective support tools for these processes.
"I try to use OneNote as my main space for storing ideas in the longer term as I can easily rearrange, annotate and formalise them. For example, images I have seen on the web can be pasted into a report, or emailed directly to other people. The other paper-based tools are generally for doing 'working out' and might only be retained a few days or even minutes. For example, a post-it note will only be retained until I have acted on the idea. If I think it might be important for the future I put it in OneNote to retain." (Response 6, Question 3)

In the above quote, there is a distinction between materials that need to be retained and organised for later use, for which Microsoft’s OneNote provides effective support, and paper-based tools used for short lived, working out, which can be considered part of productive interaction. The utility of OneNote is due to the ability to integrate these materials, which have been retained and organised (“rearrange, annotate and formalise them”) as part of longitudinal processes, with productive interactions (“can be pasted in to a report…”).

A clear implication of the need to organise large collections of material, arising from multiple sources, is one of information overload, and – given that the value of these materials is dependent on the context of their use – of making sure that relevant material is apparent when it could be valuable. 6 respondents to the open questionnaire study reported using more than 4 separate devices in response to question 1, reflecting their desire to capture and represent in different modalities and the varied availability of devices as ideas occurred (see table 9, section 4.1.3). This highlights a complex area for designing systems that allow practitioners to manage these varied media resources. Again, this notion informs the design study that follows in this chapter, the basis for PIM research being that computers can be effective in this regard if well designed. One respondent noted the utility of a PDA as a portable device in this regard:

“I take notes on anything that’s handy. I have a PDA much of the time when I’m away from home; I like it because it keeps me from losing notes on scraps of paper. When I’m home, I’m usually using scraps of paper or a "notes" file on the computer." (Response 13, Question 1)

The nature of the organisation processes required is a more complex question to be explored in this chapter. As with other aspects of creative interaction, it is clear from responses that there are individual differences in these processes that occur. There is commonly a notion of developing structures that associate items together, so for the model of longitudinal interaction described in this chapter, it is accepted that representational processes result in both retained resources, and the associations that link these. Primitives for associations that can be applied in the design of interactive systems are explored in the design study described later in the chapter.

The process of using the collected resources is also a complex one. Firstly, the availability and visibility of the resource is required at a time in productive or structural interaction where it is of value. Secondly, is it enough that the resource is visible? Or is the resource needed to actually form part of a further representation or outcome? The later requires more complex support, as there needs to be a direct ability to copy and integrate the resource. Among
the characteristics of idea representations described in chapter 4.2: *Productive Interaction*, persistence, reproducibility and malleability are important factors in the value of representation types for later use. Much of the PIM research described in chapter 4.4: *Human-Computer Interaction and Creativity* is relevant to understanding these needs. For example Karger’s (2007) approaches to the unification, rather than fragmentation of information (visual unification, standard data types and metadata) are particularly resonant with the issues raised above.

Examples of the use of previously retained resources can be found across the observation studies. In particular, the using of previous experiences and / or representations of ideas was referenced in all four of the coded filmmaking sessions (table 7, section 4.1.3.1), and was also present in both the coded Music Builder evaluations (figures 44 and 45). In the filmmaking study retained structures and knowledge of structures were also clearly utilised, for example when a participant in group 1 brought his own camera from previous shoots for use, and several participants displayed knowledge of available editing software in the process of adopting a tool for this purpose (for example in table 25, section 4.3.2.2). The musical observations included several cases where visual and written representations of previous individual and collaborative productive sessions were shared, in order to be developed further.

Three essential components of these representational interactions are therefore apparent through the above discussion. These are the ‘Retention’ of ideas and other resources, their ‘Organisation’, and ‘Using’ them in some way as part of productive interaction. All three can clearly be influenced by the design of supporting tools. A central question is therefore: What are the support needs for these processes that allow a process of retention, organisation, and use in the correct context to occur? From the exploration in this section, initial requirements would include.

### 4.4.2.3: Interpersonal

Outside of individual instances of creative tasks, interpersonal interactions occur that provide scope for sharing, learning, and the building of relationships and social structures. Explaining the geographical distribution and – in many cases - the transitory existence of creative workers, Florida (2002) argues that place matters: Creative workers and organisation are often concentrated because of the large social networks of ‘weak ties’ that are available. This holds true for historical examples such as Florence in Medici times, as well as for modern examples such as St. Ives, or Silicon Valley and the surrounding San Francisco Bay area. The ‘creative climate’ described by Florida is equally apparent on a smaller scale, with the following quote from the questionnaire study showing the value of a close community of practitioners to each individual, and to the group as a whole:

“*When sharing studio space with other artists whose work has connections with each other, ideas are fed in each direction. Each artists work is discussed and ideas can be passed on and inspiration gained from the other artist.*” (Response 9, Question 7)
As it is related to experiencing, there are similar active and passive forms of sharing. Being in a social situation as described in the quote above, there is scope to interact actively with others, but also the opportunity to observe, and to develop social relationships through chance encounters. Sharing could occur as part of learning in a teacher student relationship, or between peers in a range of social contexts. Research by Lessig (2002) and Bruns (2007) argues that the impact on sharing in creative activities of the design of networked interactive systems is immense.

A further point to make is that different forms of resources can be shared in various ways. The sharing of structures was discussed in the interpersonal section of the previous chapter on Structural Interaction (4.3). Tangible or conceptual structures such as a musical instrument or software tool can be shared so widely they become fundamental to a domain or genre, but the diffusion of structures across practitioners in a domain is also difficult to achieve, and since a central aim in most design is that the produced outcome be widely used, integration with, or development from existing structures in the domain is an essential concern.

As a starting point, the micro interactions that occur in these interpersonal processes need to be understood. Throughout the empirical studies, distinctions could be found between representations stored for personal use and those for communication. In general initial idea representations are for personal use, a common reason for this being that representations were made using conventions or terminology that would not make immediate sense to others. When asked if they showed the tools they used to represent ideas to others (question 8), respondents stated:

“Hardly. Others are not very likely to understand my notes. I may show my notes simply to show my way of working, almost never to show the ideas themselves.” (Response 11, Question 8)

“There’s not much point in showing people my notes; they wouldn’t make sense to anyone but me. "Hero needs heebles! Sailboat? Remember to put in cats...” is not informative to anyone else.” (Response 13, Question 8)

If they are not developed with sharing in mind, representations need to either be modified, or created afresh, when a need to share arises. Although the quotes above describe a process of producing individual idea representations that are not appropriate to sharing, it is clear that the networked nature of interactive systems can change approaches to those producing idea representations between the notions of a personal representation and a disseminated outcome for sharing. Erikson (1996) described how, in producing notes for an electronic notebook, the notes were in a more polished form as they could be transferred immediately to use in an email, or pasted in to a paper or report. Networked interactive systems have also changed approaches to this, for example blogs can be seen as a middle ground between personal representations and complete outcomes. They often share partially developed ideas or inspirational materials with a potential global audience in a way that contrasts with standard processes. The value of these
systems to individuals and to creative social interactions is however, yet to be effectively understood.

Whereas the interpersonal interactions discussed as a contextual factor in productive and structural interactions are considered in terms of collaboration with a shared goal, longitudinal interpersonal interactions can be understood as a looser form of ‘Creative Social Interaction’. As there is no specific shared goal or outcome to produce, the problems inherent in collaboration – production blocking etc – are less likely to be relevant. The sharing of ideas and structures instead occurs through diachronic representations (Sawyer, 2003) – for example viewing the work of a peer at an exhibition or online. This contrasts with the tight, synchronic systems used in collaboration – e.g. the verbal discussions apparent in the productive and structural interactions in the observations of filmmaking, musical composition and the evaluations of Sonic Sketchpad and Music Builder (see appendices 6.3.1 and 6.4.2). These interactions have been profoundly affected by networked interactive systems that provide scope for various forms of creative social interaction involving participation on a wider scale than was previously possible, and allowing interaction through a variety of new forms.

The use of these systems was apparent in the empirical studies in various ways. PTM model B refers to MySpace as an example of a system for both inspiration and dissemination. The lack of an effective field guarding the addition of content “gets a lot of rubbish out there” but at the same time, provides them with a “free” method for publishing their own work to a potentially “massive audience” (full analysis in appendix 6.2.2).

In addition to producing their own content, several participants in the filmmaking studies made use of online systems to find video, image and audio media for use in the films. This generally involved the collection of a set of possible alternatives or complementary pieces of media to suit an identified need, e.g. several pieces of music that could provide possible soundtrack for a particular scene, or several clips of wood being transported on a range of vehicles that would be shown sequentially as part of a story about the costs of producing paper.

Whilst these online activities can be seen as very loose social interactions – sharing without any further interaction, more active, relationship-building activities are necessary for collaborations to form, and for other needs in the production and structural interactions to be fulfilled. Analysing well-known collaborative partnerships, John-Steiner (2000) finds these often take shape over long periods of time, with shifting roles, responsibilities and leadership. Through social interaction relationships are built that form the basis for collaboration, through instances of collaboration, the collaborators develop shared structures that ideally become more effective with time. In addition to collaborators, Becker (1982) argues that a range of relationships are necessary for creative outcomes to emerge, for example with publishers or art dealers, or with those providing support for the production of the outcome, such as a printmaker or builder.
Beyond the development of relationships, some practitioners will be involved in the development of the structures that exist for creative social interaction to occur. These social developments could include starting or developing an organisation or equally a web forum, and developing the structures within this such as a meeting or discussion thread. As with other forms of structural interaction, the ability to produce new structures from existing building blocks appears key. As an example from the empirical studies, the Bath University Musical Production Society emerged through the availability of resources such as rooms, equipment, and a small budget from the Students Union. Through the work of a few individuals, the society developed to support the sharing of ideas, structures and – through access to university music staff – some organised teaching and learning for a large group of people. One of the organisers describes his work to develop new structures for interaction in the society below:

“A problem is finding people to collaborate with, because they tend to sit at home in their bedrooms, which is part of the point of the Music Production Society, is to get people together. And we have a blog, where we do collaboration by email too. You post something up, someone downloads it, edits it, sends it out again. Because its less commitment in terms of getting people to turn up at the same time for the workshops and stuff. I’m going to have a go at getting this running again this semester. Usually things go back and forth a couple of times and then peter out, but I’m hoping to get a critical mass.” (BUMPS participant C)

This excerpt makes it clear that social development is a complex process, requiring a combination of existing relationships, supporting structures, a perception of the structures that people will use, and a belief these can feasibly lead to valuable sharing and relationship building. The appropriateness of interactive systems to these purposes is raised as an alternative to face-to-face meetings, which require less commitment to sharing a time and location. It is also clear that some dedication is required to these development processes that is distinct from a general interest in producing creative outcomes. Despite a previous petering out of use, the participant feels it is worthwhile to try again to achieve a critical mass of people interacting as a community.

To conclude, interpersonal longitudinal interactions involve sub-processes of sharing, relationship building and the social development of structures through which creative practitioners interact. Networked interactive systems are increasingly key to social interaction by creative practitioners, but it is necessary to understand existing structures for creative social interaction. A detailed exploration of this is beyond the scope of this thesis, and as stated in section 4.1.3, very little explicit data on relationship building and social development were found in the studies performed for this thesis. However, the understanding developed above is utilised in the design study later in the chapter, and from it, some further understanding is gained.
4.4.3: Model of Longitudinal Interaction

The model of Longitudinal Interaction presented in figure 49 represents the activities that occur in order that a practitioner can effectively complete creative tasks. These include the intrapersonal, representational and interpersonal processes described above. In addition, the model describes how these long-term processes link with instances of structural and productive interactions.

![Figure 49: Model of Longitudinal Interaction](image)

4.4.3.1: Model Definitions

**Interpersonal:** The social activities of a person related to their creative practice.

**Relationship Building:** Developing interpersonal relationships that may become collaborations through social interactions.

**Social Development:** The development of social structures through which relationship building occur.
Sharing: Sharing ideas and structures with others through social interactions

Intrapersonal: Processes relating to individual perception and cognition.

Experiencing: The perceptions and actions of the person that provide a basis for Learning and Bisociation processes.

Learning: The development of skills and knowledge.

Bisociation: The association of experiences and memory items into novel ideas.

Representational: Processes relating to the representation of ideas and structures.

Retaining: Creating a representation of an idea for the purposes of using it at a later date, and retaining resources such as inspirational materials that may be of use in the creative process.

Organising: Developing associations and structure between retained representations.

Using: Making use of retained resources in productive and structural interactions.

Relationships: A social connection to other people who may collaborate or cooperate with the individual in productive and structural interactions.

Resources: Ideas, Inspirational materials, retained structures, and other information for use in productive and structural interactions.

Associations: Semantic links between resources.

4.4.3.2: Explanation of Model
Where the previous perspectives were modelled in terms of iterative processes, the model of longitudinal interaction represents a set of processes that in each case forms a complex system of interactions. In the middle of the longitudinal model, structural and productive interactions are represented, as these interactions are supported by, and provide an input to, longitudinal interactions.

The experiences of an individual, including those formed through productive and structural interaction, through the sharing of resources with others, and more generally, all lived experiences, provoke both learning and the bisociation processes that lead to novel ideas. Learning then informs evaluation processes in productive interactions.
The intrapersonal processes, and productive and structural interactions, lead to the retention of resources such as idea representations and structures that are retained and organised – leading to associations between resources being developed. In some cases the resources are then used in instances of productive and structural interaction. Along with this, interpersonal processes of relationship building and social development lead to relationships through which ideas are shared, completing the circle.

4.4.4: Contextual Factors

From a longitudinal perspective, the notion of contextual factors should play a significantly different role in design thinking, as a range of interpersonal, domain and expertise contexts will occur over the long-term. For example, the individual creative practitioner will improve in expertise over time, the domain will advance, and s/he may take various roles in various interpersonal interactions.

4.4.4.1: Interpersonal

The longitudinal perspective describes the various interpersonal interactions that occur outside of collaboration in productive and structural interactions. These have already been described, but this section will consider how a range of contexts can be considered in terms of the interpersonal social interactions that occur.

Some interpersonal aspects of longitudinal interaction are less domain-specific, and through these social interactions, interdisciplinary exchanges can occur and inspirational concepts spread. Where productive and structural interactions are often collaborative, interpersonal longitudinal interactions involve relationship building, and the sharing of ideas and structures in a looser fashion. It has already been identified that representations are often produced only for either intra or interpersonal use: The questionnaire study showed that scrapbooks and notepads were rarely shared in their original form (see appendix 6.1.1 and table 9 in chapter 4.1.3). The common reason for this was an unwillingness to make personal representations legible to others, as this would form an unnecessary overhead. Social interactions such as sharing generally occur through representations developed with communication in mind. An interesting development on this topic is the surge in blogging, wikis and other forms of public communication of early thoughts or work in progress. These shared, semi-formal representations are an example of a middle ground between personal idea representation and the dissemination of an outcome. Sharing ideas in this way, or – as seen in the questionnaire responses - through discussions with peers or friends, plays an important role in the long-term development of ideas.

The model introduced from this perspective completes a holistic model of the interaction of a creative practitioner, as it includes instances of the structural and productive models within it. This can therefore be used as an effective
tool with which to represent practitioners and the interactions between them. An opportunity for further work extending the use of the model would be to utilise instances of the model as nodes of a Social Network, as a basis for an analysis of the interpersonal interactions of creative practitioners. An example of how this might be achieved is shown in figure 50. Identifying where productive or structural interactions occur collaboratively, and also where social activities such as learning and sharing are occurring, could provide an effective form of analysis of the functioning of a creative social network such as an arts centre.

![Figure 50: Example Representation of a Social Network Using the Longitudinal Interaction Model](image)

Although this notion is not further developed in this thesis, the diagram above shows how social networks can conceivably be represented and analysed using the model. In this case the relationships of B with A and C are represented. Firstly, B shares ideas with A, who experiences these. A and B then collaborate in productive interactions. C is a more experienced practitioner, who shares some tangible structures with A – for example they are both guitarists. B learns from the sharing of ideas by C. Through these representations, it is envisaged that patterns in the types of social interactions of creative practitioners could be identified, and further understanding of creative social interaction could be developed.

4.4.4.2: Domain

Domains are essentially defined and built around the production of outcomes and the structures that are common in these processes. So whilst the domain of the practitioner is still very influential at this level, the effect it has on needs is markedly different, with generic considerations that are external to instances of creative task performance.
Some representational aspects of longitudinal interaction are less inherently domain-specific: We found that notebooks, cameras and voice recorders are used across domains because initial representations can often be made without requiring the specific qualities of the expected outcome. For retained ideas and materials to actually be used, they need to be available when needed. Respondents considered the review and organisation of collected materials particularly important before new periods of productive interaction.

Relationships are developed between practitioners at this level, so it is here where there is scope to design socio-technical systems that bridge gaps between domains and provide support for networking between practitioners with varied backgrounds.

4.4.4.3: Expertise

Enabling creativity pervades the lifestyle of the serious creative practitioner, so representational interactions, such as retaining and organising ideas and inspirational materials for later use, play a major role in the life of a professional. Social development processes such as developing a society are also likely to involve serious amateurs or professionals.

However there are opportunities for supporting longitudinal interaction in everyday creativity: As we generally collect and store more and more materials in the digital age, even the novice may have repositories that can be appropriated for creative purposes, although it may not have been their original intention to use them in this way. The novice or leisure user can also make use of social systems for help from experts with production and structure, or take part in interpersonal interactions that have a different focus to professional creativity. The Produsers described by Bruns (2007) develop and disseminate their creative output through systems that exemplify these kinds of interaction.
Figure 51: Experiencing and Learning in the Longitudinal Interaction Model

Figure 51 shows how the Longitudinal Interaction model includes an understanding of the development of expertise. The sharing of other practitioners’ productive and structural interactions, and the productive and structural interactions of the individual practitioner both lead to learning by the individual. The development of social relationships is therefore key to learning, as are the range of other experiences the practitioner has that relate to their practice.

4.4.5: Design Study: The Associative Scrapbook

4.4.5.1: Design Aims

As with the previous perspectives, an iterative design and evaluation study was used to explore the practical activity of designing for longitudinal interactions. From the model and the findings of the empirical studies described above, four themes can be identified which are explored as design aims in this design project:

- Supporting the translation of intrapersonal experiences into representations of ideas, inspirational materials and other resources.
- Supporting the organisation and development of these resources over the long term.
- Supporting the use of these resources in productive and structural interactions.
- Supporting interpersonal interactions at a social level, and provoking experiences based on the sharing of representations.
As noted, needs for longitudinal interactions can be seen to differ less in relation to contextual factors such as the domain. As such a final aim was to produce a system that could support a wide range of creative practitioners, rather than to provide support for a specific domain as in the previous two design projects.

The first aim is essential to the *Experiencing* and *Bisociation* aspects of the model. The questionnaire study showed that a range of media and tools were used for initial idea representation and the capture of inspirational materials. The system provides both a repository for media captured using other devices, and includes the ability to create initial, sketchy idea representations within it.

The second aim relates to the representational aspects of the model – retaining and organising. The use of scrapbooks and other means to collect, organise and display representations of ideas and inspirational material led to the adoption of the scrapbook metaphor as a basis for the system produced. In this case, the system provides a repository for all types of media, links and files, and allows users to organise and associate these resources effectively.

The integration of a tool for longitudinal interaction with productive and structural interactions became increasingly apparent as the project developed. In this project, no attempt was made to produce a system that would enable the production of creative outcomes. Instead, the system allows files of any kind to be represented in the scrapbook and opened with external applications. Essentially the system forms an overlay to the file system in this regard.

The final aim was to provide a means for users of the tool to be exposed to material shared by others, which is associated in some way to their current work, to explore how this information discovery could aid the process of creativity. The exploration of media resources that are either loosely or closely related to the current focus needs to be understood as both appear to have uses in creative work. In addition, the passive and active nature of the directing of these experiences is an interesting quality of the interactions that support intrapersonal and interpersonal interactions.

**4.4.5.2: Design of The Associative Scrapbook**

The Associative Scrapbook uses the concept of a *Scrap Object* as an information artefact that represents an idea, inspirational material or other information resource. Technically each scrap links to a file or a web resource. The system provides mechanisms for adding, creating and modifying scrap objects, for discovering related information resources, and for associating scraps together. Scraps can be added to *Pages* of a scrapbook, with each page forming a freeform workspace for the user to interact with collections of scraps. The *Library Panel* to the left shows all the local resources and allows the user to organise and access them as required, and the *Web Association*
Panel to the right is used to support the discovery of inspirational materials gleaned from the web.

4.4.5.2.1: Retaining Resources
At a basic level, a scrapbook allows the collection of a range of media. It is unrestrictive in that objects can be placed anywhere, and in any order. Like a physical scrapbook, the Associative Scrapbook has pages, used to hold scrap objects. The system acts as a repository for all kinds of computer-based resources. Notes and sketches can be created in the system, and are saved using generic file types (.txt and .png). Files of any kind can be added, either through drag and drop on to the library or directly on to a page. Alternatively single files or entire directories can be added to the library via the standard operating system directory viewer. Whilst files can be added or removed from multiple pages, they remain in the library unless users explicitly delete them from this.

It is envisaged that the system should be able to integrate with external devices such as cameras, PDAs or voice recorders, as these are commonly used for initial capture and files from these should form part of the repository to avoid information fragmentation. Whilst no specific functionality has been developed to this end in the current system, users can easily import from these devices using the file system.

4.4.5.2.2: Developing and Organising Resources Through Associations
The pages of the scrapbook provide a basis for the development of ideas by using visual thinking in a free-form space. Users can sketch anywhere on the page or create individual sketch scraps, and all scraps can be placed anywhere on the page, and linked or grouped together to show relationships.
Verbal thinking is also supported through the ability to create notes and annotate any scrap.

The process of organisation is key in developing from a set of retained resources to the use of those resources in the production of creative outcomes. There are however, a wide range of paradigms for organisational behaviour, both in general – described in PIM research – and specific to creative practice. One of the main features of Associative Scrapbook is therefore to provide various means of organising, by associating scraps together. An understanding of how information is associated in the external representations used in creative activities is lacking and would be useful to design. One aspect of this is attempting to design functionality that represents association primitives. Through these the system aims to support basic forms of association that can be utilised in a variety of situations and are effective across a range of creative activities.

This follows on from Prante et al’s (2002) conclusion from their evaluation and development of CSCW tools for ideation: That supporting the structuring of the idea space by users is an important function. The user should be responsible for creating the meaning of this structure, and the process of representing ideas should not be constrained by the tool.

Every object created in, or added to the Associative Scrapbook is a scrap – even the pages themselves. This common form supports several types of association: Firstly, scraps are added to pages, collecting and displaying them in user-defined spatial arrangements, which are found to be conducive to reflection and creative thought. Secondly, several functions have been developed for the purposes of formally associating items. These aim to be primitives for the types of association found in the empirical studies, e.g. a set of alternatives, an ordered composition, or a characteristic shared of several items. The functionality available in the current iteration of Associative Scrapbook consists of the following:

Scraps can be linked together on a one-to-one basis. This can function in a variety of ways, from use in ‘mind map’ style representation of a set of related ideas, to showing how compositions fit together, or linking a note to a related file. Links are created by dragging a line between two scraps on a page, and a visual representation of the link appears.
Scraps can also be grouped together, an action performed by pressing a ‘group’ button that appears when multiple scraps are selected. This supports similar items, or those that relate to a particular issue, to be associated. A group becomes a scrap object itself, so it can be added to multiple pages, tagged, or sent to other people.

Finally, every scrap object can have annotations added using the yellow box below it. These annotations can be used to tag objects or provide a description or title. The scraps held in the library can be searched by this...
annotation text, providing a means to add metadata, particularly useful with objects such as images or files that do not include a text component.

Through these functions, it is expected that the users can define their own meanings and find effective means to show relationships working across a range of domains and with a range of media. A particularly interesting design issue is making the associations between scraps apparent to the user, so that relationships defined by the user, or identified automatically by the system, are visible when this may be useful. The current version of the Associative Scrapbook introduced an Associations View, which displays all the scraps associated with the currently selected scrap. Further functionality related to this need could perhaps provide a mechanism that can display associations without the user needing to explicitly ask to view them, but without impeding general use of the system – perhaps as an overlay.

Once added to the library items can be replicated in multiple pages, allowing users to organise material according to various methods simultaneously. This reuse reflects one of the advantages of a virtual scrapbook above a physical one, the simple reproducibility of copies of an object, which can be dynamically updated, so changes to one copy are reflected in others.

4.4.5.2.3: Using Resources
The application can be used to create text notes and sketches, and will display images and thumbnails of video, however any kind of file can be added to the scrapbook and opened with an external application. This allows the scrapbook to provide an effective tool with which to collect media of any form. The Associative Scrapbook provides scope for user-developed structures that support the management of representations rather than performing as a specialised tool with which to produce creative outcomes in any specific domain. It does not restrict the tools creative practitioners can use, and does not requires the people that the practitioner communicates with to adopt the application.

The Associative Scrapbook aimed to support these processes from a longitudinal perspective, rather than in terms of the performance of a single task. It has however already been noted that the relationships between these long-term interactions and the performance of creative tasks are essential. It is envisaged that the tool would be used both during the process of completing creative tasks and also as a repository for materials and a tool for developing relationships and communicating with other practitioners.

4.4.5.2.4: Sharing and Finding New Resources
In response to the findings of the questionnaire study, rather than providing the ability to share the scrapbook itself or allow several users to collaborate through it, it was thought more appropriate that the scrapbook be considered a personal resource, with the ability to support communication and social interaction. The basis for communication supported in the tool is to send pages, objects or groups of objects by email along with added text comments.
Users can either develop a page specifically to communicate their idea, send existing representations with comments or send a single object quickly and easily. People objects are created as contacts with email data etc, to use for communications.

The model suggests that interpersonal processes of relationship building and sharing link to experiencing and through this, bisociation. The exposure of users to representations created by others that may be relevant is therefore an important design space for tools supporting longitudinal interaction. Simonton (1989) argues that chance encounters with loosely related inspirations often give rise to creative ideas, citing historical examples such as the development of Velcro, where sticky burrs attached to inventor George de Mestral’s legs during a walk in the woods, and the discovery of Penicillin through the mould destroying discarded bacteria cultures.

As the user goes about using the scrapbook, the web association panel shows links to images, video and text from a variety of searchable content libraries (e.g. flickr, youtube or technorati) based on search terms taken from the scrap that is currently being viewed or manipulated. This provides a passive, loose search that may inspire the user, but is not costing the user any effort on her / his part. Alternatively, the user can select a particular scrap or piece of text within a scrap and perform a search based on this for a focused, explicit search for associated material. Through analysing the use of this system we hope to understand how creative users explore associated material, and how support for these processes can best be provided.

It was also an aim that Associative Scrapbook support interpersonal interactions at a social level. Whilst this is an area that needs further exploration, Associative Scrapbook in its current form begins to explore the possibilities for creative social interaction by providing a ‘Web Association Panel’. This functionality - inspired by Koh et al’s (2006) system combiFormation, and Lieberman’s (1997) autonomous interface agents - displays material associated with the current focus of the user, collected from the web as the tool is used. This is shown in a scrolling display on the right side of the scrapbook, as shown in figure 2. This panel works in several ways, aiming to expose the user to inspirational material and also supporting explicit searches.

Whereas Lieberman’s (1997) example Letizia system integrated with a web browser and provided suggestions based on the use of this, and combiFormation worked as a single window in which collected resources and new resources were combined, Associative Scrapbook distinguishes this content from the scrapbook pages, so that the suggestions are available, but not intrusive to the wider use of the software with the users local files.

The web association panel allows scope for users to discover information shared by others, through various mechanisms from focused search to passive exposure based on their current interaction. By exploring an interface that accesses this information from the web, it can be considered how a two
way interface – the users of the system providing content that is shared with other parties through a similar mechanism – could operate. A full exploration of sharing and being exposed to this information would require a user group with sufficient critical mass, and the exploration of designs that support effective sharing without negative privacy or ownership issues arising. This is beyond the scope of this thesis, however some conclusions can be drawn here on this topic based on the use of the current system, and the software is ready to be extended in this regard in the future.

4.4.5.3: Evaluation

In analysing effective methods for the evaluation of PIM tools, Kelly and Teevan (2007) argue that combinations of naturalistic, longitudinal, lab and case study approaches are the most appropriate methodologies. Similarly it has been argued that the study of creativity support tools should involve the use of multiple methodologies (Hewett et al, 2005). In evaluating the Associative Scrapbook we took two methodologies that provided a range of data for use. Firstly, case studies were performed that provided a more in depth look at how the tool could be useful to practitioners in a variety of domains over an extended period of time. Case study participants installed the software on their own machines and were observed using the system on at least three occasions over a period of at least a month. During these sessions a think aloud protocol was used where the participants were asked to verbalise what they were doing and any thoughts they had about the software during the sessions. Secondly, the system was made available for download, with anonymous usage statistic sent back to us, and users encouraged to fill in a questionnaire and give comments online. In this way we collected both a depth and breadth of data about how the system was used and user’s reactions to it.

Developing a high fidelity prototype such as this can provide research findings in a variety of ways. Firstly the system provides an evolving artefact, which presents prospective users with an instance of a possible support tool, creating a platform through which a rich dialogue about support needs can develop (Carroll et al, 1991). Qualitative opinions were collected though an open questionnaire those who downloaded the tool or those involved in the case studies were asked to fill in, and users were also encouraged to contact us with any comments or questions. Secondly, the design and evaluation process itself highlights issues and tradeoffs that need to be dealt with. Finally, the use of the system can be analysed and patterns, preferences and types of use identified, both through the case studies, which combined observation with think aloud techniques, and through usage statistics received from those who downloaded the tool.

An important aspect of the software is its reuse and the development of users’ interaction with it over multiple sessions of use. The first session of use with any piece of software is not indicative of all aspects of how it will be used. Information management occurs over long periods of time and multiple creative tasks. For this reason case studies with multiple sessions were preferred to individual lab evaluations. Another aspect that is important in
considering how to evaluate software such as this is the protection and continuing availability of the work participants perform. If it is hoped to produce natural working conditions, the user must trust that the artefacts they produce will not be lost otherwise they are unlikely to make much effort to use the tool properly. In this project, all user’s work using the tool was saved as files such as text documents for notes and image files for sketches to avoid unexpected bugs in the prototype destroying all the user’s collected and created materials. As the participants in the case studies have the system installed on their computer, they can refer back to the work they have produced and continue with it at a later date.

4.4.5.3.1: Case Studies and Downloaders

A detailed understanding of user’s interactions with, and opinions of, the system were built through case studies. These were undertaken with 4 participants with different creative backgrounds, and involved the installation of the software on their personal computers. 3 sessions of observation and questioning were performed with each participant over an extended time period. In each case, the first session began with an introduction to the software, and an initial questionnaire about the participant’s background. Following this introduction, participants were asked to think about and describe tasks that they normally performed in their creative activities that may utilise the scrapbook in some way. The participant was then asked to use the tool in whatever way they wished, as part of their normal working practice, with a think aloud protocol used and film recorded. Each session finished with a semi-structured interview eliciting further detail based on the use observed in that session. In subsequent sessions, a description of any use of the system in between sessions was asked for, and the user proceeded as before. The participants were also asked to fill in a questionnaire on their use and opinions of the system, and any problems they had found or improvements they could think of. In full, each of the sessions lasted between 35 and 110 minutes.

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Domain</th>
<th>Foci of System Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Filmmaker</td>
<td>Scriptwriting, organisation of shoot (actors involved in each scene), video and sound editing (identifying points in footage and making notes), organisation of premiere. Ideas for design of web site for the film / previous films.</td>
</tr>
<tr>
<td>B</td>
<td>Musician</td>
<td>Finding and organising recordings for inspiration, and recordings made by own band, creating drum parts for partially developed compositions.</td>
</tr>
<tr>
<td>C</td>
<td>Animator</td>
<td>Organising requirements and ideas for a freelance project, making notes on how to use software functions, organising images of partially developed work, editing web site portfolio.</td>
</tr>
<tr>
<td>D</td>
<td>Researcher / Artist</td>
<td>Developing ideas for a set of paintings from photographs. Organising literature and definitions, planning a study and related presentation.</td>
</tr>
</tbody>
</table>

Table 28: Case Studies of Associative Scrapbook Use Performed
To collect accurate data on how the system was used - both in the case studies and from other users – Associative Scrapbook sends use statistics to a server when a user quits the application. These statistics consist of a unique user ID number, a timestamp, a code representing the use of a function in the system (e.g. ‘New Scrap Created’, ‘Added to Page’, ‘Link Created’, ‘Scrap Added from Web Association Panel’ etc) and an identifier for the scrap that has been acted on (if applicable). Users of the software are encouraged to fill in an open questionnaire, and/or give their comments about the software from a link in the interface.

The system has also been made available to download for Mac OS, Linux and Windows since 1st February 2009, and is still available from www.cs.bath.ac.uk/~tc225/AS/. Use data has been collected from 71 individuals to date, and comments and / or questionnaires responses were received from 8 of these. These respondents included a software engineer from the games industry, an art instructor and a musical composer. Their responses are included in appendix 6.5.2.3.

4.4.5.4: Analysis

The major part of the analysis for this thesis has been performed using the case studies, as a much greater depth of detail is apparent in these along with relevant background information. This data constitutes video recordings of use, along with system logs that provide an accurate representation of the use of the functionality of the system. The system logs were analysed to produce findings such as those in figure 56, and the final sessions with two participants (C and D) were transcribed and coded according to the concepts of the Longitudinal Interaction model using Transana (described below in figure 55 with transcriptions in appendix 6.5.2.1). In addition, references to improvements the participants would like to see were also coded.

The final version of each case study participants’ scrapbook was saved and explored (e.g. see figures 57 and 58). Questionnaire responses were also gathered and analysed for common themes and opinions (see appendix 6.5.2.2).

The qualitative responses from downloaders have been noted and used as a basis for identifying issues or improvements with the system (see appendix 6.5.2.2), however, the system logs of these have not yet been analysed, as it has proved difficult to achieve any real level of understanding of how the system was being used from this data alone.

Figure 55 below shows the coding sequences from the final sessions with Participants C and D. This shows a representation of 7 of the 9 major concepts that constitute the Longitudinal Interaction perspective. As such, the prototype could be said to provide some support for these processes. Retention and Organisation were the most commonly used codes, which reflects the prototype systems utility as a space to collect and arrange media of all kinds. A number of areas are also identified (‘Improvements’ codes)
where the participants had described improvements they would like to see to the prototype. These are discussed where appropriate in the findings sections.

![Sequence Map from Coding of Final Sessions with Case Study Participants 3 and 4.](image)

### 4.4.5.5: Findings

These findings draw upon the case studies and from data elicited from those who downloaded and used the prototype. A combination of the quantitative and qualitative outcomes of the analysis are used to explore how the Associative Scrapbook was used, the responses of users towards it, and the positive and negative aspects of its current design.

In general, users understood the basic aims of the software as a repository and organisational tool. One downloader said: "thanks, I've been waiting for something like this". On the other hand, the scrapbook metaphor did cause some confusion, with another downloader noting that:

"When I think of a scrapbook, I think of a document and image storage system- a book, binder, box, etc. to store items from our past to preserve them for the future. A scrapbook being a finished product full of mementos. But your scrapbook is about current projects, right? -a place to drop things while putting something bigger together??" (Downloader Response 7)

For those who downloaded the software, the system provoked dialogue about their needs as creative practitioners. The case studies were more effective in providing an in depth understanding of how such tools can be used. In the following sections, findings are presented that relate to the aspects of the design described previously in the design section.

#### 4.4.5.5.1: Intrapersonal Issues

Interpersonal interactions are seen to begin with experiences, leading to learning and bisociation. The model shows that these can occur through sharing, productive and structural interactions, and also from general
experiences away from focused creative interactions. To some degree, it is
the representation of these experiences, rather than the experiences
themselves, that Associative Scrapbook aims to support. The Web
Association Panel however provides facilities for exposure to new information.

The case studies showed extensive active use of the Web Association Panel
and web browsers to view representations of information that were related to
the person’s creative work. This active seeking of information contrasts with
the passive, autonomous, display of related material the Web Association
Panel can also provide. There were several cases where this was utilised. In
particular, Wikipedia articles appeared which were relevant to the research of
participant D. This reflects a known the issue that text orientated users are
more likely to benefit from the functionality in its current form, which can only
accurately identify themes through the identification of common words.

To other users, the passive exposure provoked interest and divergence from
their current tasks… This use of the panel is clearly more appropriate in some
cases than others. Highly focused productive work requires convergence and
active finding of relevant information, while at other times the participants
were open to being inspired by the images and text that appeared, and
opened related links. Case study participant D stated that:

“I tried to control it (the results displayed) as the topics it searched for were not quite what i
wanted. I kind of knew what I wanted to look for. Although it was useful when it analysed my
word document to find common words (as I wouldn't be able to do this myself very easily)”
(Case Study Participant D)

A repeated behaviour was to question how the passive system led to the
particular links being displayed. The participants wanted to understand how
the algorithm operated as context to the information they experienced. They
felt a need to identify how their scraps contained information that could lead to
the associated content. For example, case study participant C stated that:

“The search words could be improved too, Im not sure, how do you know which ones to pick?
I guess its a bit random…if you could get it giving more relavent stuff, its good just having it
there to look at though I suppose”. (Case Study Participant C).

Nakakoji et al (1999) identified a similar issue in their systems for collective
creativity – that the rationale behind the displayed information was requested.
It is suggested that whilst the results retain an element of looseness in their
relevance, and that the interface is a passive one, transparency of the
process performed by the system helps the user to reflect on how the
information is relevant to them.

A search bar represents functionality users expect and understand from past
computer use, and in many cases this is a useful tool as it reflects specific
user needs when converging on particular issues. Functionality such as the
passive association mechanism needs to distinguish itself from this so as not
to confuse users, however the current design does add value to the system
for users, and could do more with improved back end algorithms and minor
interface improvements. Some options for controlling the type of content that occurs could be provided, or some sort of user profile – for example based on domain and expertise context – would support closer matches to users needs.

4.4.5.5.2: Interpersonal Issues

As they represent disparate, detailed descriptions of the way Associative Scrapbook can be used and improved, the interpersonal processes apparent in the case studies are described individually:

Participant A described several types of interpersonal relationships and created people objects in the scrapbook to represent these. His filmmaking required a range of relationships, including with a large group of actors, who he needed to organise to be available together to shoot particular scenes, and a composer, where he sent and received files containing video and audio sections that would form parts of the film. He noted that the people objects should have effective means of identifying them in their different roles, and that additional information stored in, or related to, people objects should be accessible in various ways, for example having a list of all the people who were going to be available, or needed on a certain date.

Participant B worked with other band members, and he had received recordings from them – either created during practice sessions, from previous bands other members had belonged to, or other bands that represented the conceptual style the band were interested in achieving. These were listened to in the course of developing representations of drumming and fills to be played in the future. When asked, B noted that these representations of drum parts were not shared, but were for personal use. As discussed earlier, a second interpersonal interaction was the extensive viewing of video music lessons from YouTube, which B could find using the Web Association Panel. These provided scope for inspiration and learning through other practitioners’ sharing of ideas.

As a freelance animator, Participant C worked on several projects over the course of the sessions. Some were individual explorations with which the participant hoped to learn new skills and add to his portfolio, while others were jobs in which he would need to communicate with another party to establish what was required, how the work needed to be performed and the format in which the output was needed. In one such case, C requested that the details be kept confidential, as this was agreed with the company employing him. An MSN conversation with the employer was copied in to the scrapbook as this contained requirements and other information such as the date the work was needed by. The work required that a development kit was used with which C had only limited understanding, so a link to a web forum where the tool was discussed was also added. Images of similar work from the web were searched for actively using the Web Association Panel.

Although Participant D worked largely as an individual throughout the observations, she made use of the Web Association Panel and a web browser
to find inspiration for both painting and research. In the first case, she found flickr images that provided the kind of colours and images she was interested in. For research, Wikipedia articles were viewed, however she expressed a desire that more specialised resources be available through the Web Association Panel, such as access to academic libraries.

The interpersonal interactions described above show the rich range of needs, and some of the functions that interactive systems can provide to users that support these. Various aspects of relationships that have been discussed earlier, such as many cooperative roles in the development of a creative outcome, and the need to share some representations while others remain for individual use, are represented here. The Associative Scrapbook in its current form provided functions that aided this, such as the identification of people as a class of scrap objects, the Web Association Panel, and the ability to retain a range of media – such as the MSN conversation. Further support for these processes will be discussed in the Evolution of the Design and Future Improvements sections later in this chapter (4.4.5.6 and 4.4.5.7).

4.4.5.5.3: Creation and Retention of Representations

Two classes of representation have been identified: those that represent ideas or structures produced by the user, and those that represent inspirational material or other information from external sources. Scraps are therefore either created in the software or through other means and added to the system, or imported from external sources.

Figure 56: Frequency of Types of Scrap Created by Each Case Study Participant

Figure 56 indicates the frequency of instances of the different types of scrap available by the participants in the case studies. It is clear that notes are the most common item, followed by images. It is also clear that there are wide
variations based on the participant and the tasks they performed using the software. The animator made far greater use of images than other participants and was the only person to create more image scraps than note scraps. These images included partially finished shots of work from several projects, and inspirational images found using the Web Association Panel. Second in the use of images was participant D, who made use of photographs in the development of ideas for a set of paintings, and also took diagrams from the web that were relevant to her research.

Text notes were widely used because they could perform a variety of functions for the participants. As shown in figure 57, Participant B used them as a basis for representing drum parts through notation, while participant A made notes of timings in footage where edits were to be made. In both cases, specialised representational forms may have been more appropriate, the possibilities for integrating these are explored further in the future work section.

4.4.5.5.4: Organisation and Development Issues

Participants created pages to distinguish tasks from each other – for example A created a page for film edits and another to sketch out a web site. In some cases however the page metaphor was disagreeable because it limited the material that could be collected in one place…
As expected from the empirical studies, a large amount of the use of the software revolved around the development of associations between scraps in various ways: Firstly, the collection of representations on pages, which a downloader of the software discussed:

“Representing things in clumps on a single page is probably the most useful organisational tool there is but the thick pains of the scraps does limit the amount of space on the page. Having the option to hide the borders and have a depth order would encourage me to layer the scraps a bit more with maybe some background images with sketches over them.” (Downloader Response 2)

Secondly, sketching on to the pages supported the ability to show the nature of relationships informally. The same downloader discusses this:

“Most of the materials I collect are based around a single theme. They will either be scraps from the web or notes I make relating to those things or anything I might think about. The use to be able to create sketches alongside those thoughts is a great idea as well and I look forward to seeing a more advanced sketching tool.” (Downloader Response 2)

Figure 58: Screenshot of Associative Scrapbook Use by Participant D

Figure 58 shows the use of a scrapbook page by participant D as a basis to informally represent relationships between information. In this case, sketched arrows are used to show relationships, however the linking functionality was later adopted for similar purposes, once the participant understood it.

As hoped, the functions provided for formally associating scraps were utilised for a range of purposes, although some extensions to these were asked for. For example participant A in the case studies noted that:
“is fine for most applications I use. However, it might be useful to have different types of connections to help distinguish. For example, I might want a different type of connection to show that a certain video is connected to a certain audio clip, than I would to show that two video clips are in succession.” (Case Study Participant A)

The freeform visual interface was utilised for the arrangement of scraps in various ways. As well as associating, this often required interaction with parts of files, or locations within these. The ability to create sub-scraps – scraps representing a portion of a larger image or text scrap was added in response to these needs perceived in pilot evaluations before the case studies. Participant D noted the utility of these to developing her painting ideas:

“I copied and pasted a section of a photo from Preview and then used the special cropping/copying thing in the scrapbook (sub scraps). I then moved these around the page and re cropped them until I was happy with the composition.” (Case Study Participant D)

In addition to the existing facilities, it was apparent that the ability to point to a segment or location within files or objects of various kinds would have been useful to several of the participants, particularly for A and B, who worked with temporal audio and video files and need to represent the parts that a note scrap related to.

Alongside activities that can be considered specific to creative practitioners, the individuals in the case studies also performed tasks that constituted general personal information management, often of the kind described by Bernstein et al (2008) as involving information scraps. These included gathering details of a particular job such as deadlines by participant C, who was working in a freelance role. Participant A used the system to make notes about the premiere of the film, such as a todo list, and a list of who was attending, or still needed to be invited. It is important to consider that such generic tasks are of importance to the practitioners, and to be inclusive of these requirements along with more specifically creative needs.

4.4.5.5.5: Use in Productive / Structural Interactions

An aspect of the design where clear improvements can be envisaged is the integration of the system with users productive and structural interactions. The importance of this was clear in the use of it by participant B, who essentially used the tool for productive interactions (creating drum notation). In this, he required the ability to cut out or point to parts of audio recordings, and wished to be able to do this within the software, rather than having to skip between Associative Scrapbook and audio software. Participant C asked whether dynamic updates of the scraps could occur, so that he could use the Associative Scrapbook as an overview of these, seeing the most recent version of each of his files. Two downloaders of the software stated that they wanted the system to support plug ins that provided integration with specialist software – in one case, software development tools, in another case, the notation software Lilypond. In each case, dynamic thumbnail type representations in the scrapbook could provide useful material for reflection by users. Case study participant A stated that:
“The software has many uses and I could use it but it would have to allow for more file integration (as in - embedded video and audio)” (Case Study Participant D)

The empirical findings suggested that previous productive and structural interactions form one of the processes from which representations are retained. These cases show that a practical implementation of support for this requires that the various specialist tools of the practitioner’s domain are not only retained but can be represented effectively in a shared space. Whilst it is not the intention of Associative Scrapbook to support productive activities directly, it does provide some scope for this (as shown by participant B). Moreover, these reflection and organisation processes utilise facets of the representation that are specific to its form (i.e., characteristics of a piece of musical notation are important to the way in which it is used in the software). In this way, plug ins or other methods of integration are essential to improving the scope of the software.

4.4.5.6: Evolution of the Design

This section describes some of the modifications and additional features added to the Associative Scrapbook due to the findings of evaluations. These were added over the course of the case studies, but as the underlying data model did not change, participants could download the new version and continue to use the scraps they had added previously.

The initial version of the software had a separate window that provided the web association panel functionality. While this was explored by participants in the initial evaluations, the panel was not visible at all times, so could not be available for passive exposure to information. The Web Association Panel was therefore moved to a side panel, as seen on the right of figure 59.
Functionality for sketching to the page, rather than only as specific sketch objects was also added, as it was seen that the utility of sketching was commonly as a basis for showing the relationships between scraps. This informal method of association was supplemented by improvements to the support for formal association and dissection.

In addition to association, an important and somewhat opposite function is cutting up and being able to point to various sections of files. Through the evaluations it was apparent that there were various ways in which users would like to have further functionality to represent or associate with a specific part of an artefact. For example the musician and filmmaker who took part in the study both wanted to be able to add bookmarks to portions of audio and video files respectively. Figure 60 below shows the support for cutting up images and text in to sub scraps which was added, and this was utilised by participant D in composing ideas for artwork.
As the size of a page was found to be a restrictive factor in questionnaire responses, two functions were added to allow users to make maximum use of the space available. Firstly, scraps could be minimised, so that only the title was visible. This allowed users to collect large numbers of scraps together, with the trade off that they could no longer compare them in detail. Secondly, a full-screen mode, that moved the library and web association panels to the edge of the screen, was added to give more space for interaction with scraps where appropriate.

Finally, as a basis for new users to learn about the system, tutorial pages were added. These loaded when the user first started the application, and explained the purpose of the software and the functionality through note objects and sketches. An example of this is shown in figure 61.
4.4.5.7: Future Improvements

The prototype fulfilled its purpose as an artefact that provoked a dialogue about the support a system for Longitudinal Interaction should provide. This section details some of the improvements that case study participants and downloaders suggested, and approaches to implementing these.

4.4.5.7.1: Association, Dissection and Pointing

The methods of association provided between items, and the functionality related to this are subject of continuing thought and design evolution. The current set of association primitives (grouping, linking, tagging and collecting on a page) appear to cover most of needs of users across the various domains studied, however there is a need to provide better means to specify what a link or grouping means. The ways in which associated material can be utilised by the user need to be further explored. For example rather than just allowing the user to associate a set of items (e.g. this are the members of the cast involved in this scene) there is a perceived need to take this further and provide a means to utilise this data. For example, case study participant A wanted to take all the names of a set of cast members and put them in a list where he could add further information about their roles.

The evaluations showed that relationships are often between segments of files, rather than just the file as a whole. Further functionality is required that effectively supports dissection and pointing (e.g. pointing to parts of a film or audio clip, taking part of an image). The development and evaluation of Associative Scrapbook shows how this is often a domain-specific issue, as
specific types of files need specific types of dissection and pointing functionality. The next section considers these needs.

**4.4.5.7.2: Domain – Specific Needs**

Providing domain general support for creative activities in information management aspects is feasible because most creative practice has generic needs in this sense, and media forms such as notes, sketches, images and web pages are utilised across domains. Associative Scrapbook currently provides less than effective support for particular tasks and the specific tools that produce representations of ideas or other important resources, such as comparing two pieces of video in the same window, or using specialist tools. This could also be extended to include comparing various types of domain-specific media, such as dynamic visualisations of scientific data or statistics.

One method for combining the effectiveness of a generic system with domain specific needs would be an extensible open model for a scrap, similar to the plug-in systems for software such as Cubase. These plug-ins could be built so that they interact with domain-specific software, providing snapshots of the data and also additional functionality specific to that object or to associated objects of a similar kind. The notion of a domain specific language extending a piece of software (Fischer et al, 1992) could be extended to a ‘Domain-Specific Interaction’ that provided support for functionality above the generic needs that can be foreseen and implemented in the system.

**4.4.5.7.3: Availability**

The prototype was developed as a downloadable application, however, it is clear that the use of computers is often transient. A downloader stated that:

> “I never seem to find myself sitting at one computer for very long however and it's useful to be able to have everything to hand just by using a browser and web connection without having to install a multitude of apps” (Downloader Response 2)

The availability of retained resources can be seen as essential in the model, as it allows the use of these resources in Productive and Structural Interactions. A web-based system would therefore be more appropriate. One perceived difficulty that led the design process away from this was the use of large files in many creative activities (e.g. music, video and 3D models in the evaluations). An online repository would have to include a very large storage space for users, and handle interactions with these files. Movements towards ‘cloud computing’ and similar approaches to storing everything online, are however, making this possibility more likely.

**4.4.5.7.4: Social Interaction and Information Discovery**

An aspect of the system that needs further evaluation and understanding is the use of the scrapbook as a basis for distributing ideas, communication or collaboration. The findings of the questionnaire study suggest that a personal scrapbook is the most suitable design for long term use, but shared scrapbooks may also be useful in certain collaborative relationships. The use
of a scrapbook page as a basis for communicating a set of ideas and their relationships appears a suitable design, but there may be more effective media for interacting with others over ideas. This could integrate the system with existing collaboration features such as annotations, history of changes, chat windows and awareness mechanisms. An assessment of how representations such as pages of the scrapbook are capable of communicating ideas is an important step in improving our understanding of interpersonal creative interaction. This could be performed through the use of the Associative Scrapbook in an observational study of collaboration – such as the Filmmaking study performed for this thesis.

The mechanisms for finding associated content from the web in the prototype are – compared with what is possible – fairly simplistic. Better use of semantics, analysing associations with other scraps and making use of the history of use could provide a more effective mechanism for identifying interesting resources. Of particular interest is an ability to identify items that are only loosely related, e.g. concepts from a different domain, perhaps through metaphor or some similar feature. These could provide more scope for the kind of creative chance permutations that Simonton (1989) describes.

The evaluations showed evidence that information discovery should be integrated with the development and management of ideas and inspirational material. Unlike Koh et al’s (2006) combinFormation system, the passive information discovery functionality in Associative Scrapbook is kept in a separate panel. This suits users who are involved in more convergent activities – such as reflecting on their own ideas. This extends the scope for the use of the software. Other methods of passively providing exposure to information based on users activities are possible and should be exploited. One possibility is a continuously visible sidebar on the desktop, which builds an understanding of what the user is doing (e.g. what files are open? What is the user typing?). This could be more effective as it could integrate with all manner of computer based creative activities and even provide materials when the user was not specifically working on anything. Existing platforms such as Google’s Desktop Gadgets could support this type of system.

4.4.6: Designing Support for Longitudinal Interaction

As Longitudinal Interactions occur over a different timescale and hold a different purpose that Productive and Structural Interactions, the nature of support is different. The design process should therefore reflect this different focus, and take a holistic view of creative activities. The specifics of Productive and Structural Interactions can be avoided, but the integration with these activities is paramount.

4.4.6.1: Findings From the Design Study

Mindful of the aspects of Longitudinal Interaction represented in the model, the development of Associative Scrapbook integrated a range of functionality.
Points of integration and separation are key to support for Longitudinal Interaction in a number of ways, including:

- **Integration between the structures used in instances of Productive Interaction (which are likely to be multiple and dynamic), and support for the retention, organisation and reuse of the resources that result from those instances.**

Whilst this integration allows effective reflection on, organisation and reuse of resources, separating the support for Longitudinal Interaction allows multiple instances of structure to be used in instances of Productive Interactions. The freedom to utilise different structures and develop these whilst maintaining a repository for managing and reflecting on resources is clear in the design study. In addition, this separation is key in supporting interaction between practitioners, as they can use different structures for Productive Interaction at a personal level, but interact through shared systems for Longitudinal Interactions.

- **Integration of information discovery and other means of experiencing inspirational materials, and the retention, organisation and reuse of these resources.**

Use of the Web Association Panel, and of web browsers, in tandem with the Associative Scrapbook, show that the integration between information discovery and the representational processes described in the model is important. Again though, the separation of information discovery from interactions with retained information is important in supporting convergent processes.

- **Integration of resources, as a basis for bisociation and organisation**

According to Simonton (1989), Koestler (1964) and Gelernter (1994), the association of information items is the process that leads to novel ideas. Composition processes in productive interaction also require the integration of a range of ideas. Finally, organisational processes that support the availability of resources, and reflection on collected ideas, require various forms of integration, including formal and informal representations of relationships, and pointers to segments of a representation.

- **Integration and separation of personal resources with social interactions.**

As mentioned in the findings from the empirical studies, there are differences between representations of ideas for personal and social use. The evaluations of the Associative Scrapbook showed a range of interpersonal interactions. Future work could explore this further through structures for social interaction in the Web Association Panel.
4.4.6.2: Questions on Contextual Factors

Contextual factors are dynamic in Longitudinal Interactions, so design is not a case of considering the instance, but the collection of instances of context that a system may be used in, and the development of these. It has been argued in this chapter that Longitudinal Interaction support is ideally context independent, but must integrate support for particular contexts. The following questions can be used to consider these needs:

A) What kind of structures for productive interactions will the practitioner use?

B) How are the representations of ideas and outcomes produced through these structure reflected upon when retained and organised?

The Associative Scrapbook evaluations showed that, whilst many of the processes involved were generic, retention and organisation utilised domain-specific representation forms and required domain-specific affordances, such as viewing video whilst making notes that highlighted particular sections, or organising multiple views of a 3D model for animation.

C) How can the system be adapted as the user develops expertise?

This is a developmental view, so for example as expertise improves, are new structures adopted? How do they relate to the previous structures so that expertise is preserved?

D) What scope can there be for users to develop relationships through the system?

E) Further to this, what scope is there to develop structures for social interactions, both in a domain, and in an interdisciplinary context?

Sharing of ideas, relationship building, and the development of structures for social interaction are key to Longitudinal Interactions, often occurring within a domain (communities of practice), but also between domains (communities of interest).

F) What forms of associations exist between resources?

G) How can these associations be used to relate retained resources to be used in future productive and structural interactions?

Primitive forms of association were identified for Associative Scrapbook, such as linking and grouping, however, there are domain-specific relationships between items. Meaning should be able to be assigned by users, but the scope for this should be considered in the design process.
4.4.6.3: Requirements

These requirements suggest generic needs for support in creative activities from a Longitudinal perspective. The integration of productive and structural activities with those that occur over the long-term, often away from environments designed for producing creative outcomes, are a particularly important theme.

1) Support for Longitudinal Interactions should allow integration with structures for Productive Interaction, but remain independent, so that the development of these structures is not restricted or preventative of use of the system.

2) Primitive forms of associations need to be provided, that can be open to the development of meanings by users. These can include grouping, linking and tagging.

3) Functionality for viewing and arranging multiple resources simultaneously should be provided, for comparison and composition.

4) Systems should be open to extension to integrate domain specific interactions with representations (e.g. cutting up images or video files). Representations should dynamically update when they are changed in software tools for productive interactions.

5) Repositories should be available as pervasively as possible, but this should not restrict the type or size of idea representations and captured inspirations that can be retained.

4.4.7: Conclusions

This final perspective on creative interaction significantly expands the range of phenomena considered part of the processes that support creativity. It is acknowledged that from this perspective, creative interaction is more complex, and that the design space emerging this expansion is harder to envisage and predict.

The model provides a set of processes that should be considered in the design of systems that explicitly support longitudinal interactions, but also relates this to structural and productive interactions. The next chapter brings the findings together to explore how they form a holistic framework.
Part 5: Conclusions
5.1: Utilising the Findings as a Framework for Designing Interactive Systems

Unifying the findings from the four previous chapters (4.1 – 4.4), this section considers how the requirements of creative practitioners and the issues that need to be considered by designers can be usefully identified using the model and the findings at each level, and integrating an understanding of the contextual dimensions that affect how support should be developed.

The Longitudinal Interaction perspective described in the last chapter provides a view of creativity as a complex system of processes, where the relationships between these processes are as important as the pieces themselves. The designer must consider and support the development of practitioners and the context in which they create over the long term.

The Structural Interaction perspective is essential because it is structures that the designer of interactive systems is producing, for use in a context of other structures. From this view, the designer provides tangible structures that support the translation of conceptual structures into representations of ideas and realised outcomes. In supporting the full extent of human creativity, the designer should develop scope for users to evaluate, adopt, dismiss and produce structures themselves.

The Productive Interaction perspective describes the basis for the interaction between mental processes and structures in the focused production of creative outcomes. The designer must consider how sketch-like interactions develop a conception of the outcome, and how contextual factors - such as the focus and scope for iterations - affect processes and needs.

In fulfilling the aims of this thesis, it also is necessary to accept and work with the limitations of the control the designer wields over creativity. Emergent properties, appropriation and serendipity are considered key in creativity research [refs]. Serendipity, being the antonym of design, cannot be intentionally designed. But it can be designed for – that is considered as a property that should emerge from the interaction between tool and user. Designers should intentionally develop systems where the possibilities for use are too numerous to be explored, and where appropriation in a context of other tools is expected. Within this though is a need for transparency in the workings of these systems, in order that conceptual understanding can translate to actions with predictable results.

The value of a creative act is multi-dimensional, and by association the value of a creativity support tool will also be complex and difficult to evaluate. With the increasing proliferation of creative technologies should come a realisation that the value of support tools should exist not only for experts in a domain, but be inclusive, support personal development and be enjoyable to use. A further value that can be designed in our networked age is to connect
disparate people and support their creative interactions in a variety of ways, replicating and extending the idea representation forms that exist in a domain.

This chapter describes approaches to utilising the findings in the process of designing systems. It begins with a consideration of the connections between the perspectives, and then takes the approach of integrating them as a holistic platform for considering where support is needed. The use of methods for eliciting specific contextual needs is then considered, and the integration of this with generic needs. Finally, a practical consideration of the development of software for creative activities is presented.

5.1.1: Integrating the Perspectives as a Holistic Basis for Understanding Design Needs

Table 29 provides an overview of the requirements devised from the previous three chapters. As was discussed above, many tools will not attempt to cover every need of every perspective, but an awareness of these needs can allow predictions of how the tool will be integrated with others, as it can be expected that creative activities require all of the components to be supported in some form. Each segment of the models can be considered as a form of interaction or artefact that exists in the world of the creative practitioner.

This could be utilised in design as a checklist of considerations to be accounted for. More specifically, if a system does support the type of functionality mentioned, it should consider the relevant requirements. If not, integration with systems that do perform these functions should be expected.

5.1.1.1: Integrating the Design Studies as an Example of Holistic Support

The design studies provided examples of the design of support from each perspective. An interesting further exploration is the integration of these systems as a basis for holistic support.

While Music Builder actually integrated a version of the Sonic Sketchpad as the ‘Compose Space’ composition environment, the Associative Scrapbook was developed as a completely separate project. Based on the findings of the Associative Scrapbook design study, a plug-in can be envisaged that would act to integrate Longitudinal Interaction support. This would support the representation of the major ideas representation forms from Sonic Sketchpad – compositions and recorded phrases - and tangible structures from Music Builder – the instruments a user has produced. Representations of these in Associative Scrapbook could, for example, allow users to listen to compositions, point to phrases or segments within them, and show visual representations including annotations developed in Sonic Sketchpad. Instruments could be represented through the plug-in with previews of the sound they would produce, and information about their construction.
The system would also add to the Music Builder functionality by supporting the retaining, organising and sharing of instruments. Associative Scrapbook would act as both a repository for instruments and a conduit for social interaction around them.

Through this example, an effective holistic support system can be envisaged. Similar systems could be envisaged for other domains that would integrate software for productive and structural interactions with Associative Scrapbook through plug-ins.
<table>
<thead>
<tr>
<th>Productive</th>
<th>Structural</th>
<th>Longitudinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Functionality for both sketching-type interactions and the realisation of creative outcomes. Support the capture of raw ideas, provide a flexible medium for manipulation and support communication and negotiation with collaborators. Reduce the costs of idea capture, modification and removal.</td>
<td>1) Support the development of tangible structures, utilising the primitives that are common to the domain as building blocks. This should provide a basis to give tangible form to conceptual structures, and therefore realise ideas based on conceptual goals.</td>
<td>1) Support for Longitudinal Interactions should supporting integration with structures for Productive Interaction, but remain independent, so that the development of these structures is not restricted or preventative of use of the system.</td>
</tr>
<tr>
<td>2.) Allow users to add textual and graphical descriptions to any part of a representation. These can be notes for the individual, or communicate ideas to collaborators and build shared understanding.</td>
<td>2) Provide scaffolding to support the immediate use and exploration of the environment</td>
<td>2) Primitive forms of associations need to be provided, that can be open to the development of meanings by users. These can include grouping, linking and tagging.</td>
</tr>
<tr>
<td>3.) Provide the ability to review ideas without the cognitive load of representing them.</td>
<td>3) Support the sharing of developed structures and the visibility of actions in structural development</td>
<td>3) Functionality for viewing and arranging multiple resources simultaneously should be provided, for comparison and composition.</td>
</tr>
<tr>
<td>4.) Provide mechanisms for evaluating ideas and the conception of the outcome. Include how a prospective audience would view it, and support evaluation of alternatives.</td>
<td>4) Support fluid movement between productive and structural interactions.</td>
<td>4) Systems should be open to extension to integrate domain specific interactions with representations (e.g. cutting up images or video files). Representations should dynamically update when they are changed in software tools for productive interactions.</td>
</tr>
<tr>
<td>5.) New ideas occurring within collaborative meetings need to be recorded, and an individual’s previous ideas need to be presented and used as shared artefacts.</td>
<td>5) The adoption and dismissal of structures needs to be supported with little cost to the user. Standardised file formats, plug-ins or similar approaches are required that can allow creative users to move seamlessly between adopting a range of software structures.</td>
<td>5) Repositories should be available as pervasively as possible, but this should not restrict the type or size of files that can be retained.</td>
</tr>
<tr>
<td>6.) Various forms of interpersonal interactions occur in productive interactions, and the design of interactive systems should support various structures for collaboration.</td>
<td></td>
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</tr>
</tbody>
</table>

Table 29: Requirements for Each Perspective (abbreviated)
5.1.1.2: Connections Between the Perspectives

Viewing creative interaction from each of the perspectives individually has led to requirements that may not otherwise become apparent. They are defined as perspectives however, as they do overlap. For example sketching initial ideas can be seen in productive interaction with a focus on producing an outcome, and in longitudinal interaction where the purpose is to retain and develop at a later stage. The relationships between structural and productive interactions – for example choosing or manipulating a software environment – are a strong focus in creative practice. Longitudinal interactions provide the platform on which productive and structural interactions occur.

Although the design studies presented in this thesis were developed with a focus on each perspective, they integrated aspects of the others in each case. For example, Music Builder integrated the production of structure with the productive interaction support developed in Sonic Sketchpad, and Associative Scrapbook integrates with the external applications used in the productive interaction processes of users, and it was found that tighter integration should represent a major improvement.

As argued in the previous sections, the connections between perspectives are essential to design, as even if a system is design with only a single perspective in mind, most systems should integrate with other needs in some way. These are often afterthoughts in the design process however, where systems are often produced that support low-level tasks, rather than the activities they are required for (Brown, 2000). This section reviews the relationships and overlaps between the perspectives, with the purpose being that these can represent interesting spaces for design and provoke deeper thought on the nature of creative interaction. In some cases, these can be considered as blue-sky conceptualisations of future possibilities, and in others, examples already exist of practical systems.

In the following sections, the relationships between each pair of perspectives is defined and explored.

5.1.1.2.1: Productive & Structural Interaction

Prior structural interaction bounds and affords the possible actions that can be taken to externalise ideas, and provides a conceptual basis for ideation, representation and evaluation, such as goals and concepts with which to express ideas. The empirical studies and the evaluation of Music Builder both provided evidence that – where possible – structural interactions occur in tandem with productive interactions. Designers should therefore focus on the possible integrations between the two types of interaction.

Internal structures - how the current conception of the outcome structures the space in which new ideas can be integrated – exist as an overlap between productive and structural interactions, as they are a form of structure generated by productive interaction cycles. Feedback from representations of ideas in the context of a partially conceived outcome supports an
understanding of the nature of this structure; however there may be scope for tools to further integrate notions of internal constraints with productive ideation and evaluation.

Structural interaction also includes the production of structure. Computers can be particularly effective in this regard: Music Builder gives an example – by supporting the creation of musical instruments and the use of these instruments as structure with which to create compositions – of how producing both structure and ideas can be integrated in an environment, providing scope for reflection and iterative production of both.

As described in the Structural Interactions findings chapter (4.3), Productive Interactions function as the process through which structures are explored. By using a structure, experience is gained. The exploration also acts as a basis through which the structure is evaluated, which is why structural interactions often follow periods of productive interaction cycles.

Collaborative structural interactions also influence production, supporting negotiations through which teams build a shared conception of the outcome and how it will be produced. By defining and developing shared structures in Music Builder, collaborators co-ordinated their play. Due to the complexity of collaborative productive interactions, structures also need to be developed through which the collaboration can function: Responding to the structure given to them in distanced evaluations of Sonic Sketchpad, users adopted a call and response model of collaboration.

The relationships listed above highlight some of the most important areas where designers can make a difference to the ability of humans to express themselves creatively in their interactions with computers. An alternative paradigm for integrating our creative interactions with interactive systems is presented by generative and A.I approaches to creativity (Boden & Edmonds 2009, Johnson-Laird, 1993). Here humans can develop the structures – defining the space and evaluative criteria - and computers perform productive interaction cycles within them.

5.1.1.2.2: Productive & Longitudinal Interaction

Longitudinal interaction provides the ideas, inspirations and memories retained from past experiences that feed ideation, and also the knowledge that is utilised in evaluation. As such, both the mental processes necessary for Productive Interaction are developed and rely upon Longitudinal Interactions. These interactions also spawn the collaborative or cooperative relationships that are necessary for productive interactions.

Support for longitudinal interactions integrates with productive interactions through the retention of previous work, ideas, inspirational materials, and structures. Retention is only useful to production if the resources are available and visible at the point where they might be used. Effectively alerting users to the possibilities for using previously collected resources in relevant productive
interactions is central to the value of such tools. Support for association is therefore key to making collected resources visible and usable.

Sketch-like interactions also cross the boundaries between Productive and Longitudinal Interactions. Initial idea representations are commonly made for retention in the expectance of later use, rather than in the context of Productive Interaction cycles. The affordances of systems for these processes should therefore be similar, although the retention activity of Longitudinal Interaction is likely to occur in different contexts, and the focus is on producing an effective mental trigger that supports memory of the idea or inspiration. In Productive Interactions, the focus is on producing representations that support evaluation in the wider conception of an outcome, and in communicating the idea to others.

It is conceivable that the automations described in the previous section could also integrate our longitudinal interactions: Generative systems could also be envisaged that took as input a repository of resources regarded by practitioners as interesting, collected over the long term, and use this as the basis for generating outcomes through association, performing as a colleague in Lubart’s (2005) roles. Both these examples show how the framework can be of use as concepts for describing and exploring new forms of human–computer interaction in creativity.

5.1.1.2.3: Structural & Longitudinal Interaction

One of the most interesting design spaces for interactive systems is expressed in the interactions between structural and longitudinal interactions. As structures represented in a tangible, yet virtual, interface support both malleability and communication over networks, they can be shared and developed over long periods of time with less effort than was previously the case. The social implications of this are wide, relating to the development of domains, new and modified forms of interpersonal interaction, learning and interdisciplinary creative interaction.

The possibilities computers offer in this regard for new forms of creative interaction are based in two notions: The ability to easily produce and modify structures at a personal level, and the ability to share these structures socially through a range of networks.

At an intrapersonal and representational level, structures can be retained for reuse. Practically this could include saving particular settings for a software environment, representing conceptual structures, or in the example of Music Builder and other End-User Development systems, retaining the developed tangible structures. The structural development of support for Longitudinal Interaction occurs through the organisation of retained resources. The previous section noted that these association support reminders to use retained ideas where appropriate. Evidence for the development of conceptual and tangible structures that link ideas in the long term could be seen in the questionnaire study responses, and was one of the commonly
used and discussed features of the Associative Scrapbook. Designers should consider how these associative structures are developed, and how interactive systems can be developed to more effectively remind users of appropriate retained resources. The exploration of these resources prior to periods of new productive interaction is a further point where organisation was commonly found to occur.

At an interpersonal level, structures for productive interaction are one of the cornerstones of the domain. These are the set of concepts and tools that are expected to support productive interactions acceptable to the field and wider audience. The social diffusion of new structures through networks can be envisaged, supporting more fluid development and adoption of structures through social interaction. For example, instruments developed by individuals using Music Builder could be shared with others, refined, and uploaded in much the same way open-source software develops utilising repositories such as SourceForge (sourceforge.net). In this way, the domain can develop to accept or refine the structural ideas of its practitioners.

Figure 62: Recursion of Productive and Structural Interactions Across the Models

Some of the overlaps described above have a recursive nature. Figure 63 describes aspects of the models in which analogous activities occur. These include the production of structure in Structural Interactions, which can be considered as Productive Interaction where the conception of the outcome is a structure for Productive Interaction in the domain. In the Longitudinal Interaction model, structures are developed both for social interaction and in organising resources. Finally, it was considered earlier in this section that a
process analogous to Productive Interaction occurs in producing ideas that are retained for later use.

This section has considered links and overlap between the perspectives that constitute this conceptual framework. This informs design in two ways, firstly the astute integration of the processes involved is central to effective creativity support. Secondly, the overlaps – such as those shown in figure 63 – offer a chance to reuse requirements and design patterns that work in one context, as the needs and processes are similar.

5.1.2: Eliciting and Integrating Data on Contextual Factors in to the Design Process

The prospective users of a system should be understood both in terms of the generic models, and the contexts in which they will use the system.

Whilst the effective bounding of software is a topic outside the scope of this thesis, Bounds in existing software are often domain-specific (e.g. Music Creation, Photo Editing), or cross several domains of creative practice (e.g. CAD software is used by architects and engineers amongst others). Software is also often produced for beginners or children separately from the serious amateur or professional, who expects more features and scope for structural interaction due to their expertise. In many cases, software for individuals is extended to support collaboration – as in the music creation software discussed in chapter 2.3: How Creativity is Supported. In other cases, online systems for social creativity – such as NinJam, MySpace or Flickr – exist distinct from software for productive and structural interactions.

Table 30 brings together the questions developed to elicit understanding of contextual factors and provoke design ideas. Having developed these, an important question is how should designers develop answers to them? The empirical methods utilised in this thesis have shown their strengths and weaknesses in this regard.

Specifically, observations are most useful in understanding productive interactions – they can be used to analyse forms of idea representation, and the focus of and scope for iterations. Participatory Task Modelling presented elements of all three perspectives, but participants often focused on Productive Interaction aspects as these are the most commonly thought of as constituting a creative act. Further development of protocols for PTM and Participatory Design could however, push participants to focus on the other perspectives as well.

The participants chosen for any study are an important consideration. In the Participatory Design and Task Modelling sessions, those with cross-over interests in technology and creativity could be seen to have a greater vocabulary and interest in the design issues. These participants often referenced existing interactive systems in their design and modelling, while
other participants reflected detail on issues that did not relate to interactive systems, but could inspire novelty outside of existing paradigms.

Structural interactions are best informed by a deep understanding of the domain, which can be developed through reviewing related theory, or casting a wide net across the work that constitutes a domain and considering its primitive components. Longitudinal Interactions are difficult to observe, but questioning or other forms of reporting can reveal details of these processes.

As the questions were developed separately, there is some overlap in the topics covered – for example between question A in each set of questions. It is still important to consider the same factors from these different perspectives, as they bring to light different issues in each model.
<table>
<thead>
<tr>
<th>Perspective:</th>
<th>Productive</th>
<th>Structural</th>
<th>Longitudinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions:</td>
<td>A) What are the main forms of idea representation currently used in producing outcomes in the domain?</td>
<td>A) What Conceptual and Tangible structures are commonly found in the domain?</td>
<td>A) What kind of structures for productive interactions will the practitioner use?</td>
</tr>
<tr>
<td></td>
<td>B) What are the forms of idea representation currently used in sketching processes in the domain?</td>
<td>B) How are the central Conceptual Structures represented?</td>
<td>B) How are the representations of ideas and outcomes produced through these structure reflected upon when retained and organised?</td>
</tr>
<tr>
<td></td>
<td>C) What persistent or temporal forms of representation should the system support?</td>
<td>C) What are the primitive concepts that underpin structures in the domain?</td>
<td>C) How can the system be adapted as the user develops expertise?</td>
</tr>
<tr>
<td></td>
<td>D) How will the system integrate with existing forms?</td>
<td>D) What relationships are there between Tangible and Conceptual Structures in the domain?</td>
<td>D) What scope can there be for users to develop relationships through the system?</td>
</tr>
<tr>
<td></td>
<td>E) How will it improve these forms?</td>
<td>E) How can users be guided, or reflect on the ramifications as they choose to adopt, dismiss or produce structures?</td>
<td>E) Further to this, what scope is there to develop structures for social interactions, both in a domain, and in an interdisciplinary context?</td>
</tr>
<tr>
<td></td>
<td>F) What foci of iterations can be expected / supported by the system?</td>
<td>F) What understanding of the structures used in Productive Interaction should be visible to the prospective audience of the creative outcomes produced?</td>
<td>F) What forms of associations exist between resources?</td>
</tr>
<tr>
<td></td>
<td>G) Is there expected to be scope for iterations in the use of the system? Is there scope for individual and / or collaborative iterations? What bridges these?</td>
<td>G) What structures can be shared and what visibility is necessary to support collaborative development?</td>
<td>G) How can these associations be used to relate retained resources to be used in future productive and structural interactions?</td>
</tr>
</tbody>
</table>

Table 30: Questions on Contextual Factors from each Perspective
5.1.3: Practical Issues in the Design of Interactive Systems

This final section constitutes a discussion of how the conceptual framework can be utilised in the context of interactive systems design. Drawing on the background provided by chapter 2.5: Designing Interactive Systems, it is clear that interactive systems development is a complex process mixing formal methods and creativity. Systems for creative interaction have specific needs highlighted by the framework presented here. Through utilising an understanding of the concepts in the framework and their relationships, along with the requirements and the questions on contextual factors, a formal process of design can be supported, but one in which there is space for imagination to be used. The nature of creativity however, requires that further thought is undertaken on the structure of the design process itself.

A central premise in this thesis - through the Structural Interaction perspective – is that the creative practitioner is active in designing the structure in which they produce creative outcomes. This may involve the adoption of several systems in tandem, appropriation of systems beyond their designers intentions, or the production and modification of systems as a basis for novel productive interactions.

End-User Development approaches, integration between systems and extensibility of them, are all key to designing support that is inclusive of the users’ abilities to modify the context in which they work. In addition, the ability of practitioners to reflect on this context should be considered in the design of systems. Questions such as: What will emerge when these systems are used together? How will this affect my processes? Creative practitioners (other than designers themselves) are not professional designers, and their focus may be narrow in terms of the structures they wish to change. Nevertheless, the designer must consider themselves a facilitator rather than a director of the creative processes of users. Scaffolding over an open system of primitives is suggested as an effective approach to overcoming tensions between supporting immediate exploration and supporting scope for extensive modification.

A second premise – espoused in the Longitudinal Interaction perspective – is that creative practice must be seen in a dynamic and developmental light. The systems used will change, the practitioners’ focus will change, and the domain itself will change over time.

Scope for systems to develop over time without disrupting the reuse of previously retained resources is important. Iterative development approaches should be planned for, with the task-artefact cycle in mind, because the novel functionality presented by new systems will often be quickly integrated in to practice due to the thirst for novelty. Further possibilities arise from this, which the designer can exploit: Creative practitioners provide a proactive and
interested group of users for designers to interact with, and various approaches to cooperation or collaboration between designers and creative practitioners – such as those developed by Edmonds et al - should be arranged as part of design research, as these offers scope to focus and speed up task artefact cycles, leading to innovative interactive systems both for creative practitioners and the wider world.

Finally, it can be argued that a majority of the tasks performed with interactive systems – writing a letter with a word processor, social networking, or finding information, contain aspects that occur in creative activities. Through developing interactive systems for creative practitioners, the design of systems for wider use can be inspired and informed. This could work in terms of a decomposition of elements from the framework in terms of what occurs in other activities, and how these are supported in systems for creative activities. Because of the requirements for novelty and value, system for creative activities will tend to be at the forefront of interface design and the utilisation of new technologies, and this should be utilised further in general interactive systems design.
5.2: Conclusions

This thesis has presented a theoretical, empirical and design research based investigation of creative interaction, aimed at informing the design of interactive systems for creative activities. To complete the thesis, the contributions made are analysed, and directions for future work are considered.

5.2.1: Realisation of Objectives

To conclude the thesis, this section returns to the research objectives and assesses how they were achieved. The first objective was to:

1: **Build an understanding of the interaction that occurs both between humans and with humans and external artefacts in creative activities, combining a range of research methodologies to develop this understanding.**

This objective was tackled through a set of empirical studies, which were analysed with respect to the interaction that occurred. Whilst this understanding has limits in terms of the scope of creative activities and contexts that were studied, it has been built with reference to existing research, which can be used to suggest that the findings have general applicability. Understanding creativity in terms of generic models and contextual factors provides a space for discussion of some of the variations that exist across different contexts of creativity.

Each of the studies and analysis methods provided different types of useful information: The observational studies were a useful starting point as they provide detailed, objective data on the way creative activities are performed. By performing observations in two domains, some interesting contextual differences came to light. The analysis of these observations - in particular utilising Transana - provided a process for the identification of the common themes that form the concepts of the framework. This software for qualitative data analysis provides a useful structure to a complex process, and the results allow analysis of how common the framework concepts are across the studies. There is further scope for analysing the patterns that occur over time in analysed sessions of creative activity, but a larger data set would be more appropriate to this.

The open questionnaire study provides a very different kind of data. These are reports of creative practitioners of how they interact with tools and each other. They provide insight in to the long-term aspects of creative activities that are difficult to observe effectively. They also provide understanding of the subjective views of practitioners on issues such as interactive systems, bisociation and interpersonal interactions.

Finally, the participatory task modelling sessions provided a detailed understanding of how practitioners view their processes, distilled in to models that can be compared to those produced for this thesis. This method of data
collection proved very helpful as a validation of the models, and is especially interesting in terms of how it can be used in conjunction with participatory design techniques. A further data source that was not extensively analysed here was the discussions that occurred between participants as they produced their models, and how their models influenced the participatory design activities they performed.

The second objective was to:

**2: Iteratively design, implement and evaluate prototype systems to support creative activities based on the findings of objective 1.**

Three prototypes were created – Sonic Sketchpad, Music Builder and the Associative Scrapbook. These projects were important to answering the research questions in several ways: Firstly, they provided a practical orientation to the research. This balanced with the theoretical research occurring in objective 1, and helped to guide the project towards producing knowledge that was grounded for utilisation in real world design.

The projects also tested the applicability of the findings of objective 1 to design. In each case, it was found that an understanding of interaction in creative activities could inspire and guide the design projects. The projects were also evaluated with reference to the concepts produced in the findings. This provided a basis for understanding and discussing what was positive or lacking in each of the designs.

Through experiencing the process of designing for creative activities, they allowed me to gain a deeper insight into how such processes can be supported, and the processes of interaction with end users that can be fruitful. This informed the requirements, questions for designers, and the form of the conceptual framework itself.

The final objective was to:

**3: Develop a conceptual framework and guidance for the design process, that takes the findings of objective 1, refined through the understanding of designing for creative activities built through objective 2, and provides a useful tool for designers of interactive systems for creative activities.**

The conceptual framework consists of the three perspectives on interaction in creative activities, each of which includes a model, a set of general requirements, and questions to guide and inspire design based on contextual factors.

The framework was produced through a process of considering how the understanding of creativity built could be usefully represented. Existing research that has related an understanding of creativity to interactive systems design includes Shneiderman’s (2003) GENEX framework, Lubart’s (2005)
roles for the computer and Resnick et al’s (2006) principles of designing for creativity. GENEX takes a descriptive understanding of creativity from previous theory to produce a prescriptive framework for designing support. Lubart’s roles and Resnick et al’s principles are also prescriptive, based largely on the review of practical design research.

The framework produced in this thesis includes a deeper description of the interactions that occur in creative activities - represented in the models of each perspective - than the previous research achieves. It also includes prescriptive statements in the requirements, amalgamated in section 5.1.1. These are based on the concepts described in the models. Perhaps the biggest contribution of this framework is its scope to integrate contextual factors. As the instances of the models shown in sections 4.2.4, 4.3.4 and 4.4.4 present, the framework can be used to describe various types of creative activities, such as collaborations of various kinds. The questions on contextual factors, amalgamated in section 5.1.2, are an attempt to introduce a formal investigation of the contextual aspects of the activity being designed for. This combination of descriptive and prescriptive outcomes, which is in some contrast to the research mentioned above, is key to the utility of this framework.

5.2.2: Critical Analysis of the Contribution of this Thesis

Creativity is a complex phenomena, and this thesis has taken a holistic approach to understanding this, where it would be equally possible to spend the time and effort on a particular aspect of this. In taking this approach, it is to be expected that a large range of questions are raised to which answers can be pursued in future research. The concepts and relationships developed in this thesis can be applied to this work.

In taking a wide view, the focus with which the subject matter is analysed needed to be bounded effectively. While this focus narrowed as the research leading to the thesis was performed. It was in the dimension of ‘who the thesis should be useful for’, rather than towards particular contexts of creativity. The limited contexts of creativity studied in the observations and through the design studies do form some limitations on the ecological validity of the findings. Further research that applied this framework to other contexts would refine it and improve this validity, however the findings were considered in light of existing creativity research, which provides the best proxy available to this given the limited time and resources, and the impossibility of analysing all of the forms of creativity that exist in any depth.

In addition to the conceptual framework, this thesis has contributed three example prototype systems, the functionality of which could be considered for implementation in other systems. Iterative development and evaluation provides concrete information on the success of design ideas, and this can be applied again. Design ideas that developed from the empirical studies and
literature review, and were validated through evaluation, are represented in the requirements produced. With more design studies to generalise from, this approach could be developed to produce design patterns for creative interaction.

Finally, methodologies were adopted and developed to the needs of the thesis. In general, these can be considered successful in different ways in developing understanding of creativity in general and in specific contexts. The previous chapter explored the utility of these to understanding contextual factors in the design process. The application of these and other methods can therefore be considered both in further research and in user-centred design.

5.2.3: Future Work

As the previous section noted, this thesis has developed a holistic understanding, which could be extended in many ways. Through the process of performing this research, several avenues of particular interest for future work have become particularly apparent:

The social interaction described in interpersonal longitudinal interactions, and its support, is a timely subject to which the concepts developed in this thesis can be applied. This research could explore how ideas, structures and other resources are shared, and how structures for social interaction develop. The value of these interactions to practitioners needs to be understood, along with their attitudes to privacy, and the nature of idea representations for communication as opposed to personal use. Through this, networked interactive systems could be developed that add value to existing systems such as Flickr and ccMixter by improving the functionality for interaction between users. The development of domains through the diffusion of structural interactions is also key.

This thesis has argued that support for the development of tangible structures is key to improving support for creative interaction. A number of tensions are highlighted in this, and further exploration of functionality that supports the adoption, dismissal and production of structures, and reflection on these processes, is key. Structural development by collaborative groups – both in terms of the structures used in producing creative outcomes, and those used to support representation, evaluation and decision-making by multiple practitioners, is particularly fertile ground for further research.

The thesis has highlighted some of the aspects of creativity that are affected by contextual factors. It has however, focused largely on the study of those that could be considered ‘Creative Practitioners’. Creativity can enhance all our lives, and the use of interactive systems to support creative activities as therapies, and to provoke social interactions, is an important area for further research.
Finally, the general development of formal processes by which interactive systems for creative activities can evolve, based on new forms of interaction between creative practitioners and designers, could build upon the framework and experiences of the methodologies used, to provoke the development of technologies that channel human creativity through interactive systems in co-evolution. An important next step is for the framework to be used by other designers and researchers, in order to demonstrate its usefulness and to refine or add to it where necessary. Possible avenues for this would be to perform studies where designers utilise the framework as a basis for developing tools that support creative activities, and to perform participatory design studies structured by the framework. Further to this, it is hoped that disseminating the work widely to designer and researcher audiences will lead to the framework being used in real world design and research settings.
Part 6: Appendices
6.1: Questionnaire Study

6.1.1: Responses

Response 1

<table>
<thead>
<tr>
<th>Occupation/</th>
<th>Hobbies: Artist/Designer/academic/researcher/teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hobbies include:</td>
<td>music: playing guitar and piano, singing, listening to music, watching films, visiting art galleries, making jewelry, making garments, knitting, fashion, shopping...frequently window shopping for new ideas...travel...visiting new places, walking, gardening, reading</td>
</tr>
</tbody>
</table>

Question 1_: sketchbook, camera, video camera, iPod recorder, tablet PC, mobile phone

I keep my phone on me all the time for use as a camera, often have a sketchbook in my bag always if I am going anywhere special or new. I usually take a camera and video camera if I am travelling anywhere...and computer (tablet PC) to down load my photos and video

Question 2_: Yes...all of the above...especially colours...very important!

Question 3_: The inspirational material acts as a trigger for memory and enables ideas to be synthesised. The computer becomes a useful tool for blending visual ideas but hand rendered sketches and notes are also important. The sketchbook is key to idea development as it brings together ideas and images. The physical act of cutting and pasting and moving the images around in physical space is also important...also because it takes time to reflect on new and emerging ideas.

Question 4_: Yes...all the time!!! Anywhere and everywhere.

Question 5_: Top of the Empire State Building in New York...looking down from the top at the patterns of the buildings...thought about an image printed onto fabric like a patchwork of colour.

 Took photographs and made notes later in a sketchbook.

f

This became a digitally printed textile artwork.

Question 6_: I have so many ideas all the time that most get forgotten. The ones that you work with are the ones that recur or contain special meaning.

Question 7_: yes, with other artists. Sometimes in collaborative art making...or music making...often in conversations and sometimes email or on the phone. Often this involves showing a sketchbook to share visual ideas.

Question 8_: Yes, often, particularly good photos and video and frequently sketchbook ideas as it is easier to show, than to describe verbally, visual concepts

Question 9_: For design clients: as storyboards or mood boards that give the flavour of the emerging idea
For artworks: through sketches and sampling
On my website
On CD’s that are mailed to people
In email conversations

Question 10_: My collaborations are nearly always with only one other artist. There is usually a predefined outline plan of action though the rules are often broken! Computer, photography, video and hand rendered sketches, telephone and email conversations are all part of this.

Comments_: The process has to be fun and playful or the tools don't help you to capture any ideas. Poor interface design is the biggest hindrance to fluid creative play when using digital tools...that's why physical media (paint, pens and paper etc.) is such fun!! :)

Response 2

<table>
<thead>
<tr>
<th>Occupation/</th>
<th>Hobbies: I work as an AV Technician at the University of Bath. Creative hobbies include drawing, painting (using a number of mediums), sculpting and web design. I am also a recording musician and producer.</th>
</tr>
</thead>
</table>

Question 1_: My inspirations come from everywhere. To record these things, I use an M-Audio digital recorder, as well as an Olympus digital recorder. Post-It notes are always by my Mac computer (laden with software), and I never go anywhere without pens, pencils and paper. I also possess a fairly good quality 7 megapixel digital camera.

Question 2_: Sketches, photographs, recorded snippets and samples, written notes, newspaper and magazine cuttings and extracts, interviews, etc.

Question 3_: I refer to these things often because whilst at work, it isn't always convenient to down tools and rush to my easel or computer to use the ideas I have discovered or been inspired by.

Question 4_: My inspiration comes in many forms, and is totally unpredictable, hence my little list of tools and
gadgets. People I see (both known to me and strangers) are particularly fascinating, as are random events and circumstances.

Question5_: In true Picasso tradition, I once asked a girl I like the look of if I could paint her having seen her in a cafe in Bath. Fortunately, she was not too embarrassed, and fortunately, nor did I frighten her for life!

Question6_: Yes. Definitely. I still beat myself up about some of them!

Question7_: Only those I choose to see or hear my work will be exposed to it before it is ready for more public consumption.

Question8_: Occasionally, yes, but only those I trust instinctively.

Question9_: I don’t.

Question10_: I seldom collaborate as an artist, but as a musician, collaborations are a source of wonder and excitement, as well as being occasionally frustrating. Flip charts are a great tool, as are notebooks, pens and paper, and good old-fashioned talking and listening.

Comments_: Good luck with your research project!

Response 3

OccupationHobbies: Creative writing: poems, short stories, novels, short non fiction pieces.

Silk painting: creating shaws, scarves, sarongs, wall hanging etc with ideas developed through sketches on paper, before being pencilled onto silk, outlined and painted on.

Question1_: For writing: pencil, note pad, diary, general scrappy bits of paper, incl. post its, memo blocks etc. Laptop, as before.

Silk painting: similarly, scrappy bits of paper, notebooks, diary.

Question2_: For writing: short lines of ideas, descriptions of scenes, groups of lines of poetry, ie nearly entirely written words.

For silk painting: annotated quick sketches, simple shapes, that if I decide to create the project will be expanding into a to-scale drawing.

Question3_: Writing notebooks/ papers (which are kept in one single plastic file per project they refer to, this is kept with the main manuscript): when I'm stuck for ideas/ writers block. When I wish to refresh my mind of previous plans and plots.

Have starting trying to digitalise this, along with all the ideas typed in note form on my laptop, and kept in the same folder as the manuscript they are relevant too. This has proved somewhat unsuccessful due to laptop not being as accessible/ time.

Silk painting: sketches are just to get a first idea down. If I choose to follow an idea through, it'll be redrawn, and developed onto larger (eg) A3 sheets, with the original sketch providing little more than a reference to the idea.

Question4_: Ideas strike all the time, in random situations. Particularly when half asleep (for writing: dreams become storylines), amusing, unusual or anecdotal incidences are always worthy of noting, providing realism to writing.

For silkpainting, landscapes, and other people work are major sources of inspiration, and ideas therefor strike at all sorts on times.

Ideas are more likely to strike away from work/ practise...

Question5_: I keep a light up pen and notebook by my bed... similarly, I always keep a pen and some paper on me.

If I don’t have one, I try to make a “mental note” of the idea.

Question6_: Definetly, I am occasionally caught without paper! Mental notes are no where near as durable.

Question7_: Writing ideas I share with other writers only. This can trigger new ideas (bouncing ideas back and forth inspires new ones) for this reason co-writing is much easier.

Silk painting ideas are more kept to myself, although I may consult with my mother when I have problems (again, as another person with similar creative skills)

Question8_: No. Usually I only show work in progress, or will vebally explain ideas, or draw new sketches.

Question9_: Answered above.

Question10_: most co-writing I do, is discussed through msn. Occasionally I will meet face-to - face with people, where we will both sit with a pen, and one copy of he manuscript, and discuss and edit the exisiting work.
The work is usually developed through bouncing it too and fro in an email, with each person adding a new paragraph. Silk painting has only ever been a solo endeavor.

Comments:

Response 4

Occupation: administrator
hobbies: painting, performance and installation art

Question1: notebook constantly with me
Question2: Written text, sketches, images from newspapers, magazines, brochures etc
Question3: I use the notebooks to record ideas which usually happen at moments when I am not in my studio (often while travelling to/from work) so it's good to scribble down just a few words otherwise I forget about it all
Question4: Yes, all the time - sometimes I get really fed up that it is a work day
Question5: This morning on the way in to work I had (what I think) is a really good idea for a series of paintings, after a bit of time spent thinking about it I wrote down a brief description to remind me later on.
Question6: YES
Question7: If I am working collaboratively on a project, for example an installation or performance piece.
Question8: Only to close friends, usually other artists
Question9: Verbally
Question10: consensus decisions usually, when I work with a collaborator we do use email as a means to communicate and make decisions - we can send images that way.

Comments: From Winnie the Pooh's little book of wisdom:

Be Open to Creativity

Poetry and hums aren't things which you get, they're things which get you. All you can do is go where they can find you.

Response 5

Occupation: student
hobbies: football, guitar, poetry, song writing, web design (check out my work at www.ilumu.com and www.joyjolly.com)

Question1: notepad - business plans, etc
diary - record daily thoughts
post it notes - jot down any floating ideas

Question2: random notes
brain storming
written text
key words
sketches

Question3: interchange ideas between resources
adapt, improve, and pursue

Question4: in bed - low frequency
travelling - moderate frequency
looking at pile of boring lecture notes - high frequency
browsing internet - v.high frequency

Question5: randomly browsing ebay.
found out how easy it was to operate a basic website.
started out messing with html coding.
developed search engine at www.ilumu.com and www.joyjolly.com

Question6: yes, occasionally.
but it's best just to let them go.
they will come back naturally if you don't think of them. To keep on thinking about it stresses you out and reduces
chance of recovering those ideas.

Question 7: Sometimes with parents and friends if successful, through speech and computer. If not, no I keep them to myself.

Question 8: No

Question 9: Speech visually

Question 10: No I just let one thing lead onto the other. As with the website example:
First I bought a domain name, then web hosting, then the script, etc.
I prefer to let things flow.

Comments: I wish you the best of luck with your research. Have a great Easter, and if you require additional info, feel free to contact me:
Cheers.

Response 6

Occupation: Hobbies: I am currently doing a PhD in information management in engineering. My main creative hobby
is photography.

Question 1: A5 paper notepad - Used during working time at home and office for to-do lists, ideas, etc.
Whiteboard - At home and in office - generally for working out how to draw a diagram or for collaborative idea
generation - used several times a week.
Microsoft OneNote 2007 - Used on a tablet PC and a laptop to record ideas, visualise data, collect things from the
web etc, much like the whiteboard, but when I want a permanent record or need to send it somewhere. I am using
OneNote more and more now, at least on a daily basis.
Post-it notes - quick ideas at home and office, usually just a few words to remind myself of something that then gets
recorded in OneNote
Camera/video camera - Used to capture the output of brainstorming sessions, interesting products etc. Images are
then imported into OneNote for annotation
Audio recording - Have occasionally recorded meetings where we are generating ideas.

Question 2: For recording ideas on whiteboards and in OneNote, they take the form of pen sketches, mind maps and
diagrams. I also use voice, video and images pasted from the internet on OneNote.
Sometimes I photocopy pages from magazines and attach them to my whiteboard. If they are very important I scan
them and put them in OneNote as images.

Question 3: I try to use OneNote as my main space for storing ideas in the longer term as I can easily rearrange,
annotate and formalise them. For example, images I have seen on the web can be pasted into a report, or emailed
directly to other people. The other paper-based tools are generally for doing 'working out' and might only be retained
a few days or even minutes. For example, a post-it note will only be retained until I have acted on the idea. If I think
it might be important for the future I put it in OneNote to retain.

OneNote has extensive search facilities including keyword searching of audio and video via voice recognition, but I
usually locate past ideas by memory, or simply browsing through the pages. I refer to it several times during a typical
working day. I refer to them when trying to develop the ideas into formal output (journal papers, reports etc) and
when I get requests for information from colleagues. I also just browse over previous ideas when I'm bored, or for
inspiration.

Question 4: Yes. This probably happens once or twice a week.

Question 5: I often discuss things I have seen with friends at the pub etc. For example, my work involves looking at
ways of handling personal information in the engineering domain more effectively. My friend who works in IT was
talking about a new product from Microsoft called Surface. He was talking about using the product to create revenue
in pubs, but I also saw how it could have application in my work. I had no means of recording the idea, but asked him
to email me about it the next day to remind me of it.

Question 6: Yes. Particularly ideas that I've had at the pub after a few pints! If I think it is a particularly good idea, I
usually remember the gist of it, but often not all the details I thought of at the time. Mind you, I've no doubt half of the
things we come up with while drunk wouldn't stand up to scrutiny the next morning.

Question 7: Yes, frequently. I often share ideas with my supervisor and colleagues...probably once a day on
average. Sometimes it is a very brief question about something, like "what do you think of this new product?" or it
could be a very in-depth idea generation meeting lasting several hours. I use OneNote on a Tablet PC, pen and
paper, flip charts, post-it notes and whiteboards to generate and organise ideas.

Question 8: Yes. All the tools I use are visible apart from the whiteboard in my home, and my A5 notepad, which I
consider "personal" and private. I show them the tools in response to requests for information, often several times a
day and during meetings.
Question 9: As the idea develops from a word on a post-it note to diagrams and analysis in OneNote, it would eventually end up in an academic paper or a Powerpoint presentation, although I increasingly find powerpoint and the office suite in general an inadequate way to express my ideas fully.

Question 10: Answer similar to Q7. We use a variety of tools (paper, flip-charts whiteboard, OneNote, post-its) to generate new ideas, organise data (post-it notes) and annotate existing ideas or diagrams to modify them. The decisions are arrived at verbally.

Comments: This is a very interesting area that appears to overlap a bit with work we are doing in Innovative Manufacturing Research centre in 8East. I would be happy to chat to you further about this if you email me at

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Response 7

**Occupation/Hobbies:** Researcher, Musician/songwriter, Writer, Actor, Painter

**Question 1:** Notepad (small pocket size) - carry with me most places. Make lists, notes, sketches, mind-maps; pad has a pocket which gets business cards, interesting wrappers, leaves etc.
Computers - mainly use a laptop, but it's left on a desk as much as it's carried around. Used to write things up and use the web mainly; camera; mobile phone: use the notes function to make notes and lists; dictaphone - used for interviews or testing new songs; other people - used to bounce ideas off or 'can you remind me...?' requests; misc. scraps of paper - used when no notepad etc.
A5 ringbinder - used as a sort of filofax/notepad. but not with me often enough.

**Question 2:** mainly words - lists, notes and mindmaps. occasional biro sketches. collect found objects e.g. wrappers or scraps from magazines. collect quotes by email.

**Question 3:** I haven't got very smooth integration systems. Generally it's a collect and collate system, and I'll work on one project for a bit, and then another, and then back to an old one. I'll look through notes and notebook on the bus and in spare time and see what happens.

**Question 4:** Happens a lot - drifting off to sleep. In lectures/talks. When having conversations with other people. While driving.

**Question 5:** Last night was in a seminar and was remembering things I had to do - had a flash of inspiration about how to do it; wasn't appropriate to make a note then so I had to remember it. Other times, I've used my mobile phone (under the desk); I tried keeping a notepad by my bed for night-time inspiration but the scrawlings were too obtuse to be useful!

**Question 6:** Yes. But I figure that more will come...

**Question 7:** Frequently - like getting ideas off people, and I often get an idea whilst explaining something. If I'm really excited by an idea/project/concept, I'll tell everyone I meet.

**Question 8:** Yes, but only selected people. My wife is an artist and so often understands my notes/sketches and can give insight. I like songwriting with other people. I'm in bands and so the creative process there is collective.

**Question 9:** Verbally; Using computer print-outs; By email/blog

**Question 10:** Most collaborations involve a strong vision and so the what next decision seems fairly sensible. Lots of writing on paper is used, or for magazine writing, lots of word and excel documents emailed across to each other.

Comments: I'm pretty open and fluid with my inspirations and rather disorganised at the same time. I'm intrigued by the various systems to be more organised with collected ideas (http://en.wikipedia.org/wiki/Getting_Things_Done, http://www.43folders.com/, http://www.lifehack.org/, http://www.pocketmod.com/, etc) but I'm not organised or under pressure enough to employ them! If I had more money, I would probably have a palm or smart-phone which would enable me to do more electronically on the move.

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Response 8

**Occupation/Hobbies:** Occupation - Library Assistant, training for Librarianship qualification. Hobby - Writing. Completed a children's novel, a few screenplays, working on a radio play.

**Question 1:** Notepad to draft ideas, usually A4 or A5 sized. Take them with me in my bag to work. Have tried noting ideas on my mobile phone, but it doesn't really inspire me to carry on with them. Often use work computer to note down idea on a word document, then email it to my home pc to work on later.

**Question 2:** Mostly written text, in the form of 'beats' (bullet points)
Occasionally a sketch

**Question 3:** Refer to the notes when writing up the work. Usually write up in longhand and then type up later

**Question 4:** Always. Middle of the night, or when driving (so can't note it down!). Mostly when doing menial tasks like ironing or washing up.

**Question 5:** When driving, I have to turn radio off and force my self to think about the idea so I don't forget it. When safely home, note it down in book, or scrap of paper.

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Question 6: Not really. I trust in myself that if they are good enough, I'll remember them, or at least the seed of them. If I can't remember the idea, it couldn't have been that good, could it?

Question 7: No. I like to complete work before showing it off.

Question 8: No. I make sure I've got a professional piece of work to show someone. The note book is just my scribbles.

Question 9: In a final, written up form.

Question 10: Don't collaborate.

Comments: Really interesting subject - has made me think about my creative process more. Good luck with the rest of the research!

Response 9

Occupation: Hobbies: I am a Fine Art graduate but also am a landlady, I earn money mainly from letting but also from paintings.

Question 1: Mainly taking photographs and sketching

Question 2: From photographs, I try to emulate in paint different qualities captured within the image. So I would say the photographs are used to capture the inspirational material (images of light) and paint is then used to represent the ideas and inspirational material.

Question 3: When the painting needs more depth or is lacking in something the photographs offer infinite possibilities of which to explore with the medium.

Question 4: Varies at different times. Sometimes the art is everything, you go to bed thinking about it and wake up thinking about it trying to find solutions to visual problems (ie how to represent a certain type of light in paint). I have dreamt of solutions before while asleep! When painting alot ideas come regularly through the day when carrying out different unrelated tasks. I have had plenty of sudden inspirations when watching a film or music video for example.

Question 5: I was just watching TV switched off from painting and a Justin Timberlake music video came on. In the video was a silver glittering curtain made of individual long threads. The camera went out of focus with the light on the silver curtains and made a wonderful effect of light. The resulting visual effect gave me insight on how to move my painting forward.

Question 6: Yes, definitely, loads. You have to very disciplined in order to record the hundreds of ideas you have throughout the course of your daily life.

Question 7: When sharing studio space with other artists whose work has connections with each other, ideas are fed in each direction. Each artists work is discussed and ideas can be passed on and inspiration gained from the other artist.

Question 8: Sometimes, it is interesting to see where the finished painting originated from and links between them. I will demonstrate this to potential buyers of my paintings when they visit the studio if they are interested in knowing more about my work.

Question 9: Through painting.

Question 10: Generally do not collaborate with other people.

Comments:

Response 10


Creative hobbies: cartooning, graphics, writing, music, playing drums, model-making, photography

Question 1: Usually sketchpad, sometimes mobile phone.

Question 2: Mock-up web pages; Graphics; Drawings; Articles; Animations

Question 3: I use web authoring and graphics software. Sometimes I translate sketches to web pages or redraw the graphics using software. I also scan originals I've drawn and use them.

Question 4: Yes, often. Almost always get ideas when traveling on public transport. Sometimes get ideas in shops, parks, bed where ever I happen to be. The creative mind doesn't stop.

Question 5: I had an idea for a short piece of writing, the story was swimming around in my head for days. One day, I had about 2 hours between doing presentations, so I sat on a bench and wrote it down, using pencil and paper. This surprised me a lot, considering I normally use a pc for writing. There was no copy & paste, no being able to move things around. I had to use an eraser to rub out some of the mistakes but I was pleased with the result. the person i
sent to said she was very impressed.

Question6_: No. I never forget what I consider is a good idea. It's a bit harder if you can't make notes soon, but if it grabbed your attention in the first place, it's likely to stay with you.

Question7_: Yes all the time. I show others my work and in the creation of websites, this is usually a team effort. Almost all of my work is public.

Question8_: Yes. Sometimes, I show others the original sketches. Often at initial meetings, I'd sketch ideas as well as write notes. It's not always easy for people to visualise your ideas or takes on things.

Question9_: By making a verbal presentation, going into a lot of descriptive detail. The journalistic aspect of my work helps. If I had to phone through a story, I'd have to rely entirely on my verbal descriptive powers, although generally, if it was that interesting, I could probably email a picture taken on a mobile as well.

Question10_: Work is mostly deadline driven, so those decisions are automatically made. I'd usually take on the design and copywriting aspects and leave all the tech stuff to those who enjoy that sort of thing, we usually have a planning cycle such as - initial mockup, prototype, testing, beta, release, that sort of thing...but not always...:-)

Comments_: yes, it seems a fascinating area for research. Please keep me posted, I'm very interested. Good luck!

Response 11

OccupationHobbies: Professional composer, pianist, poet, performer and writer.

Question1_: Notebooks, preferably beautifully made. I write in pen.

Question2_: For poems, I may directly write the lines themselves, but I may also be writing simply lists of words and phrases later to edit into a text. For both musical compositions and poetry (and performance poems) I usually write down my thoughts, and make lots of diagrams and lists of numbers to find the right structure and the right balance of materials.

Question3_: Only for poetry do I actually write down things that I later use in the poem. More generally, I keep writing and re-writing and re-sketching the structures and number lists until they look good. By then I don't actually need to refer to my notebooks because my idea is clear enough to be entirely memorized - and often by that time, the piece is more or less finished.

Question4_: All ideas are unexpected, and they may come up in any situation.

Question5_: If the situation allows me the time to think about the idea, I think about it. I usually don't immediately write things down.

Question6_: Probably - but they would always have been ideas for new projects, never ideas for something that I'm working on. And it's not a problem because new ideas will always come up.

Question7_: Personal discussion mostly; sometimes through email. Usually only when it comes up in conversation; much more rarely, I may talk with others about ideas to sharpen them, to use other people's experience, or simply to see if the ideas are good.

Question8_: Hardly. Others are not very likely to understand my notes. I may show my notes simply to show my way of working, almost never to show the ideas themselves.

Question9_: If the work is finished, I may later write about it or give presentations.

Question10_: My favorite modes of collaboration are the ones in which you can somehow work very independently on the basis of very fixed simple constraints, such as for example the 'Cage/Cunningham-concept' in music & dance, where Cage and Cunningham would just produce a musical work and a choreography respectively of a fixed duration which would then simply be put together. This kind of approach merely requires fixing some set of rules, which is done in writing, usually through email. There may always be additional discussion but this is usually informal.

Comments:

Response 12

OccupationHobbies: Classical composer. Creative hobbies include drawing, musicology, website design

Question1_: Music: Manuscript notebook and pencil/pen
Design: Standard plain-page notebook.
The quality of the stationery I use is very important to me - I always have a plain moleskine notebook on me - at a pinch, I can rule my own manuscript to jot down ideas. My manuscript notebook is about A5 size, landscape format.

Question2_: Music: Generally just fragments of music notation, although recently I have also started to think about pieces in visual terms - line and colour. I haven't really fully explored this on paper yet, although I'm beginning to think it could be valuable
Design: I sketch out blocks and write in colour names
I'll mark a value as dotted to show the rough rhythmic relationship, but whether it's a what's I'm again, because nobody seems to be interested, not because I'm precious about my notebooks.

you've raised some interesting thoughts in my mind. I've totally that gave me the idea. aural gives me an idea, I either write down the idea or, more rarely, the name and occasion of the song/movie/picture important to me is the words. I jot down phrases, dialog, and plot porch when the weather is nice.

writing chapters in a hotel room or airport lounge or in my family's spare bedroom or in a cafe or even on my back but not for "recording ideas and inspirational material." When I use the laptop, I'm working away from home down on paper in useful form. Cool high think it does. I don't need any more inspiration; what I need is more *discipline and persistence* in getting words perspiration and only 10% inspiration. And even at that, the inspiration Inspiration is vastly overrated. Most of writing is exactly like what Thomas Edison said about inventing "notes" fi

because it keeps me from losing notes on scraps of paper. When I'm home, I'm usually using scraps of paper or a Design: Generally I work directly from the sketch into Illustrator or Photoshop. For simple designs I'd go straight to hand-coding in Dreamweaver. Usually the initial sketch encapsulates enough of what I wanted to do to keep me reminded and then work progresses directly on the computer.

I take notes on anything that's handy. I have a PDA much of the time when I'm away from home; I like it

Question1: I take notes on anything that's handy. I have a PDA much of the time when I'm away from home; I like it because it keeps me from losing notes on scraps of paper. When I'm home, I'm usually using scraps of paper or a "notes" file on the computer. For needledwork design, it's pencil and paper.

Inspiration is vastly overrated. Most of writing is exactly like what Thomas Edison said about inventing--it's 90% perspiration and only 10% inspiration. And even at that, the inspiration part doesn't work the way most nonwriters think it does. I don't need any more inspiration; what I need is more *discipline and persistence* in getting words down on paper in useful form. Cool high-tech tools are mostly a distraction. Except for the laptop; I use that a "lot", but not for "recording ideas and inspirational material." When I use the laptop, I'm working away from home -- I'm writing chapters in a hotel room or airport lounge or in my family's spare bedroom or in a cafe or even on my back porch when the weather is nice.

Question2: I take notes. Most of what I do is verbal, not visual, and I am not a visually-oriented writer -- what's important to me is the words. I jot down phrases, dialog, and plot-points as the occur to me. If something visual or aural gives me an idea, I either write down the idea or, more rarely, the name and occasion of the song/movie/picture that gave me the idea.
Um. I also do a fair amount of pre-writing work. Things like world-building and plot construction. I wouldn't classify them as "ideas and inspirational material" in the sense you seem to mean, but perhaps you would. The world-building I mostly do on my computer, in an outline form based on Patricia Wrede's Fantasy Worldbuilding Questions (available at www.sfwa.org), and I refer to the summary periodically in the course of writing the book in order to make sure I'm being consistent. Plot construction varies a lot -- sometimes I just do an outline on the computer, but for very complex novels, I've been known to take a bunch of different-colored Post-It Notes and write down scenes on each one, and then move them around on the dining room table, ordering and re-ordering them until they make sense. I've tried using various "brainstorming" software, but none of it has been of any real use (though they're great fun to play with).

Question3: Mostly, just writing it down is enough to cement it in my brain; I don't have to refer to my notes later. I do review them though, more or less at random, or when I'm a bit stuck or between projects. The outline and the worldbuilding, I refer to periodically while I'm writing -- again, the idea is to make sure I don't fluff the background consistency.

Question4: Constantly. Ideas are the easy part; they're all over. I get ideas driving on the freeway, in the shower, at 3 a.m., when I'm cooking dinner, gardening, at the computer, at the dentist, giving school presentations. It's not really unexpected anymore; I've been doing this for 30 years now, and I'm used to it.

Question5: Mostly, I ignore it. If the idea is really brilliant, I'll remember it, or it'll come back around later; if not, there'll be another idea along in about ten minutes. Ideas are the easy part. Once you get the hang of having them, you can't turn it "off". I can get ideas from filling out questionnaires...

Question6: Oh, certainly. But I have enough good ideas "now" to more than keep me occupied for the rest of my life. I'm a novelist; it takes me about a year to write a novel, and I only need one new idea to get a book rolling. Once I'm working on a book about, oh, colonizing Mars in the 22nd century, it's not going to be any use at all to get good ideas about stories set in 3rd century Rome, or about dragons -- no matter how good those ideas are, they won't fit into my book on Mars. And there's no point in saving them, because I get a whole lot more than one story idea per year, and I only "need" one, because that's all I have time to write. At least 90% of the professional writers I know are in the same boat.

Question7: Constantly. I talk to people about my books-in-process, their books-in-process, and stuff that comes up just for the fun of making things up. (Not all writers can do this; some of them find that talking about work in process or ideas just kills the story stone dead and they can't write it. But I'm a talker.) Talking about my work in process gets me pumped up to write more, and also helps me work out my plots -- other people ask questions I wouldn't have thought of, or make assumptions that let me see where I'm being too predictable. Talking about other people's work is just fun -- I get to come up with all sorts of ideas for what they could do and how they could do it, without having any of the work or responsibility for getting the words down on the page (which is the "hard" part, in case you were wondering). Making stuff up just for fun relieves the idea pressure.

Question8: There's not much point in showing people my notes; they wouldn't make sense to anyone but me. "Hero needs heebles! Sailboat? Remember to put in cats..." is not informative to anyone else. I show off my PDA and my laptop quite often to other technophiles, but that's showing off the cool technology to other geeks, not showing them the particular notes I made on it.

Question9: "Present" them?

I write novels. When the novel is finished, I sell it to a publisher, where it goes through revisions and gets published, whereupon people who want to can go to a bookstore and buy it. I don't think of this as "presenting my ideas," but if it isn't, I don't know what you mean.

Question10: I've collaborated on four novels, with two different people. In both instances, what we did was have lunch and talk about where we wanted the story to go next. In one of the cases, the other writer was very much a talk-about-it writer, so we had lots of lunches and did lots of talking; in the other case, my collaborator was the sort of writer who can't discuss her work-in-process, so we had very few lunches and very circumspect conversations, and mostly each made up our own parts of the plot and then fixed them up in revisions. In both cases, we each took occasional notes during lunch so we wouldn't forget particular plot points we'd agreed on, but they were extremely minimal -- on the order of "Don't kill subvillain for two more chapters; J. needs him for plotpoint," not anything elaborate. My colleagues both made notes in paper notebooks; I used my PDA. Maybe three or four cryptic sentences per lunch, tops.

Comments: I probably would if I had more of an idea what you were looking for. I have all sorts of opinions about the creative process and the way writers, at least, use it, and the misconceptions lots of non-writers and non-creative people have about how it all works, but I suspect that about 90% of that is going to be irrelevant to whatever you're actually interested in finding out. So I won't waste time doing a three-page rant.

Response 14

Occupation/Hobbies: Department Administrator. I also do textile art and paint.

Question1: Very small sketchbook, line drawings, words, photographs.
<table>
<thead>
<tr>
<th>Question2</th>
<th>Written text, sketches, photos, samples, mind mapping</th>
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<tbody>
<tr>
<td>Question3</td>
<td>Keep a large sketchbook when developing an idea - experiment in different ways and put in sketchbook.</td>
</tr>
<tr>
<td>Question4</td>
<td>Happens mostly in cafes, when discussing my art with my husband. Always jot in notebook.</td>
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<tr>
<td>Question5</td>
<td></td>
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<tr>
<td>Question6</td>
<td>Yes, if haven't got a notebook with me.</td>
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<tr>
<td>Question7</td>
<td>Discuss my creative ideas with my husband who is very involved in the process although he doesn't do the artwork himself. My work develops from feelings and ideas, I have used poems and words to inspire me in the past. I often try to create a mood and discuss this with my husband. For example we might take a mood and try and think of words and sounds and colours that represent it.</td>
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<td>Question8</td>
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<td>Question9</td>
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<td>Question10</td>
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<td>Comments</td>
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**Response 15**

<table>
<thead>
<tr>
<th>OccupationHobbies: University Teacher&amp; Composing music</th>
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<tbody>
<tr>
<td>Question1</td>
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<td>Question10</td>
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<tr>
<td>Comments</td>
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</tbody>
</table>

**Response 16**

<table>
<thead>
<tr>
<th>OccupationHobbies: I’m a professional jazz musician.</th>
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<tbody>
<tr>
<td>Question1</td>
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<td>Question2</td>
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<tr>
<td>Question3</td>
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<td>Question4</td>
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<td>Question6</td>
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<tr>
<td>Question7</td>
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<tr>
<td>Comments</td>
</tr>
</tbody>
</table>
get a good element of spontaneity in a jazz performance it's best not to over rehearse the music.

Question8_: Rehearsal will typically include looking at new compositions for the purpose of preparing them for performance.

Question9_: Beyond looking at the notation it is helpful to talk about various elements of the musical style to prepare the ensemble properly.

Question10_: Jazz ensembles typically have a leader who makes most of the repertoire and performance decisions. Some are open to suggestions from the group and some are not. As a leader I tend to reserve the right to make creative decisions independently of any collaborators.

Comments_: Music is a special case due to the non representational, abstract nature of the medium. The development of music notation has been an attempt to address this problem. It will probably always be necessary to discuss how the notation should be interpreted.

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Response 17

Occupation Hobbies: I am currently seeking full time work in the film or television industry, but I am also a freelance writer, director and editor.

Question1_: If it is during the writing process I use my laptop, unless I have the idea when I am out, in which case it is recorded in a small notepad. I always carry this on me, and it is also left by the side of my bed when I sleep. I have found in the past that I have many ideas last thing at night, if I do not write them down they will be gone in the morning.

Question2_: When I'm brainstorming the ideas take the form of simple notes. However, if I am working on a film and I want to convey an idea about the particular colours and tones of a scene then I use a scrap book. This scrap book contains many clippings from newspapers, magazines etc. This is because it is difficult to describe an exact colour or tone. If I say blue to the cameraman he may have one idea of blue and I may have another.

Question3_: They are central to the creative realisation of the idea.

Question4_: See Q. 1. It happens often but I ensure that all the ideas are recorded now.

Question5_: See Q. 1 again.

Question6_: See Q.1. Yes, I thought I would remember the idea in the morning. I could remember that I had thought of an idea, but I could not remember what it was.

Question7_: I will 'pitch' an idea to one of my colleagues who I worked closely with. Other than that the ideas are not shared, this is due to the nature of the industry and ensuring copyright issues. A completed script is pitched to a producer, but not before a confidential agreement has been signed.

Question8_: No.

Question9_: Verbally, but only to my colleague.

Question10_: I have one collaborator, we usually brainstorm with pen and paper (and maybe a few beers). The core idea will be typed and we will each receive a copy, then we work independently on the idea (on computers) until we meet again and the process is repeated until it is time to write the whole script. Then one of us will write it (on computer), and they other will edit it and offer feedback.

Comments_

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Response 18

Occupation Hobbies: Musician.

Question1_: None, really. When a piece of music needs writing I sit down and write it. After a break, often I see a new perspective. But I'm not taking notes.

Question2_: 

Question3_: 

Question4_: I can't recall such an occasion.

Question5_: 

Question6_: 

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Question 7: I'll discuss ideas with a director, choreographer etc.

Question 8:

Question 9:

Question 10: Production meetings, one-to-one discussions etc. But it's about deciding what to do, not particularly working out the creative process.

Comments: I need craft and experience much more than I need inspiration. :-)  

Response 19

Occupation Hobbies: I am retired after 38+ years at ABC-TV, Hollywood. My work was "everything audio". I designed, built, installed, modified and operated TV sound gear. I "mixed" every kind of TV production, from the one-microphone satellite interview to the "Academy Awards". For fifteen years I also wrote a monthly column about sound for Video Systems Magazine. My significant hobby is the care and restoration of two old automobiles ~ 1964 Chevelle Malibu Station Wagon and 1968 Cadillac Eldorado.

Question 1: Sometimes I jot down a thought on a piece of otherwise useless paper ~ an envelope, or test-print sheet. Later I might be reminded of something to pursue for added knowledge.

Question 2: I write, I speak. Sometimes I create an image via digital photography and image editing.

Question 3: I wrote, I spoke, and today I reveal whatever is useful to others.

Question 4: I subscribe to the "Bill Lear method of subconscious thought processes". Lear told his employees about a "problem" and bound them to suppress any conscious thought about it, whether "on the clock" or at home/away. 60-90 days later he would ask about the matter. His people effervesced with ideas that had developed in their subconscious minds.

Question 5: For some time a new sound mixing system (hardware) lay ahead. Whenever thoughts about its details came to mind, I consciously suppressed them. When I finally was asked formally to describe the equipment, ideas I had not recognized came forth without difficulty. I was appropriately compensated for the results.

Question 6: No.

Question 7: Sometimes I "tickles" others' thoughts by asking peripheral questions about their topics. e.g. "What color was the house? Did it have a circular driveway? How many children did she have?" This is a method taught to me by my father. It causes an otherwise-rambling talker to focus on his point.

Question 8: Sometimes. I feel it's important to bring others "up to speed" in some matters.

Question 9: I currently am working on a project that entails a physical item. I have developed a model for presentation.

Question 10: I collaborate by discussion. Sometimes pen and paper diagrams are useful, some computer-generated drawings also come into play.

Comments: Permit me to celebrate your quest. I graduated from U.C.L.A. in 1965. I cherish the unusual heritage of four grandparents who had college degrees. Verbal communication is of major importance in our world. Please tell me if I can be of any additional assistance in your project. Roy ~ rwrising@dslextreme.com

Response 20

Occupation Hobbies: Musician and recording/sound engineer

Question 1: I use my recording studio, paper, my mind and whatever else is available to jot down ideas or otherwise preserve them for future reference and use in a broader context.

Question 2: All manner and form to make sure the idea is well represented so that later reference will not leave me with head scratching, wondering what I was thinking and how the idea is supposed to sound, what it is supposed to convey.

Question 3: From inspiration to fruition (recorded for posterity), all manner and form of tools are used to work together to make the final result what it needs to be.

The need to refer back to the original concept, whether written or recorded, helps to preserve the spirit of the idea as originally conceived.

Question 4: All the time. Sometimes every day.

Question 5: I was driving to a destination over a three hour period and an inspiration came to me. I repeated it to
remember it, then visualised it in context and built on it from there until I reached my destination, at which point I sat down and wrote it all out and made sure it was going to work... and it did.

Question6 : All the time.

Question7 : Yes, I share musical concepts with band members during rehearsals. I will begin playing the ideas without announcing them; the others will join in and we will groove on the idea for a while.

It isn't so much about remembering the specific idea, but rather the style of music or the groove itself.

Question8 : Occasionally. I do this to show them the thinking behind the idea, the origin and intent of the idea.

Question9 : Sometimes I will simply discuss the ideas as 'grand schemes' and 'themes' that I am developing, describing the sweeping nature of the 'story' the concept will be telling.

Question10 : I do not so much collaborate as I do encourage participation.

Comments : not at this time.

Response 21

OccupationHobbies: Musician, songwriter-composer, audio recordist/mixer

Question1 : Notepads, paper scraps, laptop. Often have one of those nearby. I capture words with them.

Question2 : Written text.

Question3 : Read what I wrote and get back to working on it.

Question4 : Yes, and fairly often.

Question5 : Driving long distances, ideas arise and disappear. Didn't have a recorder at the time, and still don't. Should get a small digital voice recorder.

Question6 : Life is like that. More good ideas have been lost back into the ether than have ever been developed by humans.

Question7 : I share arrangement ideas with band mates, production ideas with recording clients, which may include lyrics, melodies, etc.

Question8 : Not per se. What I use is right here for anyone to see, if they're right here, too.

Question9 : I sing them my songs, play them my instrumental compositions, describe the idea, whatever, depending on the specific situation.

Question10 : I haven't collaborated with other on creative works.

Comments : Interesting sequence of questions. Good luck with this project. How will this info be used?

Response 22

OccupationHobbies: Filmmaker and scriptwriter.

Question1 : Laptop, pad and pen

Question2 : Dramatic events; impactful images, described in words. Unsequenced as to story. Article clippings and downloads.

Question3 : I accumulate the above over an indefinite period, sometimes as much as a year, or several, allowing for rewrites. I then shuffle and cull to create a storyline.

Question4 : Always. Virtually no creative flashes occur while looking at any organized form of the material. A walk, a shower, sitting on the toilet, washing dishes; enforced mental idleness promotes the waking dream.

Occasionally, it does happen while sleeping or attempting to sleep.

Question5 : It is too commonplace and unmemorable to remember.

Question6 : Yes, but it is not common or problematic.

Question7 : I have, in writers' groups.
Question 8: There is nothing worth showing, other than my bad handwriting, or a generic laptop.

Question 9: As a verbal pitch.

Question 10: The partially completed manuscripts go back and forth by email. Occasionally, working with an older person requires he receive a paper copy.

Comments: I have seen advertisements for creative tools, and own one myself, bundled with a scriptwriting program. I advocate against them. No tool can organize the dream. Inevitably, it will force an alien structure on the creation, cutting off creativity. Although I am myself a technological maven, I stay away from these things like the plague. Of course, if someone offered me good money to endorse one, I might say different :)
Question 7: I'm always willing to lend others a hand with their problems, especially technical ones in which I have some special knowledge. But artists generally have "ideas" of their own - expressing them is the hard part.

Question 8: Yes, I've made a business out of sharing my tools and techniques. I've set up websites for that purpose.

Question 9: I've done video presentations and slide shows, as well as had shows of my art and related art.

Question 10: I'm not much into collaborative art, although I've done "exquisite corpse" type projects on occasion. In that case, figuring out the rules is a big part of the game.

Comments: Share a bit more of what you've got in mind, and I'd be glad to give you my reactions. I doubt it would help my particular process much, but there are many other types of creativity...

Response 25

OccupationHobbies: singer, musician, songwriter, audio engineer, producer

Question 1: I always carry a notepad + pen with me. A lot of times I write lyrics in cafes. Sometimes I only write down a few ideas - like words, or snippets, or phrases. I write down little things that remind me of the music in my head later, but almost never write down music at all.

Musical ideas I usually record with my powerbook + garageband or logic. I quickly sing into the internal mic or record a few bars playing the guitar or piano.

Most of the time I don't write a song to record it later (I used to do that, but not anymore). I record little beats and melodies into logic, then play around with plugins, then add a little bit - one thing leads to the next.

After some time I end up with lots of little pieces that I put together to build a song.

Question 2: Sometimes I hear about something upsetting in the news, and I write lyrics expressing my anger about it.

Question 3: Anything recorded in garageband or logic I can easily use later on. I usually record the rest with logic and arrange + mix with logic and/or protools. Sometimes I also work on little ideas with audacity, if I don't have access to logic. I save those ideas as aiff files, which can be imported easily into other audio software.

Question 4: Yes, if it is something I really do not want to forget, I try to find something to sing it into. Could be a cell phone with voice recording, or I call my voice mail and leave a message, or I write it down in a way that I hope will make me remember everything later on.

Question 5:

Question 6: Yes, but not too many. Most of the time I'm prepared and I have no ideas! :) Most ideas occurred when I was in an inspiring environment (like in a studio), or somewhere near an instrument. If I sit down and play that idea a couple of times on an instrument I don't forget it until I get to record it.

Question 7: Yes, I do. I send lyrics back and forth via email. I put rough mixes and unfinished ideas on myspace. Towards the end of a project I bounce the tracks into a couple of stereo aiff files (8-10 stereo tracks or so), zip them, and put them on a web server.

Others can download these tracks, and mix or remix them in whatever software they are using - logic, protools, cubase, etc. They can give me advice on what to change before the final mix, etc.

These zip files are usually around 100 MB, so this has been working really well for me.

Question 8: I don't really show the tools to anyone, as everyone I know has their own setup. I do share loops I create myself.

Question 9: I upload them to myspace. Since the sound quality there is really bad, I email aac or mp3 files to some people. If I want someone to have a good quality file to listen to I send them an aiff via skype or I upload it to a webserver and send them the link via email.

Question 10: I don't work with a group at the moment. I give people access to the material I'm working on, and I respect their input. Sometimes they give me suggestions, sometimes they send me recordings I integrate into my music. I make the decisions, it's my music, but I listen to others, and sometimes they change my mind.

Tools I use: all of the above. Usually some means of sending music via email or putting it on a webserver, and sending lyrics and ideas via email.

Comments: I wish more people would use the internet to exchange musical ideas. Most people I know keep their ideas a secret until they can present a finished song or album. I used to invite people over to rehearsal, so even when we were just rehearsing, we had a little audience to play for. And we got feedback, which was extremely helpful. Now I'm trying to do the same over the internet, it's really quite simple.
OccupationHobbies: Ex CEO of a San Fran Multimedia Design company that became a Web Design company during the dot com boom. Now = full time fine artist/painter/musician. Hobbies - none, it's all about working for success.

Question1 : Napkins. Any available paper and writing instrument. Envelopes are excellent. My precious sketchbook that goes with me (almost) everywhere. my hand, business cards, laptop for textedit or recording thoughts, songs or quick photoshop stuff. and post-its also.

Question2 : Almost always a brain dump. quickly getting the idea out of my head and recorded onto some kind of media, singing a capella into a laptop mic, using a crayon on a napkin, writing/sketching or whatever to get the basic concept out for later review or futher development. I sketch/draw very quickly and very well so imagery is a valuable way to record thoughts. Sometimes the concepts end up in the right, back pocket of my jeans and then I forget about them until I do the wash. Then I take a look and re-evaluate the idea and judge its creative worth. If it's in my sketchbook, it's important. Anything that I dwell on intellectually ends up in my sketchbook. Sketches are often accompanied with random words to describe the emotion, textures, objective, alternative possibilities, etc.

Question3 : The initial concept is fundamental to the completed work. I hold the thought of the original image, song, poem or whatever throughout the creative development process. I believe the emotional "kernal" is key to the success of the work so I refer to the original piece often. This ensures the "flavor" or emotion is maintained. The tools I use become more sophisticated as the process evolves. For a painting, I'll start with an origal sketch (as an example). I will compose a more well-thought out image, do a photo shoot with models, compose an image using photoshop, re-draw the image working out lights and darks, use the computer for color experimentation, grid up a canvas and redraw the image scaled up, then begin working with paint (oil) and react to what's happening on the linen as the image develops.

Question4 : Does this happen often? Yes, it's an endless stream. All times, any place. My favorite time is when I lay in bed and reach that state just before falling asleep. It's when my imagination is most lucid and my mind is beggining to review the experiences of the day. During these times, I pop myself out of bed and quickly record the thought. I am constantly seeking or always open to "good ideas" for painting, writing, music, etc. When I ran my company, it was essential to have great ideas on demand. Clients expected my company to come up with killer marketing ideas overnight. Effective brainstorming was essential but more essential was the ability to discern good/great ideas from mediocre ones. My company developed marketing material and web sites for Intel, Sun, HP, Wells Fargo, Pizza Hut, IBM, 3Com, Sprint, etc. They paid big bucks for mercenary creativity.

Question5 : These "situations" are common and recorded as mentioned above.

Question6 : I have learned to ALWAYS record my ideas one way or the other WHEN THEY OCCUR. Regardless of good, bad, big small, waiting a minute, an hour, day or more is VERY risky because I can "lose" the original feeling of the idea. The value of the idea can be judged later but don't stifle it. It's important to note that the recording (sketch, drawing, writing, whatever) is very rough and more about the feeling and concept than it is the imagery or precise words, etc.

Question7 : Yes. Many people will look at my sketch book or listen to a rough music composition. I like to get feedback to help assess if the idea is eliciting the kind of feeling I want.

Question8 : Sometimes but most of the time no one is so intimately involved in my creative process to ever fully see all the components or subtle steps of its development. Some details I keep to myself although I will sometimes share details of my process to other creatives that are genuinely interested in nuances of mine.

Question9 : Usually the ideas end up in a very polished, refined form such as a completed painting, song, story or whatever. This differs greatly from my companies process where client approval at every step of development was essential. I paint for ME now. I am the only one that must approve.

Question10 : I no longer collaborate but have years of experience on the corporate side of collaboration and creative decision making.

Comments : I have many "techniques" for being creative. I didn't write about them because you didn't ask the questions. I am fascinated by the creative process and don't mind helping with your study. If you need clarification on anything my contact info is on my web site (and yes I know my site's not so hot considering I was in the design biz for years). http://www.jeffneugebauer.com - if you go to the "drawings" section you can see many original rough sketch ideas. some of the sketches have been painted - see the painting section of course.

OccupationHobbies: I work with people, young and old, at seperate times. I consider myself a people profiler.

I also write and I like to paint ceramics. I love doing free-lance photography and intend to put some books together in my future.

I have an eye for a great and interesting photo!

Question1 : I have, for the past 11 years, written on any piece of paper I could get my hands on, if I did not have access to my notebook. At times I have run out of notebooks and had to resort to post-ems or paper towels and even
envelopes. Now, if I'm not at my computer, or am too tired to sit up, knowing that writing could go on for days if the inspiration is just right, even though I have a computer, I still may use pen and notebook. The thoughts seem to flow faster through my hands that way.

Question2_: In the beginning, there were more sketches than there are now. Maybe that's because inspirational writing was new to me and I couldn't describe some of the things I was seeing so I had to draw them.

Question3_: I refer to my trusty pens and paper when I feel overwhelmed by so many things, like a blast of epiphanies, or just when I get time, I feel the need to write out what's been happening and how these situations relate to something associated with my past or with past writings, that I didn't understand when I first felt prompted to write about them. In other words, I develop a greater sense of understanding of some things as time goes on.

Question4_: Don't forget, in the shower. And it happens all the time, but not exclusively there.

I've been driving across country and suddenly come to an understanding, as though parts of a puzzle all came together, I've pulled over and often sent an entire day just writing at a mall or a rest stop.

Question5_: I wait until a number of ideas create a whole picture and then I write it out, or, I may write bits and pieces and put it all together when it makes sense, when the puzzle piece fits.

While in a writing "trance" that lasted at least three days, my mind went all the way back to when I was in my mother's womb. Of course, I had to continue writing everything I was thinking and feeling back then.

Question6_: That only occurs with dreams, if I don't write them down in time, before they dissipate. Then again, there have been times when I just didn't feel like writing and I'm sure I've missed a lot of creative ways to finish or tackle something but I'll always finish it off in a just as creative a way when the topic comes up again.

Question7_: I talk some things through with a friend of mine who has the same level of understanding as I about the particular type of topic, and we've both learned a lot from each other.

Question8_: I have shown some "prompted" parts to drive home a point, to let someone know there's a stronger force than me, involved. Sometimes things are more serious than people may like to face up to.

Question9_: Very carefully. I've learned that when I speak of the types of things I write about, it scares some people. That's because they've never allowed themselves to open up to a higher level, often times, simply because their lives have been too busy and they just never took the time to contemplate the higher plains.

I'll bet you're wondering what in the world I'm writing about now, aren't you?

This is no gag.

Question10_: I usually use my 'handy-dandy notebooks' when going over things with my friend because we usually have to resolve issues and it's better while the inspiration or thought-process is fresh in our minds. Also we can then collaborate on the processes with which we would individually prefer to resolve the issues. We can inspire each other and basically feed off of each other's individual techniques. We both are visionaries, in different senses.

Comments_: What is "idea capture and representation" for? Is this something you're teaching? Are you about to embark on a project, or are you already involved with expressing your creative side and looking for a new angle?

anymore questions, I'd be happy to cooperate.
6.2: Participatory Task Modeling / Design Study

6.2.1: Presentation Slides

---

**My Research**
- Designing Computer Tools for Creative Work (Particularly Music Creation)
- Representing Ideas
- Developing, Combining and Refining
- Communicating Ideas & Collaboration

---

**Today**
- Modelling
  - Describe what you do in a general way
- Participatory Design
  - Getting possible users involved in design
  - What do you want computers to do?
  - How could software or hardware be designed better?

---

**Questionnaire**
- Please fill in this questionnaire on your background
Model your Music Creation Process

- A model is a simplified description of a process. It is a general description rather than one particular instance.
- 1. Think about the tools you use when you make music.
- 2. Think if, when & how other people are involved, and the roles you / they have.
- 3. Think about the process of creating music.
- 4. Try drawing a diagram that fits everything together and describe it in words.

Share Your Model

- Describe your model to the other person / people and look at theirs.
- What are the similarities?
- What are the differences?
- If you worked together to make music, what would change or be added? Try combining your models to make a model of a collaboration.
Computers in Music Creation

- Look at the models and discuss how computers could be useful in each part of it
- Where could computers support you better?
- Where do you currently experience problems?
- Put some ideas down on paper

A System to Support Collaborative Creativity

- Roughly design a system that would allow you to find other people and create with them.
- Describe the features you would like.
- Draw a paper prototype of the interface
- Make a scenario of the system being used.

A System to Capture and Organise Ideas

- Roughly design a system to help you record and organise your ideas.
- Describe the features you would like.
- Draw a paper prototype of the system.
- Describe a scenario of the system being used.
### 6.2.2: Collaborative Participatory Task Model Analyses

**Key:**
- 'out' indicates outgoing directional arrow
- 'in' indicates incoming directional arrow
- O indicates part of an iterative loop

**Model A:**

<table>
<thead>
<tr>
<th>Element No.</th>
<th>Description</th>
<th>Theme(s)</th>
<th>Connected to Element(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Start Point (Riff, Brief, Art, sound)</td>
<td>Ideation, Idea representation</td>
<td>2(out), 5 (O), 7 (in)</td>
</tr>
<tr>
<td>2</td>
<td>Library / Scrapbook of sounds in head or on computer</td>
<td>Idea Representation, Retention, Organisation, Using</td>
<td>2 (in), 3(out), 7(in), 8 (O)</td>
</tr>
<tr>
<td>3</td>
<td>Elements of music / sounds</td>
<td>Idea representation</td>
<td>2 (in), 4 (out), 7 (in)</td>
</tr>
<tr>
<td>4</td>
<td>Arranging</td>
<td>Idea represented in context, Internal Structure</td>
<td>3 (in), 5 (O), 6 (out), 7 (in), 8 (out)</td>
</tr>
<tr>
<td>5</td>
<td>Final Production</td>
<td>Idea represented in context, evaluation, decision making.</td>
<td>2 (O), 4 (O), 7 (in)</td>
</tr>
<tr>
<td>6</td>
<td>Elements not working discarded / tweaked</td>
<td>Evaluation, Decision Making, Change Conception of the outcome.</td>
<td>4 (in)</td>
</tr>
<tr>
<td>7</td>
<td>Other People (suggestions, new sounds / chunks of music, expertise)</td>
<td>Collaborative productive interaction</td>
<td>1 (in), 2 (in), 3 (in), 4 (in), 5 (in)</td>
</tr>
<tr>
<td>8</td>
<td>Suggest new sounds</td>
<td>Ideation, Idea Representation</td>
<td>4 (out), 2 (in)</td>
</tr>
<tr>
<td>9</td>
<td>Production / Tweaking things</td>
<td>Idea represented in context, evaluation, decision making.</td>
<td></td>
</tr>
</tbody>
</table>

**Model B:**

<table>
<thead>
<tr>
<th>Element No.</th>
<th>Description</th>
<th>Theme(s)</th>
<th>Connected to Element(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Idea</td>
<td>Ideation, Idea Representation</td>
<td>2 (out)</td>
</tr>
<tr>
<td>2</td>
<td>Give it a bit of Structure</td>
<td>Structural Development, Idea represented in context, Internal Structure</td>
<td>1 (in), 3 (out)</td>
</tr>
<tr>
<td>3</td>
<td>Bring in other people / instruments</td>
<td>Structural Development, Tangible Structure, Collaborative Productive / Structural Interaction</td>
<td>2 (in), 4(out)</td>
</tr>
<tr>
<td>4</td>
<td>Influences / Musical Knowledge</td>
<td>Learning, Conceptual Structure</td>
<td>3 (in), 5 (out), 8 (O)</td>
</tr>
<tr>
<td>5</td>
<td>Play It!</td>
<td>Idea Represented in Context</td>
<td>4 (in), 7(O)</td>
</tr>
<tr>
<td>6</td>
<td>Is it good?</td>
<td>Evaluation</td>
<td>7 (O), 8 (O), 9 (out)</td>
</tr>
<tr>
<td>7</td>
<td>Yes. Go Yay.</td>
<td>Evaluation Represented</td>
<td>5 (O), 6 (O)</td>
</tr>
<tr>
<td>Model C:</td>
<td>Description</td>
<td>Theme(s)</td>
<td>Connected to Element(s)</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>----------</td>
<td>------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Initial Idea – chords, melody, structure (individual)</td>
<td>Ideation, Idea Representation, Internal / Conceptual Structures</td>
<td>2 (out)</td>
</tr>
<tr>
<td>2</td>
<td>Discussion, Refinement (group)</td>
<td>Evaluation, Evaluation Represented, collaborative productive interaction</td>
<td>1 (in), 3 (out)</td>
</tr>
<tr>
<td>3</td>
<td>Agreement</td>
<td>Decision making</td>
<td>2 (in), 4 (out), 5 (O)</td>
</tr>
<tr>
<td>4</td>
<td>Documentation of Ideas (Notation, Rough Recordings)</td>
<td>Retaining, Idea represented in context</td>
<td>3 (in)</td>
</tr>
<tr>
<td>5</td>
<td>Performance / Experimentation</td>
<td>Idea Represented in context, Ideation, Evaluation, collaborative productive interaction, Scope for Iteration</td>
<td>3 (O), 6 (out)</td>
</tr>
<tr>
<td>6</td>
<td>Practice</td>
<td>Idea Represented in context</td>
<td>5 (in), 7 (out)</td>
</tr>
<tr>
<td>7</td>
<td>Finalisation</td>
<td>Idea Represented in context, evaluation, decision-making</td>
<td>6 (in), 8 (out)</td>
</tr>
<tr>
<td>8</td>
<td>Output (Distribution, Circulation)</td>
<td>Sharing</td>
<td>7 (in), 9 (out)</td>
</tr>
<tr>
<td>9</td>
<td>Live Performance, MP3, CD, Tabulature Printout</td>
<td>Sharing, Scope for Iteration (i.e. performance)</td>
<td>8 (in)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model D:</th>
<th>Description</th>
<th>Theme(s)</th>
<th>Connected to Element(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Idea (What do I want to do? Vision Outcome)</td>
<td>Ideation, Idea Representation, Change conception of the outcome</td>
<td>2 (out)</td>
</tr>
<tr>
<td>2</td>
<td>Tools (Synths, Wave Editors, Samples)</td>
<td>Tangible Structure, Structural Development</td>
<td>1 (in), 3 (O)</td>
</tr>
<tr>
<td>3</td>
<td>Sound Library (Samples Edited to fit the attitude of the idea) – Pads, Rhythm, Focus?</td>
<td>Using, Idea Representation, Evaluation, Decision Making, Conceptual Structure.</td>
<td>2 (O), 4 (in), 5 (O), 6 (O)</td>
</tr>
<tr>
<td>4</td>
<td>Killerisation (a collaborator)</td>
<td>Collaborative Productive Interaction</td>
<td>3 (out)</td>
</tr>
<tr>
<td>5</td>
<td>Mastering (Wrt idea, Compression, Reverb, Spacing, Fx)</td>
<td>Idea Representation, Evaluation, Decision making</td>
<td>3 (O), 6 (O), 7 (out)</td>
</tr>
<tr>
<td>6</td>
<td>Sequencer (Stick it together) – This is dynamically evolving, includes creating melody</td>
<td>Internal Structure, Idea Represented in Context, Iteration</td>
<td>3 (O), 5 (O)</td>
</tr>
<tr>
<td>7</td>
<td>Tune</td>
<td>Outcome Produced</td>
<td>5 (in)</td>
</tr>
</tbody>
</table>
6.3: Observations of Music Composition

6.3.1: Transcripts

6.3.1.1: BUMPS Session 2

1: Discussion of what to do: A mentions some lyrics he would like to try to create a melody for.
2: C: "I could play some blues chords"
3: C picks up guitar
4: A: "I think we could try it in G"
5: A sets up microphone
6: C begins to play blues chords
7: C: "My guitar technique is not the best in the world, what do you want?"
8: A: "Well just play anything to start"
9: A: "Umm, this tempo"
10: A clicks his fingers to define tempo
11: C begins to play at defined tempo
12: A watches C and listens to guitar play
13: A begins to sing lyrics from memory
14: After a period of play, D interrupts with "Stop there"
15: A and C stop playing
16: D: "Are you changing the chords at the right time?"
17: C: "Possibly not"
18: A: "I don't know"
19: D: "Are you singing 'mmm, sure you look fine' and all of that bit is on one chord, and then you change afterwards"
20: A: "Yeah that needs a change of chord"
21: D: "You're changing for the 'and I saw you baby and you sure look fine'"
22: C: "Right"
23: D: "Do you want to play it a bit faster as well?"
24: A: "Yeah a tiny bit faster"
25: C: "Okay, you definitely haven't got enough bars there"
26: A: "Have I not?"
27: C: "That's where you need to keep going on the same chord" (points at C)
28: A and C stop
29: D mimics the guitar play with her voice, "dee duh dee duh dee duh de"
30: A: "So another one of those"
31: A: "Taps foot to define tempo"
32: A begins to play and A begins to sing simultaneously
33: After 10 seconds, D: "that it, that's ideal"
34: Play continues through a verse
35: A stops singing, shortly afterwards C stops playing
36: D: "Okay, you definitely haven't got enough bars there"
37: A: "Cool"
38: D: "Got any more verses?"
39: A: "Yeah, lets do the chorus"
40: A looks at C and C at A
41: A: "Same"
42: C: "Same Chords?"
43: A and C start to play and sing
44: After a chorus, A stops
45: A: "That's it so far"
46: D: "That's fine, ok let's have two verses and two choruses. Try and have a loud chorus"
47: D sings 'you sure look fine!' in a loud voice
48: D: "and then you could do the second chorus which is...
49: A: "Right"
50: A: "Tap your foot twice when you're going to start"
51: C: "OK"
52: C taps his feet twice and begins to play, A begins to sing
63:A and C play through two verses and choruses and then stop
64:D: “OK good, you needed to keep a bit further away from the microphone though when you’re singing the loud
bits, otherwise great, it had a real progression to it with the way you sung”
65:D: “Is that enough for one night?”
66:A: “I think we’ve done enough on that for now”

6.3.1.2: 2nd Group Session

1: Drummers (F and I) play a beat together
2: Guitarists (E and H) tune their guitars together
3: E plays a phrase
4: H: “What’s that you’re playing?”
5: E: “Just like…”
6: E strums chords, H watches E
7: H replays the chord structure played by E
8: H: “So that’s A and then E”
9: E: “Yeah, we’ll need a third chord there” (Whilst Playing)
10: H plays a different combination
11: E: “That’s good”
12: E watches H play
13: F continues to play drums
14: G: “We should just start with one drummer”
15: F: “OK”
16: G: “That should be (participant I), she’s got more talent!”
17: F: “Oh”
18: G: “I’ll try and get something here” (looks at keyboard)
19: E: “Let’s just start with something simple on the guitar”
20: H: “D, A minor and G maybe”
21: E plays D, A minor and G
22: G: “I’ll start by mirroring those chords, D A G”
23: G plays keyboard
24: G: “That’s OK isn’t it?”
25: H nods
26: G continues to play around the chords
27: H: “I don’t think we were in tune”
28: E: “Play an E”
29: E and H strum E chords
30: E: “It’s not too bad”
31: H: “Do the same chords but let’s try and get it in to a proper tune”
32: E begins to play, then stops
33: H plays the chords
34: E plays some notes over the chords
35: I begins to drum over the guitars
36: G plays short phrases
37: All stop after a minute
38: E: “When is it that you change in to the G?”
39: H: “Just when it feels right” (laughs)
40: H plays alone
41: E: “Just D and A repeated first of all”
42: H: “Yeah”
43: E, G and I join in
44: H: “We need to get the number of bars right”
45: E: “Write it down” (gets paper)
46: E: “So we play 8 bars of D” (begins to write down)
47: H: “Yeah D”
48: H strums the piece
49: H: “Over to A”
50: H: “Then repeat that”
51: H: “Then a short D”
52: H: “Short A, no long A”
53: H: “Then G”
54: E gives paper to H
55: E: “Is that it?”
56: H looks at paper
57: H: “No I don’t think so”
58: H begins to strum through the pattern again
59: H: “No sorry” (looks at paper)
60: H: “A, G” (points at part of paper)
61: E: “Is that played twice?” (points at paper)
62: H: “Same again”
63: E: “Oh yeah, its D A D A there isn’t it”
64: E writes
65: H: “Then its short D, short G” (strums)
66: F, G and I take a break
H: “Long A”
H: “Right”
H starts to play, E puts down paper in front of both of them
E starts to play
E plays through the piece solo
E: “Yeah got it”
H and E play through the piece
E: “I’ll start coming in with some notes over the chords”
I returns
E plays solo for a minute
H joins in
E: “Where’s (participant G)”
E: “Hello?” (To participant G who is at the other end of the room)
G returns
G: “Whats going on?”
H: “Right”
E: “Play this” (points at paper)
E: “What do you want us to do?”
E: “Play something D A G”
G: “Like the way I was?”
H: “Yeah yeah, like it was”
G plays
E: “Like that?”
H: “Yeah that’s pretty cool”
G: “Is that the kind of speed you want it at?”
H: “Uhh…”
G: “Maybe a bit slower?”
E plays phrase again
I: “Shall I try and do something exciting?”
H: “Yeah, you could have a little breakaway bit, sort of ‘dum, dum da dum’” (gestures with hands)
I: “Right, I’ll just have to let you get in to it before I do that”
G: “Ready?”
G and I begin to play
H joins in
E joins in
After playing for 3 minutes, E stops, followed by the rest
G: “What do you think?”
H: “Yeah not bad”
G: “I think we should put in another set of chords now”
I: “Yeah, more variation is needed”
G: “Yeah more variation!”
E: “Especially on the keyboards”
I: “Even if you just play quieter or not for a few bars, and try a few more combinations”
G: “Shall I try…” (plays new phrase)
H: “That sounds really good”
E: “Yeah”
E: “So shall we keep working on this”
I: “Yeah I thought that sounded quite good, but it needs more to it”
E and I play individually for a minute
E plays a new set of chords
E: “If I play this, can you start backing up, cos otherwise I lose the timing after a while” (Looking at I)
I: “OK”
E begins to play, I and G join in
All stop
H starts to play a new phrase
All start to play
All stop
G: “I think that’s quite good we could combine the two”
I: “Maybe we should be building up to a crescendo?”
E: “Yeah”
I: “Like it goes really mad and then it goes all quiet again”
G: “Yeah that sounds good”
I: “And we could all have solos”
G: “Maybe I’ll start small and quiet and work my way up to the full…” (plays phrase)
G: “Shall I just play a single note at first?”
E: “Not just that”
G: “Say three or five notes then”
E: “Yeah”
E: “Guitars could go sort of punk style for a bit”
E plays with amplifier, strums with distortion
H laughs
E: “Might be too loud with the other (acoustic) guitar”
H begins to play
H: “Where were we?”
E: “Barre A minor, 5th then to E” (strums)
E and H begin to play, followed shortly by I

G: “I don’t know what to do here”

E: “It was fine as you did it”

H: “What chords are we playing here exactly then?”

E: “Uhh…”

H: “It’s B and D minor”

G: “I liked the other thing better, why change it”

I: “This is a new bit, a chorus”

E: “Yeah”

G: “Shall we stop my bit though, I think it’s kind of ruining it”

I: “No, it makes it fuller, either that or you sing”

G: “Ok I’ll stick with this”

E and H play together

G: “You play the rhythm” (to H)

E and I start to play

E joins in

G joins in

All stop after 3 minutes

G: “Very good, let’s stop with that”

E: “Ok”

G leaves

E puts down guitar, picks up drum

H begins to play a new guitar piece

I joins in with drums

E plays another drum

Play for 2 minutes, then stop
6.4: Observations of Filmmaking

6.4.1: Task Description Given to Participants

Information Film Study

Task:

Your task is to create a public information film, encouraging people who frequent the university to be active in making the campus more eco friendly. Examples of this could include persuading people to recycle or not to drop litter. The film should be designed in order to play on screens around the campus. The finished piece of work should be multimedia - i.e. it should include some form of sound, text, images and / or video footage. The task should be completed as a group, with one output created between all the group members.

The task should be completed over four weeks, with a group meeting each week lasting as long as you would like. At the end of each meeting, we would like you to make a short presentation of the state of the work at that point, including any representations or rough versions of the finished piece.

To allow you to complete the task, the following resources are available:

- HP iPAQ PDAs equipped with Cameras, capable of recording video, still images, written / drawn notes and sound.
- A desktop computer and large screen with the following software:
  - Microsoft Powerpoint
  - Video editing software
  - Image editing software
  - Sound editing software
  - Note viewing software

The iPAQ is provided to support the completion of this task by allowing you to record and represent ideas in various forms through the included software. The files saved on to your PDA will be transferred to a shared computer at the beginning of group meetings, with a folder for each group member. This will allow you to share anything you have recorded with the group, and use media from the iPAQ in your created film.

If you find that you want to use any additional tools as part of the project, that is acceptable, but we would really like to know about this, and if possible see the tools and artefacts created, if it is not possible to bring the tools / artefacts to the meetings, a picture of what occurred taken with the iPAQ would be helpful.

Additionally, could all email correspondence related to the task be CC’d to t.coughlan@bath.ac.uk

6.4.2: Transcripts

6.4.2.1: Group 1, Meeting 2

C: OK, lets see what B has done
B: No lets see what D has done because D first, he had to do the introduction
B: Why am I first? No dont ruin the presentation C! (looks through files on the computer)
B: OK just to recap what we were supposed to do D you were doing the introduction?
D: err yes.
B: C you were doing ...?
C: Reduce
B: Reduce, Reuse, Recycle (points to A and himself)
B: No, guys I was doing Recycle you were doing
A: I was doing Reuse
B: Yes, Reduce, Reuse, Recycle. We all were doing Reuse! (laughs)
B: Ok thats good, you wanna (gestures towards D and computer)
D: No, I dont have any data in my PDA, I was thinking about how to start. I think we can just provide some data, like
C: Facts?
D: Huh?
C: Facts
D: Yeah just a black screen with some facts
B: OK
D: Uhh, so we could have some pictures of cutting down the forest.
C: Yes actually, I see it now. then one picture of my desk, covered in paper. Thats like three trees
D: And I thought we could have two screens, like two different persons doing it different ways
B: OK I see, like a right way and a wrong way.
D: Yes a right way and ... yeah.
D: And at a certain point, we could also have the person sending out a lot of paper...
B: OK... alright
D: Thats all
B: and then we just move in to...C! Your pitch.
C: OK, first of all (gets mouse and loads up folder of pictures)
B: Oh you have pictures too
C: Yes, but most of these are about my study here (all laugh)
B: Someones been hijacking the PDA
C: Yes this bit here is my study. But... (brings up picture of his desk)
B: Whose is that? Thats horrible (laughs)
C: That is horrible
A: You waster!
C: There are loads of papers, you can see up there printed out over there. And of course books and all that. Umm its a bit worse now, having done my study I have loads of them here on my desk... And THEN you have a big screen there, and its empty in a way, its got a nice sea or whatever. Kindof especially if we follow D’s idea, then we could have another one over here, or clean up my desk.
A: Yeah before and after.
B: We can just shoot ...’s desk or something
C: Yes and then have pages on the screen or something, sort of contrast of, you can use it electronically instead of so much paper
B: OK
C: Right so I have some facts, (picks up paper with facts on) that you could probably use in the introduction about... The average office worker uses 10000 sheets per year, umm. 40% of our garbage is paper, umm, 3.7 million tonnes of paper are used annually in the states alone, umm and then something like, only 15% of printing happening in the states is double sided, and that if you had, say this printer that has duplexing capability, it would be 350 to 500 dollars, and that in an office of 20 workers you would recoup this in a year or less. So these are some facts, and I have this quote that I like and I used myself as well: I write down everything I want to remember, that way instead of spending a lot of time remembering what it is I wrote down, I spend the time looking for the paper I wrote it down on.
OK, so that again would be kindof, suggesting how electronic media can help with that. So if you have your todo list on your mobile phone. I also found some tips and, OK so they say general stuff like use electronic media, but something more specific would be that: An ongoing piece of information that updates and changes periodically should be electronic only, right so if you have a todo list its quite dynamic or something where you keep changing it like a calendar, having a calendar on a piece of paper is a bit useless, writing a day planner on paper is a waste of time and space, a whiteboard on eye level on the wall would work better, or PDAs, PCs obviously, for reading articles and all these calendar applications. Of course there are arguments against it but we dont want to make a debate we just want to show these options to people and then hopefully they might... (zooms in to desk image and moves around)
B: How do you want to do that? I mean do you just want someone reading out these facts or some pictures...
C: No I have to admit I haven’t worked on that.
A: I would think it could be pictures and then you reading the facts, which relate to the pictures...
C: Umm, I'm thinking if that is to be played in the Parade (a bar) or in the public streets, maybe sound is not an option.
A: That's true.
C: Or maybe we should have sound only as a complementary channel, and we should have the facts bring it out. So we have a quote displayed. You can have voice on top, but not dependent on it.
A: Yeah true.
C: We can have sketches that are without dialogue, and have some nice music on top, if its not being played its not necessary.
C: We could have some funny music too.
A: I’ve been thinking of a sketch, or more the style of a sketch, so for reuse, I think something just as simple as umm: You want to print something out, and then the printer runs out of paper. And then the person says, oh we've run out of paper have to get some more. But instead of just normally, going to the next kind of... loads of sheets and loading it up again. The movie takes someone through the process of making paper. But funny, maybe Benny Hill-esq... But the thing is we could intersperse ourselves with footage we might be able to get. Such as footage of how paper is made, because I've, I can see the kind of footage I'm looking for, of like, big lorries take huge trees away, not that we could make ourselves, but. and so it could maybe be kind of speeded up as well.”
C: Yeah definitely
A: Cos it need to be short, and that would make it entertaining if it was sped up
A: And at some point when you're doing it you'd probably have to dress up as a construction worker, with a hard hat. Um so thats my idea for a sketch.
B: Yeah that could work.
A: At the moment thats only addressing reuse, i dont know how...
C: A lot of the tips I've found relate to reuse as well, for example, reuse paper thats only been used on one side for making drafts or for making signs that you stick on the wall or something like that, then this is reducing by reusing.
B: What about if we put the little few tips in between each segment. So after the segment on reducing we have a few tips. Rather than having them all at once
C: Yeah, I think that could work.
B: "Tip number 463" then whatever it says
C: Yeah, well not necessarily... Yeah tip number.
C: Yeah um, probably the laziest person in this group I was thinking whether we have to film everything because that could take quite a lot of time.
B: I think it depends whether we can find the footage.
C: Yeah
A: Yeah thats it I mean uhh...
C: Well actually, we don't have to get it perfect.
A: Yeah
C: one shot of everything would be enough.
A: I mean you could have for example speech bubbles, of what people say on the screen to compliment the sound, and then it would explain what everyone was doing.
C: Or we could have it as a silent movie. A black background with a white frame 'oh I need more paper' running around like charlie something
B: Does anyone know how to edit video by the way?
C: You do.
B: Well yes but I was just wondering what editing software we have. Windows Movie maker can do some things but Im not sure it can speed up.
B: cos Windows Movie Maker, I've not found a way that it can speed up, or slow down, or reverse or anything like that
C: I downloaded a trial version of something once, some video editing tool
B: My theory would be that if we can come up with something without needing any gimmicky kind of effects, other than some editing, it would probably be better...
C: Yeah I mean, that's an idea, if it's easy we do it, if not... whatever.
B: Right shall I show you my idea
C: Yes
B: Well my idea is sort of the same thing, do a little funny vignette BUT. Sound is necessary because its a bit of a talky piece. So I dont know how we're going to deal with that. So I'll just show you a little storyboard (Opens up images on computer). Unfortunately you may have to tilt your head to see it properly
C: No you can press a button
B: Which one this one?
C: That one (rotates image)
B: So it starts off with a character reading a letter, its an upsetting letter 'Dear John' or whatever, rejection letter from some whatever and he's not happy. So he crumples up the letter and throws it away (moves to next storyboard image). Suddenly, a disembodied voice tells him (all laugh at picture of B looking shocked as it rotates) 'What are you doing!'
A: It would be good if it did spin around like that, zoom in to the screen (laughs)
B: Like 'Whos that? whose talking?' and he says 'What are you doing throwing that paper away' and he says 'Well I dont want it anymore', then he says 'Why dont you recycle it?' Then the guy says (switches image) 'Well, there are no recycling bins around here, what am I supposed to do?' (all laugh) So we pan out to reveal (switches image) a recycling bin right behind him. He says (switches image) 'Wait a minute, thats just one recycling bin thats just doing!' (B laughs)
A: Yes
B: It might be quicker if we could just draw a speech bubble on the screen
A: Yeeea
B: And that takes a very long time as well
C: Yeah thats cool. Yeah I guess it needs sounds at least for the disembodied voice
B: mmm
C: Cos you could have a bubble for you but it wouldn't work with umm the voice
B: Yeah so thats the problem I guess
C: Maybe we could make a little err
B: What we could do... is have little subtitles like for hard of hearing things, and this loud voice HEY YOU (C laughs) exclamation mark
C: We can draw a little uh like uh, not draw, but have, introduce a little I dunno a little furry animal coming out of the screen and talking to you.
B: Yeah if you could do that. You work on that furry...
C: Come on you've been editing movies before
A: Can we have a piece of paper with a face drawn on it and then the piece of paper would be a character saying 'Hey you Im not just a useless piece of paper' (B laughs)
C: Oh the paper talking to you
A: Yeah exactly, its like theres a face drawn on the paper, and its a little character, we could have it on strings and move it around.
C: You know what its fairly easy to do stop motion, so you can have a piece of paper with that man, and you have it all wrapped up and we will be taking pictures, so it will seem like its opening up and the sketch man is talking
B: That only works if you have a tripod though
A: And that takes a very long time as well
C: Yeeea
A: It might be quicker if we could just draw a speech bubble on the screen
C: Yeah these things should be easy
B: You think so, so just keep the idea but just modify it
C: Yeah...
C: So if that is the recycle, are we going to have them sequentially?
B: Yeah I guess so
C: What about what D said about the parallel
B: Split screen?
C: Split screen
B: Split screen is difficult to do again its another video effect that not all of them do
C: Oh
B: You can shoot it but...
A: Split screen on what part?
B: In the original part, the opening,
A: And what splits the screen?
B: I think the idea was one person doing things correctly and another person...
A: Oh right that
B: I think what we need to do is we need to come up with some kind of storyboard that can you know...
C: Yeah because we dont know what, maybe we can go for it...
B: Let me think for a second, you have all those facts right?
C: mmm
C: I mean I was thinking with all these tips about using double printing printers and uh whatever, creating notepads out of leftovers... You can have somebody doing it and ahh, ill use that but it wouldnt... there are quite a few tips
B: Yeah (picks up paper with tips on)
C: That would be tedious to just film somebody doing them, and actually they fall in to different kind of things you know like reuse
B: I think if you want to show your tips (puts down paper) The way you can do it is to combine the two ideas we could have, instead of a split screen just show like, the right way and the wrong way so to speak and for commedic over effect you show the right way and just you know 'writing a day planner is a waste of time' and you have a guy with a note planner and its full of scribbles and post its and whatnot and then you show the right way and its electronically like someone else and you of course on the other side and your hair is dishevelled and everythings a mess. 'Try to use both sides of a sheet of paper' so one guys got big stack of paper and he just writes one word and he puts it on top and then the other persons got a neatly written piece of paper with thousands of words on each side something like that
C: Yeah I dunno
B: That works visually doesn't it?
C: I think it doesn't work that well in the sense of it will take too long in video to advocate one idea, one tip. And still wouldnt be completely clear if you didnt write anything on top of that. So these tips if we can just have a concise way of presenting it as text
B: mmhmm
C: Over some kind of or in between some kind of
A: Well yeah I was just thinking why isnt the tip just on the bottom of the screen and then
C: Yeah
A: Have that little movie, cos at the same time you need something to grab peoples attention, people like watching TV because someones doing something...
B: What we could do for the full video is we could have a little bit at the bottom. Heres your video and heres your text (uses screen to show where things would be) That can be done by Windows Movie Maker, they allow for that.
C: OK
B: And thats an easier thing to do And that way you can put the tips and you can put the conversations and you can put anything its not hard
A: Yep
A: And at the end we have to say, no paper was harmed in the making of this video
B: I like that, I like that
(A and C laugh)
C: OK get it down, write it on the PDA
A: Get all of that down?
B: Write it on a piece of paper and stick it the PDA
A: Yeah (A starts jotting notes on paper)
B: So what are we going to do are we going to do the double sided, good news bad news idea?
C: What?
B: You guys wanna do away with the whole Reduce Reuse Recycle triptych and just work it out as a three vignette series thing?
A: What have we got? We've got your thing, tips, facts. We can start with the facts
D: Yeah I think start with the facts and then the tips
A: Yeah yeah
C: We want some music playing
B: Music is quite easy to find uh, thats a
A: I was just thinking the best music for the facts bit is that really dramatic opera style stuff duh duh da da! I cant remember what that music is
B: What was that guys name... oh well we'll figure it out
A: We'll have a much clearer idea as well when I see what kind of footage I can get
B: I think footage is the main thing we need to get that
A: Yeah if we can get a lot of it, cos its easy to have that fact at the bottom of the screen with the bit of footage that is dump truck dumping a load of paper on a big waste site or something
B: mmhmm
A: And just have dramatic music on top or something
B: We need to do things quickly cos we dont have much time
C: No, ten days?
B: I expect this bit I could film in one day, film it edit it, do it all in one day
C: OK, and then one more day for A’s and then one more day for mine. You can do it in three days
B: Well I don’t even know what your idea is, we have some of D’s idea and A needs to get extra footage
A: It needs a lot of extra footage
C: So you think I should come up with an idea for reducing it?
B: Well we could get rid of the whole Reduce Reuse Recycle thing and just have tips. So this is one tip and you have another tip and you have another tip and we just put that together and say: and here’s some more tips dadada...
C: No it is a nice structure I think
B: Reduce Reuse Recycle
B: What’s your idea?
C: mmm...
A: I think yours would have to be the electronic...
C: Yeah I’m going back again to the pictures I had in mind of a clean desk and paper or not, I don’t know how it can be...
A: That’s easy to put in film form though.
C: Yeah
A: Its easy cos it can all be in the text at the bottom all you need is a your desk as a massive thing of paper and then a caption just kind of says ‘look at this organised person with far too much paper on the desk’
B: ‘He is a waster’
A: And then the opposite person that’s just footage that could just be ten seconds or something
B: We could do it twice once with you like this and once with you clean shaven (laughs)
A: Yeah!
C: Yeah! ha ha OK so it can be umm
C: Working around the quote pretty much, someone trying to find a piece of paper. We can work with academic papers very well as well, someone can come in and say ‘do you have a paper? do you know about him or do you have a paper I could have’ and then him looking around for it next to him OK.
B: Yeah OK
C: OK, let’s go and do it
B: Alright so, storyboards, storyboards. Wait, what hardware do we have? I have a camera, does anyone else have a camera?
C: I have a digital camera
B: Oh, a video camera, I’m saying video camera
C: No, we have here we can use that one (the one recording them, all laugh)
B: Look there’s a camera over there!
A: So these don’t do video then?
B: Uh they do
A: Would the quality be OK?
B: mmm, we could use it for it, but I’m not even sure how to download it on to our own computers
A: See I would probably use my phone in that case,
B: And I would use my video camera if I had a choice yeah
D: I can use my digital camera it can be used.
A: I don’t think my phone will be very good quality
B: Well we could all. If we plan it all together we can use the camcorder for the whole thing
D: The problem is if we use different equipment, the quality...
A: Yeah that’s true, the quality will be different. I think we best stick with...
B: Well we need to organise that to work properly so we need to come up with some kind of script or something like that

6.4.2.2: Group 1, Meeting 3

B: Reduce first? (looks at notes on paper)
A: Yeah
C: Is it Electronic Media vs Paper
B: Yeah we’ll have our little cut from one person to another person, so we could do that by pictures or we could do that with a...
C: Well we can do it with video somebody coming in, give me a paper and ah...
B: Probably better
A: Umm, so, alright so we’ll video that. So we’ll need a little bit of a script so you have to choose three or four facts I would say, then you have to fill, its like how you want to shoot each bit and then we could just make you know a little storyboard out of that um and decide how to shoot it
C: OK
B: We’ll also need, probably some other actors so you might need to hassle people in your lab
C: Oh yeah, will you know it could be you coming in and asking me or do you want to use different people?
B: It needs to be someone that looks authoritative. Someone who looks like he’s a boss. *** would be good. He works well in that context
C: ***?
B: *** would be good umm.
A: ***?
C: No if I tell him what I’m doing, he’ll say ‘you’ve got to be joking’ laughs
B: OK fine, so reduce and reuse we’ll do your bit we’ll need to find footage so...
A: Yeah that’ll be my job
B: Alright. So do you know what footage you need to look for?
A: Yeah I've got a good idea of what I want to show. And I'm also looking to what I can do with what I find as well, what editing software I've got.

B: If we can't do the bit where we cut you and put you in another scene, we could shoot scenes of you, and edit it so it looks like you're pointing at something but we'd need to find a location where it would be reasonably believable (A laughs). I mean there are some trees around here but... I dunno.

A: Yeah see I'm thinking of kind of the Redwood Forest kind of thing, huge. I don't know if we can do that, but, I know what you mean.

B: I mean people aren't expecting much

A: I know, I know this is just going to be... (C brings up notepad window on computer)

C: Yeah stop writing there, we'll write it in here, then I'll send an email

B: OK so, we've got our introduction, we've got our pictures and...

A: Captions of facts

D: Yeah, captions for facts

B: We've got our reduce bit, which is going to be electronic vs paper comparison, uh we'll need video for that (B takes control of computer keyboard and mouse)

C: So maybe we can also like have actions so I need to come up with a more, like, precise storyboard and all that...

B: Well maybe we can write it now lets see what we get uhh, which fact did you want to start off with? Start us off with one and umm. Scenario number 1 or lets say Tip number 1

C: 'Email can be used to share documents and ideas'

B: So what's the contrast to that?

C: So I'm thinking the idea of someone coming in and asking me for an article and I'm going through all my papers and I can't find it. But I can email him in my perfectly well organised umm hard drive. You see.

(B types out idea)

B: Something like that?

C: Yes

B: Along those lines

C: Yes very good

B: OK

C: And umm, could possibly do something similar with a Todo list, and thats where the quote can come in as well

B: 'Todo list'

C: So I'm doing my best trying to find within all the papers this little piece of paper saying that oh, you need to be there doing that, or I can have my fancy PDA actually, that can come in to this very much

B: But doesn't that kind of sound the same? Looking for a piece of paper here, looking for a piece of paper there...

C: Yeah it does umm Well I dunno

B: How can we do... I think double, double printing is something thats very important but that's reusing.

C: Yeah but we've already got another...

A: That could lead directly in to my thing somehow

C: Umm, but how can we do that?

A: Dunno

C: Oh! Maybe the first case, somebody is trying to do single sided and he doesn't have enough so he goes through whatever Pete is going through, but the neat person has double sided so he doesn't go

A: Maybe he could do double sided the first time and it works, and then go... we could kind of have a 'but if he would have single sided this might of happened'

C: Yeah

D: Yeah

A: and then go through my thing

B: Or the other way round you could do... well the single sided first then he goes through all that thing and then...

A: 'Or he could have just done

C: Yeah I agree again

(B types)

B: Goes through a rigouramoral process involving hard hats and pulling trees. Good.

B: I'm just using C as an example here, could be anyone (B continues typing) 'Prints double sided' done.

B: OK, how is that?

C: Ohh, it could be like a deadline submission or somthing, right so its a matter of... Im in a hurry.

A: Yeah so its a speedy thing

C: Yeah I'm doing it in one minute. And he has to go through all of that and just make it to the submission deadline or something

B: And he's whistling on those

C: Yeah and I'm like hmm

B: You're sweating and you've got little black coal all over you're face, little band aid there

B: Yeah this could be fun

C: Right

B: (writes on computer) Little storyline I wrote that needs to be filmed

C: B you'd better send that as an email to everybody.

B: Its not a very well written piece of document, Im not sure if its followable

C: Yeah its fine, what it needs is a... actions

B: (to D) Are you going to take the pictures yourself or find them off the Internet?

D: Uhh, can probably find on the Internet

B: OK, alright, what were you saying C?

C: Actions, we need them, who should do what by when?

B: OK yep (types)

B: So how are we going to do this, next couple of days. When are we going to meet next?

C: Well, we will have it finished by next Wednesday, ten days from now.

B: OK, so we should meet on Wednesday then?

C: We could if there is a reason, that will depend on the actions, I mean, I need to come...
B: Start with D, D is going to take pictures
D: Yeah
B: Right
C: And the facts
B: Yeah maybe sort out the facts
B: What are you going to do?
B: A said he was going to search for footage online
B: I think I can film my bit, I might need someone to help me out with the camera work, but I'll see who's available.
Also need a disembodied voice. So who has an authoritative, disembodied voice?
C: Me of course
B: I mean a Charlton Heston god-like voice
C: Yep
B: That's you?
C: Umm, OK, lets, we can do these bits together.
B: I could do the scene and download it in one day, its going to be a bit tough though, but I can try.
C: Well lets take it backwards, I mean if we need to deliver that on next Wednesday, we will need to have two or three days for editing...
B: Well we can edit them in bits, each one is separate from the other so...
C: Yeah, I dunno, try and deliver it by Friday? and then we could have a meeting on Friday and see what we like and what we dont like, what needs changing, ideas for editing...
B: What this Friday? The whole thing?
C: No its at least as a, as a, proposal and we can say change this and that and be also you can say that...
B: Yeah also for your bit, we'll also ... maybe for the others as well i dont know. We'll need some um audio capturing.
C: Audio capturing?
B: Audio capturing rather than just... Is that good enough already have you tried it?
C: No I haven't
B: OK
C: For what, why do we need audio capturing?
B: Well for talk over the scene. I mean you could stand behind the camera and speak in to it but its not gonna sound as well
C: Why? I dont get it
B: We have scenes for example in your bit where you're comparing the right way and the wrong way right. You're having someone talk over it you're having a voiceover?
C: Saying?
B: Saying....
C: C is this way and he is this way...
B: Or are you just having the caption?
C: Well, I should have the caption
B: mmm
C: And then we can have voice if we want to...
B: OK, alright
C: I dunno Im keen on doing the signs with captions actually coming in between
B: Ahh, that could be done, dunno about the black and white bit but we could give it a look
D: Are you gonna try the black and white and?
B: I could check if its available on Windows Movie Maker, should be able to see
D: Or I can find some other software...
B: Where is it now, accessories, ohh. (opens editing software that is installed on PC)
C: You would expect that it would have an audio capture thing
B: I think it does, I just don't know how good it is
C: Where? How is it called?
B: Audio Capture
A: Try to open uh...
(Opens test video in to editing software)
B: Windows Movie Maker is what Im going to use then.
C: (laughs)
B: Audio Capture
A: (laughs)
C: What are you trying to do here?
B: Im trying to see if this works, my documents... bluetooth...its not going to work (trying to copy in video files from Smartphone) Is that it?
D: Yeah
B: Cut and paste editing here
C: Should be a timeline?
B: Well yeah there is a timeline, but you have too... (gets test video from Smartphone in to editing software)
B: You can cut, and edit
C: Marker... set marker again... Play (play video)
B: Windows Movie Maker is what Im going to use then.
C: You see you get a number here... but...
A: I dont know how much we can edit
D: I dont think its so powerful
B: No
D: So then
B: It has a calculator! (laughs)
A: I know I can edit I just don't know if I can have any effects on mine
B: I have an editor on my personal computer, which is a Sony editor, but that means I'd have to move my uh videos on to my PC and I don't have a Firewire port on my PC so.
C: You dont need a firewire I have an external hard drive, a USB
B: No to download the video on to my PC
C: Oh from your umm camera
B: Camera. So if I could download it on to my PC, then move it on to your external hard drive then take it to my hard drive and then
C: No, no no. Wait a minute is it only firewire your camera? Cos you can connect the camera with a video cable on to a computer in there.
B: But you can't download it on a computer to edit it, you can only watch it.
C: No, we have this Dazzle thingy, and it will take the image from your camera and make it in to an MPEG file.
B: OK
C: And then you can upload the... import it in to any editing software.
B: OK
C: How did you do it before
B: I just download it on to my computer then edit it once its on my computer, using the firewire port.
C: Yeah its the same only that you dont need to have a firewire you can do it with the video cable
B: OK, cool...
B: So when are we meeting again?
C: Friday?
B: this friday?
C: Having done our bit each
B: Yeah, well you all have my number if you want to use my camera... What time friday?
C: 2 O'clock
B: 2 O'clock okay with everyone? Alright.
C: Write that down (adds to notes file on computer)
B: OK well you send the email, what are you supposed to do?
C: Film scene as well, Im filming.
B: Yeah but what scene? you havent got a plot yet.
C: Yeah its up there
B: Find (types notes) Co-actors. Alright looks good. Find disembodied voice. Next meeting, 2pm friday.
C: The 29th
B: Is there a todo list on this thing.
C: OK C, you send it out. (C takes over computer and goes to webmail)
A: I dont know
B: You get them as FLB files dont you?
D: I think you can convert it to...
A: No but if I rip something off Youtube, can I get it on to that or is there some other way I can...
B: Can you rip things off Youtube?
A: I: dont know
B: You get them as FLB files dont you?
D: I think you can convert it to...
A: The thing is theres a number of ways I could do it, I could have it running on the screen and then I could record the screen. Or maybe that wouldnt work...
B: There must be some environmental websites which would probably show something.
A: Yeah true, I'll see what I can find, Youtube was just going to be my first port of call but yeah, I'll see what I can get.
(C sends email)
C: is that it?
B: Well go to sent mail and find out
C: Actually I sent it to myself so... No its not here (C resends with attachements)
B: We forgot to discuss the most important bit. How are we going to get credit for this film. I suggest alphabetical order
A laughs.
B: And I be on top with Big Name
A: With big stars around it
B: Yeah!
B: Ohh we still haven't got a title, we need a title
C: Not yet
B: Oh and we need a theme song
A: I think we should focus more on this paper character, then we could call it the adventures of, but then we need a name for him
B: But then we gotta use stop motion!
C: Come on, 'paperless city' or something
B: Papy the paper?
A: Happy the Paper
C: Pulpy?
A: Pulpy yeah! Pulpy the paper
B: Hello Im Pulpy the Paper! In fact we dont even need any special effects he just... go a bit close up.
B: I think we're done.
Group 2, Meeting 1

F: Okay, so guys any ideas?
H: No laughs
F: OH so the idea could be the have four films about recycling, that are related with things?
G: Four?
H: One each
G: I think we want to make it a continuation, such as a series.
F: Well lets think about options, and then we make decisions, so first option is short films but in a sequence
G: Short films, but in sequence so they keep coming back and try to look for the place where it fits with the next part.
F: So in sequence but the short films they make sense on their own.
G: Could be like, four films in the same world, and there in conclusion they all come together, watching four separate lives
H: All the same area?
G: Yeah But we've got four cameras, so... We just need four characters, four stories
E: Four characters, four stories and a puzzle.
F: Err, keep talking
E: If you've seen all four stories you can solve the puzzle, but if you can, if you havent
F: This is getting difficult!
E: I dont think it is because they do it in the Independent every weekend, and they put a series of pictures and you've got to guess and maybe then, people watching it can...
F: Why does guessing? What do they get?
E: Its an incentive to see all the different films solve the puzzle
F: Why do they need to solve the puzzle?
G: Because you just want to get to the end, and you can only see part of the puzzle everytime if - I guess - you recycle.
H: Yeah but that comes a lot slower
F: But if you want to attract people who are not recycling, it wont work
H: Yeah
H: Also, you imagine its going to be seen by other people in the area.
E: Perhaps we're making this all too complicated, if you see somebody throwing a can in, there's an underlying persuasiveness there, you might go I've got an empty can, I'll throw it in but, maybe its a persuasive thing.
E: Isnt it a reminder thing? I go to the supermarket, I get to the checkout, and then I remembeber - wheres the bags - well they are still in the car and im not going to run out to the car. Im in the checkout queue, what i need to see is lots of people with bags outside the supermarket, because you dont go in to supermarkets with bags in your hand. Well you do now, but you didnt then, its a sort of underlying message, people have their bags
F: 'I dont want to be different' thats the point
E: I dont want to be different, and so thats another theme
H: I think what i like is the idea that, if we've got more than one film and its random, you've got variety there, its not something you switch off to so much, because if you've seen it ten times, you know what's going to happen, theres a bit of variety, and a bit of puzzle, you will still notice it, have I seen it all?
F: But once you've got the puzzle...
H: Yeah but that comes a lot slower
F: What about just short films that make sense on their own. We could do 50 of these things, but we only produce 1 or 2 (in this project) So the first question is, is the film shown to someone who recycles, or someone who doesn't? its a really different thing isnt it
H: If you're showing it to people who recycle, then you are rewarding them for recycling, if not
F:Whats the message?
E: Hasnt all this been solved really?
E: Perhaps the film is just a reminder, I just forget to do it (recycling)
F: So you are talking about someone passing by?
E: Talking about someone passing by, I quite like this idea of reminders as you pass by.
F: OK you pass by and you see something, a message, just saying LOOK! This is the recycle bin...
E: Thats...Well I think the silly animal trick is quite funny sometimes...
G: How does that go?
F: Noise?
E: Well you just have an animal
F: Ahh thats good
F: Oh I see, you just have an animal...it grabs attention
E: you have that... people like animals it grabs attention.
G: So a cow?
E: Ducks... 'What's that duck doing there?'
F: OK that's interesting, you hear the sound of an animal, but it has nothing to do with animals. You hear the animal then you look at the screen and...
E: Its just a thought, its a trick, you see it a lot in adverts on the tele(vision).
H: Yeah, it's a good idea but if we're putting it somewhere where a lot of people are walking past...
E: It this going to make them fed up.
H: Its going to make them crazy.
F: And we need to put sound? do we?
H: I'd like the idea of it being almost interactive, not just a public information film - sit down and watch it - this seems to be a much better idea.
F: OK so we have some ideas but no conclusions
E: So are we going to have four themes?
F: I dont think we should worry too much, maybe it wont work, the university would be full of sounds, but we can be creative, its a crazy idea but...
E: Perhaps we should just go sound, say right, theres four of us, if you were doing this for yourself now, what is on the top of your head? how would you do it?
F: I like the idea of animals. I think animals could be... you are walking and you hear the sound of a snake - not a snake! -
E: Yeah go on, I like the idea of the sound of a snake!
F: So the person is passing by and there is a sound, and the
G: What about a seductive sound? So its gender specific, detecting now! And theres a hot women there!
E: So G is going to go for the women!
F: I think we should produce just one film, thats it
G: OK
F: If we have the time we produce a second one, I dont think there is time
G: So one of the things then was the idea of, a sound, how do we all feel about a sound being an attention getter
F: Yeah
G: Yeah
F: Thats good
F: So we can think about, umm, there is a sensor, someone walking there, there is a sound, and immediately the film starts, it is a short film, one of about 50. It should be something that appeals to young people
E: The question is what is our target audience? Its more likely to be students, young people.
F: We can say that our target audience is students, maybe next year we do something else...
G: Yeah I guess its targeted towards first year undergrads, because they are moving away from home for the first time.
F: Its a campaign for the first month, freshers.
H: The black and white parodys of old information films done toungue in cheek.
F: What sorry?
H: Harry Enfield did similar things a while back
F: Silent film, charlie chaplin use to do them.
E: Quicktime sort of
F: An old film, black and white
H: Have you seen them? (at H)
E: No but I know what you mean
F: They need to think 'he's recycling its cool'
E: I think what - I dont like to use the word they - but I think what happens is that people of that age tend to see what their peers are doing and just do it, i think if you tell them its cool they dont give a ... they dont like to be patronised.
F: So I like the idea that for first year students, its trying to make new students aware of the locations of the bins
H: Yeah
F: They can talk about it, they can tell their friends, 'have you seen that its crazy'
E: So you need the different people to make the film interesting, as you walk along, you get to it, a person goes across and put something in the bin. You see it out of the corner of your eye its like your gender thing, if you had gender detection it would be great, because youre looking for an avatar whose doing it.
F: Ideally we could have uhh... celebrities doing this! all laugh
E: Random celebrities excellent, Yeah love that!
F: Or just lookalikes! laughs
G: Thats cheaper!
F: But do it in a funny way, somebody dressed like Britany Spears, or the queen comes in!
H: I like the idea its good
E: 'Everybodies doing it'
F: Thats it thats the film!
G: Think about the soundtrack too because thats important
F: At the end of the film maybe, There is a song by Jack Johnson, its for children, its part of a film, I can show you the song. If its too childish we can drop it, but otherwise the soundtrack is done for us
E: By the way. Emails? Are we going to share emails? and are we going to use these phones? F collects group email addresses
F: I mean are we going to call each other? Are we going to use these (The smartphones) things?
F: We use this to communicate, is that the idea
H: Yeah, We should use it to note ideas... and to use the internet
F: The problem is carrying two mobile phones now, I dont like carrying these things, this is big
E: Quicktime sort of
F: So one of the possibilities is using look alikes, celebrity look alikes, or just regular people?
H: Celebrity look alikes is a good idea, I dont know how we are going to do that in a week
G: Think it could be funny if you want to, have some look alike, but have people who dont look like celebrities it could be comedic
F: Oh they are trying to look like it
G: They look absolutely nothing like it, but they try to do their best, the way they speak
E: laughs I love that!
F: Why not someone yeah, OK, All G is a possibility, another one... umm
F: We could do this with one, so a celebrity impersonator, goes there, puts the can in the right bin, thats it, make a gesture and a song, we could have a song and some words
G: He could dance
F: He could dance of course...
F: Ahh and the song could be attached to the celebrity if it is a singer or...
G: Well, think of a song that a celebrity could be attached to.
F: A song, uh for instance Tom Cruise attached to Mission Impossible
H: Ozzy Osbourne? laughs
F: Uhh, Britany Spears with one of her songs, or who else, who is cool at the moment
G: Backstreet boys? New Kids on the Block? laughs
F: This is too old!
E: Sorry im nowhere with this stuff
G: 80s music is cool, thats coming back again
F: Abba?
G: Michael Jackson?
F: Who else, David Beckham?
G: Does he sing?
F: No but, you could put in a Spice Girl song
E: Im sure he would have a go given half a chance!
F: Who else? well if we are producing only one film, we can choose one person, is it too difficult...
G: It would be good if we had a group of say three
F: Three celebrities or three films?
E: Three celebrities?
F: From the same film maybe?
G: Its just something they do, I think the recycling, its just something the celebrities do in their everyday business
F: It answers the question of it being a puzzle
G: Have you seen Dave doing his impression of Elvis, The underlying message is.. hes just going past the bin and putting something in it, but its Elvis doing it. Dave being Elvis
F: Three very simple films
F: lets see, Elvis, Ali G and Britany Spears?
G: And an animal, the animal is just there in the corner, looking at you, thats the point of it its a duck or a squirrel, and its the only thing in the film thats looking AT YOU
F: So we have three different films, and they are showing almost the same thing, cans, bottles? paper, whatever, it doesn't matter, three films with three different celebrities
G: Good

6.4.2.4: Group 2, Meeting 4

E: My cameras in the car. I thought with this rain we wouldn't be bothering with much."
G: we can film in the rain.
F: Well, er, E just said...
E: The camera's in the car'
G: We can film with the PDA'
H: Yeah, we can film with the PDA
F: Okay so we've made decisions, did you all see Matts email?
E: I haven't seen todays
F:Oh todays was, nothing
E: Oh yes I saw this (looks at printout from F)
F: This is a second version
E: Oh right yeah
F: Umm, so yeah whos going to be Indiana Jones?
H: Umm, me.
F: It looks like hims
G: Yeah, H does have a resemblance to him
F: OK so what does he do?
H: I just walk in
F: Walk in with what? what are you recycling
H: Cans
F: Oh the cans we were supposed to have empty beer cans
H: I think we have some coke cans next door,
F: OK
H: I might want to wear a jacket as well if its raining
F: It is raining
G: I think he's supposed to whip the can or something, we'll get some wires, have lots of wires around here we can use
F: Get a cable then
G: Sound effects should work
F: So done with Indy, next one is James Bond
E: I vote you (to F)
F: James Bond?
G: Im terrible in front of the camera
G: You could be like the old James Bond...
F: Thats the good thing, anyone can be James Bond, because they keep changing the actors.
G: Thats true
E: So I stop off in front of the camera.
G: It has to be you, you have the British accent, we dont, and H is already doing.. (E laughs)
E: Oh I've got one of those
G: No ones going to imagine an American James Bond now
H: No you couldn't possibly the press would have a field day
F: Lets see, yeah so James Bond walks in recycles empty what? a bottle of Martini (looks at script)
E: I've got one chance to get it in, one shot.. because Im not going in to get it out!
F: So looks at the Camera as if its a mirror, checks if hes too... looks daper and walks off, are you OK? (looks at script)
E: Umm (looks at script)
F: Is that fine?
E: Umm (looks at script)
F: So what are you doing, the camera is there, you come in, you have the bottle there
E: Look at the camera
F: Check yourself, and walk off.
E: Actually this is more of a rehearsal, of how it would be.
F: So what do we have?
H: producers Bow Tie from bag This is a clip on
E: No I dont find those easy, so... (brings out his own bow tie) velvet one
E: I dont have a jacket
H: Well were not getting prizes, so...
E: He's managed to get out of it (points at H, who doesn't have to do any acting)
G: He can be an extra in every scene
E: Its OK, H can do the editing.
F: So we have...Oh have you checked the audio files
G: Yeah I have
F: Err, terminator played by G. Terminator Walks in, carries something to recycle?
G: a PDA? laughs
H: Bunch of paper?
H: Yeah, umm I can get some from next door
F: Paper yeah? So we have to carry some paper, problem is it will get wet. Ummm, so recycles it, looks at the camera, says something 'I'll be back or 'hasta la vista baby' maybe
G: right
H: In the moment, you choose!
F: we can do two or three takes
G: yeah OK we've got a lot of paper. I still want you to be a character in the background
F: OK
G: Consistently! People we be like 'who is that guy?' 'have you ever noticed that guy?'
F: No problems!
F: laughs He is always there
F: So are we going to use, that one? or (points at Smartphone)
E: Have we worked out how to make them take video?
H: Yep I think so, but this ones just gone on charge, so it might be a while
F: This ones on 50%, So I'll get some paper
G: OK meet back here
F and H leave the room, E and G play with the Smartphone to understand how to record video.
H returns
E: It might end up on youtube this, things do.
E:
F: How do you uh, get the camera?
G: You have 50% on yours, how much do you have?
E: I've got 60
E: How do you use the video on these
F: Oh here, so you press this button, and then I think here...
E: Oh right, you've gone sideways So which is the right way up?
G: Yeah you have to have it like...
E: But if we get it the wrong way round, you've got to rotate the video and that might be difficult
G: Yeah it will distort the pixels
H: 12%
G: you've only got 12%? thats funny...
E: How do you record?
G: Like this right.
E: Well do we know which way round it will be when you download it?
F: Theres an icon here
H: I'd imagine its this way.
F: OK its recording, H say something
H: Hello
G: Its supposed to be recording but its not.
E: You did a photo, not a video
E: So its that way round. Its that way round
H: It doesn't matter about the sound, we'll dub it over anyway
G: Yeah
E: How do I get it back in camera mode?
F: Like this
H: Yeah they aren't particularly good are they
F: Where is it (the recorded file). Its so difficult to operate this thing. Why does it have a play button there and thats it
E: Its a general purpose device.
F: plays the test recording
H: Yeah But it goes alright doesn't it?
F: Yeah
F: OK, so are we all ready?
G: How do I view videos then?
F: You go to...
G: But to play not to record
F: Yeah its the same thing
G: The sound is hard to hear
F: Yeah but we don't need the sound, ohh except...
F: Only he (G) is meant to say something. What we can do is use the film version of it
G: Yeah
E: So can I view something, how do I view something...
F: Like this
G: Wow its slow.
F: Yeah you have an error.
G: Lets ignore this one, and do it on your one.
G: So it should be this way up?
H: If it comes out sideways, we'll edit it sideways.
G: I've had a lot of problems with editing software, you got to have really expensive editing software to do stuff like rotating.
F: OK lets do it
G: Right Im going to abandon this one (smartphone)
Observer: Where are you going then?
F: There are some recycling bins over there, so yeah...
E: Have you got the bottle?
All leave. They are observed filming three pieces of footage, where a character impersonating a celebrity puts a different piece of rubbish in a recycling bin.

6.4.2.5:Keyword Report Summaries

Summary: Group 1 Meeting 2

Longitudinal: Using Experiences 6 0:08:04.7
Productive: Decision Making 9 0:02:19.3
Productive: Evaluation Represented 20 0:04:18.6
Productive: Idea Externalised 12 0:11:24.8
Productive: Idea Represented in Context 12 0:04:11.0
Productive: Iteration: Convergence 8 0:04:34.9
Productive: Iteration: Divergence 2 0:01:50.4
Productive: Scope For Iteration Discussed 1 0:00:30.8
Representation Types: Storyboard 3 0:06:06.8
Representation Types: Verbal 1 0:29:28.0
Representation Types: Video Recording 1 0:00:30.2
Representation Types: Written/Typed Representation 4 0:03:38.1
Structural: Conceptual Structure 6 0:02:13.0
Structural: Internal Structure 9 0:03:16.7
Structural: Reference to Audience 2 0:00:47.1
Structural: Structure Adopted 1 0:00:05.3
Structural: Structuring Collaboration 10 0:06:19.0
Structural: Tangible Structure 2 0:02:37.0
Clips: 62 Total Time: 1:05:35.8

Summary: Group 1 Meeting 3

Longitudinal: Using 2 0:00:43.7
Longitudinal: Using Experiences 5 0:02:51.6
Productive: Decision Making 2 0:00:25.6
Productive: Evaluation Represented 13 0:02:39.4
Productive: Idea Externalised 5 0:02:22.8
Productive: Idea Represented in Context 7 0:02:24.5
Productive: Iteration: Convergence 5 0:01:18.4
Productive: Scope For Iteration Discussed 1 0:01:07.3
Representation Types: Audio Recording 2 0:02:39.0
Representation Types: Storyboard 1 0:00:21.1
Representation Types: Verbal 1 0:23:22.9
Representation Types: Video Recording 3 0:02:18.8
Representation Types: Written/Typed Representation 9 0:05:13.2
Structural: Conceptual Structure 4 0:00:38.3

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Summary: Group 2 Meeting 1

Longitudinal: Using Experiences 4 0:03:19.7
Productive: Decision Making 4 0:03:13.0
Productive: Evaluation Represented 11 0:05:26.9
Productive: Idea Externalised 8 0:05:32.4
Productive: Idea Represented in Context 2 0:01:34.5
Productive: Iteration: Convergence 7 0:04:54.1
Productive: Iteration: Divergence 1 0:00:17.2
Productive: Scope For Iteration Discussed 1 0:00:43.9
Representation Types: Verbal 1 0:28:00.8
Structural: Conceptual Structure 10 0:07:45.9
Structural: Internal Structure 2 0:02:17.9
Structural: Reference to Audience 6 0:12:50.2
Structural: Structure Adopted 3 0:04:44.6
Structural: Structure Dropped 1 0:02:25.9
Structural: Structure Produced 4 0:02:52.4
Structural: Structuring Collaboration 3 0:03:11.0 Clips: 38
Total Time: 1:03:11.1

Summary: Group 2, Meeting 4

Longitudinal: Using 1 0:02:54.6
Longitudinal: Using Experiences 2 0:00:29.4
Productive: Evaluation Represented 1 0:00:00.3
Productive: Idea Externalised 4 0:01:36.9
Productive: Idea Represented in Context 5 0:13:56.2
Productive: Iteration: Convergence 1 0:00:05.5
Representation Types: Acting 1 0:11:56.6
Representation Types: Verbal 1 0:30:02.2
Representation Types: Video Recording 1 0:11:56.6
Representation Types: Written/ Typed Representation 1 0:07:49.2
Structural: Conceptual Structure 1 0:00:06.6
Structural: Structuring Collaboration 5 0:04:38.0
Structural: Tangible Structure 4 0:10:33.6
Structural: Tangible Structure Explored 1 0:09:51.6 Clips: 20
Total Time: 1:10:29.0

6.4.3: Questionnaire Responses

6.4.3.1: Background Questionnaires

Participant A:

What creative or artistic hobbies or occupations do you have now or have had in the past? Please detail your experience in each case.
I have been playing the drums for 10 years. This required devising parts to play with other musicians. I also recently did some web work involving design and programming solutions.

What experience, if any, do you have of recording videos, video editing or creating films?
I have no experience of making films.

What experience do you have of using PDAs or similar devices?
I have never owned or used a PDA for a significant period. However my mobile phone has many of the features of the PDA, e.g. camera, video, notes etc. I have owned a mobile since about 1999 and always carry it with me. I use it primarily to make calls, send messages, take pictures, and organise/remind me of things I need to attend or do.
<table>
<thead>
<tr>
<th>Participant</th>
<th>What creative or artistic hobbies or occupations do you have now or have had in the past? Please detail your experience in each case.</th>
<th>What experience, if any, do you have of recording videos, video editing or creating films?</th>
<th>What experience do you have of using PDAs or similar devices?</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>1. Writing prose (short stories, novellas, that sort of thing) – mostly in the past, though from time to time I dabble. 2. Short film making. Mainly interested in the editing aspect.</td>
<td>I have my own camcorder which I have used to videotape many things (for example, my sister’s wedding and reception ceremonies). I’ve also made short films which are now on YouTube.</td>
<td>None whatsoever.</td>
</tr>
<tr>
<td>C</td>
<td>No artistic occupations. On irregular, infrequent basis I might write a poem or a short story, design a bad webpage, draw with crayons.</td>
<td>I might have once or twice cut off bits of a video clip or rearrange them.</td>
<td>No experience of creating films.</td>
</tr>
<tr>
<td>D</td>
<td>I have used an older iPAQ for a few months. I regard myself quite proficient with using mobile devices (such as smart phones, PDAs etc.).</td>
<td>I have used other PDAs before, but can’t recall. All the operations are easy with me so I don’t need to read through the instruction.</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>My Father was a Painter and a Poet, loved Trad Jazz and classical and merely tolerated his day job. My Mother and Father were both musical. I did an Art and Design course in ’68 but did not complete it unfortunately. I have never stopped doing this really. I do a bit of graphic design using Illustrator and Photoshop mostly. I am a musician in a band: <a href="http://www.englishdance.co.uk">www.englishdance.co.uk</a>. I have played music since I was about 9. I have a very wide taste in music, but I love traditional and folk music. I have a small but very capable multi-track audio recording capability to support my music making and multi-track editing using pro-tools software. I do photography and muck about with video. I often find I have to make stuff to do what I want. Therefore I have a small home engineering workshop. I am half way through making a small Computer Numerical Controlled milling machine that will be used mostly artistically. I have pursued a career at Smiths Aerospace as a creative software engineer for about 23 years, putting together research prototype demonstrator hardware and software and research trials equipment mostly for novel cockpit HCI-related projects. Many of these projects have been associated with my own self-motivated ideas.</td>
<td>I think I have used other PDAs before, but can’t recall. All the operations are easy with me so I don’t need to read through the instruction.</td>
<td>2.</td>
</tr>
<tr>
<td>F</td>
<td>I learned how to play the guitar when I was 5. This lasted for 3 years, but I used to play with friends until I was around 25.</td>
<td>No much. I never had a video camera, but used several in special occasions like parties.</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>I play the guitar and use music as my creative outlet. I feel that when I start putting a bunch of notes together and start playing a melody, I get easily caught up in a creative process and lose sense of time.</td>
<td>My mobile phone (Sony Ericsson P910) is also a PDA, and I use it all the time, but mainly to keep my diary.</td>
<td></td>
</tr>
</tbody>
</table>

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I have never used a PDA before in my life. I prefer to use specialist equipment when it comes to recording various forms of multimedia.

Participant H:

What creative or artistic hobbies or occupations do you have now or have had in the past? Please detail your experience in each case.

Playing Guitar for approx. 15 years.

What experience, if any, do you have of recording videos, video editing or creating films?

Directed and edited a 15 minute documentary for Leicester Cable TV in 1998.

What experience do you have of using PDAs or similar devices?

Very little.

6.4.3.2: Exit Questionnaires

Participant A

1) During the study, how much time did you spend carrying the PDA with you? Please detail when you did or did not have it close to you.

I carried the PDA with me for about 2 days, but found it too large to fit in my pocket, compared to my mobile phone, so that stopped. I kept it next to me in my office, but this made it surplus to requirements because of the desktop I work on. I did bring it to all meetings and used it then to record brief notes. Although I used my mobile phone to enter a reminder for myself about the times of the meetings. This was mainly because I knew I would always have my phone on me and that the reminder was reliable and worked.

2) What did you use the PDA for during the study?

I used it to search the internet a few times and kept notes regarding what I needed to do between each meeting.

3) What problems did you find when using the PDA?

Mainly it was not powerful enough or inferior to other tools (or slower than desktop/laptops) to perform the tasks I required; Shooting high quality video, watching streaming videos online and converting, cutting and editing existing videos.

4) What other tools did you use in the process of completing the task? If the PDA could have been used for the same purpose, why did you choose to use an alternative?

I used my desktop to search and view online videos because its connection was faster and the software required for downloading and converting was not compatible with the PDA. The actions I needed to perform did not require a mobile component. Only the video shooting needed this, but we opted for better quality with Ali's video camera. Also since we could attend the meeting times arranged at the end of each meeting it was not necessary to contact each other to rearrange a time outside of the meetings. The only time it was (to arrange filming with Ali) I sent an email because it was not an urgent message.

5) What was your opinion of the support provided in the meeting room? What additional / different tools or setup would you have liked to have?

I think the support provided in the meeting room was adequate for our task.

6) Do you have any further comments about the study or the tools provided to complete it?

It was great fun. The way I approached the task I didn’t really need the PDA (ripping off youtube). I think a task with a limited time would require more interaction (if that’s what you want?) with the PDAs. I guess overall the PDA did not support us well for this task, but would if the constraints were different; a time constraint for example in a task of drawing a detailed document or film to help people find their way around campus. This would need sketching, photographs, video and creativity in the way it is presented (just look at how well the London underground map works). Situations using PDAs makes me think of the Apprentice and situations where tasks require information to be gathered quickly on the move.

Participant B

1) During the study, how much time did you spend carrying the PDA with you? Please detail when you did or did not have it close to you.

Throughout the study I kept the PDA in my office, using it very rarely. In the first week, I took some pictures around campus to create a storyboard, but besides that I did not use or carry the PDA outside meetings. The picture-taking took less than an hour.

2) What did you use the PDA for during the study?

Taking photographs to create a storyboard. Making (or attempting to make) some phonecalls. Taking down notes during meetings.

3) What problems did you find when using the PDA?

The PDA was extremely slow, specifically when taking pictures and videos. It was also quite confusing, as it was hard to find certain features. The keyboard was also too small to be used efficiently. I would think that there is some alternate design for PDA keyboards which could be far more efficient and relatively easy to learn. I was also unsure at times whether I had shut down the PDA or not. Basically, it looked a lot like a regular computer running a familiar operating systems (Windows) but was acting in a different way.

4) What other tools did you use in the process of completing the task? If the PDA could have been used for the same purpose, why did you choose to use an alternative?

1. Digital camcorder for video. I use my camcorder to video quite frequently, and am therefore more familiar with it. Since it is a machine designed specifically for taking high-quality video images, it was a natural option over the PDA.

2. Mobile phone and email for communication. I am quite familiar with two of the other participants in the experiment (viz. Stavros Garzonis and Peter Goodison) and so would prefer to use telephone calls or email for communication. I realise that the PDA had a telephone in it as well as a prepaid sim card, but I only used it a couple of times to make calls. Mainly, this was a product of habit. Also, I believe I mostly just walked over to Stavros or Peter's office if I...
**1) During the study, how much time did you spend carrying the PDA with you? Please detail when you did or did not have it close to you.**

I had it pretty much all the time with me as I replaced my normal mobile phone with it. I always turn it off when I go to bed. Sometimes I would leave it on my office desk for lunch breaks or while exercising. At home it would be lying around somewhere on the same or next room.

**2) What did you use the PDA for during the study?**

I took one picture to show to the rest of the group (in order to support an idea). I used the ‘notes’ application during the meetings to write down decisions and actions. I read these notes maybe once or twice. Soon after we started using the desktop and emails.

**3) What problems did you find when using the PDA?**

- UNACCEPTABLY slow for a phone/PDA. Unlocking keypad, answering incoming calls, opening applications, taking pictures.. everything needs patience.
- Battery life too short (especially if using wi-fi, Bluetooth, GPS and phone)
- Could not activate any handwriting input method.
- Accessing the wi-fi at the university required authentication every time
- Not obvious way of batch deleting contacts or resetting the device (weird combination of 3 keys plus stylus press)
- After each major shut down (take battery off) I got an incomprehensible message (gps coordinates or something).
- Uncomfortably large physical size.

**4) What other tools did you use in the process of completing the task? If the PDA could have been used for the same purpose, why did you choose to use an alternative?**

A portable camcorder was used for filming, dazzle to import the clip on a PC and editing tool for creating the final clip. I guess in the end of the day the PDAs played a very minor role in the study. Outside of the photographs I took for the storyboard (which I probably wouldn't have used my own camera for) they didn’t provide me with any particular use. I am curious to see what kind of video a group without access to a digital camcorder would make. That is, would they use the software provide in the PDA to make an actual film, or would they make a photo-montage video simply because it’s easier?

**5) What was your opinion of the support provided in the meeting room? What additional / different tools or setup would you have liked to have?**

The support in the meeting room was quite good, although a more automatic linkage between the PDA and main computer would have been nice. It would also have been useful to have several input devices, so we could each make changes from our seats.

**6) Do you have any further comments about the study or the tools provided to complete it?**

I believe in the end of the day the PDAs played a very minor role in the study. Outside of the photographs I took for the storyboard (which I probably wouldn't have used my own camera for) they didn't provide me with any particular use. I am curious to see what kind of video a group without access to a digital camcorder would make. That is, would they use the software provide in the PDA to make an actual film, or would they make a photo-montage video simply because it’s easier?
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<tr>
<th>Participant</th>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>1) During the study, how much time did you spend carrying the PDA with you? Please detail when you did or did not have it close to you.</td>
<td>I carried the PDA with me during the days the group decided to arrange a meeting. As on occasions I used the PDA for an hour’s time once a week to try further exploring its functionalities and limitations.</td>
</tr>
<tr>
<td></td>
<td>2) What did you use the PDA for during the study?</td>
<td>I used the PDA mainly for taking pictures and video filming.</td>
</tr>
<tr>
<td></td>
<td>3) What problems did you find when using the PDA?</td>
<td>The lack of usability, functionality and size was an issue when using the PDA. I did not enjoy the overall experience of working with the provided PDA.</td>
</tr>
<tr>
<td></td>
<td>4) What other tools did you use in the process of completing the task? If the PDA could have been used for the same purpose, why did you choose to use an alternative?</td>
<td>Video-editing software that was provided on the computers. Fabio and Matt worked with it.</td>
</tr>
<tr>
<td></td>
<td>5) What was your opinion of the support provided in the meeting room? What additional / different tools or setup would you have liked to have?</td>
<td>I would have preferred alternative equipment that is more up-to-date and relevant to the purpose of the project. Video-cameras and industry-standard editing software would have been more beneficial and efficient.</td>
</tr>
<tr>
<td></td>
<td>6) Do you have any further comments about the study or the tools provided to complete it?</td>
<td>I think we only used chairs, a table, pen and paper. No need for anything else for the meetings.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant</th>
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<th>Response</th>
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</thead>
<tbody>
<tr>
<td>G</td>
<td>1) During the study, how much time did you spend carrying the PDA with you? Please detail when you did or did not have it close to you.</td>
<td>I used email to communicate with the members of the group. We didn’t find necessary to use the PDA. I didn’t even use my own mobile phone to complete the task. So, I didn’t find a need for the PDA.</td>
</tr>
<tr>
<td></td>
<td>2) What did you use the PDA for during the study?</td>
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<tbody>
<tr>
<td>H</td>
<td>1) During the study, how much time did you spend carrying the PDA with you? Please detail when you did or did not have it close to you.</td>
<td>I tended to keep the PDA in my rucksack. This meant that it was in close proximity to me at most times, be that at uni, home or at work. However, this meant that the PDA was only accessible to me if I was at (or going to/from) somewhere where I would normally expect to work.</td>
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<td></td>
<td>2) What did you use the PDA for during the study?</td>
<td>Difficult to navigate. Laborious for data-entry. Confusing GUI (layers and icons). Slow to take photographs. Poor quality image (film and photo). Display was too small to be useful for writing or accessing the internet. Could not fathom how to use it as a telephone.</td>
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<tr>
<td></td>
<td>3) What problems did you find when using the PDA?</td>
<td>Desktop computer – easier to input, edit and display information/write emails. Pen and paper – easier to input, edit and display information.</td>
</tr>
<tr>
<td></td>
<td>4) What other tools did you use in the process of completing the task? If the PDA could have been used for the same purpose, why did you choose to use an alternative</td>
<td>Tea/coffee and biscuits would have been nice!</td>
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<td></td>
<td>5) What was your opinion of the support provided in the meeting room? What additional / different tools or setup would you have liked to have?</td>
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</tr>
<tr>
<td></td>
<td>6) Do you have any further comments about the study or the tools provided to complete it?</td>
<td>There seemed little incentive to produce our ‘best effort’, given the task that we had – to fully realise our vision would have required a greater investment of resources (time and money) than we were willing to expend. The PDA’s served no purpose whatsoever – there was no incentive to learn how to use them given the short span of the project and the fact that other tools (computer/telephone/pen and paper) were more familiar and easier to integrate into our working practice.</td>
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6.5: Design & Evaluation Studies

6.5.1: Music Builder

6.5.1.1: Post-Session Questionnaire for Participants

Please answer the following questions on a five-point scale from 1 (strongly disagree) to 5 (strongly agree)

1) It was easy to use the environment to play music
   1  2  3  4  5
   (strongly (disagree) (neutral) (agree) (strongly agree) disagree)

2) It was easy to use the environment to compose a piece of music
   1  2  3  4  5
   (strongly (disagree) (neutral) (agree) (strongly agree) disagree)

3) Over the course of the session, I feel that my ability to play the instruments improved
   1  2  3  4  5
   (strongly (disagree) (neutral) (agree) (strongly agree) disagree)

4) It was easy to communicate ideas to the other person
   1  2  3  4  5
   (strongly (disagree) (neutral) (agree) (strongly agree) disagree)

5) We understood what each other was doing throughout the task
   1  2  3  4  5
   (strongly (disagree) (neutral) (agree) (strongly agree) disagree)

6) We made decisions together
   1  2  3  4  5
   (strongly (disagree) (neutral) (agree) (strongly agree) disagree)

Please describe how you completed the task

Did you find using the environment frustrating at any points? What was happening at these times?

Do you have any other comments?
6.5.1.2: System Logs from Evaluation Sessions

G3 C1 P2 log activity

G3 C2 P1: Activity Log

G3 C2 P2 Activity Log
6.5.1.3: Transcripts of Evaluations Sessions

6.5.1.3.1: Pair 1, Session 3

B: Umm, I suppose we should try doing something a little bit more exciting this time
A: OK
A and B both go to load instrument dialogue
A: Load something to start, or we could build an instrument this time I suppose
B: Yeah Ok lets do that
A: Lets build our own instrument.
A loads previously built instrument
A: Ahh I've still got this glockenspiel here from before
A plays glockenspiel
A: Thats not bad is it?
B: Thats good yeah
A: Bit of glockenspiel
B: See what I can do as well. Kind of like something like a... a harp or something, that could just go along the screen like that and then. You could just go...
A: Right yeah yeah
B: Is there anything like that...Orchestral Harp. (loads instrument patch and tests)
A: Huh
B: So umm, you would want it on hit wouldn't you, other wise you'll have to press it.
A: So... hit (sets option) Then add one (adds interaction shape then sound source)
A: ahh there we go (goes to play space and tests)

A: Ah right so that works, so I need to be able to well have four or five of these?
B: Yeah
A: So if... obviously thats 'C' (back to build space)
B: Well you should be able to get a whole load of them at once
A: Yeah
B: Well, you know more about this than I do
A: Create another one, what happens if you change pitch, then um... try... yeah
B: Isn't that if you hit it there?
A: OK, try vertical hit position maybe, see what that does (B adds further interactions shape)
B: Play that. (goes to play space)
A: Ahh and its press this time.
B: How do you edit it?
A: select it, change it to hit
B: Ahh
A: There you go thats it (adds further interaction shape)
B tests new instrument
B: Yeah my aim was to build a number of them but its probably easier just to have it on this one isn't it
A: Yeah
B goes back to build space
B: How do you delete it? is it just
A: Yeah, you could have a whole row of them
B: 'Change pitch'
A: Oh yeah, this one could go from 13 or something (refers to starting pitch of instrument)
B: Yep
A: That's it
B: Up to... OK
(B edits his instrument further)
B plays new instrument
A: Lovely
B: Yes, great
A: We're in business! (A returns to testing his instrument)
B: So what are you going to do then?
A: Uhh dunno (plays glockenspiel modification)
B: Is it possible to stretch this out, so its more spacious? (to evaluator)
Evaluator: Yes, you go to build, select it, and then you have two green tabs there (to resize it)
A: Oh right simple (stretches it) yey.
B: Ah yes I like that (B stretches out his interaction shapes too)
Both play their instruments
A: So... (continues to play, plays 'twinkle twinkle little star' style phrase)
B: Why don't you play that, and I'll just mess around over it?
A: OK, let me try and work it out
B: (continues to play) OK, ahh (gets note wrong, repeats phrase)
A: Ok so lets play that
B: just the two recordings together (points at recording interface)
A: Yeah thats it
B: ready?
A: yeah
B starts dual recording, both play and record
B: OK, so we'll listen to that (adds to compose space,) Thats yours
A: Yep
B: Its that one isn't it, with the plus
A: Yep
B: links recordings and plays.
B: OK, and then...
A: Thats it, just play (Plays composition)

6.5.1.3.2: Pair 6, Session 3
K Plays some drums
L: Are you going to make the track first then?
K: Umm, its only just occured to me, can you have one circle and one square triggering multiple sounds?
E: Yes
K: So if I just attach it up to different drum kits...
E: Yes that should work
K: Aha, might have a breakthrough L!
K: Of course, that makes it so much easier
Both K and L build instruments using the drum template, switching between build and play spaces to test sounds
L: laughs
L loads Theramin template and modifies
L: New Instrument
L loads drum template again and plays, K continues to build drum kit
K loads modified theramin from previous session
Both laugh at the sounds made by K
L: Thats interesting, well we could have a nice intro anyway
L plays, K continues to develop new drum kit.
K: Sorry, could you turn it down! I can't hear myself here
L: Thats a new one, the drummer can't hear himself!
L plays
L loads modified Piano template from previous session and plays it
K plays new drum instrument
K: Ahh, see now I know how you do it! Now it all makes sense! right...
L loads new instrument, begins to play phrase K returns to editing drums
K continues playing, L plays the recording he made
L: laughs, "We can't stay in time"
K: "you'd better do the drum beat first then"
L: Yeah
L makes gestures indicating he is thinking about timing, then both start playing.
K: Okay we can record it synch
L: Yeah as long as its quite slow
K: Shall we try that?
L: Yeah I'll do a count in as well
K: Are you gonna press the synch record thingy?
L: OK
Both press record
L: Haha, ah see we were both so in sync we pressed it at the same time.
K: Shall I press record... I dont mind who does it actually you can go first
K: Shall I do it?
L: Well no should we record it one at a time like we did last time?
L: Oh I'll just record
K: Shall I press record
L records drum phrase
K: "It no it lagged, hmm I suppose I could just play a bit, cut it and double it up."
L records a further drum phrase
K: Whoops I went wrong
L records again
K: Theres a big lag in it, its alright up to this point then it goes wrong
L and K move to compose space
K: Going to do the cutting thing
L: Haha
L plays his drum loops, cutting off a small part
K: Yeah
L: Umm, can we just get the bit... yeah there you go, you've done it
K: laughs
L: You just chop off the first four count in thing
K: plays the combined modified phrase
L: So cut that one back a bit, no not that one, are you cutting the right one? I would have thought it was the one on the left
K: I was going to do the one on the right
K modifies a phrase and plays it
L: Well try playing that
K modifies a phrase and plays it
L: Well, OK, you need to chop off a bit from the one on the right, the first bit
K: Yeah
K cuts more then plays the modified phrase
L: Yeah what'll I do, you can make that as long as you want
K: Alright yeah I'll try... copies and adds new copies of drum phrase
K: I'll do one more bar then compose something over it
K: In that case you can compose something, I'll make more drums and end it in a fill
K returns to play space, L to build space
L records phrase
K: thats almost there
L: Yeah
L modifies instrument, K composes using drum and piano phrases
L tests instrument then returns to modify it
K: Yeah
L: What?
K: We've got another little beat in it somewhere
L: I've been editing my stuff, building
K records over the drum phrases
L continues building drums, K loads new instruments and tests them
K records using new instrument
L plays new drum kit, K plays new instrument
L: Quality! Like a slap bass
K records using new instrument
L: Are you still recording?
K: Yeah
K plays new recording in context
L: What is that? Telephone ring?
L: Are they press ones or hit ones?
K: Hit, I don't think the scale is long enough for this though edits instrument.
L tests new drums, K moves to compose space
K: Your doing the best to fill up the space with recordings!
L: Ha yeah
K and L play composition and listen to it, laugh
L: How do I join two bits... reads tutorial
K records phrase with composition playing
Both use compose space
K: I've got no idea what state yours is in...
L records another drum fill
L: laughs, theirs our ending fill
K plays the modified composition, drum fill occurs too early, both laugh
L: Its not supposed to be there
K modifies composition and plays it again both laugh as ending is still wrong
L: Well you can cut... Cut two snare notes off the front, but it doesn't matter
K: Yeah its trial and error but... modifies and plays it again
No it doesn't fit!
K: I reckon just a little bit there and it will work modifies and plays again
K: It's not bad, just needs one more bit off there modifies and plays again
L: I could record something else instead of 31
K: No thats fine, yeah thats it
K: I guess we'll just listen to our masterpiece again! plays final compositions

6.5.1.4: Tabulated Response Data for Questions 1 - 5

<table>
<thead>
<tr>
<th>Q1</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
<th>Q4</th>
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6.5.2: Associative Scrapbook

6.5.2.1: Transcripts of Coded Sessions

6.5.2.1.1: Case Study C, Session 3

Adds new page and note
Umm yeah right let me think.
Adds image file, writes a note about it
And these are links? Yeah links two items together
Ahh, what is this doing
E: That creates a sub part of the image
Will it resample the original image?
E: No.
Thats pretty cool though, its quite handy to be able to link these together
What happens when you add a web page? Its just a link isn't it?
E: Yeah
Drags in web page link
I like that being able to cut bits out of images, but its a shame it doesn't resample the original image. Because then you could have it zoomed out, but then it would be good to cut bits out and then have them all linked to the original
adds further notes
Ahh I see that will open the actual file, so if I do that with an image does it open the image?
E: Yeah
Opens image file
Did I put that in the library? I must have double clicked on it...
Adds more notes about image
So that will set the search names for there Web association Panel
Switches to Overview
So I can drag stuff straight on to here...
Switches back to pages
adds more notes
Draws on to page using graphic tablet
I really cant draw, thats the problem, but its pretty cool
If you start drawing on here, you can use it for sketching down anything. You should try out adding the pressure
sensitive stuff. But I guess this is all you need for the basic stuff. It doesn’t identify the eraser on the tablet pen
though.
I used this the tablet to sculp these hills, but I'm only just getting in to it
I suppose you could put arrows in to things scraps
E: Yeah that would be nice, but it gets complicated with the interface functions like dragging.
Maybe if you could just draw within something?
You could just draw within here, because then you could sketch in stuff you wanted to do
E: Thats a good idea, it could just recognise you were sketching with a function
Yeah that would be really cool
The search words could be improved too, Im not sure, how do you know which ones to pick I guess its a bit random
E: It just counts them, takes out some simple words like 'or' then there is an element of randomness, but I think if it
was made more transparent how it works
Yeah, if you could get it giving more relevent stuff, its good just having it there to look at though I suppose
Cant think of much more to do right now.

6.5.2.1.2: Case Study D, Session 3

"Im revisiting what I did before..."
Looking at scraps on screen
* Oh you can link things! *
"Hmm no I dont want that anymore mine is much better" (A diagram taken from the web) ... thats my study plan OK"
"Hmm I just thought of an example, I'll just look at my notes in Evernote and search for it"
(Goes to Evernote window)
"Yeah that was it, 'typing a word, writing a novel or hitting a key on the keyboard'.
(Copies note in to Scrapbook)
"Thats a thought I had at work, but now I'll put it in here, I captured it at work, but I didnt have this scrapbook with me
at the time"
"What else have I got in here, I've got my study plan, which has actually progressed. I've got a word document."
"I'll get some files off the desktop."
(Goes to finder)
"I've got some pilot study files, here are my interviews, I'm dragging and dropping them in, I have my interviews, study
design, and template, "and then I'll put my presentation on another page "
adds new page and titles it
"I'll drag and drop that one there, and I have some stuff on this, that I have on my Evernote page I'll look for
presentation,"
(Goes to Evernote window)
"but I don't think I can drop those on, No. But I can put them on as notes, because thats what they are"
(copies and pastes text in to new note objects)
"So I'm copying this in to my notes, because its not a file type I would recognise"
"A picture of social activity..." (copies and pastes again)
"I'm just putting in notes of examples I want to use" (for a presentation)
"I've been trying to think of examples for people who don't know about Activity Theory, and those are the kind of thing that just comes in to your head when your just sat at your desk. I have notes, I'm always thinking of examples while I'm working, but I don't have time to write them down properly, so I just have little notes"
"And here I can bring all my examples together and I could organise them. So what does the linking do?"
E: "It links things together"
"So I can connect them and then move them around and..."
(looks at Association Panel)
"I keep getting the technorati logo, OOH social interaction Vygotsky"
(Clicks on Web Association Panel link and reads web page)
"But now I've gone off on a tangent, I'm just it scanning to see if there's any nice examples."
"Anyway that can go now" (Dismisses Web Page).
"Actually I want to group these" (Creates Group of example scraps)"I'm going to give it the title 'examples'"
"What I have been gathering, is lots of definitions, I've been writing them down as definitions of things to do with Activity Theory. I was thinking I could put them up" (in to the scrapbook) "I can't drag them in though I guess" (From Evernote)
E: "You could cut and paste them"
"So if I copy and paste this..." (Selects and Copies from Evernote)
"Ohh there we go, this is my definition of actions and goals, but I've put it on the wrong page" (deletes it and adds to new page, adding title 'Definitions')
"How do I change the names of a note"
E: "It's just the first line of the note"
"OK, 'operations', functions" (adds titles)
"Because I find it useful to have the definitions to hand, keeping them relatively brief, but something I can go to if I want to."
"Object..." (Copies and pastes another definition)
"And this will be cool because once I've got all of these, I can organise them logically ."
"Also if I put the names in it (the web association panel) will come up with things based on the words, which would be cool"
"Ohh, look, something from Wikipedia"
"Contradictions.." (Adds another definition)
"I suppose in a way it would be good if it linked to the actual file, because then it would update. I'll probably update these definitions from here,"
E: "So you want the file then a link to the note?"
"Ideally it would be a link, so it would show me the text, so I would be able to see this" (points at note)
"but it would be updated, although I could just type it in to here, that would be the ideal thing I suppose"
E: "Yes, it could link to another file and update it if you had used a text file rather than evernote"
"Ideally it would be dynamic, this is where I organise and link things, but because it might be quite a long document, and I might want to edit it elsewhere, but then it still appear here."
"So 1,2,3,4,5,6,7..." (Counts number of definitions)
(Goes back to Evernote)
"*1,2,3,4,5,6,7 missed one, oh yeah mediation*
"So now I have all my things, so I want to say that 'functional organs' are kind of a seperate thing," (_moves item on page) "'contradictions' 'internalisation' 'externalisation' are kind of different" (Moves items on page)
"The main thing you have ... where is motive?" (copies and pastes in motive text)
"And then you have an activity, that has a motive..." (moving items on page)
"um, you can just draw on the screen randomly right?"
E: "Yes thats right, press the pen button but at the top"
"So you have an object...kind of link this" (moving the items in to a hierarchy)
"Then you have operations, and actions and goals, cos its hierarchical" (continues moving)
"Its kind of cool because you can think of them as objects that you can link together as ideas,(the scraps), but they also have the definitions in them"
"See cos I've got quite a visual memory and I visualise activity theory a lot based on the diagrams that I see where they draw it out. So if I can have my definitions in a drawing it would work for me I'd imagine."
(Starts drawing lines between objects)
"You act on an object to achieve a motive, oh this is the same level as that"
"Activities, actions and goals, and operations"
(Draws another line)
"I'm so bad at drawing, I could just link them but I'm drawing arrows"
E: "So why did you draw rather than using links?"
"Its a directional link, well maybe not even that"
"So thats these, then theres all these other things and I'm not sure how they link in" (selects items gathered on the right of page)
"Hmm it doesn't seem to have copied all of this across, its only copied a little bit, its actually a really long document" E: "If you try expanding the note it should be there"
"Oh yeah it is"
(Scrolls through web association panel)
"Umm, anyway"
"Now I've organised my definitions, the idea was - I don't have any pictures - but the idea was I would be able to take photos of stuff, and put that in here as well"
"So I have this photo of a book, I'll see if I can copy it in"
E: "If you have the file, you can import it"
(Starts new page)
"This is going to be about a new tool at work"
(Finds image files in finder)
“So if I do this, No idea which file this is...”

(Imports the file)

“Oh it did” (get added to page)

“So the only problem is I need to know the name of the scrap (file), but I can just open them and see”

E: “So is the underlying file structure of Evernote visible?”

“Yeah I guess so”

“It’s not ideal, but I can go and say I know this file was made today at 16:10, so I can find it and add it that way.

<END OF SESSION>

6.5.2.2: Online Questionnaire for Users

Please fill in this questionnaire to help us understand how you used the Associative Scrapbook, and how it could be improved.

Give as much detail as you can, but don’t feel like you have to answer all the questions if you can’t think of anything to say. If you have any queries or additional comments please email us at tc225@bath.ac.uk

Please describe your occupation and any creative hobbies:

1) Describe what you have used the Associative Scrapbook software for, and how you did this:

2) Do you have any other tools that provide similar support? If so list them, and describe how the Associative Scrapbook differs.

Please include any features that you feel are missing from the software that the other tools provide, and any features that make the software better than the other tools.

3) What relationships are there between the materials you use in your work, how are they organised, connected? How are any notes, sketches etc you created connected with media?

4) Did the software provide effective methods to represent the relationships between these materials? If so, describe how you have / would use the software to do this. If not, how could the software be improved to support this?

5) Can you think of any other materials - in any form - that you wanted in the scrapbook but could not easily import? What were they? How do you currently keep them?

6) What did you think about the web association panel (showing related items from the web on the right of the screen)?

7) Did you import anything from it to your library/ pages? If so, what?

8) Did you leave the web association panel to find materials automatically, or did you control what it searched for? If you controlled it, describe how.

9) How would you improve this feature?

10) Have you used the email function to communicate using scraps or pages? If so, describe how and what you sent.

11) How would you improve this feature?

12) Do you feel that you will continue to use the software? If no, what improvements would convince you to do so?

Do you have any other comments about the software?

6.5.2.3: Responses

Response 1:

Occupation: Hobbies: composition of music

Question1: working out concepts, collecting ideas

Question2: -

Question3: -

Question4: If the program used the LilyPond compiler to display musical material, it would be really great. There is a plugin for OpenOffice which does exactly this.

Question5: *.ly (Lilypondfiles)

see (4)

Question6: It slows performance and internet connection down. No Need for that, as the material does not really shows what I need. (But maybe that’s because of my special wishes ;))

Question7: -

Question8: It’s easier to me to search things manually.

Question9: -
Question10: -

Question11: -

Question12: I won't use it very much, but maybe from time to time.

I use such programs to plan my work and collect ideas. That means other programs are open and scrapbook should be in background but for all that easy to reach and ready to write things in it or to have a look on the ideas /copy them.

To reach this I thought about:

- something like a sidepanel
- integration with Quicksilver (MAC related)
- Scrapbook as jEdit-Plugin, as jEdit uses the Java Environment and has a highly developed plugin integration

The latter point would be really cool - think about that!

Response 2:

Occupation/Hobbies: I am a software engineer working in the computer games industry. I also like using computers for general browsing, socialising and news.

Question1: I was creating a scrapbook of ideas for use in creating a new game project I'm planning to work on at home.

I was using the Scrapbook to first collect together some of the links I've collected in Firefox and then working on arranging these and fleshing out the scrapbook with various images and notes, arranging them in various groups and associations.

Question2: I have previously used Mindjet's MindManager (http://www.mindjet.com/?google_uk=mindjet&gclid=CMyEzrXG95gCFUU_3godBldsmw) which is really good for creating associative mindmaps including vector graphics and various clippings.

I never seem to find myself sitting at one computer for very long however and it's useful to be able to have everything to hand just by using a browser and web connection without having to install a multitude of apps on a computer that I might only be using for 20 minutes.

Foxmarks is the best thing that I've ever installed as it's really simple place just to dump and organise links to all those little snippets of web-pages I find but then allows them to be synchronised between any computer I ever use.

The most useful tools are those with collaboration built in.

Facebook's Group functions allow me to jot down ideas in a bit more depth, collect links to web-pages (with an associated image and notes) and communicate with other people if I want. That would be the tool most like Scrapbook that I use.

Google Maps allows me to create useful maps of key locations and share them with family and friends which is great for meeting up with people in strange locations or getting an idea of somewhere new. I'm moving to London for the first time shortly and throwing tube stations and buildings down onto a single map is brilliant for getting my bearings.

I'm awful at remembering anything more than 3 days in advance so MS's Live Calendar is brilliant and I can share events with anyone with a Live Passport.

I've found MS's Live Mesh even better than Google Docs for keeping my documents together. Even at home I'm working between 3 machines and then a 4th for printing and they're never the same computers for long. So remembering which one has the most recent copy on and ensuring I don't lose my flashpen and everything is backed up is a nightmare. I don't really like the way Google docs formats things and Live Mesh allows me to work directly on my main machine using whatever applications I want, synchronises those files between whatever machines I want it to and then allows me to log on to the web interface when I'm working on someone else's computer (friend's, Internet cafe, work) for quick reference, e-mailing out or printing.

Question3: Most of the materials I collect are based around a single theme. They will either be scraps from the web or notes I make relating to those things or anything I might think about. The use to be able to create sketches alongside those thoughts is a great idea as well and I look forward to seeing a more advanced sketching tool.

The work I do is generally based around computer games so it's a highly visual medium with lots of reference artwork or videos of various locations, events or other products.

Underneath games are quite academic as well so lots of research papers, programming constructs and mathematical formulas are involved as well.

Question4: Representing things in clumps on a single page is probably the most useful organisational tool there is but the thick pains of the scraps does limit the amount of space on the page. Having the option to hide the borders and have a depth order would encourage me to layer the scraps a bit more with maybe some background images with sketches over them (comedy moustaches of course!) and notes written on top.

Having the ability to create a set of associations between disparate scraps would be nice as well. Scrap a) could be
associated with scraps b) and c) so clicking on a scrap could bring up some thumbnails of other scraps on the page or another page.

Question5: Having webpage previews or thumbnails would be extremely useful. Even just a single image or opening paragraph (ala Facebook Links) would be handy.

In regards to mathematical formula and program structure a blackboard/whiteboard tool that is less structured than a text editor but less messy than a drawing app would be extremely useful.

Something that can be used at the beginning of development for jotting ideas that aren't part of formal software development methodologies which are already catered for by the likes of UML modellers and flowchart packages.

Having the ability to extend the Scrapbook by adding in any tools that were necessary through plug-ins would be a great advantage though.

I can imagine people having uses for scraps for things as diverse as musical score editors, basic image manipulators, embedded pdf files, web-pages and videos.

Identifying and developing all those scrap controls in one place would be difficult but opening it up to plug-in developers like Eclipse, Photoshop or 3DS Max would greatly increase its potential.

Question6_: I thought it was a great idea although some of the choices it came up with seemed a little random. Based on the words ‘intro’ and ‘Hmmm’ I got links as diverse as the Simpsons and (disturbingly) a webcam sex line! Maybe some kind of safe-search option would be useful.

Question7: Not yet but I don't think my Scrapbook has enough text in it yet to be useful.

Question8: The web association panel was mostly on automatic search but when I did try and use it with a couple of web links the slashes and dots were removed leaving me with a single garbled 'eclispeorgdougcdt' search string which didn't really do much use

Question9: 

Question10: 

Question12: I'll keep using it for a while I think. Just the ability to throw things into a single space is very useful and as the tools become more refined I can see it being very handy indeed.

The main drawback to me using it long-term would be my computer drifter usage and the ability to collaborate across multiple machines with multiple users.

I can imagine using it as an organiser for my work and therefore a portal to other applications on my computer. As such a ToDo scrap would be very useful.

Response 3: 

OccupationHobbies: I am an EngD student. I don't have many creative hobbies but I like to do art sometimes for fun (even though I am not good at it)

Question1: I was trying to design some artwork for my room by chopping and rearranging sections from a photograph that I took.

I copied and pasted a section of a photo from Preview and then used the special cropping/copying thing in the scrapbook (sub scraps). I then moved these around the page and re cropped them until I was happy with the composition.

Question2: I can crop using iPhoto but this crops the picture into one single smaller picture. By using the scrapbook I was able to make a number of sub scraps from the same picture. This was a useful feature that I have not found in any of my other software tools (although I don't have many).

Question3: 

Question4: 

Question5: I had a mindmap (in another session) that I wanted to import as a picture. But it showed up as a link instead. It would have been useful to see the mindmap. Although I understand that this would be difficult as it is a non-compatible bit of software. I could open it from the file but in this way I couldn't combine my external mindmap with the things I was using in the scrapbook (i.e. I could link a website or bit of media to an idea in my initial mind map)

Question6_: I didn't use this for my artistic work as it was not relevant.

For mindmapping it would be useful however some academic sources would be useful.
Question 8: I added additional search terms by typing into the search box.

Question 9: I would have more sources of information in the search (i.e. academic stuff etc.)

Question 10: Nope

Question 12: I might do. However as most of my work is research based I might not make full use of the features (i.e. images etc.). I would most likely use the software for mindmapping or similar activities as the one stated above.

If there were better cropping/picture editing facilities it would be useful for planning out art work as mentioned above.

If there were more academic links and more advanced mind mapping features I would probably use it to plan papers and organise my ideas.

Response 4:
OccupationHobbies: I am a PhD student - computer science in the University of Bath.

My main hobbie is filmmaking. I work on both production (shooting, directing) and post-production (video editing, audio editing, special effects such as colour correcting).

Question 1: I have used Associate Scrapbook to:

a. Plan out the audio editing for my film. I use a main scrap (note) to list all the audio errors that need fixing by mentioning time and problem, and then I use several smaller notes to describe the specific problems. I create links between the main scrap and the sub-scraps and remove them when the problem is fixed. I can then see all the problems that need fixing by clicking on the "see all associated scraps" button of the main note.

b. design a web page for promoting my films. I used sketch scraps to represent the individual pages and drew a general design. I used the notes function at the bottom to describe what the page is, plus other information, such as what I should or should not use. I used the links to represent the hierarchy and connectivity of the pages.

Question 2: I do not have any other tools

Question 3: The software provides one method for connecting between scraps as far as I know which is the link function. This is fine for most applications I use. However, it might be useful to have different types of connections to help distinguish. For example, I might want a different type of connection to show that a certain video is connected to a certain audio clip, than I would to show that two video clips are in succession.

Question 5: Most of the material I used on this occasion were either abstract or easily imported.

Question 6: I did not use it for this task.

Question 7: Some audio clips - as this is what I was working on/fixing.

Question 8: Did not use.

Question 9: Not on this function.

Question 12: Perhaps some changes to the design layout and some extra options for representing data and connecting them.

Response 5:
OccupationHobbies: I am a drummer for a band. We write original material so I have to make drum parts to fit the song.

Question 1: Creating drum parts for songs. These were recorded by tab notation.

Question 2: I have used finale which lets you write out proper music and play the sounds. But it is specialist software for notation and doesn't search for sources or display scraps.

Question 3: I use audio material for generating ideas. These come from CDs I own or watching clips on youtube or from music books. Generally media clips or music in books are organised in terms of types or styles. CDs will be a particular band. Notation is useful for showing the 'how to play it' while audio clips give you 'how it should sound' and the overall sound of playing like that with other instruments.
The notes I created were parts to fit the our songs. So I might have used a pattern from media and orchestrated it in a new way. Or liked a sound of a song and used it to choose what I should hit to produce a similar feel.

Question4: For my use it would need to have very specific functionality such as listening to specific sections of files and hearing the parts I create.

Question5:

Question6: Might be useful to be able to reduce the sources that produces the hits. I tend to only use a small number of sites so a lot of the material wasn't relevant.

Question7:

Question8:

Question9: See Q6.

Question10: No

Question11:

Question12: It would need very specific functionality for me to continue.

Response 6:

OccupationHobbies:

Question1: I used it to try and plan a study and organise my research thoughts

Question2: Freemind

Papers

Word

Question3:

Question4: I didn't really organise them today. I might in the future. Today I just organised them by positioning them on the page.

Question5: I would like to be able to access academic papers

Question6: It would be useful if it included academic resources

Question7: A picture of somebody elses study and also a wikipedia page

Question8: I tried to control it as the topics it searched for were not quite what I wanted. I kind of knew what I wanted to look for. Although it was useful when it analysed my word document to find common words (as I wouldn't be able to do this myself very easily)

Question9:

Question10:

Question11:

Question12:

Response 7:

Thanks for the reply, Tim.

I'll work with scrapbook this afternoon or evening and let you know. I'm getting the impression that scrapbook for the computer is like the kitchen table to a stay at home mom. Throughout the day, there is laundry, mail & school papers, toys to go downstairs, lost earring waiting for the other, and anything else that needs a place while getting to the next spot. Am I on the right track?

When I think of a scrapbook, I think of a document and image storage system- a book, binder, box, etc. to store items from our past to preserve them for the future. A scrapbook being a finished product full of mementos. But your scrapbook is about current projects, right? -a place to drop things while putting something bigger together??

If this is too tedious for you, please let me know. I'll certainly not bother you.

One last thought, how is scrapbook like a wiki? Is it?

Fondly,

****

PS

I hope it doesn't offend you to compare/contrast to other programs. It is simply a way for me to understand or grasp...
existing ideas.

For example, when asked how is one car like the other, I'd benefit from the salesperson explaining that the cars are similar in appearance, but one engine is more fuel efficient than the other. Also, while the cars may look similar, one car is able to travel at higher speeds, turn corners faster, etc.

I'm not sure what you call this type of thinking or learning, but I wish I'd find it more often. It puts difficult to understand material in an easy to learn language. At least for me, and all the third graders!

On Mar 25, 2009, at 5:47 AM, Tim Coughlan wrote:

Hi *****,

Thanks for your message, its great for me to have discussions like this as part of my research.

The scrapbook aims to provide something more suited to the way creative people work than many of the standard tools available, based on studies we've done with people from various creative disciplines over the past few years. At the moment I am studying a film maker who has been using the tool to write a script and make notes with filming and editing etc. Another example is system has been used by someone developing ideas for a set of paintings. She collected images then put them on pages to compare them. She also cut up parts of them to see how sections of them could look positioned in various ways.

I know there are a lot of tools out there and I'm interested to know what you think of any you have tried. To give you an idea of where the scrapbook fits it is somewhere between a brainstorming tool, a notepad, sketchpad and a place to organise images and files. Whilst there are a lot of tools for creative activities being produced, it isn't very clear to anyone which ones are useful and what for. Understanding this is the topic of my research.

If you have any questions about how to do things using the scrapbook tool I'm always here to help so please try it out and email me. Part of the reason for building and releasing a tool like this is to create a dialogue with people like you, to understand what kind of tools could help you and how to improve them.

Best Wishes,

Tim.

On 25 Mar 2009, at 03:22, ***** wrote:

Hi Tim,

With all the available programs, apps, add-ons, widgets, and more (you get what I'm saying, right?) can you tell me how scrapbook is similar and/or different? I've read the website, but I was hoping for some examples of what users have done with it.

Why did you develop it? I'm asking because I'm curious if it was born out necessity. I'm a stay at home mom, sometimes teacher, volunteer art instructor and much, much more. But I am NOT a computer expert! I'm learning as much and as fast as I can...I have to admit I love all the new creative resources available on the net.

Any help would be appreciated.

Fondly,

*****
Part 7: References


Coughlan T., (2004) Designing software for creativity support and idea representation: informing the design of software to support musical composition through theory and empirical research, MSc Thesis, Department of Computer Science, University of Bath.


