Designing Effective Animated Icons for Children

A Thesis Submitted for the Degree of Doctor of Philosophy

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ABSTRACT

Information Technology is an essential part of the National Curriculum in the UK, yet despite the growth of IT in schools that this has generated, there is evidence that children are not to be taken into consideration enough when designing aspects of educational software. The functionality available in education software packages tends to be made available through static icons, yet there are problems with their implementation as they can at times cause confusion for the user in terms of the functionality that they are aiming to represent. In order to make icons in educational software more effective, and to meet the needs of children, of the use of animated icons has been suggested. Animating the function of the icon aims to provide a clarification of its meaning and demonstrate its capabilities, as well as explaining to the user the method of use. However, there is little information available on how to support the design of effective animated icons. Focusing on a target age group of 11 to 12 year olds, this thesis argues that some form of support mechanism should be developed for the design of animated icons to ensure that consideration is being given to the types of object that children find useful and accessible. A set of dimensions where guidance on visual aspects of the icon may be useful are developed through analysis of relevant literature and it is highlighted that they do not provide any insight into what types of object may be helpful in designing the animated icons. This thesis then argues that animated icon design can be usefully informed by psychological theories of learning and that using such theories as a base may provide an understanding of how children identify icon functionality. The thesis introduces and critiques Piaget's Genetic Epistemology theory, Vygotsky's Sociocultural theory and Leontjev's Activity Theory, identifying aspects of the theories which may be of relevance to the design of animated icons. By investigating the relationships between the dimensions of animated icons and the concepts from the theories of learning, insights are developed into the impact of visual factors on a child's identification and understanding of icon functionality. The thesis goes on to report a practical study where the sample is a group of 11 to 12 year old children. The practical study consists of three phases. The first phase gathers data related to the children's familiarity with computers and the types of software packages that they use. The second phase looks at their use and recognition of static icon functionality. The last phase involves using the findings from phases 1 and 2 to create and evaluate a set of animated icons, the development of which is based on the relationships between the concepts from theories of learning and the identified dimensions of animated icons. The analysis of the evidence from the practical study leads to a small set of design principles being proposed that are aimed to provide advice/guidance on how to design animated icons effectively for this target age group, with an emphasis on the types of object that might be used. The principles are underpinned by the concepts from the theories of learning and presented in a manner that aims to be understandable by, and accessible to, designers.

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Chapter One

Introduction

1.1 Introduction

Information Technology is an essential part of the National Curriculum in the UK (Zhang et al. 2010; Ching 2009; McKenney 2008; Chalmers 2003; Selwyn & Bollon 2000; Sharp et al. 2000; Uden & Dix 2000), yet despite the growth of IT in schools that this has generated, children still tend not to be taken into consideration as a user group when designing educational software (Donke & Reitsma 2007; Chen et al. 2004; Druin et al. 2001; Inkpen 2001). This is borne out by research which has suggested that educational software developed for children does not meet their requirements (Donke & Reitsma 2007; Druin 2002; 1996; Inkpen 2001; Hanna et al. 1997;1999) – which may, in turn, lead to unsuccessful software. However, there is a lack of information regarding developing suitable interfaces for children (Bilal & Bichar 2007; Chen et al. 2004; Druin et al. 2001). As a result, children are having to compromise, using interfaces that are not suitable for them (Komlodi et al. 2007; Chen et al. 2004). One important area of requirements for children is the visual appeal of the software: research suggests that children want images that make sense to them, and animation and video that offer them interesting characters (Chang et al. 2005; Druin et al. 2001; Underwood & Underwood 1998; Nanny 1990) and that providing interesting visualisations, with dynamic screen layouts, may aid the child in his/her use of the software and facilitate learning (Bilal & Bichar 2007; Chang et al. 2005; Chen et al. 2004; Lewalter 2003; Lowe 2003; Cairncross & Mannion 2001; Druin 1996; 1999).

By looking at the computers that are most commonly found in schools it can be observed that they are the same type of machines that are being used in the

workplace. They have not therefore been designed with the interactions of children in mind (Donke & Reitsma 2007; Chen et al. 2004; Inkpen 2001). It has been suggested that, at times, developers are taking design decisions based on incorrect common sense theories of users rather than observing users' actual behaviour (Komlodi et al. 2007; Poltrock & Grudin 1994). Indeed, research has suggested that developers think that a successful strategy in designing software for children is to add a new user interface with animation and primary colours on top of an existing product that had been designed for adults. However, for children aged between 7 and 12 years old there is evidence to suggest that this approach may not be appropriate as it can lead to children becoming easily bored or frustrated (Chen et al. 2004; Druin 1999).

The user interfaces that are developed need to be specific to the age group the product is aimed for (Druin 1999). It is important that, when user interfaces are being developed for children, developers remember that children are not small adults. Children must be recognised as a user group that have their own specific likes and dislikes (Komlodi et al. 2007; Druin 2002; Uden & Dix 2000; Brouwer-Janse 1997). Research carried out by Druin (2002; 1999; 1996) has focused upon the shortcomings of interface design for children and has provided several recommendations that aim to make user interfaces developed for children more user-friendly, allowing them to make effective use of the software's functions.

The functionality in educational software packages tends to be made available through static icons (Huang 2008; Uden & Dix 2000; Wiedenbeck 1999). They are pictographic symbols on an interface to represent objects (for example files and folders) in a computer system (Huang 2008; Passini et al. 2008; Gittins 1986), and actions that a user may carry out, such as printing or deleting a file (Wiedenbeck 1999). However, there are issues with the implementation of static icons as they can at times cause confusion for the user with respect to the functionality that they are aiming to represent (Passini et al. 2008; Baecker 2002; Benbasat & Todd 1993; Jones 1990; Gittins 1986) – a problem which could, at least partly, be due to the lack of design guidance available to guide icon design (Kim 2010; Bodner & MacKenzie 1997; Dormann 1994; Benbasat & Todd 1993; Gittins 1986). In order to make icons in educational software more effective, and to meet the needs of children, the concept of animated icons has been introduced. Animating the

function of the icon aims to provide a clarification of the icon's meaning and demonstrate its capabilities, as well as explaining to the user the method of use (Dalacosta et al. 2011; Uden & Dix 2000; Bodner & Mackenzie 1994; Tiritoglu & Juola 1993; Baecker et al. 1991).

It has been suggested that animated icons should be easier to recall and be more meaningful to the user than static icons (Dalacosta et al. 2009; Preece et al. 1994). As such, the implementation of animated icons may be useful for educational software packages designed specifically for children. However, there is little information available on how to design effective animated icons. This may lead to the designer including aspects within the animation that s/he perceives to be significant but which may not be seen as such by the user.

This thesis argues that there needs to be a focus on the functionality and the type of objects that may be useful in representing the function. Additionally, some type of support mechanism needs to be developed to ensure consideration is being given to the types of objects that children find useful and accessible. This will ensure that developers have an early focus on the children for whom they are developing. As part of this, designers need to understand the user's cognitive and behavioural characteristics (Poltrock & Grudin 1994) in order to apply objects that the user group can associate with specific icon functionality. By taking into consideration certain aspects of theories of learning, an useful understanding may be established into the child's cognitive development during their time at school (Cairncross & Mannion 2001; Schneider 1996). This should aid in the gaining a perspective on how children perceive and identify objects at the interface, which can in turn inform practical design guidance. The relevant theories of learning that may be influential will be discussed in more depth in Chapter Two.

This leads to the broad aim of this thesis, which is to investigate the recognition of animated icons designed for children between the ages of 11-12 years old when the icon design is underpinned with concepts from the theories of learning. One reason for focusing on this age group is that research has suggested that this is the age at which computers start to become a consistent part of the national curriculum (Zhang et al. 2010; Abbott 2001; Sharp et al. 2000; Solomon 1986).

The remainder of this chapter aims to provide background analysis of the problem area. Section 1.2 will provide a brief introduction to the development of animated icons. Section 1.3 will provide a brief overview of the importance of a designer understanding how children learn information. Section 1.4 will highlight existing research in the area and identifies core limitations with it. Section 1.5 will set out the aims of the thesis, while section 1.6 will present the objectives that are investigated in the subsequent chapters. Finally, section 1.7 will provide an overview of each of the subsequent chapters to provide a road-map for the thesis.

1.2 Animated Icons: An Introduction

Animating the function of an icon aims to provide clarification of the icon's meaning and demonstrate its capabilities, as well as explaining to the user the method of its use (Thomas & Calder 2005; Baecker et al. 1991). It has been suggested that animated icons should be easier to recall and be more meaningful to the user than static icons. Research suggests that interface users find animated icons to be more useful in conveying the purpose of the icon than static icons (Tversky et al. 2002; Uden & Dix 2000; Bodner & MacKenzie 1997; Bodner 1994; Tiritoglu & Juola 1993; Baecker et al. 1991; Jones 1990). The advantage of animated icons is that instead of making the user imagine what the function of the icon is, the animation does it for them, seeking to clearly display the function (Bilal & Bachir 2007; Preece et al. 1994). Animation can help the user in building a mental model of the function that the animated icon is representing (Uden & Dix 2000; Byrne et al. 1999), enabling a deeper understanding than a static representation would have created (Lewalter 2003).

Animation can also facilitate learning as the function of the icon is clearly displayed to the user, therefore, reducing the learning curve in both time and effort, in the long run facilitating user performance and reducing errors (Lewalter 2003; Tversky et al. 2002; Byrne et al. 1999; Bodner 1994). However, as discussed in section 1.1, it is important to understand the types of object that the user group is able to identify and associate with the icon functionality. Section 1.3 will discuss this further.

1.3 Understanding the Function of Animated Icons

To be able to design successful animated icons, an understanding needs to be developed into how children identify information at the interface. Research needs to be carried out into the types of object that children are able to associate with icon functionality. This will aid the designer in developing an understanding of the types of object with which children are familiar and that may be useful to apply in representing the function of the icon to the child. It is important to look consider this carefully as children are not like adults and, at different stages of cognitive development, are able to understand different things (Donke & Reitsma 2007; Druin 1999; Brouwer-Janse et al. 1997).

For this thesis, an understanding needs to be established into how learning takes place in computer environments. This thesis will argue that animated icon design can be usefully informed by psychological theories of learning. Using such theories as a base may provide an understanding of how children learn about animated icons and how they perceive and interact with them. The underlying concepts from relevant theories may help the designer to incorporate the key features that are needed to improve a child's recognition of an icon's function. In Chapter Two theories of learning will be discussed in more depth. However, it is useful to take into consideration at this point previous research that exists within this area to help use frame the direction of the thesis. As such, section 1.4 discusses relevant research and its limitations.

1.4 Existing Research and its Limitations

Existing research has emphasised the relative value of animated icon versus static icons with respect to icon recognition. For example, previous studies have provided positive feedback in relation to the effects of animated icons (Uden & Dix 2000; Bodner & MacKenzie 1997; Bodner 1994; Tiritoglu & Juola 1993; Baecker et al. 1991; Jones 1990) and studies have shown that users prefer animated icons at the interface rather than static icons, as they found them more useful (Baecker et al. 1991).

However, in previous studies little information has been provided on the design decisions related to the types of object that have been selected to represent the

function. With the lack of support mechanisms available to underpin the design of animated icons, designers may face difficulties in deciding on the objects that they will use to represent the function. Yet, this thesis argues that it is important that an understanding be developed into the types of object that may be most useful to represent specific icon functionality to children and that psychological theories of learning may aid in investigating how children in our target age group (11-12 years old) are able to understand and identify icon functionality. Currently, there is a lack of literature regarding the implications of designing icons that are underpinned with the concepts from the theories of learning and in Chapter Two the theories of learning will be discussed further. The relationships that relevant concepts from theories of learning have with animated icon design will be discussed in Chapter Three.

1.5 Aim of Research

This leads to the broad aim of this thesis, which is to investigate the recognition of animated icons designed for children between the ages of 11 and 12 years old when the icon design is underpinned with concepts from the theories of learning. From this position, and having suggested that the lack of support for designers of animated icons may be a problem, this thesis aims to provide a support mechanism in the form of a set of principles to guide the design of animated icons such that children are enable to more easily recognise the represented functionality. The set of principles will be based around the concepts from the theories of learning and the dimensions of animated icons that will be discussed in Chapter Two.

In order to explore the recognition of animated icons, this thesis reports on a practical study of children between the ages of 11 and 12 years old – the age group where computers become part of the national curriculum and are applied in certain subjects such as maths (Abbott 2001; Sharp et al. 2000; Solomon 1986), giving children formal access to computers as part of their school life.

1.6 Research Objectives

To meet the stated aims, this thesis proposes the following research objectives, which will be explored through subsequent chapters:

O1 Carry out a literature review and identify suitable theories of learning which may aid animated icon design.

O2 To identify the key dimensions of animated icons design and to explore the potential relationships they may have with concepts from the theories of learning.

O3 To design animated icons based on the relationships between the key dimensions of animated icons and the concepts from theories of learning.

O4 To design and carry out a practical study to investigate children's identification of animated icon functionality, when designed taking into consideration the key dimensions and concepts from the theories of learning.

O5 To analyse and evaluate the key findings of the practical study on icon recognition.

O6 Prepare a set of design principles to guide animated icon design based on the concepts from the theories of learning.

1.7 Structure of Thesis

The remaining chapters of the thesis are outlined below to provide a road-map for the work.

Chapter Two looks at the background of the work, considering previous research into theories of learning and the potential theories that could be applied to the problem area. The chapter identifies the application of theories of learning in designing animated icons. Previous work, particularly Vygotsky's Sociocultural

Theory, Piaget's Genetic Epistemology and Leontjev's Activity Theory, is discussed in relation to animated icon design. These theories of learning provide different perspectives of how children learn in their environment. This chapter also highlights five dimensions (semantic distance, spatial organisation, familiarity, simplicity and colour) of animated icons that should be taken into consideration by the designer when designing animated icons for an interface.

Chapter Three investigates the relationships between the dimensions of animated icons and the core concepts from the theories of learning discussed in Chapter Two. The chapter provides justification for the relationships that have been formed and discusses the impact that they may have on the design of animated icons. Research questions are developed in this chapter that aim to investigate each of the relationships further in order to establish the impact that they have on identifying the function of an animated icon.

Chapter Four examines the key aspects involved in developing an experimental design for the practical study used to investigate the research questions specified in Chapter Three. The chapter provides an outline of the research method that was applied in each of the phases within the practical study. Justification is provided of the choice of research method. Each of the phases of the practical study is detailed in the chapter, together with the data collection methods used. A pilot study that was undertaken is reported, and lessons learned and applied to the main practical study are presented.

Chapter Five reports the each of the phases of the main study and presents the findings. The static icon functionality selected to be animated for the practical study is highlighted and the design of a series of animated icons is discussed in depth, covering how each of the research question and concepts from the theories of learning underpin the designs. The testing of the animated icons by the children is reported to evaluate the icons' effectiveness in conveying the function of the icon. This chapter identifies the key findings from the practical study and highlights important themes that emerge from them.

Chapter Six presents a detailed analysis of the effect that the concepts from the theories of learning and the dimensions of animated icons may have had on the

identification of the animated icon functionalities. This chapter aims to bring together the knowledge gained from the practical study to frame a series of design principles for animated icon design which are underpinned by the concepts from the theories of learning and presented in a way that is accessible.

Chapter Seven review the thesis and the extent to which its aims and objectives have been met. It also seeks to bring together the results and conclusions from the practical study and identify key contributions to the research area that have been made by this thesis. The limitations of the study are discussed along with recommendations for future research that build on this research effort.

Chapter Two

Analysing the Relationship Between Animated Icon Design and Theories of Learning

2.1 Introduction

Chapter 1 introduced the background of the thesis, asserting the view that the implementation of animated icons may help children to identify icon functionality. However, there is little information available on how to support the design of effective animated icons (Bilal & Bachir 2007; Jessa & Burns 2007; Alm 2003; Batram et al. 2003; Dormann 1994). In order to produce support mechanisms for the designer, it is important to understand what types of object are likely to be useful in conveying the purpose of an icon to the child. This chapter will argue that animated icon design can be usefully informed by considering psychological theories of learning. Using such theories as a base may provide an understanding of how children identify the functionality associated with animated icons and how they perceive and interact with them. The underlying concepts from relevant theories may help the designer to incorporate the key features that are needed to improve a child's recognition of an icon's function. This chapter will introduce and critique theories from Piaget, Vygotsky and Leontjev, identifying aspects of the theories which may be of relevance to the design of animated icons.

This chapter is divided into two main parts. The first part of the chapter provides an insight into iconic representation at the interface and the second part of the chapter introduces psychological theories of learning and their impact on the design of animated icons. The sections of the chapter are as follows. Section 2.2 discusses the use of static icons and the problems associated with their implementation.

Section 2.3 will emphasise the effectiveness of implementing animated icons and the impact that they can have on users when identifying icon functionality. Section 2.4 will outline the key dimensions based on visual aspects of icon design, which are required to develop effective animated icons. Each of the key dimensions will be discussed, providing examples where appropriate. Section 2.5 directly addresses the limitations regarding the literature available on how to support animated icon design, and considers the impact of developing support mechanisms that are underpinned by concepts drawn from psychological theories of learning. Section 2.6 discusses and justifies this dissertation's focus on particular theories of learning. The chosen theories are: the Genetic Epistemology of Jean Piaget (1896-1980); Lev Vygotsky's Sociocultural Theory (1896-1943); and Leontjev's Activity Theory (1904-1979). Each theory is justified and discussed in relation to animated icon design.

2.2 Static Icons

Static icons in computing were established by Xerox when they applied pictorial representations that corresponded to objects in the real world, with which the users may be familiar and that are self-explanatory (Huang 2008; Passini et al. 2008; Kunnath et al. 2007; Böcker 1996; Sutcliffe 1995; Rogers 1989; Gittens 1986). For example, the real life objects in the office environment on which Xerox were seeking to draw in developing their computer desktop were in-trays, filing-cabinets, folders and wastepaper baskets (Böcker 1996; Sutcliffe 1995). The Xerox-developed static icons were simple pictures whose representation of the object in the system did not change (Kunnath et al. 2007; Fairchild et al. 1989). Graphical user interfaces that employ icons are now commonplace and the standard interface form, replacing text (Kunnath et al. 2007; Huang et al. 2002; Weidenbeck 1999).

Static icons provide a means by which the user can easily recognise and remember the function of the icon (Chan et al. 2008; Huang et al. 2002). They provide products such as software applications with a consistent appearance and do not have the barrier of textual language (Bilal & Bachir 2007; Weidenbeck 1999; Böcker 1996; Haramundanis 1996; Horton 1996). Icons have been seen as an influential form of communication as they provide user interfaces that are universally meaningful (Bilal & Bachir 2007; Huang et al. 2002; Rogers 1989). Research suggests that the implementation of icons can support efficiency and reliability of

work and may enable the user immediately to recognise the function of the icon (Kunnath et al. 2007; Weidenbeck 1999; Horton 1996). However, there can be problems with their implementation, leading them at times to cause confusion for the user in terms of the functionality that they are aiming to represent (Kunnath et al. 2007; Benbasat & Todd 1993; Jones 1990; Rogers 1989; Gittins 1986). Icons can suffer from a great deal of ambiguity; for example, the trash-can or recycle icon can be interpreted by users in many different ways, such as a message basket or as a secure place by novice users (Huang et al. 2002; Sutcliffe 1995). Therefore, the use of the icon as a metaphor for children needs a great deal of care by the designer as the way in which they interpret information varies from adults (Chen et al. 2004; Chen et al. 2002; Benbasat & Todd 1993; Jones 1990).

To provide educational software packages with icons that may be more meaningful to children between the ages of 11 and 12 years old, the concept of animated icons could be introduced. Animated icons could be used to 'bring icons to life' with the aim of clarifying the meaning of the icon (Baecker et al. 1991). The effectiveness of animated icons at the interface will be discussed in more depth in section 2.3.

2.3 Animated Icons

Research has suggested that the implementation of animated icons can provide the user with clarification of the meaning of the icon, demonstrate to the user the function of the icon and explain the method of use (Dalacosta et al. 2011; Lewalter 2003; Uden & Dix 2000; Bodner & MacKenzie 1997; Bodner 1994; Tiritoglu & Juola 1993; Baecker et al. 1991). Their aim is to 'bring icons to life', as animation provides the learners with dynamic information (Lowe 2003; Byrne et al. 1999). Animated icons change in a predetermined order, which usually involves looping through a series of images in order to represent to the user the function of the icon (Fairchild et al. 1989). By animating the function of the icon it should be easier for the user to recall and for the icon to be more meaningful (Dalacosta et al. 2009; Lewalter 2003; Preece et al. 1994).

A study carried out by Baecker et al. (1991) looked into how many adult users were able to identify functionality correctly when it was presented to them in animated and static form. Overall, the study demonstrated that the users were more easily able to identify the functionality of the selected icons through the animation as it

provided a step-by-step visual representation of the function. Research has suggested that animated icons have been very useful and helpful to the user in identifying the purpose and functionality of the icon as they are an effective technique for conveying information to the user (Thomas & Calder 2005; Bartram et al. 2003; Lewalter 2003; Uden & Dix 2000; Bodner 1994, 1997; Baecker et al. 1991; Jones 1990). Consequently, animation can help the user to identify the icon's functionality, be they a novice or an experienced user, as the function of the icon is clearly displayed to the user explaining the method of use (Bodner 1994).

It has been suggested that the implementation of animated icons will lead to an increase in the amount of information that is contained in the iconic representation and will consequently clarify the meaning of the icon through the use of animation rather than static symbols (Jessa & Burns 2007; Bartram et al. 2003; Tiritoglu & Juola 1993; Baecker & Mander 1992). This may aid in reducing the amount of ambiguity and confusion that users may encounter with static icon functionality whilst trying to identify the function. However, many of the previous studies have focused on how adults recognise animated icons, and there is not much research on children and the effect that the implementation of animated icons may have on recognition of the function. This thesis will seek to address this by investigating how children between the ages of 11 and 12 years old identify animated icon functionality.

However, to be able to develop effective animated icons a number of aspects need to be taken into account. Section 2.4 discusses dimensions that may relate to animated icon design and that can help the designer to identify key things that they should be taken into consideration during an icon's design.

2.4 Dimensions of Animated Icons

There is a lack of guidance available on the objects that may assist in developing animated icons, as highlighted in section 1.4. This can be an issue of concern as each designer may tend to incorporate objects that s/he considers to be important. Some type of guidance may be useful to help the designer to understand elements that may be required to be included in the design of animated icons. Taking this issue into consideration, it may be useful to examine the type of guidance mechanisms available for static icons as a starting point.

Research suggests that a variety of mechanisms exist that provide assistance in looking at the design dimensions that need to be taken into account whilst designing '*static'* icons (Bartram et al. 2003; Huang et al. 2002; Gittins 1986). From these mechanisms for static icons, there are selected design dimensions that can be learnt from and applied to the design of animated icons, as the animation can be thought of as a set of linked static images (Thomas & Calder 2005; Lewalter 2003; Bodner & MacKenzie 1997). An example of a design dimension could be to keep the icon as visually simple as possible. This dimension may apply to both the design of static and animated icons. As well as identifying key dimensions from static icon literature, studies of animated icons have highlighted additional key themes that may be useful when designing icons (Alm 2003; Uden & Dix 2000; Bodner 1994, 1997; Baecker et al. 1991; Jones 1990). However, they have not been combined to provide guidance for the development of animated icons (Bartram et al. 2003; Uden & Dix 2000; Bodner 1994, 1997; Baecker et al. 1991; Jones 1990). By combining these two 'pieces' (static and animated design elements), an overall picture may be formed of the dimensions that would seem to be important in developing effective animated icons. Table 2.1 highlights each of the dimensions that has emerged from the literature review and provides a brief description of each.

Dimension	Description of dimension
Semantic Distance	This dimension refers to the gap between the user's interpretation of the icon and the icon representation used at the interface (Huang & Lai 2007; Huang et al. 2002; Preece et al. 1994). The design of animated icons should aim to have a low semantic distance, which would enable children to correctly identify the icon functionality.
Spatial organisation	This refers to the organisation of icons and their location on the screen (Byrne 1993). Positional consistency in presenting the icons to children has an effect on usability and, once learned, can help overcome any initial differences the user may have in recognising the function (Bilal & Bachir 2007; Huang & Lai 2007; Wiedenbeck 1999).
Familiarity	This dimension highlights the types of object that might be helpful in representing icon functionality. Applying objects with which children are familiar and which they are able to relate to the real world may aid children in identifying the function (Uden & Dix 2000).
Simplicity	This dimension refers to the simplicity of animated icon design. By applying this dimension, the design of the icons should aim to be simple, with the relevant elements of the function grouped together in the animation to enable the children to identify the function (Huang & Lai 2007; Kunnath et al. 2007; Alm 2003; Huang et al. 2002; Uden & Dix 2000; Tiritoglu & Juola 1993).
Colour	This dimension highlights the use of colour in animated icon design. Colour may help children identify the object/functionality to something they carry out in their environment. Also, the application of colour will provide an interface which is appealing and captures the attention of a child (Huang 2007; Huang & Lai 2007; Noiwan & Norcio 2006; Bartram et al. 2003; Huang et al. 2002; Druin 1999).

Table 2.1: Five dimensions of animated icons

Table 2.1 highlights five key dimensions that provide guidance on the visual aspects of icon design. Each of the dimensions discussed in table 2.1 has been selected as it is adaptable for use for static and animated icon design. The five dimensions are interrelated and in most cases complement one another when applied. For example, the dimension of familiarity may in many cases be related to the colour

dimension; the application of colour to a familiar object may aid a child in identifying the functionality of an animated icon resulting in low semantic distance.

The dimensions may be useful in helping the designer to explore the visual aspects of animated icons. However, the research literature that supports them only provides a limited set of recommendations for the design of animated icons. The dimensions do not provide any assistance into what types of object may be helpful in designing animated icons for children. In addition to these identified dimensions of animated icons, this dissertation argues that a set of support mechanisms is required to provide assistance to the designer on the key areas of animated icon design to enable the implementation of effective icons. The development of existing support mechanisms is discussed in section 2.5.

2.5 Support Mechanisms for Developing Animated Icons

There is little information on how to support the design of effective animated icons (Bartram et al. 2003; Uden & Dix 2000; Dormann 1994). This may cause problems, as each software designer may produce icons that are not widely appealing owing to design which overplays his/her own cultural background, education and environmental influences. As such, the designer will include aspects in the animation that s/he perceives to be significant when designing the icons. With no specific support for animated icon design, problems can occur as there is no information regarding effective length, content, ordering and visual representation of animated icons (Jessa & Burns 2007; Alm 2003; Bodner 1994).

The design dimensions discussed in table 2.1 may be of value in providing an overview to the designer of certain visual aspects of icon design. However, the dimensions in and of themselves do not provide any support/assistance for the design of animated icons. For animated icons to be effective in helping children to identify functionality, they need to have a focus on the activities associated with the function. If the function is not the central point of focus, the designer may find that the animated icons are a set of confusing, moving elements on the screen that the user does not understand (Uden & Dix 2000; Preece et al 1994). Focusing on the functionality of the icon, an understanding needs to be developed of the types of object that should be applied to represent the functionality and how it should change through the animation. Support mechanisms should to be developed that take into

consideration the types of object that children find most useful to identify icon functionality (Bilal & Bachir 2007). This may help the designer to incorporate the key objects that are needed to improve a child's recognition of an animated icon's function. Children need to have objects at the interface that they are able to recognise and relate to their environment. At different stages of the child's development they are able to understand and recognise different objects (Donke & Reitsma 2007; Druin 1999; Brouwer-Janse et al. 1997). Psychological theories of learning may provide a base from which an understanding can be established of how children between 11 and 12 years old learn about animated icons, perceive and interact with them (Kunnath et al. 2007). Concepts from theories of learning may help the designer to get an understanding of how children understand and relate to the dimensions of animated icons. This will be discussed further in sections 2.6 and 2.7.

2.6 Comparison of Theories of Learning

The study of learning can be conceptualised as falling into/belonging to different schools of thought. For this thesis, the cognitive school of thought will be argued to be the most appropriate. There are other schools of thought that have developed in psychology as a discipline, but they are not applicable to the problem area being investigated as they focus on different aspects of human behaviour. Many of the 'non-cognitive' schools of thought see learning arising as a result of behavioural responses to stimuli in the child's environment. The cognitive school of thought is about the thinking and organising systems of the brain and involves language, mental imagery, thinking, reasoning, problem solving, and memory development (Anderson 2000). As individuals, we all perceive things in a different way and these factors are the ones in which cognitive development is interested, as cognitive psychologists believe that this gives an overall view of how the individual is learning information rather than just relying on observable human behaviour to provide the answers (Schultz & Schultz 1996). For example, cognitive development is interested in looking into how the individual perceives things and looks into individuals' memory stores, attention and perception of objects. The cognitive school of thought is seen as being applicable to the design of animated icons as it focuses on how the child may perceive the icon and the process of identification of its functionality.

Each of the theories that have been selected from the cognitive school of thought for consideration in this thesis takes a different perspective on how learning takes place and takes into account different factors that may affect how children identify animated icons. Piaget's Genetic Epistemology Theory has been selected as it discusses how a child manipulates an object in its environment and how the child learns from this activity without any social influences. In relation to animated icon design, this theory may aid in understanding how children associate activities with objects in the real world. The second theory that will be considered is Vygotsky's Sociocultural Theory, which takes into account the social and environmental factors that affect the child's learning processes. This theory may help us to look into the social factors that need to be taken into account whilst designing icon functionality for children. The final theory to be discussed is Leontjev's Activity Theory, which takes into account the activities that are undertaken to perform a certain operation. This theory may help to look into how children identify with activities carried out for icon functionality. Both Vygotsky's and Leontjev's theories to some extent overlap in their views. However, for this work separate areas have been focused on from the theories which makes it worthwhile looking at each theory separately.

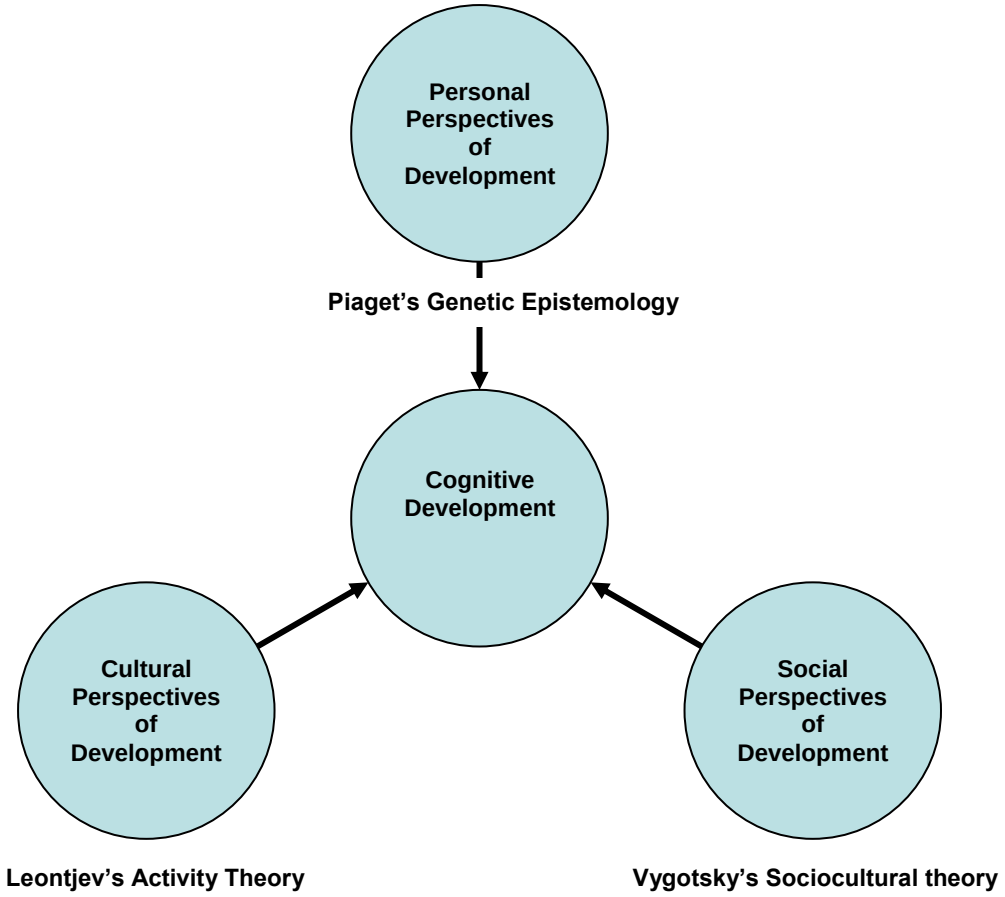

Figure 2.1: Illustration of the different areas of focus of each of the chosen theories of learning.

Figure 2.1 highlights the different perspectives taken by each of the theories of learning considered in this thesis. Each of the theories focuses on how children learn, develop intelligence and knowledge within their environmental settings. However, the focus of this thesis is to develop an understanding of the types of object that would be useful in conveying the function of an animated icon to a child. Concepts drawn from the theories of learning may, it is argued, be used to provide a theoretical foundation that may/will be useful when designing animated icons. The theories may be used to provide different perspectives on how a child may interact with animated icons in different scenarios. As noted earlier, each of the theories discussed takes a different perspective on how learning takes place: Piaget's theory

has an emphasis on understanding how children learn from interacting with objects in the environment (Cohen 1983); Vygotsky's theory is interested in the social aspects of learning (Miller 1993); and, Leontjev's theory has a focus on the activities that a child undertakes to get to their main objective (Nardi 1996). For this thesis, this will enable an understanding to be developed of how children interpret information based on their physical object manipulations, and social as well as cultural interactions with their environment.

The theories will be discussed in sections 2.6.1-2.6.3, with a focus on the key concepts that may affect the design of animated icons. The impact of the concepts on the design of animated icons needs to be investigated as they may provide a broad base on which support mechanisms may be developed to aid the designer. Following on from this, in Chapter 3 the concepts derived from the analysis in Chapter 2 will be discussed further in relation to the effect that they have on animated icon design.

2.6.1 Piaget's Genetic Epistemology

In this section, an overview is provided of Piaget's Genetic Epistemology theory and the concepts within it that relate to the selected age group for this study. Piaget made many contributions to the study of child development, but only those applicable to the 11 to 12 year old age group on which this study focuses will be considered.

The focus of Genetic Epistemology is on the organisation of intelligence and how it changes as children grow older. Originally, the work was based on the observations of Piaget's three children (Feldman 2004; Gross 1998; Miller 1993; Hilgard & Bower 1975). Piaget defined intelligence as a component that allows an organism to deal with its environment effectively. Piaget's detailed observations of children led him to many asserrtions, the most central in his theory being the nature of the human organism to adapt to its environment. However, in contrast to many other learning theorists, Piaget believed that the environmental factors did not have an effect on a child's cognitive development. Rather, he argued that it is the child who actively seeks to understand their environment. Whilst undertaking this process the child explores, manipulates and examines the objects and the people in the environment

surrounding him/her (Bee 1995; Cohen 1983). In summary, Piaget sees the development of intelligence as arising from the child interacting with its environment (Hayes & Orrell 1993).

According to Piaget, as a child learns and masters new skills these are represented in the thought processes by way of cognitive structures known as schemata (or schema) (Carlson et al. 2000; Hayes & Orrell 1993; Cohen 1983). The concept of schemata is very important in Piaget's theory (Hergenhahn 1982); for Piaget, schemata are the basic building blocks or units of intelligent behaviour - mental structures that organise past experiences and provide a way of understanding future experiences. As we grow, our schemata become increasingly complex (Gebhardt et al. 2008; Gross 1998; Hilgard & Bower 1975). The schemata present in an individual will determine how they respond to the physical environment surrounding them. The schemata within us contain all of the ideas, memories, skills and associations to do with a specific series of operations on the environment. Piaget claimed that cognitive development takes place by the process of building up and developing new schemata and expanding existing ones so that they can be applied to a wider range of experiences (Hilgard & Bower 1975).

Within Genetic Epistemology, 'assimilation' is the process of an organism taking in information and modifying it to fit existing schemata (Gross 1998; Hergenhahn 1982; Hilgard & Bower 1975). The process of assimilation requires matching the physical environment you have at present with your existing cognitive structures (Gebhardt et al. 2008; Illeris 2003; Hergenhahn 1982; Sahakian 1976). The cognitive structures that are present within the organism set bounds on what can be assimilated. However, as the child grows older their cognitive structures change making it possible for the child to assimilate different aspects of the environment (Carpendale & Racine 2011; Miller 1993; Hergenhahn 1982; Sahakian 1976).

In order for children to have intellectual growth they need to assimilate information. Therefore, Piaget proposed another concept, that of 'accommodation', which is the process by which old schemas are changed by new experiences (Illeris 2003; Bee 1995). Accommodation can result in either new schemas or changes to existing ones (Gebhardt et al. 2008; Illeris 2003; Hayes & Orrell 1993; Cohen 1983). Consequently, in Piaget's theory, the process of accommodation is vital to

developmental change as it is through accommodation that we change and reorganise our thoughts, improve our skills and alter our strategies (Gebhardt et al. 2008; Bee 1995).

For Piaget, the driving force for intellectual growth is the concept of 'equilibration'. This process involves the organism creating a balanced relationship between themselves and their environment. Piaget believed that equilibration was the innate tendency for the organism to organise their experiences to make sure they encounter maximum adaptation (Murray 1983; Hergenhahn 1982; Hilgard & Bower 1975). This perspective argues that even children at a young age are striving for coherence, to stay in balance, in order to have an understanding of the world that will make sense to them (Bee 1995). Research carried out by Murray (1983) has suggested that measuring the process of equilibration in children is complex as there is little clarity on the types of behavioural sign that might occur during this process. An additional issue, from the perspective of this research, is that the concept of equilibration focuses on the child's movement from one developmental stage to the next. Though of central importance to Piaget's theory in terms of cognitive development equilibration is of less direct interest to this study as the research has a narrower focus on the last two stages of development and is more concerned with how children understand and identify information rather than, specifically, the transition between stages. As such, this concept will not be explicitly considered in this remainder of the thesis.

Piaget saw three particularly significant points in development when reorganisation or equilibration took place; each of these points was argued by Piaget to represent the transition to a new stage in a child's development. In total Piaget defined four developmental stages through which children go in order. For this research, only the last two stages are of interest as they focus on the selected age group of 11 to 12 year olds. These two stages are discussed below.

- **The concrete operational stage, from seven to about the age of 11**

From this stage onwards, the child's thinking processes are starting to change as s/he is developing new strategies, which Piaget calls concrete operations. The new strategies are so called because children are able to apply them immediately to present objects (Torres et al. 2007; Nichol et al. 1987). At this stage, the child's

thinking becomes more flexible as s/he is looking at problems from different perspectives rather than just focusing on their own perspective (Carlson et al. 2000; Smith et al. 1998). At this stage, a child's thinking is very similar to that of an adult; however, the child still has extreme difficulty in dealing with abstract concepts, as they need to relate things to the world in order to understand them (Hayes & Orrell 1983). Any thought processes that the child has are directed towards real life events that they have observed. However, at this stage the child can now perform complex operations on problems as long as they are not abstract (Hergenhahn 1982; Hilgard & Bower 1975).

- **The formal operational stage, from the age of 11 to 15 years**

Piaget argued that the final stage of cognitive development begins at the age of 11 and continues to emerge throughout the teenage years (Torres et al. 2007; Bee 1995). In this final stage, concrete objects do not necessarily bind the mental operations carried out by children (Torres et al. 2007; Miller 1993). At this stage, the child's thinking is like an adult and is the highest form of thought, according to Piaget who argued that from this stage onwards the child could extend its knowledge and was no longer limited by concepts such as egocentricity, when they think of themselves only and not the world around them (Carlson et al. 2000; Hayes & Orrell 1983). Children at this stage can think hypothetically; that is, they can think about what might happen as well as what actually has happened (Gross 1998; Nichol et al. 1987; Sahakian 1976). In this final stage of development, children can handle abstract logic, develop hypotheses about the world and test them out (Hergenhahn 1982).

The order and structure of Piaget's stages suggest that the process of adaptation to the environment occurs gradually throughout the child's cognitive development. It is only as the child gets older and goes through the other stages that they start to have increasing control of the environment and develop the skills of rational thought and forward planning (Hayes & Orrell 1983).

Table 2.2 lists the key concepts from the theory that are going to be taken forward into chapter Three.

Piaget's Genetic Epistemology Learning Theory Concepts
1. Schemas
2. Assimilation
3. Accommodation
4. Developmental Stages from 11 years onwards

Table 2.2: List of concepts from Piaget's theory

Although Piaget's theory proposed new concepts and broke new ground, it did have several weaknesses (Feldman 2004; Miller 1993), meaning that not all of Piaget's conclusions have been accepted uncritically (Carlson et al. 2000; Gross 1998). Concepts such as assimilation, accommodation and equilibration suggest that a child's mind is highly active and self-organising, but there is no technique by which this can be assessed (Bol 1984). For this thesis, however, the position that is adopted is that these concepts may help in identifying factors that may affect animated icon design as they provide a perspective on how children at selected age groups are able to relate to objects in their environment. As such, the theory is seen as useful.

However, Piaget's theory does not explain the social aspects that can affect a child's learning. He gave little attention to sociocultural influences, emotions and the nature of development of cognition regarding people and social events (Feldman 2004; Miller 1993; Cohen 1983). In order to address this perspective for the purposes of this research, other relevant theories of learning will be considered. Vygotsky's Sociocultural Theory aims to understand how the social aspect of a child's environment affects learning, whereas Piaget's theory provides insight into how children learn through object manipulation in total isolation from the social world. Vygotsky's and Piaget's theories complement each other as they address different aspects of learning, and combining the two theories may give a broader perspective on how children learn in their environment, a position endorsed by Shayer (1997). Vygotsky's Sociocultural Theory is therefore discussed in the following section.

2.6.2 Vygotsky's Sociocultural Theory

This section provides an outline of Vygotsky's Sociocultural Theory and the concepts linked to it. All the concepts discussed in this section will be taken into consideration in Chapter 3, where they will be discussed in terms of their relationships to the dimensions from section 2.4. Vygotsky has made many contributions to the area of psychology, however the focus for this research is only on his Sociocultural Theory as it looks at the social and environmental aspects of learning argued to be missing in Piaget's work.

Vygotsky (Miller 1993) proposed an important alternative to Piaget (Gross 1998), though he agreed with Piaget in some areas. For example, Vygotsky also saw the child as playing an active part in constructing knowledge and their understanding of the environment (Fernyhough 2008; Smith et al. 1998). Piaget's main focus was on children's interactions with the physical world, with the underlying concept being that children form internal representations of the world based on the experiences that they have with physical objects (Carlson et al. 2000), and Vygotsky agreed that experience with physical objects has an impact on cognitive development. However, he argued that the child's cognitive development does not occur in a social vacuum (Fernyhough 2008; Miller 1993). Instead, Vygotsky believed that cognitive development takes place through social relationships (Fernyhough 2008; Hakvoort 2002; Strauss 1993; Crook 1987). He believed that a child's intellectual life starts in the community and from there onwards the child jointly constructs his/her understanding of issues and events occurring in the world (Smith et al. 1998). Therefore, the cultural context has an effect on children, as what the child hears others say about the world, how s/he sees others interacting in the world and physical aspects of the world affect the child's perception of the world (Lei 2008; Gross 1998; Blanck 1990; Vygotsky 1978). With the help of teachers, parents and peers, children are able to acquire ideas and views of how the world operates (Williams et al. 2007; Carlson et al. 2000). Vygotsky believed that other knowledgeable individuals could assist a child in the learning process, so he introduced the concept of the 'intervention' of those that are more knowledgeable as an important aspect of learning (Lei 2008; Smith et al. 1998).

Unlike Piaget, Vygotsky did not believe that you have to wait until the child is ready to learn; instead he believed that a child starts to learn from other people at an early age (Smith et al.1998). According to Vygotsky, instruction is at the heart of learning, and he introduced a concept called 'scaffolding', which refers to the role played by parents, teachers and others in the child's environment in assisting the child to acquire knowledge and skills. Gradually, as the child becomes more and more familiar with the task, those that scaffold leave the child to do the task until they can perform the task successfully on their own (Williams et al. 2007; Gross 1998).

Another central concept of Vygotsky's theory that can be related to the design of animated icons is the 'zone of proximal development' (ZPD), which seeks to explain how the child learns with the assistance of others (Ohta 2005; Smith et al. 1998). Vygotsky suggested that the ZPD is formed by two core components: the actual level of development for a child and the potential level of development. The actual level of development relates to those things where the child has the ability to solve a problem without the assistance of others. The potential level of development relates to those things where the child is unable to solve problems by him/herself and requires assistance from others, such as teachers, parents or peers. As they achieve their potential level of development, either by observing others or by doing the activity themselves, the response now becomes internalised or remembered by the child. Therefore, what has been learnt by the child now becomes the new actual level of development and they now start working towards their new potential level of development (Warford 2011; Ohta 2005; Strauss 1993; Wertsch & Tulviste 1992).

With the process of scaffolding, more knowledgeable people in the child's environment collaborate with them to help them move from where the child is now to where the child can be with help (Harland 2003; Miller 1993; Vygotsky 1978). This may be done by using prompts, cues, explanations, joint participation, leading questions, encouragement and so on (Miller 1993). Eventually, as the child develops, the scaffold will 'disappear' and a new one will be built to help them reach the next stage (Harland 2003; Wertsch & Tulviste 1992).

The main criticisms of Vygotsky's theory relate to the ZPD. The difference between the actual and potential levels has been argued not to provide an accurate view of the child's learning ability, style of learning, current level of development compared

to children of the same age group, and the degree of motivation for the child (Miller 1993).

Another limitation of Vygotsky's theory is that the nature of the developmental processes involved in the child moving from one zone to the next is vague and whether it is the same for all children of that age group has not been addressed (Miller 1993). For this thesis, however, the position that has been adopted is that the concepts may aid in providing a perspective into the child's social and environmental processes and how this might affect the design of animated icons. Table 2.3 lists the key concepts that are to be taken forward into chapter 3 to investigate the impact that they may have upon the design of animated icons.

Vygotsky's Sociocultural Learning Theory Concepts
1. ZPD
2. Scaffolding
3. Culture
4. Context

Table 2.3: List of concepts from Vygotsky's theory

However, Vygotsky's Sociocultural theory does not explain how the child may interact with objects in his/her environment and the reasoning behind the behaviour (Nardi 1996). In order to address this perspective for the purposes of this research, Activity Theory has been considered. Leontjev's Activity Theory aims to investigate the human interaction issues that an individual may experience in their environment, whereas Vygotsky's theory only focuses on how children learn through social interaction with others. Activity Theory is discussed in the next section.

2.6.3 Leontjev's Activity Theory

The main aim of Activity Theory is to provide a broad theoretical framework for describing the structure, development and the context of human activity (O'Leary 2010; Kaptelinin et al. 1999; Kuutti & Arvonen 1992). It was Vygotsky and the cultural-historical school of Soviet psychology that laid down the main foundations of Activity Theory in the 1920s and early 1930s, which was later developed by the

work of Leontjev (Cluts 2003; Turner et al. 1999; Bellamy 1996; Kuutti 1996). The main focus of Activity Theory is to understand the union of consciousness and activity (Cluts 2003; Nardi 1996; Kaptelinin 1993). In this context, the expression "consciousness" refers to the human mind as a whole and the expression "activity" refers to human interaction with reality. According to this, the human mind emerges and exists as a special element of human interaction with the environment. Activity Theorists believe that the mind acts as a special component of an organism and helps it to survive. Therefore, in order to understand consciousness, which is part of the mind, it is important to understand the context of the activity being carried out (Cluts 2003; Kaptelinin 1996; 1993).

The study of consciousness may help in understanding how the child learns the function of animated icons as it incorporates many aspects of the child's cognitive resources. Like Vygotsky, the Activity Theorists believe that people are in a social matrix that is composed of people and artefacts (Bellamy 1996; Nardi 1996). Overall, Activity Theory attempts to integrate three different perspectives into one: 1. the objective; 2. the ecological; and 3. the sociocultural perspective (Kaptelinin 1996; 1993). By combining these three perspectives, Activity Theory is able to provide an overall view of a human being and the activities that they carry out in their environment. Consequently, Activity Theorists believe that in order to analyse human activity it is best to have people in their natural environment. This aspect of the theory agrees with Piaget's approach; however Activity Theorists argue that cultural factors and development aspects of human life must be taken into consideration whilst analysing human activity (O'Leary 2010; Kaptelinin 1996).

In summary, there are two basic views that underpin Activity Theory. The first view is that the human mind emerges, exists and can only be understood within the context of human interaction with the world. The second view is that the interaction with the world is an activity that is socially and culturally determined (Kapetelinin et al. 1999). These views are developed further in the five basic principles of Activity Theory which are presented in Table 2.4.

Principle	Description of principle
Object-orientedness	This principle states that human beings live in a reality that is objective in a broad sense (Nardi & Kaptelinin 1997). It states that every activity that is undertaken is always aimed towards something that objectively exists in the world (Kaptelinin et al. 1999). Activity Theorists consider the social and cultural properties of the individual's environment to be objective as well as the biological, physical and chemical properties being objective (Kaptelinin 1996). They believe the environment within which an individual interacts has an effect on the activities they undertake, therefore, the properties of the environment are objective as it is meaningful in itself.
Hierarchical structure of activity	This principle relates to the belief that within Activity Theory the unit of analysis is the activity aimed at an object, which in turn motivates the activity, giving it a particular direction. The activities that are undertaken are part of a goal-directed action that has to be taken in order to fulfil the object. The actions that are taken by an individual are conscious and different actions can be taken by the individual to meet the same goal (Nardi & Kaptelinin 1997).
Internalisation /Externalisation	This principle aims to describe the mechanisms that are underlying the original mental processes (Kaptelinin 1996). Activity Theory states that internal activities will not be understood clearly if they are analysed individually from external activities as both internal and external activities transform into each other. Internalisation refers to external activities being transformed into internal activities. Externalisation refers to internal activities becoming external activities. This process of externalisation may become necessary when an internal activity needs to be repaired or scaled (Nardi & Kaptelinin 1997).
Mediation	This principle refers to the fact that Activity Theorists emphasise that human activity is mediated by tools that are both internal and external (Nardi & Kaptelinin 1997; Kaptelinin 1996). An example of internal tools would be concepts or heuristics; for external tools, an example would be a hammer, a pair of scissors or a computer. Activity Theorists believe that during the development of an activity these tools are created and transformed by the individual (Nardi & Kaptelinin 1997). Consequently, the use of these culture-specific tools can lead to the way in which people act and the way in which the process of internalisation will take place that will have an effect on mental development. Therefore, the tools used to carry out an activity are a way in which cultural knowledge and social experience can be carried forward (Kaptelinin 1996). An example of this would be that the tools used in specific countries can relate to the type in which culture of the individual has grown up.
Development	The final principle relates to understanding how things are developed in their existing form. The principle of development gives the possibility to undertake thorough scientific analysis (Kaptelinin 1996). People need to understand how the tools they mediate are used not only once but over time. In turn, this may lead to development occurring, making the tool being used more efficient and useful. An individual's development can be studied via active participation and monitoring of any developmental changes (Kaptelinin et al. 1999).

Table 2.4: Five principles of Activity Theory

The basic principles of Activity Theory, though presented separately in table 2.4, should be looked as an integrated set of principles because they are clearly associated with many aspects of the whole activity (Nardi & Kaptelinin 1997).

The major drawback with Activity Theory is that the actual benefits of the theory have not been observed or noted in specific empirical studies (Nardi 1996). However, for this thesis the position has been adopted that the concepts aid in developing an understanding of the type of activities that children go through when identifying and using icon functionality.

2.7 Summary

This chapter has explored the field of iconic representation at the interface, driven in particular by the application of animated icons for interfaces designed for children between the ages of 11 and 12 years old. The visual dimensions of animated icons were outlined in this chapter, providing an insight into how these aspects can aid in recognition of an icon's function.

This chapter has also highlighted the lack of information relating to support mechanisms to aid in designing effective animated icons. From the literature review, design dimensions were identified from the support guidance available for static icons, which may be applicable to the design of animated icons. However, they do not provide information on the types of object that can be used to convey the functionality of animated icons to children.

This chapter has argued that animated icon design could be usefully informed by concepts derived from relevant theories of learning. The theories of learning discussed in this chapter are from the cognitive school of thought and each has introduced a different stance of how learning takes place. By investigating the concepts from each of the theories, an insight may be developed into how children learn within their environment. This may help the designer to encompass the key features and objects that are required to improve a child's recognition of an icon's function. The concepts that have been discussed from each of the selected theories of learning are to be taken forward into Chapter Three. In this chapter, the concepts will be discussed in relation to animated icon design and the dimensions of animated icons identified in section 2.4. Based on the relationships between the two

aspects, a series of research questions will be developed for consideration in the remainder of this thesis.

Chapter Three

Bridging the Gap Between Dimensions of Animated Icons and Theories of Learning

3.1 Introduction

Chapter Two explored the potential impact of psychological theories of learning on the design of animated icons. It argued that the use of animated icons may help children to recognise the functionality that the icons are aiming to represent. The chapter suggested that concepts from relevant learning theories may help the designer to incorporate objects that may improve a child's recognition of an icon's function.

Given the issues raised in Chapters One and Two regarding the design of animated icons for children, this chapter aims to investigate this problem further by bridging the gap between the dimensions of animated icons and theories of learning, both of which were discussed in Chapter Two. Table 2.1 outlined the key dimensions of animated icons and sections 2.6.1–2.6.3 discussed relevant concepts from selected theories of learning. This chapter will investigate how the dimensions of animated icons are complemented by the concepts from the theories of learning. Based on the relationships between the two, a series of research questions will be developed in this chapter. The research questions will act as a basis for the design of the practical studies in Chapter Four.

This chapter is structured as follows. Section 3.2 will introduce a general research question aimed at investigating the objectives that were set in section 1.6. In subsequent sections of this chapter, this research question will be broken down

further in order to be able to fully investigate the impact of the concepts from each of the selected theories of learning. Following on from this, section 3.3 will discuss the integration of the three theories of learning discussed in Chapter Two and how they are able to be used together to provide a wider view that takes into consideration many factors of the child's learning environment. Section 3.3 is important as it will highlight the key relationships between the dimensions of animated icons and the concepts from the theories of learning. Sections 3.3.1 – 3.3.5 will discuss the relationships between the dimensions of animated icons and the concepts from the selected theories of learning and provide examples of how these relationships may affect the design of animated icons. Following on from this analysis, section 3.4 will present a series of research questions to be investigated in the remainder of this study with each question based around the relationships between specific dimensions of animated icons and concepts from the theories of learning.

Based on the research questions, a series of practical studies will be designed and presented in Chapters Four and Five with the aim of evaluating the impact that the concepts from the theories of learning have upon animated icon recognition.

3.2 General Research Question

The overall aim of this research is to identify the relationships between the dimensions of animated icons and theories of learning and to investigate the impact that they have on animated icon recognition. Therefore, a general research question can be stated which captures the research objectives from section 1.6.

RQ

"What is the effect on recognition of the function of animated icons when they are designed taking into account relevant concepts from theories of learning?"

This research question provides a broad scope and needs to be broken down into more detailed/specific questions based on the relationships between the dimensions of animated icons and concepts identified from the theories of learning. Section 3.3 will define the relationships and develop the detailed research questions to be explored in this study.

3.3 Defining the Relationships between Dimensions of Animated Icons and Theories of Learning

Chapter Two introduced each of the theories of learning selected for consideration in this thesis. Each of the theories has their own interpretation of how learning takes place. Each concept from the theories of learning may aid in developing an understanding of how children interpret and relate to the dimensions of animated icons, highlighted in section 2.4. The dimensions aim to provide the designer with areas where guidance on the visual aspects of the icon may be useful. By investigating the possibility of relationships between the dimensions of animated icons and the concepts from the theories of learning, insights may be developed into the impact of the visual factors on a child's identification and understanding of icon functionality. Each relationship that is developed between the concepts from the theories of learning and the dimensions of animated icons is based on the common links between them. For example, a concept such as 'schema' from Piaget's theory is likely to have a relationship to the dimension of semantic distance, as both of these aspects refer to how an object is identified based on the child's experiences in the real world.

Table 3.1 presents the relationships between the theories of learning and the dimensions of animated icons and aims to illustrate the relevant concepts from theories of learning which inform each of the dimensions. This will lead, in the reminder of section 3.3, to the development of a series of research questions which will be used to further investigate the relationships.

Theories of Learning		Dimensions of Animated Icons				
		Semantic Distance	Spatial Organisation	Familiarity	Simplicity	Colour
Genetic Epistemology Theory (Piaget 1896-1980)	Development Stage	✓		✓		
	Schemas	✓	✓	✓		✓
	Assimilation	✓	✓	✓		✓
	Accommodation	✓	✓			✓
Sociocultural Theory (Vygotsky 1896-1934)	ZPD	✓		✓		
	Scaffolding		✓	✓		
	Context	✓		✓		
	Culture	✓	✓	✓		✓
Activity Theory (Leontjev 1904-1979)	Hierarchical Structure of Activity	✓		✓		
	Object Orientedness	✓		✓		✓
	Mediation	✓		✓	✓	✓
	Development	✓		✓		
	Internalisation/ Externalisation			✓	✓	

Table 3.1: Illustrating the suggested relationships between theories of learning and dimensions of animated icons.

Each of the concepts from the theories of learning relates in some way to the dimensions of animated icons. For this thesis, the dimension of spatial organisation will not be investigated further as it was felt that to effectively investigate this dimension would require the animated icons to be presented to the children in the context of a software package. For this thesis, it was not possible to secure a way of modifying appropriate commercial software in which the icons are presented (such as Microsoft Word and Explorer – packages with which the participants would have been familiar). For completeness, the dimension of spatial organisation will be discussed in section 3.3.2 and a research question will be developed but will not be taken forward into the study for the reason outlined above. Each of the remaining dimensions and their relationships with the concepts from the theories of learning are discussed in sections 3.3.1-3.3.5.

3.3.1 Relationship of the Semantic Distance Dimension to the Theories of Learning

As discussed in table 2.1, semantic distance refers to the difference between the user's interpretation of the icon and the icon functionality at the interface. This dimension is focused on the type of object that is used to represent the functionality and how the child identifies with it. Based on this, semantic distance has relationships across all three of the theories of learning considered (as suggested in table 3.1). Each theory will now be discussed in order to investigate each relationship further; this will follow the same sequence as that presented in table 3.1, on the left hand side of the table.

A series of concepts from Piaget's Genetic Epistemology has relationships with the dimension of semantic distance. The first concept to be discussed is of developmental stages, with a focus on the formal operational stage for this study. The remainder of Piaget's concepts will be discussed further in this section. The remaining concepts have been grouped with concepts from other theories of learning, as many of these expressed similar points but in different ways. The concept of developmental stages argues that children go through a series of logical stages in which they develop the way in which they understand and identify with objects (Torres et al. 2007; Brouwer-Janse 1997). Therefore, if consideration is given to the child's formal operational stage, this will result in being able to develop

an understanding of how 11-12 year olds interpret information. This will enable icon design to be focused on the child's age group and the ways in which they are able to identify objects. This may enable the semantic distance to be low as the objects used to represent the functionality will be something with which the child is familiar.
Research has been carried out on the developmental stages concept and the semantic distance dimension independently of each other. For Piaget's formal operational stages, research was carried out by Ernick & Welsh (2005) that investigates to what degree Piaget's formal operational stage has predicted performance in cognitive processes such as planning and working memory. Their findings represented preliminary evidence that thought associated with the formal operational stage does indeed make a contribution to the performance of key tasks. Applying objects to animated icons the child is able to identify tasks they carry out in their environment may help them to identify the functionality in the formal operational developmental stage. A study carried out by Jones (1990) investigated the key features of computer interfaces with a focus on animated computer icons. The research suggested that the animated icon content should be meaningful to children and linked to the type of information that they are able to understand. This would enable a low semantic distance as the child would be able to identify the object with the tasks they carry out. Ernick & Welsh (2005) and Jones (1990) both suggest that the child's developmental stage may have an effect on the type of information that s/he is able to process. However, the relationship between Piaget's formal operational development stage concept and the semantic distance dimension has been not investigated in current research. This relationship needs to be explored further in order to establish the impact that the developmental stage may have on icon design and the child. Research Question 1 aims to capture the essence of this relationship and will be taken forward into subsequent chapters for further investigation.

Research Question 1

Does taking into consideration the child's developmental stage in the design of the animated icon, have an effect on how the child identifies the icon's functionality?

Vygotsky's concept of the Zone of Proximal Development (ZPD) is relevant to the dimension of semantic distance. The ZPD ensures that children are aiming towards their potential level of development and seeks to determine their actual

development level. If icons are designed taking into consideration the levels of development in the ZPD, the designer can aim to design icons that meet the child's potential level of development. A computer user's ZPD level can be established by observation and interviews (Miller 1993). This will enable the designer to observe the type of activity that the child is carrying out whilst using a computer and develop an understanding of the types of object that they are able to identify. This will ensure that there is low semantic distance between the pictorial representations of the real-object that the icon is aiming to represent and the object itself. In turn, this will help the child to achieve their potential level of development and aid the child in understanding the function of the animated icon.

Research suggests that the ZPD is an influential concept in a child's development, especially in the areas of language learning and acquisition (Ohta 2005). Research has also suggested that the ZPD should be more actively applied in educational programs (Allal & Ducrey 2000). The ZPD provides the opportunity to develop an understanding into information that the child is easily able to understand and to identify where s/he requires assistance. Research carried out by Goonetilleke et al. (2001) suggested that whilst ensuring that the design of icons is simple, the objects applied to represent the functionality should be something with which the user is familiar in their environment and should aim to cover all elements of the function. This would enable a focus on the semantic distance dimension and the ZPD. The studies discussed in this section demonstrate the importance, or potential, of ZPD in considering semantic distance, but they have not looked at this from the perspective of animated icon design, leading to research question 2 which will be investigated further in Chapter 4.

Research Question 2

Will designing animated icons aimed at the child's potential level of development help them to recognise the icon's function?

As noted at the start of this section, analysis of the concepts from the theories of learning found that some concepts express similar things but in different ways. In the remainder of this chapter, the focus of the concepts discussed is on the identification of objects that are familiar to a child within their environment,

depending on their ZPD. Therefore, the concepts can be 'rationalised' and brought together to form one research question based on one or more concept.

From Piaget's theory of Genetic Epistemology, the concept of schema is relevant to the dimension of semantic distance. This concept is concerned with the way in which the child organises ideas, memories, skills and associations that they carry out within the environment (Gebhardt et al. 2008; Gross 1998; Hilgard & Bower 1975). Basically, a schema is defined as a set of intelligent behaviours that the child has carried out and with which s/he is familiar. Taking this into consideration, objects that are applied to represent functionality should aim to be those that are present in the child's schema; this process will enable the semantic distance to be low as the child should be able to recognise the object representing the functionality. Similarly, concepts such as assimilation, accommodation and equilibration are built on the relationship between semantic distance and the schema, as discussed in section 2.6.1.

Linking back to Vygotsky's theory, the concept of culture also relates to semantic distance; a designer needs to understand the child's cultural settings whilst designing animated icons. Each country differs culturally and an animated icon that may have low semantic distance in one country may have high semantic distance for children of the same age in another country. The second concept from Vygotsky's theory that is relevant here is that of context. To enable low semantic distance, the designer needs to ensure that the design of the icon is context specific and has a focus on the functionality of the icon.

Moving on to the last of the selected theories, all five principles from Activity Theory are relevant to the dimension of semantic distance. Firstly, mediation, which refers to how human beings use and acquire information from tools they use, is linked to semantic distance in that it enables the designer to look at the type of object that is being applied to represent the function, and question what type of information the user may already have on the usage of the object. Therefore, when an animated icon is designed and the object used to represent the function is closely related to the object in real life, the user can 'mediate' the function and remember how that particular object worked in real-life. The basis of the relationship links in closely with the principles of hierarchical structure of activity and object orientedness. The

essence of this relationship is based on the activities the child carries out with the object used to represent the function can be associated to the real world. This relationship is essential when designing animated icons as when a user carries out a function they have an activity that they intend to do, and if a link can be developed to the type of activity the child may carry out with the object in real-life, it may enable the icon functionality to be more easily understood. The fourth principle of internalisation/externalisation is also closely related to semantic distance. When designing animated icons, the designer should be aiming for internalisation to occur, leading to the user being able to recognise and remember the function of the icon without any trial and error. However, in order for internalisation to occur it is important for the semantic distance to be low. This will ensure that the final principle of development is occurring for the child, as they are able to get an understanding of how the function of the animated icon works

As highlighted earlier, the focus of relationships in this section of the chapter is on how children identify objects with which they are familiar. A previous study, conducted by Uden & Dix (2000), focused on iconic interfaces for children aged 5-6. This research suggests that to design an effective search tool, an understanding needs to be developed into how children interpret information in the real world. The researchers found that what they thought the children were able to understand differed to the actual results that they obtained during the practical study. The study highlights that developing something that is meaningful and familiar to a child will increase usage of tools that are developed for them. However, the relationships between semantic distance and the concepts of theories of learning need to be investigated further from the perspective of icon design for children aged 11-12, as there is no relevant research for this age group. Research question 3 below aims to capture the dimension of semantic distance and each of the concepts of theories of learning discussed above.

Research Question 3

Will designing animated icons that are context specific and that use objects that exist within the child's environment allow the child to mediate the icon's functionality and identify it?

Each of the research questions that have been highlighted during this discussion will be taken forward into Chapter Four for further investigation.

3.3.2 Relationship of the Spatial Organisation Dimension to the Theories of Learning

The dimension of spatial organisation refers to the organisation of the icons and their location within the interface. For example, if we take into consideration Microsoft Office software packages, each of the packages has a menu bar and choice of icons at the top of the screen. In relation to Piaget's theory, this dimension has a relationship with the following concepts: schemas; assimilation; and accommodation. Firstly, with respect to the concept of schemas, when a child opens up a software package s/he may expect the icons to be available on the top of the screen as this is what s/he has assimilated into his/her schema and this is the first place s/he is going to look for the icons. However, some software packages place icons differently and they may have the choice of icons on the left hand side of the screen, requiring the child to accommodate the location of the icons into his/her schemas. Therefore, consideration needs to be given as to where and how the animated icons are going to be presented to the child at the interface.

Looking at Vygotsky's theory, this dimension has two key relationships, with the concepts of scaffolding and culture. The concept of scaffolding is complemented by this dimension as placing the animated icons in the same location for all interfaces that are designed for children may assist them in the scaffolding process as they are easily able to locate the icons as there is consistency in the location. Once again, this is an important relationship to establish as culturally each country may differ in the location of their icons at an interface. Therefore, it is the designer's responsibility to ensure that they are aware of any culture-specific issues in relation to icon location.

A study carried out by Huang et al. (2002) suggested that the location of the icons could affect the way in which the child interprets and identifies icon functionality. As

previously highlighted in this chapter, the interface should be designed in a manner with which the children are familiar so that they can easily locate the icons that they need. This links in closely with Piaget's concepts of schemas and assimilation and Activity Theory's concept of internalisation/externalisation.

A study by Choong & Salvendy (1998) focused on the cultural aspects of icon design and concluded that cultural factors affected a user's performance and should be taken into account when designing interfaces. They argued that taking cultural factors into consideration should enable better performance and provide users with the mechanism to perform tasks effectively. Consequently, Huang et al. (2002) and Choong & Salvendy (1998) highlighted that it is useful to understand where the users are able to find and use icon functionality. However, the relationship between the dimension of spatial organisation and the concepts from theories of learning has not been investigated in detail in current research. Therefore, the following research question is proposed to investigate this relationship further and to help understand the impact it may have on animated icon design. However, the research question will not be investigated further in this thesis because of the practical issues outlined on page 36. It is therefore presented here merely for completeness and not given a number and will be returned to in section 7.6 which considers directions for future work.

Research Question

Will a change in location on the screen for the animated icons affect the user's recognition of the functionality?

3.3.3 Relationship of Familiarity Dimension with Theories of Learning

Analysis of the dimensions found that some are about strands of the same thing – the extent to which the icon and animation reflect the child's real life experience. The dimensions that focus on this particular strand are familiarity and simplicity. Each of these dimensions is about the icon's attributes and how they relate to one another. The dimension of familiarity focuses on concrete objects or activities associated to those objects that exist in the child's environment. In the sequence of animation that is used to present the functionality the aim should be to present the icon's functionality to the child in the simplest form so that they are able to make the

association between the object presenting the functionality and the activities it is used to carry out in their environment. Therefore, for this thesis, the dimensions of familiarity and simplicity will be brought together to form one research question.

The dimension of familiarity has relationships with concepts across all three theories of learning. Many of the concepts from Piaget's theory of Genetic Epistemology complement the dimension of familiarity. The first concept to be taken into consideration is of developmental stages. In order to investigate the types of object with which a child is familiar, it is important to understand the developmental stage in which the child falls. By considering the developmental stage that the child is at, the designer can appreciate how the child is able to understand and interpret information presented to him/her at the interface. By going through this process, the designer may be able to develop an insight into the types of object or feature with which the child might be familiar and apply these to the design of animated icon functionality. This should allow objects that exist within a child's schema and activities that have been assimilated to be incorporated into the design of animated icons.

The first relationship discussed in this section was that between familiarity and Piaget's developmental stages. This relationship is underpinned by RQ1, developed in section 3.3.1. The research question investigates children's identification of icon functionality within Piaget's developmental stage. This research question focuses on the effect of identification of animated icons based on objects that are familiar within the child's developmental stage, capturing the relationship between the developmental stages and the 'familiarity' dimension. Therefore a separate research question has not been developed for this relationship.

The rest of this section will discuss the remaining relationships that the dimension of familiarity has with the concepts from the theories of learning. Analysis of the concepts shows that many of them provide a similar view, but captured slightly differently. The underlying factor associated with all of the concepts in this section is how objects and the associated actions are identified by children.

The first theory to be discussed is Vygotsky's Sociocultural Theory. The concept of ZPD complements the dimension of familiarity. This concept is based on the child

achieving his/her potential level of development through the process of scaffolding. By applying objects with which the child is familiar, and through the process of applying animation as the scaffold, the child may be able to identify the function of the icon. The next relationship is that of Vygotsky's concepts of culture and context with the dimension of familiarity. This relationship is a very important one for the designer to understand; this relationship outlines the fact that the design of an animated icon must ensure that it is context specific and that the users are familiar with the pictorial representations that are going to be used to illustrate the function of the icon.

This leads onto Leontjev's Activity Theory principles. The first principle to be discussed is hierarchical structure of activity; if the object is familiar to the child s/he may be more likely to understand the types of activity that s/he can carry out and the functionality s/he may be able to acquire from this particular animated icon. Therefore, the relationship between mediation and familiarity is apparent here; as the child is already familiar with the object they see at the interface, they are able to relate to how they use it in real-life and achieve the functionality they require. This will lead to the user achieving internalisation because they will already be familiar with the object that has been used to display the animated icon. This may lead to the principle of development to occur as the child will be able to use the icon more efficiently as they understand the functionality it offers. Lastly, the relationship between the principle of object-orientedness and familiarity is that the object applied to represent the functionality is something with which the child is already familiar as they may use it on a daily basis.

As previously highlighted, the focus of the remaining relationships was on how objects and the associated actions are identified by children. A previous study which captures this focus was carried out by Liaw et al. (2007), who concluded that Activity Theory is an appropriate theory for understanding e-learning systems for users. The theory provided the opportunity to be able to develop a view into how the users were able to construct their knowledge and actively apply it. In relation to this, studies conducted by Huang et al. (2002) and Uden and Dix (2000) highlight that for icons to be effective and useful, users have to be presented with objects with which they are familiar. These objects should be meaningful to the user and clearly represent the activities associated with the functionality. Both of these

studies capture similar things. However, while the studies have each looked at the key issues, they have not investigated the relationships between the concepts from theories of learning and the dimension of familiarity. The research question below aims to capture these relationships to investigate further in chapter 4.

Research Question 4

If an animated icon implements an object with which a child is familiar, will the child be able to mediate and recognise the functionality the icon represents?

3.3.4 Relationship of Simplicity Dimension with Theories of Learning

This section discusses the relationships that simplicity has with the concepts from the theories of learning. As discussed in section 3.3.3, a separate research question has not been formed for this dimension and the relationships will be investigated further through RQ4, as discussed in section 3.3.3.

The 'simplicity' dimension has key relationships with two concepts from Leontjev's Activity Theory: mediation and internalisation/externalisation. The principle of mediation and the dimension of simplicity may be argued to be related, as keeping the animated icon simple may help to ensure that the animated icon is able to represent the functionality to the user more clearly. Also, this will avoid overloading the screen with inappropriate animation (Bodner 1994). By keeping the animated icon simple, the designer is ensuring that the user is able to mediate between the representation of the animated icon used for that particular function and the real-life object used to undertake the same activity. This makes it more likely that the user will be able to internalise the function of the animated icon.

Studies carried by Huang et al. (2002) and Byrne (1993) highlighted that keeping icons simple they tend to be 'eye catching' and they become appealing to users. A study carried out by Liaw et al. (2007) makes reference to designing e-learning systems underpinned by Activity Theory; they suggest that this enables the design of the interface to be simple and specific for the user community. Nevertheless, the concepts from Activity Theory and the dimension of simplicity have not been investigated in any detail in current research into animated icon design. In essence, the dimension of simplicity should be applied to all animated icon functionality designed for children. However, in relation to this thesis the effect of this dimension

will be investigated through research question 4. A separate research question has therefore not been developed for this dimension.

3.3.5 Relationship of Colour Dimension with Theories of Learning

This dimension aims to highlight the significance of applying colour to objects that are used to represent icon functionality. The application of this dimension can assist the icon objects in representing real-life objects with which the child may be familiar (Huang et al. 2002). In relation to Piaget's concept of schemas, when designing animated icons with objects that exist in the child's environment it can help to apply similar colours that they may see. This will help children to identify objects that they use in the real world and to apply the concept of either assimilation or accommodation to identify the functionality.

The dimension of colour is also related to Vygotsky's concept of culture. Colour can help represent objects with which the child is familiar in their environment. However, the designer needs to check that the colours that are used to represent the object are culturally-specific to the child, as the way in which the object is represented in one country may vary from another.

From Leontjev's Activity Theory, the dimension of colour has relationships with the following principles: object-orientedness and mediation. The principle of object orientedness argues that any activity that people do is aimed towards something that exists in their environment (Kaptelinin et al. 1999). The activities could be affected by the child's environment and cultural settings. Applying an object that is present in the child's environment, and aiming to present it to them using similar colours, may aid them in identifying the activities associated with the object. The dimension of colour also helps the user in mediating the function of the icon as it helps the object to reflect the real life representation.

As previously mentioned, the focus of the relationships in this section is on how the icon functionality is presented to the child to represent something that s/he is able to identify with the assistance of colour. A study carried out by Huang (2007) investigated the effects of colour combinations with college graduates aged between 20 and 41 years old. It was suggested that colour significantly affected the

time it took the users to find a computer icon. However, to be able to fully understand the impact of colour on the identification of animated icon functionality with children aged 11-12 years, a series of practical studies should be undertaken, since Huang's (2007) findings may not apply to this younger age group that forms the focus of our study. Research question 5 aims to capture the key aspects of this dimension's relationships and will be investigated further in the next chapter.

Research Question 5

By designing animated icons that are context specific and applying objects to the design that exist within the child's environment, will s/he still be able to recognise the functionality of the icon as easily when it is presented in black and white?

3.4 Specific Research Questions

The overall aim of this research is to evaluate the effectiveness of animated icons when informed by the concepts from the theories of learning. The relationships that have been formed between the theories of learning and the dimensions of animated icons need to be investigated further in order to establish the effect the relationships will have upon the design of animated icons. In section 3.2, a general research question was stated. However, this question provided only a broad perspective on the subject matter for this thesis. Therefore, a set of more specific research questions have been developed to support the investigation of the relationships between the concepts from theories of learning and the dimensions of animated icons and to allow reflection on the child's ability to recognise the function of the icon. Research questions 3 and 4 may sound similar in their area of focus; however they investigate different dimensions of animated icons.

The research questions are re-stated here for ease of reference.

RQ1

Does taking into consideration the child's developmental stage in the design of the animated icon, have an effect on how the child identifies the icon's functionality?

RQ2

Will designing animated icons aimed at the child's potential level of development help him/her to recognise the icon's function?

RQ3

Will designing animated icons that are context specific and that use objects that exist within the child's environment allow the child to mediate the icon's functionality and identify it?

RQ4

If an animated icon implements an object with which a child is familiar, will the child be able to mediate and recognise the functionality the icon represents?

RQ5

By designing animated icons that are context specific and applying objects to the design that exist within the child's environment, will s/he still be able to recognise the functionality of the icon as easily when it is presented in black and white?

Table 3.2 provides a summary of each research question, and shows the dimension(s) and concept(s) are related to each question.

RQ No.	Dimension	Theory	Concept
RQ 1	Semantic distance, Familiarity	• Piaget's Genetic Epistemology theory	• Developmental Stages.
RQ 2	Semantic Distance	• Vygotsky Sociocultural theory	• Zone of Proximal Development (ZPD)
RQ 3	Semantic Distance	• Piaget's Genetic Epistemology theory • Vygotsky's Sociocultural theory • Leontjev's Activity theory	• Piaget – Schemas, Assimilation, Accommodation. • Vygotsky – Context, Culture. • Leontjev – Object-orientedness, mediation
RQ 4	Familiarity, Simplicity	• Piaget's Genetic Epistemology theory • Vygotsky's Sociocultural theory • Leontjev's Activity theory	• Piaget – Schemas, Assimilation, Developmental stages. • Vygotsky – ZPD, Scaffolding, Context, Culture. • Leontjev – Hierarchical Structure of Activity, Mediation, Development, Internalisation/Externalisation.
RQ 5	Colour	• Piaget's Genetic Epistemology theory • Vygotsky's Sociocultural theory • Leontjev's Activity theory	• Piaget – Schemas, Assimilation, Accommodation. • Vygotsky – Culture. • Leontjev – Object-orientedness, Mediation

Table 3.2: Summarising the key concepts being investigated in each research question

The research questions (1-5) will be investigated further in the subsequent chapters in this thesis. Chapter Four will develop a series of practical studies to investigate each of the research questions.

3.5 Summary

This chapter has explored the relationships between the theories of learning and dimensions of animated icons. Each of the relationships has been discussed with suggestions of how they may affect the design of animated icons. Throughout sections 3.3.1 to 3.4 it has been argued the relationships that have been formed between the dimensions of animated icons and theories of learning need to be

investigated further, leading to a series of research questions being developed (see section 3.4). The research questions will now be taken forward into Chapter Four which will outline the practical study phases used to explore them.

Chapter Four

Study Design

4.1 Introduction

This chapter will outline the practical study design used to investigate the research questions, developed in Chapter Three, that explore the relationship between aspects of the theories of learning and the dimensions of animated icons. The series of studies defined in this chapter aims to investigate 11-12 years old recognition of animated icon functionality when their design is underpinned with concepts from the selected theories of learning. The practical studies will aim to provide evidence around the impact that the concepts from the theories of learning may have had on recognition of animated icon functionality. This may aid in developing an understanding of the type and form of objects that might be useful in conveying the functionality of animated icons to children.

The chapter is structured as follows. Section 4.2 will provide a brief analysis of qualitative and quantitative research methods, outlining their applicability to this research area. The section then provides an overview of the specific method adopted for this research and details the type of data collected. Section 4.3 provides a detailed account of the design of the phases for the study that allows exploration of the research questions developed in Chapter Three. Sections 4.3.1-4.3.3 will discuss the key aspects of the study and the approach taken. This section will also highlight the data collection methods applied in order to obtain the evidence required within each of the phases of the study. Section 4.4 outlines the design adopted for the practical study, then goes onto discuss the key lessons from a pilot

study that was undertaken and whether any changes were required as a result to the design of the phases. The outcome of this chapter will be a detailed account of the practical study design.

4.2 Quantitative versus Qualitative Approach

There are many research methods, though they tend to be categorised into qualitative (interpretative) methods and quantitative (positivistic) methods. Selecting which method to use depends on the hypothesis or research questions being investigated (Grinnel & Unrau 2005; Silverman 2000). The categories represent opposing views; however they can, at times, be used to complement each other (Neuman 2003).

Quantitative research methods are based on means to measure on some numerical basis and have little or no detailed contact with people involved in the research (Silverman 2000; Coolican 1994; Hammersley & Atkinson 1989). The characteristics of methods of this type are control, operational definition, replication and hypothesis testing (Abusabha & Woelfel 2003; Neuman 2003; Burns 2000). Generally, the data collected in quantitative research is reduced to a set of numbers/statistics and interpreted in what tend to be short statements (Abusabha & Woelfel 2003; Hammersley 1992; Hammersley & Atkinson 1989). A limitation of this approach is that it fails to take into consideration characteristics of individuals participating in the research (Punch 1998).

Qualitative methods involve developing an understanding of human behaviour and the motive behind the behaviour (Lempp & Kingsley 2007; Denzin & Lincoln 2005). Methods of this type typically rely on four key methods for gathering information: (1) participation in the research setting; (2) observation; (3) interviews; and (4) analysis of documents (Lempp & Kingsley 2007; Abusabha & Woelfel 2003; Marshall & Rossman 1999). A limitation of qualitative approaches is that the conditions or events for the study cannot be replicated to any extent (Burns 2000), meaning the generalisation of results can be difficult (if not impossible).

For this thesis, the position that is adopted is that a combination of quantitative and qualitative methods would be most useful. This approach has been selected as each stance will be useful for different parts of the practical study. The first phase of

the study will aim to identify the types of software package that children use and how often they use them. At this stage of the practical study quantitative methods will be applicable as they will enable simple data to be gathered on the type of software packages used by the children and the frequency of usage in order to help understand the type of icon functionality they use. The second phase of the study will involve developing an in-depth understanding of how children currently view and use static icon functionality and their current level of understanding of objects used to represent the functions. For this part of the study a qualitative approach is helpful as it allows the researcher to be present within the classroom setting and have direct contact with the children. Applying a qualitative approach at this stage of the study enables the smallest of changes in behaviour or comments made by the children to be recorded (Chai & Lim 2004; Burns 2000; Fetterman 1998; Hammersley 1992). The third phase of the study will require children to view a series of animated icons and explain the functionality. Again, for this part of the study a qualitative approach is most useful for all the reasons listed above. Previous studies have applied qualitative research methods when working with children as they enabled the scope to clarify things with the children as well as question them further (Chai & Lim 2004; Theng et al. 2001; Mumtaz 2001; Selwyn & Bollon 2000; Uden & Dix 2000; Jacko 1996; Jones 1990), giving confidence in the decision to use the approach in this research.

Section 4.3 will discuss the practical study in more depth and detail the qualitative and quantitative methods used.

4.3 The Structure of the Practical Study

To investigate the research questions developed in Chapter Three, a series of phases were designed for the practical study. Each of the phases relate to one another and need to be completed in order as each underpins the next phase. The practical study was broken down into the following three phases:

- Phase 1 – Background and Insight Study of Computer Usage.
- Phase 2 – Understanding of Static Icon Usage and Recognition.
- Phase 3 – Development and Testing of Animated icons.

The aim of the first two phases was to understand the type of software packages that the target group of children use and the type of static icon functionality that they may use to carry out a task. The results obtained from phases 1 and 2 underpin the

development of a series of animated icons aimed at 11-12 year olds and are appropriate for the type of activities that the children may carry out at school. Figure 4.1 illustrates each of the phases and its aims as part of the practical study, as well as the showing the research questions each phase addresses. The figure also demonstrates how each of the phases interacts with the others.

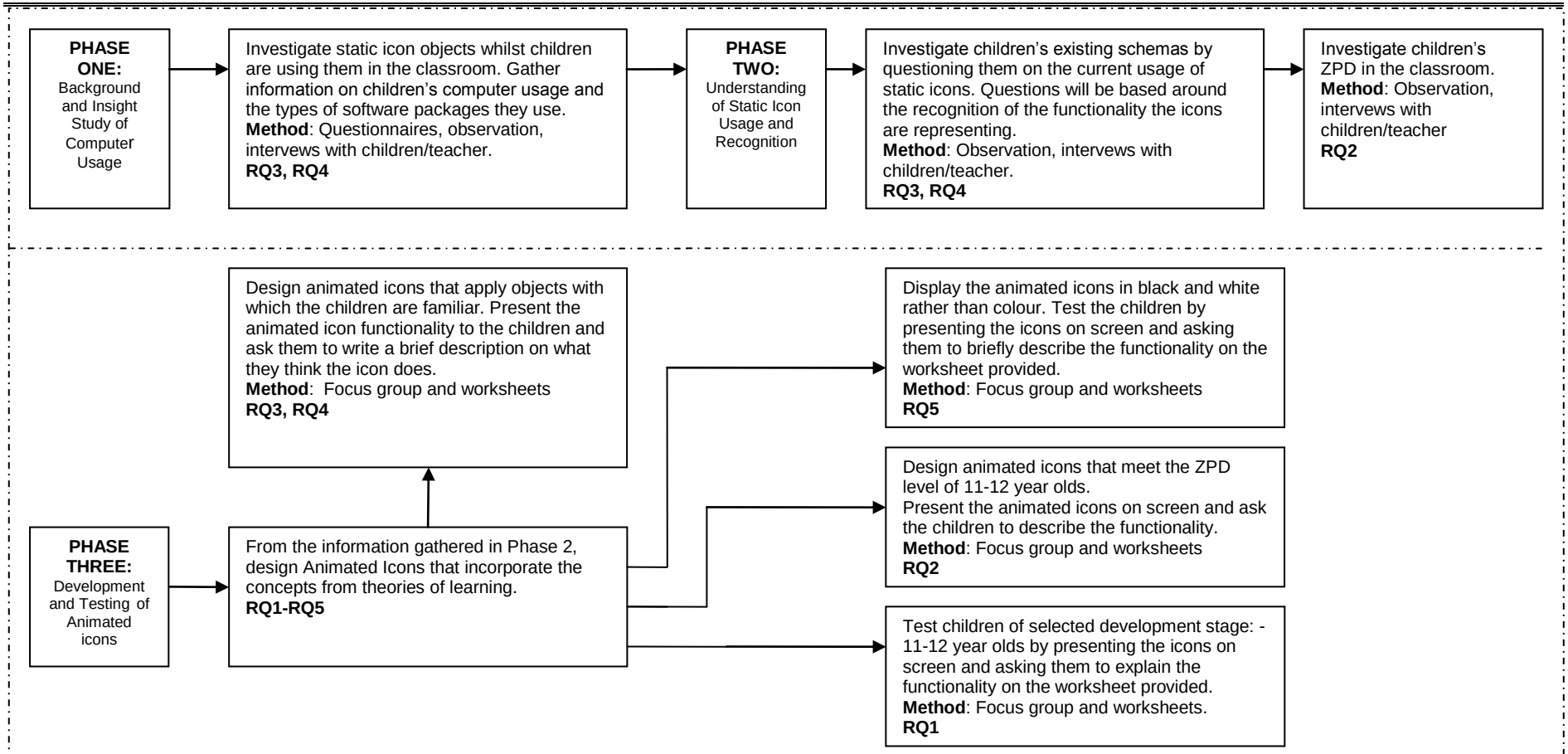

Figure 4.1: A schematic of the key relationships between the phases of the practical study, the research questions addressed and the methods used

Phases one and two of the study contribute to phase three and assist in investigating the research questions that have been developed from the relationships between the concepts from the theories of learning and the dimensions of animated icons that were discussed in sections 3.3.1-3.3.6. The total duration of the practical study was 12 weeks. The time allocated to phase 1 and 2 of the study was eight weeks and the last four weeks formed phase 3 of the study. Each of the phases aims to involve 57 children within the age range of 11 to 12. The choice of sample size is supported by previous research which used a similar sample size in secondary school studies (Calcaterra et al. 2005; Jong et al. 2005; Jacko 1996; Jones 1990). Previous studies have suggested that with an increased sample size, issues can occur in terms of underlying level of reliability in the results, as greater influences in the environment, such as the type of school and location, may cause variations within the sample (Cunningham et al. 2001). In order to evaluate the practical study design a pilot study was carried out. This helped identify any changes that may have been required before proceeding to the main study. The pilot study results are discussed in section 4.4.

In each of the phases, a series of data collection methods was applied to investigate the research questions further. In order to enable clustering of information and aid in identifying patterns across data, a coding technique was applied to the data collected during each of the phases in the study using a simple coding technique. The approach used was similar to the process outlined in Miles & Huberman (1994) and the approach outlined by Strijbos et al. (2006). The pilot study observations were differentiated by using a code of PS1 to stand for “pilot study 1”. The main study observation phase has the code of OB (observation), followed by the session number. For example, session 1 was given the code of OB1. Each line in the observation was given a letter to ensure a unique code for each particular segment of data to enable clustering of information across observations. A similar type of approach was applied to the interviews carried out with the children, with a unique code of IS (interview subject) being used, followed by the interview number. For example, Interview subject 1 was given the code of IS1. Following the convention the observation coding technique, a letter was applied after each code for a particular segment of data to support the identification of patterns across different interviewees. The same technique was applied to the teacher interview carried out, which was given the code TS1 (teacher subject 1).

Sections 4.3.1-4.3.3 build on figure 4.1 and provide a more detailed description of each of the study's phases and the data collection methods used.

4.3.1 Phase 1: Background and Insight Study of Computer Usage

The objective of phase 1 was to gather information on children's familiarity with computers and the type of packages that they use at school and home. Phase 1 of the study consisted of two parts. The first part of the study took the form of a questionnaire that gathered information on the children's computer usage. Appendix A.2 provides a copy of the questionnaire used during the study. The advantages of using a questionnaire are: that it is relatively quick to gather the information required (Coolican 1994); the responses are gathered in a standardised manner, so the questionnaires are more objective (Burns 2000); and for the age group selected the questionnaire approach is simple and quick to complete and the questions can be phrased in a clear manner so that the children understand their meaning (Grinnel & Unrau 2005; Neuman 2003; Coolican 1994). The structure of the questionnaire was based on previous research undertaken with children of a similar age and was based around how children used and perceived computers (Mumtaz 2001). The questionnaire was structured into three sections, which will be described in turn.

Section 1: Demographic Information

This part of the questionnaire presented questions about the child's gender, age, school and year group. Each of these points has their importance in relation to the research area being investigated. Information regarding the child's gender is important to give an indication of the ratio of male and female students in the sample. Also, previous research has suggested that there are gender differences in the way in which children use computers (Colley 2003), so it was important for this research to aim to have a gender balance in its sample. The question regarding the age group category the children fall into is very important to this research as the focus age group is 11-12 year olds and inclusion in the sample was on this basis. The last question in the questionnaire looked at the school attended by the child, as more than one school was used within the research and it was important to be able to identify where the information was obtained from both to allow follow-up (where necessary) and to be able to identify any variations across the schools that took part.

Section 2: Frequency of Computer Use at Home and School

This part of the questionnaire related to the children's use of computers and how familiar the children were in using computers away from the school environment. This question was important as provided an indication of how often the children were using computers and related to questions asked in the following section.

Section 3: Frequency of Computer Activities in the Home and School

The last part of the questionnaire was important to the subsequent phases of the study. The aim of this part of the questionnaire was to get an understanding of the types of software package that the children were using, how often they were using these packages and the types of computer activities that they were carrying out whilst using the packages. The information collected from this section of the questionnaire identified the most commonly used software packages and the types of activities for which they were used, which aided in identifying candidates of icon functionality to animate as part of the later phases of the study.

The second part of phase 1 was an observational study undertaken to observe the types of software packages children used at school. The information gathered during this phase was carried forward to Phase 2 and investigated further in order to gather information related to how children use and identify static icon functionality.

The questionnaire was administered during lesson time and the children were guided through the questions in order to ensure that they understood what each question meant. The observational study was also undertaken during the children's lessons in order to avoid disruption for the children. From the results obtained from the questionnaire and the observational studies, a view of the types of software packages children was developed and this helped to inform the design of Phases 2 and 3 of the study.

4.3.2 Phase 2: Understanding of Static Icon Usage and Recognition

The objective of Phase 2 was to develop an understanding into the types of objects that exist in the child's environment and how they interact with them. According to Piaget, it is important to investigate the objects that exist in the child's environment as they build on the child's internal schema (Gross 1998; Hilgard & Bower 1975). Investigating the child's usage of computers will enable a picture of the child's

knowledge base of computer use to be built. Also, this phase aimed to investigate Vygotsky's concept of the Zone of Proximal Development (ZPD) by a series of methods. In Chapter Two, these concepts from the theories of learning were defined and the importance of encompassing the concepts in the design of animated icons was highlighted. Therefore, this part of the study aimed to investigate the participants' ZPD levels and how they identify static icons. Phase 2 of the study aimed to investigate Research Questions 2, 3 and 4.

The first part of phase 2 study investigated the objects that exist in the child's environment. This was achieved by conducting an observational study. Following on from this, interviews were used to establish the child's identification of static icon functionality and whether they were able to accurately identify icon functionality.

The observational study and interview gained data on the following issues:

- The objects with which the children were familiar.
- The type of static icon functionality that the children used.
- How they identified static icon functionality.
- The frequency of static icon usage.

The points made above are important for this research as they will lead to an understanding of the type of static icon functionality that the children were using in their schools. From the study, an analysis can be undertaken of the type of static icon functionality that the children were able to identify. The observations allowed gathering of rich data in natural settings, a better description and understanding of the research area (Chai & Lim 2004). Questioning children on the functionality of the static icons that they use can help to establish whether the children are able to recognise the function. In order to validate the information collected from the children and gain a further understanding into how children use static icons at school, an interview was carried out with the teacher. This approach enabled an understanding to be developed from the teacher's perspective on the type of functionality that they thought that children might be using in undertaking classroom tasks and/or coursework. The interview was based on a semi-structured approach which enabled questions to be tailored where required. The results of the interview are shown in Appendix B.3.

From the information collected in phase 2, a series of 'problematic' static icons was selected which children had not applied properly or were not using, as they were unable to identify the function. Once the static icon functionality had been selected for animation, the types of object to be applied to represent the functionality needed to be selected. A focus group was run to get an insight into what types of object the children identified with the functionality being animated. This part of phase 2 aided in the design of the animated icons. A total of 14 animated icons were to be developed. The focus group consisted of six children between 11-12 years old and took place during an ICT lesson lasting 50 minutes. A sample of six children were selected randomly from two classes to be included in this phase as it enabled a focused discussion to take place on the type of objects they thought would be useful to illustrate the functionality.

The main concern of the focus group study was about abstract icons, as they are used to convey to the user abstract concepts and use geometric shapes or graphic symbols instead of concrete images (Weidenbeck 1999; Benbasat & Todd 1993). Results gathered in phase 2 illustrated abstract static icons were the most problematic for children when identifying the functionality. However, there are difficulties in designing these types of icon as it can become very difficult to design icons to convey a certain message to the user as each user will have a different interpretation of the meaning of the icon and it may not be the same as that of the designer (Benbasat & Todd 1993). Therefore, abstract icons can suffer from a great deal of ambiguity. By setting up a focus group consisting of six children it was felt that an understanding might be developed into the types of object that the children related to abstract icon functionality and enabled the group to stay focused on the task. For each of the abstract icons, children were shown pictures of the abstract static icons to be animated (i.e, as shown in appendix B.1) and then questioned on what they thought the functionality meant to them by using the same phrase used by the software packages to describe the functionality when the children put the mouse cursor over the static icon.

Once the children had explained their view of the meaning of each icon, they were then told what the icon actually did. Following on from this, the children were asked for their views on the type of object that they thought might be suitable for representing this type of functionality as an animated icon. In the session, the

children shared ideas on the types of object and sequence of animation that could be applied to represent the functionality. During the session all of the input from the children was recorded (see Appendix B.5). This was then taken forward into Phase 3 of the study.

4.3.3 Phase 3: Development and Testing of Animated icons

The objective of this phase was to design animated icons based on the research questions proposed in Chapter Three and investigate how children identify the functionality. Analysis carried out in Phase 2 led to a series of 'problematic' static icon functionalities being animated. In order to develop an insight into the types of object that the children were able to understand a focus group was set-up. Following on from the input received from the focus group, a set of animated icons were designed and displayed to the children via an Internet browser in the form of a presentation. At the beginning of the session the children were provided with a worksheet to complete (see Appendix D.1) and, as they viewed the icon functionality, they were asked to provide a brief description of what they thought each icon did. The worksheet provided the children with a set of instructions on how to view the animated icons and what they needed to do. This approach was taken by previous research undertaken with animated icons (Uden & Dix 2000; Jones 1990). During the children's interactions with the animated icons, they were asked questions on their choice of explanation. This process aimed to ensure that subjects did not just guess the answer as they had to provide an explanation in support of their choice. In previous research, such 'intrusive' questioning has been used to ensure that the subjects understand the functionality that the icons represent (Baecker et al. 1991; Jones 1990).

4.4 Pilot Study

The three phases that formed the practical study have been outlined in sections (4.3.1-4.3.3). To give confidence in phases 1 and 2, a pilot study was carried out to allow reflection on the process and findings, to ensure they met the requirements of the study before moving on to conduct a (possibly revised) main study encompassing all three phases. The pilot study's aim was to evaluate the effectiveness of the first two phases and data collection methods. The pilot study

was conducted in a school based in Shropshire and a total of 30 children took part. This involved the children completing the questionnaire and the undertaking of the observational study while children were participating in their ICT lesson. As discussed in section 4.3.1, the questionnaire was handed out to the children during their lesson time. Following on from the completion of the questionnaire, the class was asked by the teacher how well they thought the questionnaire was structured and whether they understood each of the questions. The key outcome from the pilot study was that the questionnaire provided the level of information required for phase one of the study and that the children were easily able to complete it. Therefore, there was nothing exceptional to note from the pilot to suggest changes to the practical study and the pilot study results were therefore consolidated into the main study and will be discussed further in sections 5.2 and 5.3. (For the results of the pilot study only see Appendix A.1).

4.5 Summary

This chapter has provided a detailed account of the practical study applied to investigate the research questions developed in section 3.4. Each of the phases in the study has been explained, giving details of the data collection methods used. The aim and operation of the pilot study has been discussed and it was noted that no changes were made to the main study as a result of the pilot. Chapter Five will now provide a detailed account of the results obtained during the three phases of the study.

Chapter Five

Reporting on the Practical Study

5.1 Introduction

Chapter Four introduced the three main phases of the practical study. The phases were constructed to help gain an understanding of how the children used icon functionality and to inform the design of the animated icons so that the research questions formed in Chapter Three could be investigated. Phases 1 and 2 aimed to develop an insight into the children's familiarity with static icon objects and to develop an understanding of how the children used static icons. Both of these phases aided in addressing objective four from Chapter One – 'to carry out practical study investigating recognition of animated icon functionality for children aged 11-12'. A pilot study was carried out to evaluate the approach being applied in phases 1 and 2 before the main study was undertaken. Each study (pilot and main) were carried out at different schools. Analysis of the findings from phases 1 and 2 formed the basis from which decisions were made about the specific icon functionality to be animated as part of phase 3.

The outcome of the chapter is the analysis from each of the phases in the main study. This chapter is structured to reflect the practical study phases. Section 5.2 discusses the results obtained from the study in phase 1 and section 5.3 outlines the results gathered in phase 2 of the practical study. The static icon functionality that was chosen for animation will be determined and discussed in section 5.4. Section 5.5 and 5.6 will discuss the animated icon design in depth, taking into consideration the findings from each of the phases and the research questions outlined in Chapter Three. This will aid in investigating the effect of animated icon recognition by children when the design is underpinned with the concepts from the

theories of learning, the results of which will be taken forward to Chapter Six. Finally, section 5.7 discusses the findings from phase 3 of the study.

5.2 Phase 1: Results

Phase one of the study had a total of 98 subjects (including the pilot study sample). The sample was split across two ICT classes with the same teacher. Feedback from the pilot study suggested that the questionnaire was easy to understand for the children and provided the level of data required for the phase (See Appendix A.1 for pilot study results and Appendix A.2 for the questionnaire design). The questionnaire was administered during the children's ICT class, during which they were asked to complete it and hand it in. The same approach used in the pilot study was applied to the main study, explaining the aim of the questionnaire and providing instructions to the children on how to complete it. Tables 5.1 and 5.2 provide a summary of the data collected within this phase of the practical study.

Results from the questionnaires show that slightly more females participated than males, and an almost equal number of 11 and 12 year olds took part in the study. The study indicated that the children had access to a computer at least once a week, with the majority having access every day. The second part of the questionnaire focused on the types of software packages that the children were using at school and home. The study showed that the most popular software packages that were accessed at least once a week were: Microsoft Word, Powerpoint and Internet Explorer (see table 5.2).

Questionnaire Data	
Demographic Information: *Gender*	
Male	46
Female	52
Demographic Information: *Age Category*	
10 years old	1
11 years old	47
12 years old	50
13 years old	0
Frequency of Computer Use at School & Home: *Access to Computer at Home*	
Yes	93
No	5
Frequency of Computer Use at School & Home: *Usage Frequency at Home*	
Never	0
Occasionally	6
Once a month	6
Once a week	32
Everyday	54
Frequency of Computer Use at School & Home: *Usage Frequency at School*	
Never	0
Occasionally	15
Once a month	0
Once a week	78
Everyday	5

Table 5.1: Summary of the questionnaire data collected in phase 1 of the study.

Questionnaire Data								
Software Package Usage	Word	Access	Excel	PowerPoint	Publisher	Outlook	Internet Explorer	Paint Shop Pro
Never	4	55	34	3	38	48	3	49
Occasionally	18	30	32	26	28	16	14	17
Once a month	15	1	15	26	12	4	8	7
Once a week	52	9	12	37	14	16	33	17
Everyday	9	3	5	6	6	14	40	8

Table 5.2: Summary of the frequency of software packages used by the children questioned in phase 1.

Phase 1 of the study observation was carried out whilst the children were in their ICT lesson working on coursework based on a range of Microsoft software packages. The observation was split evenly across two ICT classes, with 57 children observed overall. The observation for this part of the study was carried out over a two week period. The most common software packages that were used by the children during the observation were Microsoft Word and Internet Explorer (see Appendix A.3-PS1A, PS1B, OB1A, OB2A, OB4B, OB5B). On a couple of occasions, children also used Microsoft Excel for a short period of time; however instructions were provided by the teacher on what to do and which icons to click to execute certain functionality (see Appendix A.3-OB3A, OB3D).

5.3 Phase 2: Observation and Interview Results

The aim of phase 2 was to develop an understanding of the types of object that the children were able to identify and associate with the icon. Also, this phase aimed to investigate the child's ZPD level by developing an insight into the types of icon that the children were unable to identify. Two data collection methods were used in this phase, as explained in section 4.3.2. The first method was of observing children in their ICT lesson. This part of phase 2 built on the data collected in phase 1, which

investigated static icon usage. The observations of the children were carried out in their ICT lessons. During the observation, 'intrusive' questioning was applied in order to fully understand why the children were carrying out certain activities. Intrusive questioning enabled the children to be questioned whilst they were actually using the static icon functionality.

The second method in phase 2 involved interviewing the children. The aim of this method was to develop a deeper understanding of how the children identified icon functionality Across the two ICT lessons, a total of 20 children were randomly selected to be interviewed. The interviews were designed to gather information on the key issues raised in section 4.3.2 (See Appendix B.3 for the interview questions and transcripts.)

In phase 2 observation, it was found that the children were using the very basic icons of 'save', 'print' and 'text formatting' options (See Appendix A.3-PS1G, PS1J, OB1D, OB2F, OB4E). Whilst executing certain functionality ('spell check' or 'open') children tended to use the menu structure (See Appendix A.3-PS1H) rather than selecting the icon that represented the functionality. When the subjects were questioned, it was found that they were unable to relate the icon functionality to the object that had been applied to represent it. They found that by putting the mouse pointer over the static icon object, the text helped them to guess what the functionality of the icon might be (See Appendix A.3-PS1D, PS1E). The types of static icon that the children most commonly used were the 'formatting' icons in Microsoft Word and the 'back' icon in Internet Explorer (see Appendix A.3-PS1J, PS1K, OB4D, OB5E, OB5F). Microsoft Word formatting icons used included 'font size', 'font type' and 'colour'. When questioned, the children were easily able to identify the functionality of the static icons that they more commonly used (see Appendix A.3-OB1D, OB2F).

Table 5.3 summarises the static icon functionality that the children were using successfully and, when questioned, were able to identify.

Software Packages	**Static Icon Functionality**
Microsoft Word	Bold Underline Paragraph Alignment Font Type Font Size Font Colour
Microsoft Excel	Save
Internet Explorer	Back Forward

Table 5.3: List of static icon functionality children were able to identify.

To develop a deeper understanding of the type of icon functionality that the children were required to use in lessons, an interview with the teacher was conducted. The interview provided insights into the types of activity that children aged 11-12 carried out. The results from the interview aligned with the questionnaire results regarding software package usage. The ICT teacher confirmed that children aged 11-12 years old are most likely to be using Microsoft Word, PowerPoint and Internet Explorer during school time (Appendix B.4-TS1A). Static icon usage among children of this age group seemed to be quite low according to the teacher (this was also observed by the researcher), as for simple activities children used the menu structure (see Appendix A.3-PS1H, OB1C, OB2E & Appendix B.4-TS1B). Results from the teacher interview suggested that the static icons that the children were most likely to use were ‘save’, ‘formatting’, ‘bullets’, ‘numbering’, etc. (Appendix B.4-TS1E). The static icon functionality that the subjects were unable to identify will be discussed further.

The interviews with the children sought to develop an understanding of the type of static icon functionality that they were using at home and to look into the types of object that the children were able to relate to certain functionality. During the interviews, sample static icons were shown to the subjects. The sample icons were from software packages that were most often used by the children. The software

packages and functionality were selected based on the questionnaire results and observations carried out in phase 1, as well as the results obtained from the interview carried out with the teacher (See Appendix B.4). These static icons were used to investigate children's understanding of icon functionality that they may have been required to use during their lessons. Each of the software packages was given a unique code, as was each icon, to make it easier to record the icon functionality that the children were able or unable to understand when questioned during the interview sessions. (The sample static icons shown to the children are presented in Appendix B.1)

The static icon functionality that was most commonly used and understood by the children interviewed were icons such as 'print'. For example, in the case of the 'print' icon they were able to recognise the functionality as the object provided a representation of something with which the child was familiar and which he/she had used whether at home or at school (see Appendix B.3 – IS3C, IS4C, IS5C, IS6C, IS8C, IS9C, IS13D, IS13E, IS15C, IS17D & Appendix B.4 – TS1E). The 'save' static icon functionality was identified and used regularly (see Appendix B.3 – IS4C, IS5C, IS6C, IS8C, IS9C, IS13D, IS14C, IS15C, IS17D, Appendix B.4 –TS1E). The results suggest that the children recognised the 'save' function as they had been told by peers or teachers what the icon did (see Appendix B.4 - TS1C, Appendix B.3 - IS20C & Appendix A.3 - OB3D). The other icons that were most commonly understood by children were the basic formatting icons such as 'bold', 'italic', 'font styles', etc. (see Appendix B.3 – IS3C, IS4C, IS6C, IS7C, IS10J, IS11C, IS18C). They felt that the objects used to represent the functionality of these types of icons told them exactly what the icons did (see Appendix B.3 – IS1M, IS13D). Also, the children found that these icons were available across software package, and remembered what they did, allowing them to apply their existing knowledge/understanding (see Appendix B.3 – IS1U, IS13E).

The results of the interviews suggested that children aged between 11 and 12 had difficulty in identifying and associating objects to the functionality being offered. For example, for an icon such as 'spell check' in Microsoft Word, the children interviewed experienced difficulty in identifying its functionality (see Appendix B.3 – IS1J, IS2D, IS3I, IS7K, IS9I, IS11J). They found the object used to represent the functionality confusing and thought that it did not tell them clearly what the icon did

(see Appendix B.3 – IS2P, IS8O, IS11K, IS13F, IS17E). The interview results suggested that the children view the objects used to present the functionality as a suggestion of what the icon might do but they felt that they then had to explore for themselves (Appendix B.3 – IS1I, IS1K, IS6E). However, several of the children interviewed found many of the objects applied to illustrate the functionality of icons confusing and said that they did not clearly represent what the icon actually did (see Appendix B.3 – IS1P, IS2J, IS3F, IS3G, IS7E, IS10D, IS12D, IS15D, IS20E). At times, when the children had tried to guess what an icon meant by just looking at the object, they found that the icon did something different to what they had initially thought (Appendix B.3 – IS5I, IS7F, IS13F, IS17E, IS19E). This caused confusion and difficulty in the way in which children perceive and relate objects to icon functionality (see Appendix B.3 – IS7H). This led to the children going through trial and error at home to find out what particular icons did (Appendix B.3 – IS1V, IS5E, IS11C, IS13G, IS19F). In some cases, children were avoiding using static icons completely and preferred to use the menu structure (Appendix B.3 – IS10E, IS12E, IS15F, IS16F, IS18F). The objects that were used to represent the functionality were seen as being not clear enough for them to recognise. The children did try to identify the functionality of the static icon by looking at the 'mouse over text' but found the explanation to be unclear in relation to what the icon did and often the text did not make sense to them (see Appendix B.3 – IS1L, IS2O, IS6H, IS12I, IS14G, IS16K).

The interview that was conducted with the teacher, also suggested that many of the children went through the menu structure to access icon functionality (see Appendix B.4 – TSIB). This was further confirmed by the interviews with the children where many of the children said that they preferred to use the menu structure rather than static icons (see Appendix B.3 – IS2H, IS2P, IS4K, IS4L, IS5L, IS5M, IS6F, IS8J, IS10E, IS12D, IS14G, IS15F, IS16F, IS17F). Preference for the menu structure was explained as being down to the text helping the children to identify the functionality that was being offered to them (see Appendix B.3 – IS4K, IS5L, IS10G, IS12E, IS14G, IS17I). It seems that the children found using the menu structure easier and felt that it provided them with some level of assurance as they were clicking on textual descriptions for the functionality that they required (see Appendix B.3 – IS2I, IS5L, IS5M). From the interviews it seems that the children had been taught to go, or got into the habit of going to, the menu structure to access functionality and felt

comfortable in following this process (Appendix B.3 – IS6F, IS8K), as the static icons were sometimes not clear and at times the children were unsure of the functionality being offered so avoided using them (Appendix B.3 – IS5M, IS7J).

The study found that many children only used those icons that they understood or had been taught by either teachers or peers (Appendix B.3 – IS3J, IS5G, IS7J, IS13H, IS15H, IS20C). The materials provided by the teacher aimed to encompass using icons for coursework and an explanation was provided on what individual icons did (see Appendix B.4 – TS1D). However, whilst speaking to the children during the interviews, it was found that they still avoided using icons at school as they were worried about clicking on the wrong type of icon and losing their work (see Appendix B.3 – IS5M, IS7J, IS11D, IS11G, IS15G, IS16G, IS18H). To help increase the use of static icons, the children said that they wanted icons with clearer objects that represented the functionality and clearly told them what the icon did (see Appendix B.3 – IS1T, IS9M, IS12N, IS15L, IS16L, IS17J, IS19I & Appendix B.4 – TS1H). The next section looks into the type of icon functionality that was selected for animation in phase 3 of the study.

5.4 Phase 1 and 2 Outcome: Icon Selection and Procedure

The results gathered during phases 1 and 2 informed the process of icon selection for animation. Phase 1 identified the key software packages that children use and from which icons for animation could reasonably be drawn. The observations and interviews carried out in Phase 2 of the study helped to identify icon functionality that the children did not understand. Static icon functionality to be investigated further was selected based on issues including the types of task that the children were likely to carry out at school. This subsequently enabled animated icons to be developed that targeted functionality that the children previously accessed through the menu structure. This section outlines the process involved in selecting the static icons that were candidates for animation. Section 5.4.1 then discusses the results received from the focus group that helped further inform the design of the animated icons.

Icon selection was based on the most common software packages used by the children (as shown in table 5.2): Microsoft Word and Microsoft Internet Explorer. From the classroom observations it was seen that, for some tasks, the children used

the menu structure rather than the static icons and it was these functions that were considered for animation. Table 5.4 lists the static icons that were identified during the observations and interviews as being most commonly not understood by children.

Software Packages	**Icon Functionality**
Microsoft Word	Undo
	Redo
	Cut
	Copy
	Paste
	Bullets
	Numbering
	Spell Check
	Insert Table
	Tables & Borders
	Insert Hyperlinks
	Insert Diagram/Organisation Chart
	Shadow Style
	3-D Style
	Indent
	Help
Microsoft Internet Explorer	Stop
	Refresh
	Home
	History
	Favourites
	Search
	MSN Messenger

Table 5.4: List of static icon functionality that the children were unable to identify.

Following on from the analysis presented in section 5.3 and the discussion with the ICT teacher, a shortlist of key functions as candidates for animation was drawn up, based on the functions that the children were most likely to use in ICT lessons. Table 5.5 shows the static icon functionality that was selected for animation.

Software Package	Static Icon Functionality	Static Icon Object
Internet Explorer	Stop	
Internet Explorer	Home	
Internet Explorer	Favourites	
Internet Explorer	History	
Internet Explorer	Refresh	
Microsoft Word	Cut	
Microsoft Word	Copy	
Microsoft Word	Bullets	
Microsoft Word	Numbering	
Microsoft Word	Undo	
Microsoft Word	Redo	
Microsoft Word	Spell Check	
Microsoft Word	Insert Table	
Microsoft Word	Help	

Table 5.5: Static icon functionality selected for development as animated icons.

- **Microsoft Word Icon Functionality Selected for Animation**

Children in the target age group of 11 to 12 were most likely to be using icon functionality such as ‘formatting’, ‘bullets’ and ‘numbering’ (see Appendix B.4 –

TS1E). However, during the interviews with the children it was found that many of them did not understand what the 'bullet' or the 'numbering' icon did in Microsoft Word (Appendix B.3 – IS4M, IS5N, IS6G, IS7K, IS8L, IS9I, IS16H, IS17G, IS18I, IS20H). As such, this icon functionality was selected to be animated. Another basic functionality selected was the 'spell check' function offered by Microsoft Word. This function was used by the children in their lessons but during the interviews it was found that many of the children were unable to identify the functionality being offered by the relevant static icon (Appendix B.3 – IS2D, IS2E, IS7D). This was mainly because they found the object used to the represent the function confusing and felt that it did not clearly convey what the icon did (Appendix B.3 – IS3I).

The static icons representing the 'undo' and 'redo' functions were also selected for animation owing to the nature of the functionality being offered to the children. When questioned during the interviews, the children were unable to identify the functionality offered by either of these static icons (see Appendix B.3 – IS2M, IS7K, IS9I, IS12G, IS13I, IS15I, IS16H, IS18I, IS20H). During the interview with the teacher, it was suggested that the children were likely to be using the 'copy' functionality during lesson time (Appendix B.4 – TS1E). However, in the interviews with the children it was found that many of them did not understand what the static version of the 'copy' icon did (see Appendix B.3 – IS1J, IS2M, IS5N, IS6G, IS10F, IS11J, IS13I, IS16H, IS17G, IS18I, IS19G), so this functionality was selected to be animated. Another basic icon functionality that the children were unable to identify when questioned was the 'help' icon, available in Microsoft Word (Appendix B.3 – IS8L, IS9I, IS10F, IS12G, IS13I, IS15I, IS16H, IS18I); a function which may be useful to children when they require assistance. The static icon representing 'insert table' was also selected to be animated as, during an observational study (Appendix A.3 – OB1A), it was found that the children used this functionality but when questioned they were unable to associate the static icon object to the icon functionality (Appendix B.3 – IS6G, IS7K, IS9I, IS10F, IS11J, IS12G, IS13I, IS15I, IS16H, IS20H).

The final static icon selected to be animated from Microsoft Word was the 'cut' function. It was found that children use the 'cut' function in lesson time (Appendix B.4 – TS1E), but during the interviews with the children it was found that many of them could identify the object that was used to represent the function but not then

correctly explain/describe the functionality that it represented (Appendix B.3 – IS5N, IS7K, IS9I, IS10F, IS11J, IS13I, IS15I, IS16H, IS18I, IS20H).

- **Microsoft Internet Explorer Icon Functionality Selected for Animation**

The second software package commonly used by the children was Microsoft Internet Explorer. The results from phases 1 and 2 suggested that the 'stop' and 'home' functionality were most commonly misunderstood by children (Appendix A.3 – OB4F, OB5G & Appendix B.3 - IS1J, IS2M, IS3K, IS4M, IS5N, IS6G). For example, during an observational session, one of the children clicked on the 'stop' icon to see what it did as they were unable to guess the functionality of the icon. After, clicking on the icon they thought that the "Internet had crashed" (Appendix A.3 – OB4F).

The other Internet Explorer static icons that were selected for animation as a result of the children's lack of recognition of the functionality that they represented were 'favourites', 'history' and 'refresh'. The 'favourites' icon was selected because, although the children were able to identify the functionality of the icon by the text associated with the icon, they were unable to understand the functionality by looking at the icon (Appendix B.3 – IS7K, IS10F, IS15I, IS17G, IS20H). The object used to the present the icon was found not to be very effective in telling the children what the icon did (see Appendix B.3 – IS14E). Both the 'history' and the 'refresh' icons were seen by the children as being unidentifiable or at least not easily understood (Appendix B.3 – IS1J, IS2M, IS3K, IS4M, IS5N, IS6G, IS7K, IS8L, IS91, IS11J, IS13I, IS14H, IS15I, IS16H, IS17G, IS18I, IS20H). For example, the refresh icon was identified as representing a recycle function (see Appendix B.3 – IS2M, IS14F).

Once the static icons for animation had been identified, the objects that were going to be used to represent the functionality had to be selected. A focus group was set up to develop an understanding of the type of objects and animations that the children thought might be useful in conveying the selected functions.

5.4.1 Phase 2: Focus Group Results

The method for the focus group was discussed in section 4.3.3 and the transcripts from it are presented in Appendix B.5.

In the discussion during the focus group sessions, the static icons ‘bullets’, ‘numbering’, ‘home’, ‘spell check’ and ‘insert table’ were not discussed in detail. This was mainly owing to the decision being made that the static icon objects used to represent these functions could be used in the animations. All other identified static icons were discussed with the participants and objects that could be applied to represent the functionality were suggested. Table 5.6 presents the suggestions made by the participants on the types of object and/or sequences of animation to be applied to represent the functionality.

In table 5.6, each of the icons has been given an acronym; this is followed by a backward slash (‘/”) to show the end of the acronym; a number is then given to denote the line when the characterisation of the function was made in the focus group transcript. For example, the ’stop’ icon has been given the acronym ‘ST’; there are then three instances (‘ST/3’, ‘ST/4’ and ‘ST/5’) denoting different descriptions of the ‘stop’ icon’s function from the focus group transcript. This approach allowed each of the recommendations provided by the focus group to be given a unique code that captured the specific icon and the provenance from the focus group transcript of the specific description to be taken forward into the design of the animated icon functionality.

Icon Functionality	Focus Group Suggestions
Favourites	1. Chocolates (FA/3). 2. Thumbs up (FA/4).
History	1. Pictures of people from history (HI/3). 2. Timeline with text (HI/4).
Refresh	1. Man with long hair, smelly. Then he has a bath, hair cut and no smell (REF/3). 2. Stick man with a bubble over his head with refresh or reload text inside it (REF/5). 3. Stick man appearing big first, going smaller and smaller. Then reappearing to a normal size (REF/6).
Copy	1. Picture being copied from one to two (CO/3).
Undo	1. Rubber – similar to one used in Paint (UN/3). 2. Hand appearing on screen rubbing out a mistake (UN/4)
Redo	1. Rewind button similar to the ones on videos (RE/5).
Help	1. Use text (HE/3). 2. Man scratching his head and looking confused (HE/4). 3. Man looking sad to happy (HE/5). 4. Man with question mark bubble over his head. Bubble to have help text inside it (HE/6). 5. A light bulb (HE/7).
Stop	1. Small hand and then getting bigger (ST/3). 2. Traffic lights (ST/4). 3. Lollipop lady with a stop sign (ST/5).

Table 5.6: Suggestions made for icons drawn from the focus group (see Appendix B.5 for full details)

All of the suggestions made by the focus group were taken forward into the design stages of the animated icons and will be discussed further in section 5.5.

5.5 Phase 3: Animated Icon Design in Relation to Theories of Learning

In section 5.4.1, the static icon functionalities selected for animation were outlined and discussed. Following on from the selection process, each of these functions had to be animated. The aim of phase 3 was to investigate the impact of icon recognition for children when the design of animated icons is underpinned with the selected concepts from theories of learning. Each of the icon functionalities selected were designed taking into consideration the concepts of theories of learning discussed in Chapter Two.

This section will summarise the concepts from each of the theories of learning that were taken into account during the design of each animated icon and provide an illustration of how the concepts were incorporated into the design of each specific icon animation. Table 5.7 shows the concepts that were taken into account during the design of each of the animated icons.

		Genetic Epistemology Theory (Piaget 1896-1980)				Sociocultural Theory (Vygotsky 1896-1934)				Activity Theory (Leontjev 1904-1979)				
		Schemas	Assimilation	Accommodation	Development Stages	ZPD	Scaffolding	Context	Culture	Activity structure	Object Orientedness	Mediation	Development	I/Externalisation
Internet Explorer Functionality	Stop	✓	✓	✓				✓	✓		✓	✓		
	Home	✓	✓	✓					✓		✓	✓		
	History					✓								
	Refresh				✓									
	Favourites				✓									
Microsoft Word Functionality	Cut	✓	✓	✓				✓	✓		✓	✓		
	Copy					✓								
	Undo					✓								
	Redo	✓	✓	✓					✓		✓	✓		
	Bullets	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓
	Numbering	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓
	Insert Table	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓
	Spell Check	✓	✓	✓					✓		✓	✓		
	Help				✓									

Table 5.7: Summary of the concepts from the theories of learning taken into account during the design of each animated icon.

More details on how the concepts were incorporated into the design of a specific animated icon (the ‘stop’ icon) are given in table 5.8 as an illustration of the approach taken. This process was completed for each of the static icon functionalities selected for animation as can be seen in Appendix C.1.

Internet Explorer Stop Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Schemas	Schemas are a concept introduced by Piaget and outline the mental structures that children develop within their environment. Based on this concept, the object selected to represent this functionality was a set of traffic lights. This object was present in the child's environment and they were familiar with the colours that were used to represent certain activities; for example, green means go. Also, during the focus group studies, the children suggested that traffic lights may be a useful way in which the stop functionality could be presented (See Appendix B.5 –S1D) as they identified the red colour as meaning stop.
Assimilation	This concept underpins the design of the animated icon as the object aims to help children assimilate the meaning and identify the functionality based on their previous experiences with the object in their environment. In the focus groups it was found that many of the children were familiar with the object of traffic lights and associated the end point of the animation as the lights changing to red, meaning stop (See Appendix B.5 –S1D).
Accommodation	This concept was taken into account to ensure that the object selected to represent the function was an object that the children were able to understand and identify in real-life. It was found during the focus group that the children were aware of what the traffic light object stood for and were able to identify its associated activities and in turn may be able to accommodate the functionality (See Appendix B.5 –S1D).
Sociocultural Theory	
Context	Context was taken into account whilst designing this icon to ensure that the object applied to represent the function closely matched the representation of traffic lights used in real-life. The animation for the functionality followed the same sequence as for real-world traffic lights. (Section 5.5.1 will outline the animation sequence.)
Culture	The culture concept was reflected in the design of this animated icon as the traffic light object is dependent on the child's cultural setting – depending on which location this icon is designed for, the object attributes may differ. This seeks to take into consideration the activities of the object in the child's environment and may vary depending on which country the child is in. For this thesis, the focus was on children based in the UK.
Activity Theory	
Object –orientedness	This concept is reflected in the design of the animated icon as traffic lights are something that objectively exists in the child's world. With this concept the child should be able to identify the functionality of the icon as they are able to relate the object back to the activities that the traffic lights object carry out in the child's everyday environment. For example, the red light means stop.
Mediation	This concept was taken into account during the design of the animated icons as the object used to represent the function was something that was within a child's environment. They should be able to 'mediate' the functionality as they are able to link it back to how the object works in real-life.

Table 5.8: An illustration of how each concept from the theories of learning underpinned the design of the stop icon functionality.

Following the selection process of the objects and decisions about how to make use of the concepts from the theories of learning in the design of each animated icon, the sequence of the animation had to be designed. Section 5.5.1 provides an illustration of the animation sequence, frame by frame, for the 'stop' icon functionality. The other animated icons that were developed are detailed in Appendix C.2.

5.5.1 Phase 3: Animated Icon Design/Story Board

The animated icons were designed in a sequence of four frames; a similar approach to that used in previous studies (see Bodner & Mackenzie 1997). This section outlines the sequence of the animation frame by frame for the 'stop' icon using a 'story board' (see Figure 5.1). The story board provides a walk through outlining each distinct stage of the icon's animation. Frame 1 was the starting point of the animation and frame 4 was the end point. Once the animation had finished playing it displayed a static version of frame four.

Icon Functionality 1: ***Microsoft Internet Explorer Stop Function***

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure 5.1: Illustrating the sequence of animation for the 'stop' icon.

A series of 14 animated icons were designed (as discussed in section 5.4.1). Each of the animated icons was designed taking into account the research questions, framed in section 3.4 to investigate the effect of recognition when the design of animated icons are underpinned with the concepts from the theories of learning. Section 5.6 will discuss each of the research questions and the animated icons that were designed to investigate the effect on recognition.

5.6 Phase 3: Research Questions in Relation to Animated Icon Design

A series of research questions were formed based on the relationships between the theories of learning and dimensions of animated icons, as outlined in section 3.4. Each of the research questions had specific conditions that needed to be investigated. In this section, each of the research questions will be discussed in relation to the functionality that was animated. The sequence in which the animated icons were displayed to the children is the same as that shown in the storyboards in Appendix C.2

Each of the animated icons developed was linked to a specific question. For each of the research questions, two or more animated icons were designed for the particular condition, leading to a total of 14 animated icons being developed. Each of the research questions and the animated icons that sought to explore them are captured in table 5.9.

RQ	Animated Icon Functionality	Reasons for Choice
1	Favourites Refresh Help	This RQ aims to investigate the impact of the developmental stages introduced by Piaget. The focus for this thesis was the formal operational stage in which children are starting to understand abstract concepts. Each of the icons selected for animation for this RQ is abstract in nature and the objects used to represent the functionality are based on the recommendations from the focus group (See Appendix B.5 - FA/4, REF/6 & HE/7).
2	Copy History Undo	This RQ is looking into the child's ZPD level and the types of object that they are able to understand dependent on their level. During the focus group, an understanding was developed of the type of object that the children thought may be useful in representing the selected functionality (See Appendix B.5 - CO/3, HI/4 & UN/3). This enabled an understanding to be developed into the child's actual development level and the type of functionality that they were able to relate to certain objects or actions.
3	Stop Cut Insert Table	The aim of this RQ is to investigate the impact on icon recognition when icons are designed with objects with which the children are familiar and are that present within their everyday environment.. For example, the object used to represent the 'stop' icon functionality was of traffic lights, something that the children see on a daily basis, and was an object recommendation by the focus group (ST/3).
4	Bullets Numbering Insert Table	This RQ is based on investigating the value of the icon functionality being presented simply to the child. The icon functionality that was selected for animation for this RQ aimed made use of the same objects used in the software packages with which the children were already familiar. (As such, and as noted in section 5.4.1, the functionality of the icons used to explore this RQ was not discussed in the focus group; see Appendix C.2 for the sequence of animation for each icon functionality).
5	Home Spell Check Redo	RQ5 investigates how children identify icon functionality when an icon is designed with an object with which the child is familiar, but which is presented to the child in black and white rather than in colour. The three icon functionalities selected for animation here aimed to capture objects with which the children were familiar. One of them, 'redo', was drawn from recommendations made by the focus groups. As noted in section 5.4.1, the others, 'spell check' and 'home', were not discussed in depth during the focus group as the objects used to represent the functionalities through static icons in the software packages that the children already used were adopted for animation (see Appendix C.2 for animation sequence & Appendix B.5 - RE/5).

Table 5.9: An overview of the research questions in relation to the animated icon functionality.

Following a high level analysis of each of the research questions, it was found that there were shortcomings in the design of the practical study in relation to RQ5. These were based around the children only being shown the animated icon functionality in black and white. To be able to properly evaluate the impact of the 'colour' dimension, the children should have viewed the same icon functionality in colour, to identify any differences in recognition. Therefore, at this stage a decision was taken not to continue with the consideration of RQ5, meaning that it will not be

discussed in Chapter Six. Further recommendations in relation to it will be made in Chapter Seven.

5.7 Phase 3: Developmental Framework of Animated Icons

In phase 3 the animated icons were made visible to the children via a 'slide show' presented using Internet Explorer. In total the slide show consisted of 14 pages, with only one animated icon presented per page. Once the children entered a page they had to click the 'play' button in order for the animation to start. The animation played from frame 1 and stopped at frame 4. An animation could be viewed again by re-clicking the 'play' button. All but the final page also had a 'next' button which enabled the children to move to the next page of the slide show and view the next animated icon.

5.7.1 Phase 3: Method and Results

Phase 3 was the final phase of the practical study and it aimed to investigate the children's recognition of animated icons the designs of which were underpinned with concepts from the theories of learning. As a result of the analysis carried out in previous phases, a set of static icon functionalities was selected to be animated. In phase 3, the animated icon functionality was shown to the children in the form of a slide show using Microsoft Internet Explorer for ease of presentation. As each child viewed the slide show, they were provided with a worksheet to fill in that aimed to capture what the animated icon represented. The children were asked to explain in a few words what they thought that each of the icons would do (see Appendix D.1). In this part of phase 3, a total of 53 subjects viewed the animated icons. The sample was split across two ICT lessons; the children that had taken part in the focus group study were not involved in phase 3 to avoid bias. The children were provided with instructions related to how to use the 'slide show' and complete the worksheets that were provided. The session was carried out in silence and no conversing was allowed.

The next step in the analysis of the results for phase 3 was to broadly categorise the children's descriptions provided in the worksheets for each animated icon function. To support the discussion of the results gathered during this phase, the

results were allocated to broad categories, identified during a first pass through the results:

- Category 1: the icon functionality has been correctly described in the child's description.
- Category 2: in the description the child has provided the function of the icon but done so in a less than concise way.
- Category 3: the child's description describes the images shown in the animation of the icon but does not explain the function that it represents.
- Category 4: the child's description does not identify the icon's functionality or describe the animation.

The detailed results gathered during phase 3 of the study are given in Appendix D.2 where set of tables is presented for each animated icon demonstrating the types and frequencies of responses gathered from the children through their responses recorded on the worksheets.

To illustrate the allocation of the results to categories, an example is given in Table 5.10, which presents the frequencies of the responses for the animated icon stop function in each of the four categories along with the children's actual responses.

Internet Explorer Stop Function Responses							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Stop	27	Go, slow down, stop	4	Ready, steady, go	1	Something to change	1
		Stop, ready, go	4	Go, steady, go	1		
		Stop, think, go	2	Yes, maybe, no	1		
		Go, stop	2	Green, orange to red	1		
		Go, ready, stop	4	Traffic Lights	5		

Table 5.10: The frequency of the children's responses for the stop icon in the four categories.

As can be seen in table 5.10, the category 1 and 2 responses drawn from the worksheets identify the stop functionality. Category 1 was the most frequent response type (27 instances) and identified the stop functionality succinctly. Category 2 was second most frequent (16 instances) and identified the stop functionality in a range of more roundabout ways. Category 3 responses (of which there were nine instances) described the sequence of animation in a range of ways without specifically identifying stop as the functionality of the animation. There was a single instance of a category 4 response, which did not identify the stop function or describe the animation.

Appendix D.2 highlights the types of response received from the children for each of the animated icons during phase 3 of the practical study. Each of the responses has been allocated to one of the four categories. Table 5.11 presents the frequencies of the responses provided by the children in each of the categories for the animated Microsoft Internet Explorer icons.

Microsoft Internet Explorer Animated Icon Functionality				
	Category 1	**Category 2**	**Category 3**	**Category 4**
Favourites	2	0	25	26
History	4	16	26	6
Refresh	0	0	33	20
Stop	27	16	9	1
Home	7	7	37	2

Table 5.11: Frequency of response in each of the four categories for the animated Microsoft Internet Explorer icons in phase 3

As table 5.11 shows, the stop icon seemed to be the most successful of the animated icons in conveying its function to the children, as category 1 responses were the most frequent (27 instances). However, it seems from the results that the children encountered difficulty in clearly identifying other of the icon functionalities from Microsoft Internet Explorer. Many of the responses were seen as category 3 responses, where only the sequence of animation was described rather than the

child being able to identify the icon's function - this was the case for the 'favourites' (25 instances), 'history' (26 instances), 'refresh' (33 instances) and 'home' (37 instances) icons.

Table 5.12 provides a summary of the frequencies of responses provided for each of the four response categories for the animated Microsoft Word icons.

Microsoft Word Animated Icon Functionality				
	Category 1	**Category 2**	**Category 3**	**Category 4**
Cut	50	0	1	2
Copy	9	24	12	8
Bullets	39	6	5	4
Numbering	27	3	5	14
Undo	0	2	2	49
Redo	0	0	26	27
Spell Check	22	10	12	8
Insert Table	33	7	6	7
Help	5	2	42	4

Table 5.12: Frequency of responses for each category for the animated Microsoft Word icons in phase 3

As table 5.12 shows, the key animated icons to be identified clearly by category 1 responses were: 'cut' (50 instances), 'bullets' (39 instances), 'numbering' (27 instances) and 'insert table' (33 instances). During the practical study, the children were more able to successfully identify the functionality of an icon where it has employed an object that existed in the child's environment. The children were able to identify the activity that the object performed and apply this in the description of the icon's functionality that they provided. The animated icons where the children encountered issues with identification of functionality seem to be those that were abstract in nature, for example the 'undo' and 'redo' icons. As can be seen from table 5.12, there were no category 1 responses for either of these icons, reflecting

the fact that none of the children in the sample were able to succinctly identify the icon functionality. This issue will be explored further in Chapter Six.

After the children had viewed the series of 14 animated icons, they were required to answer two key questions at the back of their worksheet. The aim of these questions was to elicit responses that would provide insights into how effective the children thought that the icons had been in conveying the functionality being represented. In Appendix D.2, tables D.15 and D.16 illustrate the responses to these two questions. Overall, the responses suggested that the children found the animated icons useful and easy to understand, with comments that the icons were useful in conveying the meaning of the icon through the animation applied to represent the function (see Appendix D.2 – Table D.16). Some of the children did, though, did find the icons confusing and ineffective in conveying the icon's intended meaning. However, comments such as these were made by only a small number of children (see Appendix D.2 – Table D.16).

To more deeply explore the impact of animated icons on recognition, the phase 3 results will be taken forward into Chapter Six where there will be further analysis to investigate the effects of animated icons on recognition in relation to the research questions proposed in Chapter Three.

5.8 Key Lessons

The key lessons learned during the practical studies are that the children rarely applied existing icon functionality to the tasks that they carried out at school. In many cases, they found the objects used as static icons confusing and were not clear about the function that the icons were meant to convey. Many of the children said that, when at school, they preferred to use the menu structure to access functions as they felt this approach was more reliable and clearer than using static icons as text was used to explain the functions. The results of the study also suggest that abstract icons were more difficult for the children to understand as they were unable to relate to the object being used to represent the icon functionality. It is important that there is appropriate reflection on the results gained from phase three to consider how the findings from the practical study may aid in the development of design principles for animated icon design. This will be discussed further in Chapter Six.

5.9 Summary

This chapter has given a detailed account of the results obtained during each of the phases of the practical study. The chapter reported on each phase of the study, identifying the static icon functionality that were candidates for animation from the findings of phases one and two. The design of the animated icons was discussed, highlighting how objects were selected to represent the functionality and underpinned with the concepts from the theories of learning. The recognition of these animated icons in phase 3 of the study was explored and reported.

Chapter Six

Impact of Theories Of Learning Concepts on the Design of Animated Icons

6.1 Introduction

Chapter Five presented the data collected during the practical study, which consisted of three interlinked phases to explore animated icon recognition in the target group of 11-12 year olds. Each of the animated icons used in phase 3 of the study was designed to support the examination of the research questions presented in Chapter Three. The research questions aim to investigate children's recognition of animated icon functionality when the design of the icons is underpinned by concepts from the theories of learning analysed in Chapter Two. Chapter Six seeks to reflect on and make use of the findings from the practical study to frame design principles that are informed by the dimensions of animated icons and the concepts from the theories of learning. The aim of the design principles is to provide a support mechanism for designers that will help them take into account important issues in the design of animated icons that will promote their correct identification by children.

This chapter is structured as follows. Section 6.2 provides the high level findings from the practical study. Section 6.3 considers the findings from the practical study in relation to the research questions presented in section 3.4, and seeks to provide 'answers' to them. Following on from this, section 6.4 explores what the findings mean for the design of animated icons and how they are positioned in relation to existing research. Section 6.5 highlights the types of support mechanism available to aid the design of animated icons and section 6.6 presents the proposed design

guidance draw from the analysis of the findings of the practical study and reflection on existing literature. This supports the overall aim of this chapter which is to develop a series of design principles based on the concepts from theories of learning that will help design animated icons for children.

6.2 High Level Findings from Practical Study

The practical study was based on three phases, described in sections 4.3.1 – 4.3.3. Phases 1 and 2 sought to develop an understanding of children's icon usage patterns and led to a set of support mechanisms based on the findings for use in phase 3 (see section 5.5). Figure 6.1 illustrates the relationships between the phases.

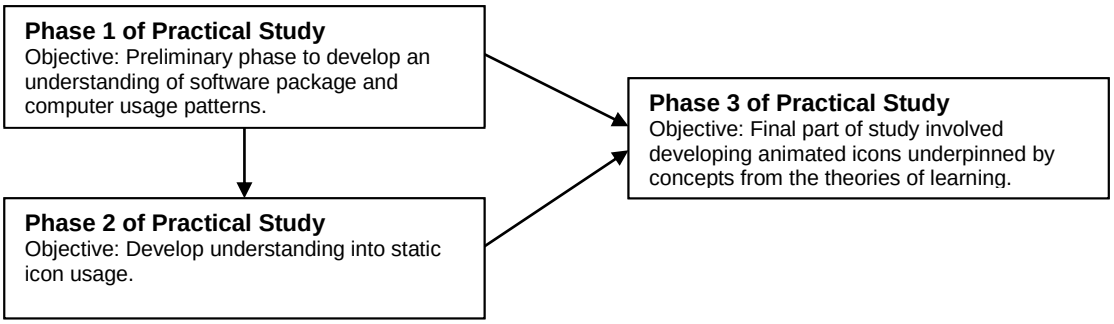

Figure 6.1: An illustration of the interrelationships between the three phases of the practical study

The key findings from phase 1 of the practical study were the types of software packages children used on a frequent basis. It was found that Microsoft Word and Microsoft Internet Explorer (see table 5.2) the most popular for use in the school and at home. Phase two of the study aimed to look into gaining an understanding into how children were currently using and identifying static icon functionality. The study found that many of the children were accessing functionality through the menu structure as they found the text provided them with a guide on what the functionality might do. The type of static icon functionality that the children did use was the formatting icons such as 'bold', 'font size' etc. They found these icons to be easier to understand as the object used to represent the function told them exactly what the icon did. However, when the children were questioned about other static icon functionality available they stated they experienced difficulty in understanding the objects that were used to represent the function as they were unsure of what

they exactly did. This phase of the practical study aided in developing an understanding of the types of static icon functionality children may be required to use during lesson time which aided in selecting icon functionality to be animated for phase 3. The key focus of phase 3 was on the design of the animated icons and involved children viewing a series of animated icons that were designed taking into account the research questions formed in Chapter Three. The findings from phase 3 suggest that the children found that animated icons that used objects that they were familiar with or that existed in their environment easier to identify as they were able to relate the functionality to the actions associated to the object. They also found the animation to be useful in conveying the functionality as it provided step by step illustration of what the animated icon did.

Having set out the high-level outcomes from the practical study, it is important to now discuss them with respect to the research questions that were presented in section 3.4, seeking to provide ‘answers’ to each of the questions. The research questions are based on the relationships between concepts from the theories of learning and the dimensions of animated icons identified in chapter Two, and they seek to understand what issues may affect the identification of animated icon functionality by 11-12 year olds and make use of it in the design of animated icons. Table 6.1 restates the research questions, and their associated underpinning concepts from the theories of learning and relevant dimensions; the icon functionality used in phase 3 of the practical study to explore the questions is also restated.

Research Questions	**Dimensions**	**Theories of Learning: Concepts**	**Animated Icon Functionality**
1. Does taking into consideration the child's developmental stage in the design of the animated icon, have an effect on how the child identifies the icon's functionality?	Semantic distance, Familiarity	• Piaget - Developmental Stages.	Favourites Refresh Help
2. Will designing animated icons aimed at the child's potential level of development help him/her to recognise the icon's function?	Semantic Distance	• Vygotsky - Zone of Proximal Development (ZPD)	Copy History Undo
3. Will designing animated icons that are context specific and that use objects that exist within the child's environment allow the child to mediate the icon's functionality and identify it?	Semantic Distance	• Piaget – Schemas, Assimilation, Accommodation. • Vygotsky – Context, Culture. • Leontjev – Object-orientedness, mediation	Stop Cut Insert Table
4. If an animated icon implements an object with which a child is familiar, will the child be able to mediate and recognise the functionality the icon represents?	Familiarity, Simplicity	• Piaget – Schemas, Assimilation, Developmental stages. • Vygotsky – ZPD, Scaffolding, Context, Culture. • Leontjev – Hierarchical Structure of Activity, Development, Internalisation/ • Externalisation.	Bullets Numbering Insert Table
5. By designing animated icons that are context specific and applying objects to the design that exist within the child's environment, will s/he still be able to recognise the functionality of the icon as easily when it is presented in black and white?	Colour	• Piaget – Schemas, Assimilation, Accommodation. • Vygotsky – Culture. • Leontjev – Object-orientedness, Mediation	Home Spell Check Redo

Table 6.1: A summary of each research question with the underpinning concepts, dimensions and associated animated icon functionality.

Section 6.3 will discuss each of the research questions and seek to provide answers.

6.3 Providing 'Answers' to the Research Questions

This section seeks to explore whether the understanding of the concepts from the theories of learning developing through analysis in Chapters Two and Three, and their application in the design of the animated icons reported in Chapters Four and Five, led to the icons that were recognisable to the children who took part in the practical study. To do this, each of the research questions will be explored in relation to the results gathered in phase 3 of the practical study, and each of this dissertation's research questions will be discussed in turn along with the concepts linked to it.

RQ 1: Does taking into consideration the child's developmental stage in the design of the animated icon, have an effect on how the child identifies the icon's functionality?

The developmental stage considered in this research was the formal operational stage for children aged between 11 and 15. Piaget proposed that at this stage children are thinking hypothetically and can think about what might happen as well as what actually does happen/is happening (Gross 1998; Nichol et al. 1987; Sahakian 1976). At this stage, children can deal with abstract logic and apply it to the environment, develop hypotheses about the world and test them out (Hergenhahn 1982). The 'dimensions' (as defined and explained in Chapter Two) underpinning this research question are 'semantic distance', which refers to the gap that exists between the child's understanding of the icon and the icon representation used at the interface (Preece et al. 1994), and 'familiarity', which seeks to make use of objects which the child is able to relate to and understand. The children taking part in this study were at the early stages of the formal operational stage (as described in section 5.2) – the majority of the sample was 11 years old (see table 5.1).

To help analyse the impact of the developmental stage on how children identified the icon functionality – and therefore to allow the exploration of this research question – the icon functionalities selected for animation were abstract in nature: the Internet Explorer 'refresh', 'favourites' functions and Microsoft Word's 'help' function
.

From the results it can be seen that the children were unable to associate the object and its animation to the 'refresh' icon's function. In relation to Piaget's theory of developmental stages, the children described the individual frames of the animation rather than formulating an abstract concept from the sequence and linking it to the function of the icon. The semantic distance for this icon was high as the children's interpretation of the icon and the icon representation at the interface differed, further suggesting that they were unable to associate the objects with the functionality. For the 'refresh' icon, the object and the sequence of the animation could not reasonably be associated with any action or response present in the child's environment, which may explain why the children encountered difficulty in identifying this abstract icon function.

The types of response gathered for the 'favourite' icon differed to those for the 'refresh' and 'help' icon. In the responses, the children described the sequence of the animation; but in the descriptions they were able to link this to the basics of the 'favourites' icon functionality. As shown in Appendix D.2: Table D.5, the responses illustrate that although the exact words may not have been used by the children to illustrate what the icon meant, the essence of the icon's functionality was captured in the descriptions that they provided. For the 'favourites' icon functionality, the children were able to describe what they interpreted the icon functionality to be. This may have been due to the meaning that the children were associating with the object used to represent the function. The object selected was a 'thumbs up' sign. Depending on a child's experience, this may mean something good or positive and this is reflected in the responses that they gave. The semantic distance for this icon may be argued to have been low as the functionality represented was identified by the children.

The three icons that were animated for this research question returned different results, and this means that a conclusive answer to research question 1 cannot be provided. However, from the analysis of the results it seems the object used to present the function should be of something with which the child is familiar within its environment and/or that the object is linked in the child's experience to a specific behaviour/response that they relate to the abstract functionality of the icon.

An area of concern for this study might be that the developmental stage selected for this question may not be appropriate and that other stages could have been considered and led to more conclusive results. The formal operational stage 'covers' children aged 11 to 15 years old, and in this study the majority of the children that took part were at the beginning of this developmental stage. Repeating the study with slightly older children, towards the latter end of the formal operational stage (for example, 13 year olds), may have provided more conclusive results. The age grouping of the stages is something that could also be investigated further, as this study's findings may suggest that the concrete and formal operational stages overlap with one another.

In summary, the findings in relation to research question 1 suggest that considering the developmental stage may provide some insights into how a child may identify the object used to represent the an animated icon's function, but that this is very much dependent on the individual child's experiences and environment and would need to be carefully considered in designing any animated icons if this were to be useful in offering improved chances of icon recognition.

RQ 2: Will designing animated icons aimed at the child's potential level of development help them to recognise the icon's function?

The aim of this question was to understand how the Zone of Proximal Development (ZPD) affects recognition of animated icons. The ZPD consists of two main components: the actual development level and the potential level of development (Vygotsky 1978). The concept is concerned with how children attain the potential level of development through the assistance of others. As part of the consideration of ZPD, Vygotsky introduced the concept of the process of scaffolding, which involves knowledgeable individuals in the child's environment collaborating with him/her to help the child move from where s/he is now to where s/he can be with help (Harland 2003; Miller 1993; Vygotsky 1978). Once the child has reached the potential level of development, whatever has been learned by the child now becomes the new actual development level for the child and s/he would then start to work towards achieving the new, next developmental stage (Harland 2003; Strauss 1993; Wertsch & Tulviste 1992). Research question 2 was 'underpinned' with the dimension of 'semantic distance' which looks into the difference between how the

child identified the icon function and the icon representation used at the interface; where semantic distance is high, it would be expected that children would (for whatever reason) not be able to understand and explain the icon presented, despite the 'scaffolding' presented by the animation.

In the context of the ZPD, the child's actual development level was seen as the static icon functionality that s/he was able to identify without help or intervention through the study. To investigate the child's actual level of development, it was necessary to look into the types of static icon that the children were using during their ICT lessons and/or at home, as well as how they identified the static icon functionality (i.e., by learning and association between icon and function, or by inferring function from the icon). To this end, a series of interviews were carried out with the children and teacher (see section 5.3) to identify the candidate functions that were then animated. This led to the following icon functions were selected for animation to explore this research question further: Internet Explorer 'history'; and the Microsoft Word 'copy' and 'undo' functions.

The potential level of development of the ZPD for this study looked into how many children were able to identify correctly these three animated icon functionalities. Each animated icon aimed to provide cues or prompts to help the children in identifying and understanding the functionality being offered. The animation sought to provide the children with a visual step-by-step illustration of the functionality being offered by the icon. The animation may be thought of as providing a process of scaffolding to aid the child in attaining their potential level of development (as defined in this study). Figure 6.2 illustrates how each of the phases of the study played a part in the exploration of the ZPD concept.

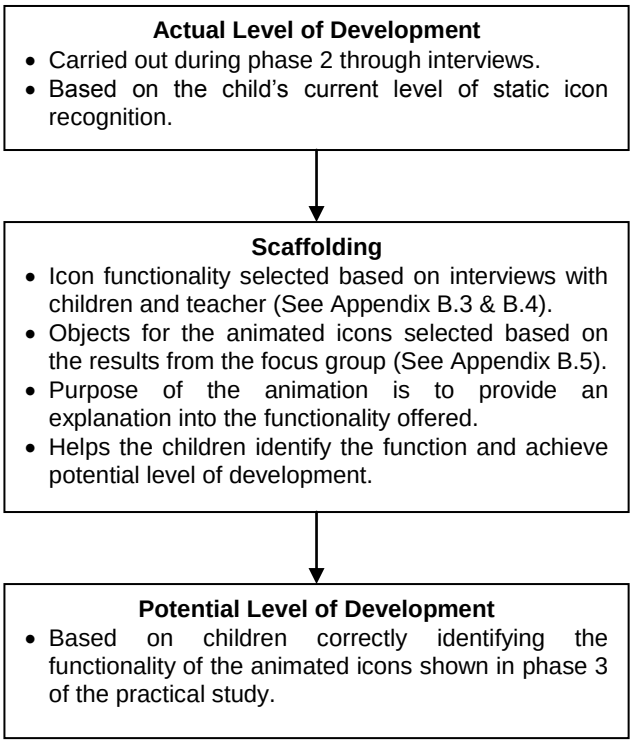

Figure 6.2: ZPD Framework for Research Question 2

The results showed that the majority of the children were able to identify the 'copy' icon functionality (See table 5.12). The animation provided a change in the icon object's state (i.e., the object turned from 1 into 2 as shown in Appendix C.2 – Figure C.4) and the children were able to identify the function represented by the icon. However, for the next two icons considered – 'history' and 'undo' – the majority of children taking part in the study were unable to identify the function from the animated icon that was presented. In these two cases, the semantic distance was high, evidenced by a gap between the descriptions provided by the children and what the icon was intended to represent/convey.

This may have been the case because animations of functionality work more effectively for certain types of icon where the key objects and actions employed are already understood within the child's environment. The icon functionality selected for animation for this RQ were, conversely, abstract in nature and in order to properly understand and identify them the child may have required further support.

The study can, though, be argued to be useful in having helped to identify where using icons (animated or static) is likely to be more problematic. In such cases identification/association with icon function by the child is likely only as a result of the icon being explicitly taught or explained through, for example, the used of roll-over text in line with Widenbeck's (1999) and Blankenberger & Hahm's (1991) suggestions.

Despite the lack of concrete findings for this research question, it has been has suggested that the ZPD should be more actively applied in educational programs (Allal & Ducrey 2000). The ZPD provides the opportunity to develop an understanding of information that the child is easily able to understand and to identify where s/he requires assistance. However, measuring the ZPD can be difficult and complex (Miller 1993), as can be seen in the study's attempt to address this research question, because the concept refers to internal cognitive processes (i.e., the child moving from actual level of development to potential level of development). Other studies suggest that the ZPD can be measured by constant dialogue between the learner and expert whilst the interaction is taking place for each child (Allal & Ducrey 2000; Aljaafreh & Lantolf 1995). However, this type of method can be time consuming and was not used in this study, which instead relied on the observable behaviour of the child.

Another area of concern for this study was the process by which the child reaches the potential level of development, which Vygotsky defined as the 'scaffolding' concept. This concept relies on looking into the sociological dimensions of acquiring new information – that is, learning through interaction with others and the environment (Woo & Reeves 2007). This study adopted the position that using a computer can also be viewed as a social experience and provides a form of interactive learning for the user. Though this is open to challenge, it is a position taken in other studies, such as Woo & Reeves (2007), Chuang & Tsai (2005) and Crook 1991.

In summary the concept of ZPD was useful in developing an understanding into the types of static icon functionality children were able/not able to identify (i.e., the child's actual level of development). However, investigating the potential level of development is more complex as this relies on internal cognitive processes which

cannot be seen or measured. Therefore, no decisive answer can be provided for this research question.

RQ 3: Will designing animated icons that are context specific and that use objects that exist within the child's environment allow the child to mediate the icon's functionality and identify it?

This research question incorporates several concepts from the three theories of learning considered in Chapter Two. These concepts 'share' the basic perspective of building on the existing information assimilated by the child and facilitating the accommodation of new information through interaction with the environment

The concepts from Piaget's theory that are associated with this research question are schemata, assimilation and accommodation (as described in section 2.7.1). Piaget believed that children develop a basic building block or unit of intelligent behaviour called the schemata or schema (Hilgard & Bower 1975). To support the idea of the schema, Piaget introduced a concept called assimilation – the process through which a child takes in information which will then be modified to fit into the child's existing schema (Gross 1998; Hergenhahn 1982; Hilgard & Bower 1975). For those segments of information that the child is unable to assimilate into an existing schema, Piaget proposed another concept called accommodation, which is the process by which an existing schema is changed as a result of new experiences being assimilated (Illeris 2003; Bee 1995).

Vygotsky's Sociocultural Theory informed the research question through its concept of context, which relates to how the child's cognitive development takes place through his/her interaction with the environment. Cultural context has an effect on the child's interaction with his/her environment through, for example, what the child hears others say about the world, how s/he sees others interacting in the world and the physical aspects of the world, all of which affect the child's perception (Gross 1998; Blanck 1990; Vygotsky 1978).

Lastly, Activity Theory informed the research question through its concepts of object-orientedness and mediation. Object-orientedness sees all activity carried out as being aimed towards something that objectively exists in the world (Kaptelinin et

al. 1999). Activity Theorists believe that the activities that the individual carries out are affected by their interaction within their environment. Following on from this is the concept of mediation which refers to how human activity is understood by tools that are both internal and external to the individual (Nardi & Kaptelinin 1997; Kaptelinin 1996). Examples of internal tools are the concepts and heuristics 'held' by an individual; examples of external tools are a hammer and a pair of scissors.

The 'dimension' underpinning this research question – relevant to the concepts from all three theories – is 'semantic distance', which aims to look into the differences between the child's identification of an icon's functionality and the icon representation used at the interface.

In order to investigate this research question further and to explore the effect of the concepts on icon recognition, three candidate icons were selected for animation – the Internet Explorer 'stop' and Microsoft Word 'cut' and 'insert table' functions. The results from the practical study reported in Chapter Five suggest that the majority of the children questioned were able to identify all three of these icon functionalities from the animations that were developed, associating the animation with the icon functionality (see tables 5.11 and 5.12). As such, the semantic distance can be thought of as having been low, as reflected in the tendency to have only small differences between the descriptions provided by the children and the actual icon functionalities.

This positive finding may have been because the animated icon functionality incorporated objects (or tools) that existed within the child's environment and/or because the animation visually demonstrated to the children the context in which the icons' functions could be used.

As noted, the results seem to suggest that the children were able to correctly associate the action/behaviour with the icon functionality – for example the use of the traffic lights, which are a common object in the children's everyday environment, to represent the Internet Explorer 'stop' icon function seemed to aid recognition of the icon's function (see also Shin et al. 2008). In this case, the animation showed the children the sequence of activities that a traffic light would carry out in the real world environment, with the red (stop) light being the final frame of the animation

(see section 5.5.1 and Appendix D.2 – Table D.1). Being able to identify the object and the activities associated with it suggests that it already existed in the child's schema and that they were able to assimilate and identify the animated icon functionality as a result. This might also be explained by the Activity Theory concept of object orientedness, as the children were able to link the activities associated to the object in their environment to the functionality being offered at the interface.

The next two icon functionalities selected for animation were the Microsoft Word 'cut' and 'insert table' functions. The results gathered in phase 2 of the study suggest that these two icon functionalities were used by the children during class work (Appendix B.4 – TS1E). The static icon objects used to represent these functions were also used in the animations. The objects (though not physical) should therefore have already been familiar to the children, even if they were unable to clearly understand the functions associated with the static icons that they represented.

The results illustrate that many of the children were able to identify the 'cut' and 'insert table' animated icon functionalities correctly (see Table 5.12). The object applied to represent the 'cut' function was a pair of scissors, which Activity Theorists (with reference to the concept of mediation) would classify as an example of an external tool that a child may use in his/her environment (Nardi & Kaptelinin 1997). To represent the functionality, the animation demonstrated the same type of activity that the child would carry out with this external tool in their real-world environment (i.e., using a pair of scissors to cut along a dotted line) (see Appendix C.2 – Figure C.3). The results for the 'cut' function seem to demonstrate the effectiveness of making use of a representation of a familiar object that exists within the child's environment in an animation that clearly illustrates the activities associated with the object, as the majority of the children were able to map the activity to the object, which was not the case when the same object was used in the static icon.

This finding may be interpreted in terms of the Vygotskian concept of context and the Activity Theory concept of object orientedness as they are both concerned with the activities that the child may associate with the object used to represent the function. It may be argued that when a familiar static icon object or an object that exists within the child's environment is animated and presented to the children in

the way in which it is used within their environment, they are able to easily identify the functionality. This reflects the experiences of other studies which also suggest that by representing clearly objects that refer directly to a function user's can identify the icon functionality by recognising it from their real-world experiences (Passini et al. 2008).

Moving on to the final animated icon considered in relation to this research question, the case is somewhat different. For the 'insert table' function, the static icon object that was used as the basis for the animation was an object which was not physically present in the environment but with which the children should have been familiar owing to their use of Microsoft Word (see Table 5.2). The results suggest that the majority of children were able to identify the functionality successfully from the animation (see Table 5.12) – they had not been able to associate the static icon with the associated functionality earlier in the study. The animation provided a step-by-step visual representation of the activities associated with the 'insert table' functionality which was able to 'mirror' the activities that would be executed when the child applied the function within Microsoft Word. The results suggest that the children were able to associate an abstract object to the icon functionality with the assistance of the animation.

A way in which these findings may be interpreted is from the Piagetian perspective looking at the concepts of schema, assimilation and accommodation. From this perspective, the static object used to represent the function may have already existed in the children's' schema as they were familiar with it from their use of Microsoft Word (see Table 5.2). The animation provided information related to the functionality which the children were able to assimilate and accommodate. The findings may also be interpreted in terms of the Vygotskian concept of context: the animation provided a means by which the children could view the function in the context in which it would be used. The study carried out by Dalacosta et al. (2009) adds weight to these findings as they have also suggested that the familiarity of objects and the application of animation can be useful as a learning aid for most young children.

The results for this research question demonstrate that the children were able to identify the functionality for each of the icons selected for animation. The focus of

this research question was on whether children would be better able to identify icon functionality if they used objects (physical or abstract) that already exist within their environment and where the animation is context specific. The results suggest that recognition may be more straightforward when the object used in the animation is 'physical', such as in the case of the 'cut' icon, but the 'insert table' icon suggests that the children are able to make use of abstract objects with which they are familiar to help them to understand function represented by the animation. This was the case even where a familiar static icon object that the children were unable to understand was used for the animated icons (see section 5.5 & table 5.12).

Caution must be exercise in making claims here, however, as only a small number of icons were animated. It would be useful to undertake additional animation studies that make use of a wider range of physical and abstract objects with which children are familiar to test the interpretations posited in response to this research question. This is an area that will be returned to in Chapter Seven, when suggestions for future works are discussed.

RQ 4: If an animated icon implements an object with which a child is familiar, will the child be able to mediate and recognise the functionality the icon represents?

This research question captures many concepts across the three theories of learning considered in Chapter Two. The concepts represent cores perspectives associated with how children acquire information through objects with which they are familiar and with which they interact in their environment. Research questions 3 and 4 overlap in their areas of focus; however, they investigate different dimensions of animated icons and draw on different concepts from the theories of learning.

For this research question the concepts that were 'adopted' from Piaget's theory were schemata, assimilation, and accommodation (as described in section 2.7.1; RQ3). Relating to Piaget's concept of accommodation is the concept of scaffolding, introduced by Vygotsky. The process of scaffolding involves the child learning from others in his/her environment through collaboration (Harland 2003; Miller 1993; Vygotsky 1978). Another concept from Vygotsky's theory – that of culture – is also important with respect to this research question. This concept is concerned with how the child's intellectual life begins in their environment (Smith et al. 1998) and

how he/she may be influenced by the behaviour of others (Gross 1998; Blanck 1990; Vygotsky 1978). The third and fourth concepts from Vygotsky's theory that are relevant to this research question are those of context (which was described in the discussion of RQ3) and ZPD (which was discussed in relation to RQ2).

Lastly, three concepts from Activity Theory are relevant to RQ4: hierarchical structure of activity; internalisation/externalisation; and development. The concept of hierarchical structure of activity is based on the belief that every activity carried out is aimed at an object, which in turn motivates the activity to take a certain direction (Nardi & Kaptelinin 1997). Following on from this, the concept of internalisation/externalisation is used to describe the underlying, original mental processes involved (Kaptelinin 1996). The term 'internalisation' refers to external activities being transformed into internal activities, whereas the term externalisation refers to internal activities becoming external activities (Nardi & Kaptelinin 1997). The third concept of relevance from Activity Theory is 'development', which refers to how the tools that are mediated are used, not only once but over a long period of time. The understanding that an individual may have of how a tool works may, over time, lead to development in the individual that makes the tool usage more efficient and useful (Kaptelinin et al. 1999). The 'dimensions' (as defined and explained in Chapter Two) underpinning this research question were 'familiarity' and 'simplicity' – the aim being to apply objects to the animation that are familiar to the child and which simply illustrate the icon's function (Uden & Dix 2000). Other studies have also suggested that ensuring animated graphics applied to interactive packages are simple and clear can aid young children's understanding in complex subject areas (Kartiko et al. 2010; Dalacosta et al. 2009).

To explore this research question further, the following Microsoft Word icon functionalities were selected for animation: 'insert table'; 'bullets'; and 'numbering'. As highlighted in RQ3, for the 'insert table' function the same object that was applied in Word to represent the static icon version was used as the basis for the animated version. The same approach – using the existing icons as the starting point – was used in developing the 'bullets' and 'numbering' animated icons. The results related to this research question showed that the majority of the children were able to recognise all three of the icon functionalities, with the children's

responses suggesting that they were able to 'map' the animation to the icon functionality in each of the three cases (see table 5.12).

The positive findings may have been because the animated icon functionality presented to the children applied objects that they were familiar and/or the animation provided a clear demonstration of the functionality being offered.

A way in which these findings may be interpreted is by looking into the Piagetian concept of developmental stages. The focus of this study was on the formal operational stage, the key characteristic of the stage being that children are not limited to only understanding concrete objects; at this stage, they are able to handle abstract objects (Miller 1993; Hergenhahn 1982). For the Microsoft Word 'bullets' and 'numbering' icon functionalities the children viewed the same object that was used in the corresponding static icon representation (which the children could not uniformly identify), but the object was used in an animation to convey the function.

In the discussion of RQ3 it was suggested that the argument could be made that the objects that were used existed within the children's schemas and that they were familiar with them from their use of Microsoft Word (see table 5.2). However, in their use within Microsoft Word's static icons, the children were unable to map the functionality to the static object (see table 5.4). In contrast, the results suggest that the animation was able to provide a clear demonstration of the functionality which the children were able to assimilate.

These results can also be interpreted in relation to the Vygotskian concept of context and the Activity Theory concept of hierarchical structure of activity, as both are relevant to the activities that a child associates with an object in order to achieve a desired outcome in a task. It may be argued from the findings in relation to this research question that when a familiar static icon object is animated and presented in context, clearly demonstrating the series of activities associated with the functionality that the icon represents, the children were able to identify the function without difficulty. According to the Activity Theory perspective, the animation may have enabled the icon functionality to be internalised, with the children 'developing' in such a way as to enable them to understand how the function works so that they can apply it in the future.

As previously stated, the majority of the children who took part in the study were able to identify all three icon functionalities effectively (see table 5.12). Taking into consideration the Vygotskian concept of ZPD and the application of the framework outlined in Figure 6.2, the animation seems to have been able to provide the children with a scaffold to achieve their potential level of development (as outlined in RQ2), as it was able to clearly illustrate, step-by-step, the functionality being offered, in turn enabling the children to identify the function.

To recap, the results for this research question demonstrate that the children were able to identify each of the icon functionalities selected for animation. The focus of this research question was to look into how children identify icon functionality when presented with familiar objects. The results suggest that the children were able to identify the animated icon functionality when they were portrayed using familiar abstract objects. Each animation seemed to aid in demonstrating to the children the activities associated with the icon functionality. However, as outlined in RQ3, only a small number of icons were animated in this study. It would be useful to carry out further studies of the effectiveness of animated icons with a wider range of familiar (and unfamiliar) abstract objects. This will be discussed further in Chapter Seven when considering future work.

6.4 What these 'Answers' Mean for the Design of Animated Icons

This section seeks to explore how the answers to the research questions may aid animated icon design for children and to identify key themes emerging from the research. This section will also consider the types of support mechanism currently available for animated or static icons in order to select an appropriate form through which to express the findings from this research. Following on from this, the section will look into how the answers to the research questions may address identified gaps within the research field.

The aim of this research was to explore the effects on recognition when animated icon design is underpinned with concepts from theories of learning. The practical study aimed to focus on the functionality of the icon and identify objects that would be best suited to represent the chosen functionality to children aged 11-12. The analysis of the 'answers' provided for each of the research questions led to the

identification of different types of icon functionality. We suggest that these icon types provide a useful starting point from which to understand how icon functionality could be more effectively displayed to the user and may be useful in the design of animated (and static) icon functionality. Table 6.2 presents and defines each of the icon types.

Icon Type	**Definition**
1. Object exists in child's environment	This icon type makes use of objects that physically exist within the child's environment; through this class of object's use in animations, the child is able to directly map the object used to the functionality of the icon (i.e., in the case of the cut function).
2. Activities carried out during the animation	This icon type makes use of activities/actions in the animation that directly reflect an activity or experience of which the child has direct experience in the real world, or in the virtual sense from using software packages (i.e., the bullets and numbering function in Microsoft Word).
3. Extra assistance required alongside animation	This icon type covers those icon functionalities which are abstract in nature (i.e., the help function) and where it is extremely difficult (or impossible) to identify physical objects or activities that naturally convey the meaning through association or 'mirroring' of real-world experience. For this type of icon functionality, additional assistance outside the animation may well be required (i.e., the use of 'roll-over' text to aid the user in identifying the help function).
4. Dependent on child's previous activity	This icon type refers to those icon functionalities that are context specific and dependent on a specific (usually recent) activity of the child (i.e., the undo function). Icon functionalities of this type are difficult to capture via animation as selecting a physical object or activity to represent the function can be complex as there needs to be awareness of the context and situation that the child (user) is in. For this type of icon functionality it may be useful to provide the user with extra assistance (i.e., the use of 'key tag words' that children relate to the functionality may assist in identifying the undo function).

Table 6.2: Categorisation of the icon types to emerge from the 'answers' developed to the research questions

The icon types in table 6.2 highlight key areas that should be taken into consideration when designing animated icons for 11-12 year old children. As discussed in section 2.5, there is little information available to designers on the effective design of animated icons for children (Bartram et al. 2003; Uden & Dix 2000; Dormann 1994). This can cause many issues in the design of animated icons

as the design may become solely driven by the designer's own perception of what s/he perceives to be of importance. Also, with no clear specific support for animated icon design, problems can occur as there is no information regarding visual representation of animated icons (Jessa & Burns 2007; Alm 2003; Bodner 1994).

This dissertation argues that some type of support should be made available to designers which incorporate the key issues that have emerged in 'answering' each research question in this thesis. This may help designers to understand and incorporate key issues in their animations that should improve a child's recognition of animated icon functionality. Sections 6.5 will discuss further the types of support mechanism that could be used and suggest which will be most useful.

6.5 Reflecting the 'Answers' in Accessible Design Principles

Section 2.5 highlighted the lack of support mechanisms available to support (or inform) the design of effective animated icons. The type of support mechanism that is suggested as most useful in the context of this thesis and its findings is design principles, though other support mechanisms were reviewed to explore their potential when used in this research area. Table 6.3 summarises the types of support mechanism available, with the context of guidance types that are used in the field of interface design taken as the starting point.

Type of Support Mechanism	**Definition**
Rules	Design rules provide pieces of guidance that prescribe what is possible or allowable within the design of a user interface. Studies have suggested that rules are often created as part of the development of standards. The rules seek to ensure that there is a clear description of what needs to be done and that the guidance is consistently applied (Morris 2010).
Standards	A standard is defined as an agreed, repeatable way of doing something. It is published guidance that contains technical specifications and is designed to be used consistently (BSI Group 2010). It has been argued that design standards are too prescriptive, or rigid, and allow little scope for flexibility which leads to difficulty in practical implementation (Sidney 1991).
Guidelines	Guidelines are detailed recommendations with examples, added explanations, and other commentary that may be required to support the design of the interface (Sidney 1991). The development of guidelines is driven by expert judgement and practical experiences rather than on experimental data (Abascal & Nicolle 2005; Sidney 1991).
Principles	Design principles provide recommendations based on the fundamental ideas about the practice of good visual design. This type of support mechanism provides guidance and informs the designer of aspects that maybe of use in the design. This type of support mechanism is open to interpretation, offering the designer flexibility in how s/he makes use of the specific guidance provided (Lee et al. 2010).

Table 6.3: An overview of the different types of support mechanism.

The key requirements for a support mechanism in this research is that it should be flexible and adaptable in its approach as the focus is on designing for young children whose requirements can change. It should aim to inform the design of animated icons based on best practice; however, if should also allow a certain level of autonomy to the designer. By looking at the key requirements and the definitions provided for each support mechanisms in table 6.3, design principles seemed to be the most appropriate approach to apply in seeking to frame guidance from the findings associated with this research effort. Guidelines may also have been an appropriate approach for this research, but it was felt that a larger sample of practical experiences would have been required to usefully develop guidelines. Therefore, this thesis will concentrate on the development of high-level design principles which, in conjunction with expert judgement, may be subsequently developed into guidelines. Section 6.6 will discuss the design principles and the process by which they were developed.

6.6 Presenting and Justifying the Proposed Design Principles

This section presents the design principles and discusses how each principle was developed by taking into consideration the findings in relation to the research questions. The section will also highlight how each of the principles should support animated icon design and how they may be used in a wider context.

The aim of this research was to develop a set of design principles to inform the design of animated icons. Section 6.4 highlighted the key icon types that emerged from the analysis of the results gathered for each of the research questions (see table 6.2); the design principles that have been developed are framed around the icon types. This approach helped ensure that the key issues that emerged during the practical study were represented in the design principles. It is suggested that animated icon designers should aim to make a judgement on the icon type that they are developing and select the appropriate design principle that applies to it as a starting point for thinking about their design. Table 6.4 introduces each of the proposed principles.

Icon Design Principle	Practical Study Icon Functionality	RQ	Icon Type
Principle 1 Designers should use objects in the design of animated icons that are familiar to, and physically exist in, the child's everyday life.	Stop Cut	3	1
Principle 2 Designers should use familiar objects and provide children with animations that clearly illustrate the pattern of activities linked to what the icon does.	Insert Table Bullets Numbering	3 3/4 4 4	2
Principle 3 Designers should provide roll over text to those icon functions where real world physical or familiar objects cannot be used to illustrate what the icon does.	Help Favourites Refresh	1 1	3
Principle 4 Designers should provide children with key tag words that the children relate to those icon functions that depend on the user's previous or recent activity.	Copy History Undo	1 2 2 2	4

Table 6.4: The four design principles

The development of each of the design principles outlined in table 6.4 will now be discussed further.

Principle 1

The basis of the first design principle is to make use of objects that physically exist within the child's environment. Making use of this principle will focus the designer on incorporating objects into the animation with which the children are familiar and where they understand what the object does, 'importing' into the animation the meaning and activity that the child associates with the object in the real world.

This principle was embodied during the practical study for two animated icon functionalities: the Microsoft Internet Explorer 'stop' and Microsoft Word 'cut' functions. The objects selected to represent the functionalities were ones that existed within the child's everyday environment and the subsequent animations made use of activities that were associated with the real world objects. The results for each of these icon functionalities showed that most of the children were able to identify the function successfully (see Section 6.3 – RQ3), giving confidence in the value of the principle.

Considering this principle from a Piagetian perspective, it may be argued that it is underpinned by the concepts of 'schema', 'assimilation' and 'accommodation'. As the principle suggests, making use of objects that already exist within the child's 'schema' enables him/her to identify the object and its use within their environment and 'impose' them onto the animation to infer its meaning, and the icon's functionality. A Vygotskyian perspective would stress the concept of 'context' and Activity Theory would stress 'object orientedness', both of which are concerned with how an object is used in the child's environment.

Principle 2

The focus of the second principle is on the choice and nature of the activities/actions that are presented to the children as part of an animation. This principle encourages the linking of the animation sequence to activities or experiences that the child has had in the real world or, in the virtual sense, when using software packages.

This value of the sentiment of this principle was seen during the practical study when looking at icon functionalities such those of Microsoft Word's 'bullets' and 'numbering'. The static icon objects used in Word were employed as the basis for the animation – they were familiar objects for the children owing to their use of Microsoft Word, which had been established during the classroom observations. However, the observations and subsequent practical study showed that, though the objects were familiar to the children, the children were unable to identify the static version of the icon (see table 5.12). The animation, however, was able to provide the children with a step-by-step visual representation of the activities associated

with the icon functionalities. The animation sequence demonstrated to the children a concrete repeatable and predictable pattern of activity which made use of the familiar object and clearly illustrated the functionality being offered. The results for both of these icon functionalities suggest that this approach to animation in these cases led the children to be able to identify the function successfully (see section 6.3 – RQ4).

Looking at this principle from a Vygotskian perspective, it can be argued that the concepts of 'scaffolding' and 'context' underpin the principle – applying it led to an animation that demonstrated the icon functionality in the context in which it might be used. This 'scaffolding' helped the children to achieve their potential level of development, correctly identifying and using the icon. From an Activity Theory perspective, the concept of 'hierarchical structure of activity', which highlights how activities are aimed towards attaining a certain goal, is reflected in the principle. Successfully applying this principle should lead to animations that are able to demonstrate the activities associated with the icon functionality that will be achieved as a result of clicking on the icon (as, for example, demonstrated in the 'numbering' icon functionality).

Principle 3

Principle 3 is applicable to those icon functionalities that are completely abstract in nature, such as the 'help' function. It is difficult to select a physical real-world object or set of activities that are able to reflect the functionality through association or 'mirroring' of real-world experiences. Therefore, this principle proposes that icon functionalities of this type will benefit from the provision of additional assistance outside the animation, such as 'roll over' text to help the children identify the icon functionality. As a result, for icon functionalities of this type it would be useful for the designer to discuss and develop an understanding with relevant children of the types (and combination) of object and text that are most likely to be successful in conveying the icon functionality.

This principle was demonstrated during the practical study where it was found that children were encountering difficulty in identifying abstract icon functionality – the following icon functionalities were in this category: Microsoft Internet Explorer's 'favourites' and 'refresh' functions; and Microsoft Word's 'help' function. The focus

group made recommendations as to the types of object that might be best suited to represent these functions (See Appendix B.5 – FA/4, REF/6, HE/7). However, the focus group also suggested using text alongside the animation in order to aid recognition (See Appendix B.5 – REF/7, HE/3, HE/7). This suggestion was not taken forward into the design of the animated icons as the focus of this thesis was to apply objects to represent the functionality. However, noting the issues that the children subsequently encountered in identifying this type of icon, the use of text alongside the animation may well be of significant benefit.

Looking at this principle from a Piagetian perspective, it can be argued that the concept of 'developmental stages' is relevant. This study focused on the formal operational stage where it has been suggested that children are starting to understand abstract information. The children that took part in this study were at the beginning of this stage which may have had an impact on the results (as discussed in relation to RQ1). To effectively make use of this principle, the designer should talk to children from the target age group to gain insights into the types of object and text that the children would relate to the abstract icon functionality. This will encourage the designer to focus on specific needs of the target age group, as children of different ages interpret information differently depending on their age and environment. There may, though, be issues where the software in which the animated icons are used is general purpose, rather than aimed at a narrow age range, and designers should be aware of this.

Principle 4

Principle 4 is relevant to those icon functionalities that are context specific and dependent on the user's previous activities or actions, such as the 'undo' function – the concept of 'undo' is meaningful only in respect to an action or activity that immediately precedes it. For icon functionalities of this type (i.e., those that are dependent on context to convey meaning), selecting an appropriate physical object to appropriately represent the function is complex, if not impossible. Therefore, this principle suggests that additional assistance is provided in the form of key words that the children associate with the functionality. The choice of meaningful descriptors should be informed by evidence from children in the target user group – though the issue about general purpose software, noted in relation to principle 3, is also relevant here.

The issues represented in this principle were demonstrated in the practical study where it was found that many of the children encountered difficulty in identifying animated icon functionality that was context specific (i.e., related to a user's previous activity). Examples of icon functionalities that fall into this category are Microsoft Word's 'undo' and 'copy' functions, and Internet Explorer's 'history' function. In the focus group, the children did suggest that some form of text representing the icon functionality should be added to the animation for the 'undo' function, for example (See Appendix B.5 – UN/4). Though this was not implemented in the design of the animated icons in the practical study, since this thesis' focus was on only applying objects to represent the functionality, the problems that the children subsequently had in identifying this type of icon suggest that the use of descriptive text alongside the icon would be wise.

Looking at this principle from a Vygotskian perspective, it can be argued that the concept of 'ZPD' is relevant. The use of text with the animation forms part of the scaffolding process, enabling the child to achieve his/her potential level of development by being able to identify the icon functionality successfully. Piagetian 'developmental stages' may also be relevant, as children understand and interpret information differently depending on their age. This principle suggests that, alongside the animation, the designer needs to understand and identify the key words and objects that children may relate to icon functionalities that are dependent on a user's activity.

To conclude, the principles set out in table 6.4 provide a set of guidance/advice that designers should take into account when designing animated icons for children. The nature of the principles is that they are generic and focus the designer on the objects and activities that could be applied to effectively convey icon functionality to the user. The principles are necessarily broad and should not be considered in isolation, but integrated with the designer's experience and other forms of evidence about effective design.

6.7 Summary

This chapter has aimed to explore the research questions further and provide 'answers' to them. For each of the research questions, suggestions have been made on how the concepts from the theories of learning may have impacted on the children's identification of the animated icon functionality during the practical studies. The chapter has reviewed the types of support mechanism available and suggested that design principles would be the most appropriate form of guidance arising from this research. The analysis has led to a small set of design principles being proposed that are aimed to provide advice/guidance on how to design animated icons effectively for children. The principles are underpinned with the concepts from the theories of learning but described in a manner that aims to be understandable and accessible to designers.

Chapter Seven

Conclusions

7.1 Introduction

Chapter Seven concludes the dissertation and summarises the key contributions that have emerged during this research. The chapter is structured as follows. Section 7.2 provides a summary of the dissertation, through brief reviews of each chapter. Section 7.3 presents the high-level conclusions that have been drawn from the research and positions them in relation to the original objectives that were set up in Chapter One. Section 7.4 presents and discusses the original contributions to the research field that have arisen out of the research carried out for this dissertation. Section 7.5 discusses the limitations of the research, before Section 7.6 suggests areas for future research arising from this research effort.

7.2 Summary of Dissertation

This section provides a brief overview of the preceding six chapters of the dissertation, presenting the aim of each chapter and a summary of the key points that were raised and conclusions drawn.

Chapter One introduced the study, giving an overview of the wider context of the dissertation. The chapter highlighted that the dissertation's main focus was on the visual representation of icon functionality in educational software packages for children. The chapter began by focusing on the issues surrounding the importance of interface design and the increasing need to take into consideration the requirements of children when designing software that they are likely to be using. The discussion highlighted the way in which functionality is presented to children in

educational software packages and the difficulties that children face when trying to identify icon functionality. This was linked to the topic of animated icons as it was argued that presenting functionality by applying animation may help the target group of children, aged 11-12 years, to identify the functions. The chapter then went onto argue that it is important to develop an understanding into how children learn and acquire knowledge through interaction with computers and the environment, and suggested that psychological theories of learning may assist in the design of animated icons.

Chapter Two explored the field of psychological theories of learning in more depth, driven in particular by the need to develop an understanding of how children acquire knowledge by interacting with the environment. Key schools of thoughts were examined to review their appropriateness to the research area and issues arising from them were noted. The Cognitive school of thought was selected for this research as it has a key focus on how individuals perceive things in their environment as well as investigating factors that may affect their interpretations. Key concepts from cognitive theories of learning were derived from a literature analysis and were highlighted in the chapter. The chapter also looked into key dimensions that support animated icon design. The focus of the dimensions was on the structural layout of the icons; however, this did not provide an insight into the types of object that could be incorporated into the design of animated icons to aid recognition.

Chapter Three presented and discussed the possible relationships between the dimensions of animated icons and the concepts from the theories of learning presented in Chapter Two. The chapter explored the commonalities between the two aspects and discussed how the relationships may impact the design of animated icons with respect to aiding icon recognition. The chapter concluded by presenting a series of research questions based on the relationships between the theories of learning and the dimensions of animated icons.

Chapter Four sought to define the practical studies to investigate the research questions framed in Chapter Three. Phase 1 of the studies investigated children's familiarity with computers and their usage patterns; this part of the study consisted of a combination of questionnaires and observation. The second part of the

practical study comprised interviews and further observation of children in ICT lessons. This second phase sought to provide an understanding of the types of objects to which the children were able to map the icon functionality. The last phase of the practical study took into consideration the results collected in Phase 2 of the study. A set of animated icons was developed based on each of the research questions and data collection undertaken that aimed to explore whether the children were now able to identify the icon functionality successfully.

Chapter Five presented the analysis of the results collected during each of the phases of the practical study. This chapter, through the reporting of the results from Phases 1 and 2 of the study, explored and identified static icon functionalities that the children were unable to identify and that were therefore candidates for animation in Phase 3 of the study. This chapter discussed the design of the animated icons and the underpinning concepts from the theories of learning. The results of Phase 3 were explored and reported.

Chapter Six provided an evaluation of the data gathered in Phase 3 of the practical study. Each of the research questions was examined and conclusions provided in relation to how the theories of learning and dimensions of animated icons (discussed in Chapter Two) may have affected the identification of the icon functionalities. The analysis led to the framing of a series of design principles, the aim of which was to provide high level advice/guidance on how to design effective animated icons for children.

7.3 Revisting the Research Objectives

In order to present a set of conclusions arising from this work, the research objectives highlighted in Chapter One (section 1.6) will now be revisited to demonstrate how this research has addressed each in turn.

O1 Carry out a literature review and identify suitable theories of learning which may aid animated icon design.

The focus of this research objective was to investigate and explore the theories of learning that were appropriate for the design of animated icons. This research objective was addressed through the literature review conducted in Chapter Two.

In the review, a number of schools of thought and related theories of learning were evaluated in order to establish those most applicable to this research (see section 2.6). The cognitive school of thought was argued to be most relevant owing to the emphasis that it places on mental processes (Anderson 2000). By looking into selected theories of learning within this school of thought, an understanding was developed into how a child may perceive and identify icon functionality. Three cognitive theories of learning were selected as they all take a different perspective on how a child is able to learn information: Piaget's Genetic Epistemology; Vygotsky's Sociocultural theory; and Leontjev's Activity Theory. Each of the theories of learning contained concepts that provided an insight into how children are able to identify and understand new information. However, the way in which these concepts may be incorporated into the design of animated icons and the impact that they may have upon identification needed to be investigated.

O2 To identify the key dimensions of animated icons design and to explore the potential relationships they may have with concepts from the theories of learning.

The focus of this research objective was to investigate relationships between existing literature on icon design and the concepts from the chosen theories of learning. In the literature review, a set of dimensions were developed which led to particular design elements being identified that may be useful in the design of animated icons (see table 2.1). However, the dimensions did not provide guidance to help to select the types of object that could be applied to represent an icon's functionality. This was an area where the application of the concepts from the theories of learning was seen as being potentially useful. In addressing this research objective, the dissertation developed an understanding of how the concepts from the theories of learning complement, and relate to, the dimensions of animated icons. A series of research questions were then formed based on the relationships between the theories of learning and the dimensions of animated icons.

O3 To design animated icons based on the relationships between the key dimensions of animated icons and the concepts from theories of learning.

The focus of this research objective was to design animated icons that are underpinned with the concepts from the theories of learning and the dimensions of animated icons. The animated icons designed at this stage aimed to allow the research questions developed in Chapter Three to be 'answered'.

The focus of this research objective was to develop an understanding into how 11-12 year old children use computers and static icon functionality (see section 4.3). This formed Phases 1 and 2 of the practical study. This approach enabled identification of icon functionality that the children were already able to recognise successfully and apply in school/home. This led to further exploration of those icon functionalities that the children were unable to identify but which, given the functions that they represented, were likely to be of use to them. As a result, a shortlist of key functions as candidates for animation was prepared, based on the type of icon functionality that the children were most likely to use in ICT lessons (see table 5.5). Each of the animated icons was designed based on the research questions which took into consideration the concepts from the previously identified theories of learning and the dimensions of animated icons.

O4 To design and carry out a practical study to investigate children's identification of animated icon functionality, when designed taking into consideration the key dimensions and concepts from the theories of learning.

The aim of this research objective was to develop and design a practical study where children were able to view animated icons whose design was underpinned by the concepts from the theories of learning. As reported in Chapter Four, the practical study was split into three phases. The aim of Phases 1 and 2 was to develop an understanding of how children used icons and to select and develop icons for animation in Phase 3.

O5 To analyse and evaluate the key findings of the practical study on icon recognition.

The focus of this research objective was to analyse the findings from the practical study and to look at the effects that they may have had on icon recognition. The findings from each of the phases were analysed and evaluated in order to examine how the concepts from the theories of learning may have helped to explain how the children identified the functionality. The Phase 3 findings were looked at from the perspective of each research question and the underpinning concepts and dimensions of the animated icons. The analysis of the research questions led to the suggestion of different icon types which might provide a starting point for the designer to recognise and understand how icon functionality of a certain type would be more effectively displayed to a user.

O6 Prepare a set of design principles to guide animated icon design based on the concepts from the theories of learning.

This research objective was addressed during the analysis work reported in Chapter Six. Section 6.3 provided an analysis of the research questions covering the concepts from theories of learning and the dimensions of animated icons, which led to a set of design principles that may aid in designing animated icons for children. The principles were based on the icon types that were developed from the analysis of the practical study data.

7.4 Contributions

This study makes four inter-related contributions to the research area of animated icon design: (i) the identification of key dimensions relevant to animated icon design; (ii) the identification of the relationships between the concepts from the selected theories of learning and the dimensions of animated icons; (iii) the development of a set of animated icons underpinned by the concepts from theories of learning; and (iv) the development of a set of design principles for animated icon design. Each contribution will be discussed in turn.

The first contribution that this work has made is the identification of the dimensions of animated icons. The dimensions were drawn from literature on static icons and studies of animated icon design that highlighted key themes that could be of use when designing icons (see Chapter Two, section 2.4). Combining these two areas (static and animated design elements) allowed insights into the dimensions that are of importance in designing animated icons for children (with a focus on 11-12 year olds), where previously these aspects have either not been taken into account or their significance has been undervalued (Bartram et al. 2003; Uden & Dix 2000; Bodner 1997; 1994). Five dimensions (semantic distance, spatial organisation, familiarity, simplicity and colour) were identified. Previous research suggests that these types of dimension are effective in displaying information to users (Alm 2003; Bartram et al. 2003; Chalmers 2003). The importance of highlighting the dimensions is in providing the designer with a focus on relevant visual aspects of animated icon design. This contribution aims to help designers to focus on key visual aspects of icon design.

The second contribution that this work has made is in establishing and articulating the relationships between the dimensions of animated icons and concepts from relevant theories of learning. This contribution is relevant to researchers in the field and seeks to frame a theory-based perspective on how icon design may be influenced by the concepts from the selected theories of learning. The literature review (see Chapter Two) suggested theories of learning that may aid the design of animated icons. Vygotsky's Sociocultural Theory, Piaget's Genetic Epistemology and Leontjev's Activity Theory were discussed in relation to their potential influence on the design of animated icons. Each of the theories provided a different perspective on how children identify and perceive objects and activities in their environment. The concepts drawn from each of the theories of learning provided a theoretical foundation that, it was argued, may be of use in designing animated icons. This enabled an understanding to be developed of how children interpret information based on their physical object manipulations, and social as well as cultural interactions with their environment. Identifying links between the concepts from the theories of learning and the dimensions of animated icons enabled insights to be developed into the impact of the visual factors on the child's identification and understanding of icon functionality (see Chapter Three, section 3.3).

The third contribution that this work has made is in designing animated icons that are underpinned with the concepts from theories of learning. Each of the animated icons in the practical study was designed to incorporate (or reflect) key concepts from the selected theories of learning. This enabled an understanding of how children aged 11-12 identify and interact with icons at the interface. The results of the practical study illustrated the value of taking into consideration the concepts from the theories of learning in the design of animated icons which can, in turn, be used to provide support to designers who are developing abstract and concrete animated icons for children, and area which previous research has indicated can be difficult (Uden & Dix 2000). This contribution is relevant to academic researchers as it demonstrates how the concepts from the theories of learning underpinned the design of the animated icons used in the practical study.

The fourth contribution made by this research is the framing of a small set of design principles to support effective animated icon design for 11-12 year old children (see Chapter Six, section 6.5). The principles were developed from the evidence collated in the practical study and are one of the few offerings of practical guidance on effective animated icon design for children. This contribution relates to software development, as the proposed principles could be used to provide designers with assistance in designing animated icons. Though the design principles are based on a single study, further research should aid in their future refinement – as Bartram et al. (2003) note, empirical work is much needed in this area.

7.5 Limitations

The contributions that this thesis makes must be set in a context of its limitations, most notably within the practical study. The limitations have been grouped into three key areas: (i) measuring the value/contribution of the concepts from the theories of learning; (ii) the practical study design; and (iii) the context of the animated icons. Each limitation will be discussed in turn.

The first limitation area is focused on the difficulties of being able to measure the value/contribution of the concepts from the theories of learning, as they are related to mental cognitive processes which are difficult (if not impossible) to measure. While this is a characteristic of this study (and of any that seek to look at cognitive

issues through observation), it is suggested that the concepts were useful in developing an understanding into how children understand and interpret the information presented to them during the study. Alternative approaches to data collection may have helped further. For example, previous work by Allal & Ducrey (2000) has suggested that the measuring of concepts such as the ZPD should involve constant interaction with the child. However, this type of method is heavily resource intensive and was not possible in this study, which instead focused on the observable behaviour of the child, as it would have been too disruptive to the children's study.

The second limitation area is based on the practical study design. There are three limitations in this area. First, for this study the sample size selected was relatively small and a bigger sample may have been able to provide a better insight into how children identified the icon functionality. That being said, previous studies carried out by Calcaterra et al. (2005) and Jong et al. (2005) have used a similar sample sizes in secondary school studies, meaning that the research reported in this thesis fits with the samples sizes that are often seen in relevant studies. Having a smaller sample size enabled the researcher to develop a close relationship with the children, which helped them to express their views and ideas openly.

The second, associated, limitation in this area is that the dimension of 'spatial organisation' was not investigated further in the practical study as it was felt that to investigate this dimension the icons would need to be in the context of the software package. Therefore, the impact of this dimension was not investigated through the practical work. The third limitation in this area was associated with 'colour'. The dimension of 'colour' was investigated, but during the analysis of the results it was found that there were shortcomings in the design of the practical study with respect to this dimension. Children were only shown the relevant icon functionality in black and white, yet to be able to properly evaluate the impact of the colour dimension the children should have been able to view the same icon functionality presented in colour, with data gathered that allowed any differences in recognition to be identified.

Finally, the last limitation area was that the children were unable to view and apply the animated icons in the context of a meaningful application such as Microsoft

Word – as a result the size of the animated icons was also increased to ensure that the children could clearly view each icon's animation. For practical reasons, it was not possible to display the animated icons in the context of an application – for example, it was not possible to gain secure access to modify the commercial software in which the icons were presented (such as Microsoft Word and Explorer). Consequently, the animated icons did not have the 'look or feel' of professionally-developed animated icons for software packages such as Microsoft Word. Though not raised as an issue by the children who took part in the study, this may have had an impact on the recognition of the functionality associated with the animations.

Each of the limitations outlined in this section are discussed further in section 7.6 as avenues for future work.

7.6 Future Work

This section addresses issues left outstanding as a result of this study, highlighting key areas that it may be advantageous to explore further within the field of animated icon design.

A limitation area for this study was around the area of the way in which the concepts from the theories of learning were measured. A recommendation for future work, if resources allowed, would be to build on the practical study and to have constant interaction with the children throughout the study. Though this would mean that more time would have to be allocated to this process, it would enable an even closer interaction with each child and constant data collection at all the stages of the practical study. Also, an increase in the sample size for the practical study might aid in developing further insights into how children identify icon functionality and provide greater confidence in the results gained.

Another area for future work is to investigate the two remaining dimensions that were not appropriately explored through the research reported in this dissertation: spatial organisation and colour. Looking into the impact that they may have on animated icon design would provide more complete coverage of the dimensions of animated icons scoped within this study and may provide additional evidence that could be used to offer support to designers of animated icons.

Section 7.5 also highlighted the limitation of the animated icons in the practical study not being presented to the children in the context of an application. A recommendation for future work is to build on the practical study carried out and present a series of animated icons to the children in the context of relevant applications (or high-fidelity 'mock-ups' of them if access to the source application is not possible) and to set-up requirements for the children to identify and use the appropriate icon functionality in undertaking meaningful tasks. This would enable evaluation to be carried out on professionally-designed animated icons and support an exploration of how they might be implemented into everyday software used by children. This would also give an indication into how children identify and interpret the animated functionality when presented to them in a context of a meaningful educational task.

In section 7.4 it was noted that one of the key aim and contributions of this study was the development of a set of design principles (detailed in Chapter Six) which provide guidance on the development of animated icons for 11-12 year old children. Each of the principles proposed was underpinned by concepts from theories of learning and developed from the results gathered during the practical study. The avenues for future work suggested in this section should lead to further development and refinement of these principles and the wider evaluation of their value in, and impact on, animated icon design.

7.7 Conclusion

This chapter has provided a detailed account of the contributions, limitations and potential future work associated with this research. As outlined in Chapter 1, this research aimed to explore the effect that psychological theories of learning may have on the design of animated icons for use by children of a certain age. As a result this research has provided a support mechanism, in the form of a small set of design principles, that aims to help the designer approach key issues in animated icon design.

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APPENDIX A.1

Pilot Study Results

This section presents the observation field notes collected during the pilot study and the questionnaire data collected during the pilot study. The aim of the observation was to develop an understanding into children's icon usage patterns. The information collected during the pilot study observation sessions has been differentiated by the code that has been applied. The coded approach is similar to the process outlined in Miles & Huberman (1994) and approach outlined by Strijbos et al. (2006). For the pilot study the code of PS1 has been applied to stand for "pilot study 1". Each line in the observation has been applied a letter after the PS1 to apply a unique code to that particular segment of data and enable clustering of information. The same type of approach has been applied to the main study observations.

Observation Field Notes Pilot Study (PS1)

Observation Code: PS1 (Pilot study - session 1)

Date of observation: 20/06/05

Where children observed: ICT Lesson

The Wrockwardine Wood School

No. of children observed: 30

Classroom teacher: Jim Milwaters

Time/day to check back: 9.50am till 11.05am (1hr 15 mins)

Code	Tasks Set by Teacher for the ICT Lesson
PS1A	Carry out research on the Internet.
PS1B	Present the research carried out on a subject area they enjoy on Microsoft Word.

Code	Observation Comments
PS1C	Children have access to the school computers everyday and are able to use them during breaks.
PS1D PS1E	In order to understand what an icon the child has to put the mouse over the icon and wait till the text appears to understand what it does. A lot of trial and error is involved in the child recognising the icon.
PS1F	Experienced children use keyboard shortcuts.
PS1G	The basic icons used across packages such as save, print and open are the ones that used and understood by the class. Also the formatting options available they are able to understand.
PS1H	They use the menu structure rather than the icons for simple things like save, print preview etc.
PS1I	When questioned the icons they didn't understand: Microsoft Word Undo Document Map Indent Read Help Research Insert Diagram or organisation chart Show/Hide Spell check

Code	Software	Static Icon Functionality	Frequency	Tasks Executed Accurately	
				Yes	No
PS1J	Microsoft Word	Font Type	11	✓	
		Font Size	10	✓	
		Font Colour	7	✓	
		Bold	6	✓	
		Underline	3	✓	
		Text Alignment	8	✓	
PS1K	Internet Explorer	Back	7	✓	
		Forward	15	✓	

Pilot Study Questionnaire Data	
Demographic Information: *Gender*	
Male	20
Female	21
Demographic Information: *Age Category*	
10 years old	0
11 years old	6
12 years old	35
13 years old	0
Frequency of Computer Use at School & Home*: Access to Computer at Home*	
Yes	39
No	2
Frequency of Computer Use at School & Home*: Usage Frequency at Home*	
Never	0
Occasionally	4
Once a month	3
Once a week	10
Everyday	24
Frequency of Computer Use at School & Home*: Usage Frequency at School*	
Never	0
Occasionally	10
Once a month	0
Once a week	28
Everyday	3

Table A.1: Summary of the questionnaire data collected in the pilot study.

Pilot Study Questionnaire Data								
Software Package Usage	Word	Access	Excel	PowerPoint	Publisher	Outlook	Internet Explorer	Paint Shop Pro
Never	2	26	16	2	16	21	1	19
Occasionally	11	14	15	15	13	8	4	9
Once a month	5	0	6	13	6	3	2	5
Once a week	20	0	3	10	5	3	14	5
Everyday	3	1	1	1	1	6	20	3

Table A.2: Summary of the frequency of software packages used by children in the pilot study.

APPENDIX A.2

Questionnaire Design

Thank you for agreeing to take part in this survey. The purpose of this study is to investigate children's recognition of animated icons which are designed with psychological theories of learning. It will seek to show that animated icons assist children in recognising the function of the icon, arguing that they provide a clear and dynamic explanatory visual representation of the functionality of an icon, which at times static icons are unable to provide due to the ambiguity of the pictographic symbols (Bodner 1994).

The responses received from this questionnaire will help in understanding children's use of software packages and the type of activities they carry out whilst using computers. This will aid in developing an understanding into the types of static icons they are applying to execute the functionality they require and whether they are able to recognise the functionality being represented in the form of a static icon.

Your responses will be treated in the strictest of confidence and no reference will be made to individuals' names, so please feel free to answer the questions as accurately as you can. The questionnaire should not take more than 10 minutes to complete as most questions require you to simply select an answer from the options provided. The results of the study will be used purely for academic purposes.

Participation is voluntary and the children are free to withdraw at any time or decline to answer any particular question. If you have any questions regarding the survey or in general, please contact Mandy at: Manjinder.Shoker@brunel.ac.uk, a research student at Brunel University who is conducting this study.

Thank you once again!

Questionnaire Design for Insight Study 1

Demographic Information

1. Are you:
   - ☐ Male
   - ☐ Female

2. How old are you in? Please tick the appropriate box below.
   - ☐ 10 years old
   - ☐ 11 years old
   - ☐ 12 years old
   - ☐ 13 years old

3. What is the name of the school you attend and which year are you in?

_____

_____

Frequency of Computer Use at Home & School

4. Do you have access to a computer at home? If your answer is no then move to question 6.
   - ☐ Yes
   - ☐ No

5. How frequently do you use a computer at home? Please select one of the options below.
   - ☐ 0 – Never
   - ☐ 1 – Occasionally
   - ☐ 2 – At least once a month
   - ☐ 3 – At least once a week
   - ☐ 4 – Everyday

6. How frequently do you use a computer at school? Please select one of the options below.
   - ☐ 0 – Never
   - ☐ 1 – Occasionally
   - ☐ 2 – At least once a month
   - ☐ 3 – At least once a week
   - ☐ 4 – Everyday

Frequency of Computer Activities in the Home & School

Software Packages	Computer Activities	How often do you use the software package
☐ Microsoft Word	☐ Drawing ☐ Word Processing	☐ 0 – Never ☐ 1 – Occasionally ☐ 2 – At least once a month ☐ 3 – At least once a week ☐ 4 – Everyday
☐ Microsoft Access	☐ Databases	☐ 0 – Never ☐ 1 – Occasionally ☐ 2 – At least once a month ☐ 3 – At least once a week ☐ 4 – Everyday
☐ Microsoft Excel	☐ Spreadsheets	☐ 0 – Never ☐ 1 – Occasionally ☐ 2 – At least once a month ☐ 3 – At least once a week ☐ 4 – Everyday
☐ Microsoft PowerPoint	☐ Presentation ☐ Slide show ☐ Drawing	☐ 0 – Never ☐ 1 – Occasionally ☐ 2 – At least once a month ☐ 3 – At least once a week ☐ 4 – Everyday
☐ Microsoft Publisher	☐ Newsletters ☐ Flyers ☐ Brochures ☐ Web sites	☐ 0 – Never ☐ 1 – Occasionally ☐ 2 – At least once a month ☐ 3 – At least once a week ☐ 4 – Everyday
☐ Microsoft Outlook	☐ E-mail	☐ 0 – Never ☐ 1 – Occasionally ☐ 2 – At least once a month ☐ 3 – At least once a week ☐ 4 – Everyday
☐ Internet Explorer	☐ Web Browsing ☐ Playing Games	☐ 0 – Never ☐ 1 – Occasionally ☐ 2 – At least once a month ☐ 3 – At least once a week ☐ 4 – Everyday
☐ Paint Shop Pro	☐ Editing Photos ☐ Image Editing ☐ Creating new images	☐ 0 – Never ☐ 1 – Occasionally ☐ 2 – At least once a month ☐ 3 – At least once a week ☐ 4 – Everyday

APPENDIX A.3

Observation Field Notes

This section presents the observation field notes collected during the pilot and main study. The aim of the observation was to develop an understanding into children's icon usage patterns. The information collected during each of the pilot and main study observation sessions has been differentiated by the code that has been applied. The coded approach is similar to the process outlined in Miles & Huberman (1994) and approach outlined by Strijbos et al. (2006). For the pilot study the code of PS1 has been applied to stand for "pilot study 1". Each line in the observation has been applied a letter after the PS1 to apply a unique code to that particular segment of data and enable clustering of information. The same type of approach has been applied to the main study observations.

Observation Field Notes Pilot Study (PS1)

Observation Code: PS1 (Pilot study - session 1)

Date of observation: 20/06/05

Where children observed: ICT Lesson

The Wrockwardine Wood School

No. of children observed: 30

Classroom teacher: Jim Milwaters

Time/day to check back: 9.50am till 11.05am (1hr 15 mins)

Code	Tasks Set by Teacher for the ICT Lesson
PS1A	Carry out research on the Internet.
PS1B	Present the research carried out on a subject area they enjoy on Microsoft Word.

Code	Observation Comments
PS1C	Children have access to the school computers everyday and are able to use them during breaks.
PS1D PS1E	In order to understand what an icon the child has to put the mouse over the icon and wait till the text appears to understand what it does. A lot of trial and error is involved in the child recognising the icon.
PS1F	Experienced children use keyboard shortcuts.
PS1G	The basic icons used across packages such as save, print and open are the ones that used and understood by the class. Also the formatting options available they are able to understand.
PS1H	They use the menu structure rather than the icons for simple things like save, print preview etc.
PS1I	When questioned the icons they didn't understand: Microsoft Word Undo Document Map Indent Read Help Research Insert Diagram or organisation chart Show/Hide Spell check

Code	Software	Static Icon Functionality	Frequency	Tasks Executed Accurately	
				Yes	No
PS1J	Microsoft Word	Font Type	11	✓	
		Font Size	10	✓	
		Font Colour	7	✓	
		Bold	6	✓	
		Underline	3	✓	
		Text Alignment	8	✓	
PS1K	Internet Explorer	Back	7	✓	
		Forward	15	✓	

Observation Field Notes Main Study

Observation Code: OB1 (Main study – session 1)

Date of observation: 01/12/05

Where children observed: ICT Lesson

The Chalfonts Community College

No. of children observed: 21

Classroom teacher: Mr Lakhani

Time/day to check back: 8.20am till 9.10am (50 minutes)

Code	Tasks Set by Teacher for the ICT Lesson
OB1A	Time spent by the teacher explaining to the children different types of options i.e. text formatting, tables available within Microsoft Word to improve design layout of quiz.
OB1B	Everyone used Microsoft Word within the class today.
OB1C	Toolbar options explained such as header/footer.

Code	Observation Comments
OB1C	Not many icons used today most work done through the menu bar options.
OB1D	When questioned I found that they understand the basic Word icons such as save, print, open etc.
OB1E	After the children were explained what the numbering point's icon meant. I found that children still were not using the icon and were manually putting the numbers in – when questioned I found they didn't understand what it did.

Code	Software	Static Icon Functionality	Frequency	Tasks Executed Accurately	
				Yes	No
OB1F	Microsoft Word	Font Type	6	✓	
		Font Size	4	✓	
		Font Colour	11	✓	
		Numbering points	5		✓
		Undo	2	✓	

Observation Code: OB2 (Main study – session 2)

Date of observation: 02/12/05

Where children observed: ICT Lesson

The Chalfonts Community College

No. of children observed: 29

Classroom teacher: Mrs Bhudiya

Time/day to check back: 10.15am till 11.05am (50 minutes)

Code	Tasks Set by Teacher for the ICT Lesson
OB2A	Time spent by the teacher explaining to the children different types of options available within Microsoft Word to improve design layout of quiz.
OB2B	Everyone used Microsoft Word within the class today.
OB2C	Toolbar options explained such as header/footer.
OB2D	They were also instructed to use the Internet to carry on with their research.

Code	Observation Comments
OB2E	Not many icons used today most work done through the menu bar options.
OB2F OB2G	When questioned I found that they understand the basic Word icons such as save, print, open etc. Other icon recognition was based on trial and error something they did at home rather than school as they worried they would loose their work.
OB2H	Some of them spell checked work and did not click on the icon at all. When questioned they didn't understand what the icon meant.
OB2I	Bullet/numbering points is an icon that is no used at all by the children even though it's been explained earlier on by the teacher. In the lesson they were required to number the questions they were putting in. when questioned children did not know which one it was.
OB2J	Drawing tools in this lesson the textbox icon was used.

Code	Software	Static Icon Functionality	Frequency	Tasks Executed Accurately	
				Yes	No
OB2K	Microsoft Word	Font Type	7	✓	
		Font Size	7	✓	
		Font Colour	2	✓	
		Bold	1	✓	
		Underline	2	✓	
		Numbering points	8		✓
		Undo	2	✓	
		Spell Check	3		✓
		Paragraph Alignment	2	✓	
		Indent	1		✓
		Text Box	4	✓	
OB2L	Internet Explorer	Back	6	✓	
		Forward	3	✓	
		Stop	4		✓
		Refresh	2		✓
		Discuss	4		✓
		History	3		✓
		Favourites	1		✓
		Search	1		✓

Observation Code: OB3 (Main study – session 3)

Date of observation: 03/11/05

Where children observed: ICT Lesson

The Chalfonts Community College

No. of children observed: 32

Classroom teacher: Mrs Bhudiya / Mr Lakhani

Time/day to check back: 8.20am till 9.10 am (50 minutes)

Code	Tasks Set by Teacher for the ICT Lesson
OB3A	Microsoft Excel – log book. Fill in the log book today providing detail of the tasks they have completed. A new topic was to be introduced the subsequent week.
OB3B	The children are having to type in the activities they have completed and how well they think they have done.
OB3C	No icons use observed today apart from the 'save icon' instructions provided by the teacher.
OB3D	Teacher provided step by step instructions i.e. click once on the save icon or floppy disk.

Code	Teacher Comments
OB3E	Within Excel they will only use the typical icons set such as: font, font size, and colour, print and save. As they mostly recognise these icons from Microsoft Word as this is the package that is mostly used by the children.
OB3F	Any other icons they unable to understand and only use when they are instructed by the teacher as they are unable to identify what the icon actually does.

Code	Software	Static Icon Functionality	Frequency	Tasks Executed Accurately	
				Yes	No
OB3G	Microsoft Excel	Save (the children were instructed to click on the icon by the teacher. However, after questioning them I found they were able to understand the meaning of the icon.)	32	✓	

Observation Code: OB4 (Main study – session 4)

Date of observation: 10/11/05

Where children observed: ICT Lesson

The Chalfonts Community College

No. of children observed: 29

Classroom teacher: Mr Lakhani

Time/day to check back: 8.20am till 9.10am (50 minutes)

Code	Tasks Set by Teacher for the ICT Lesson
OB4A	Time spent by the teacher on instruction and explaining the differences between quiz and questionnaires.
OB4B	Last part of the lesson time was given to children to do some research on the Internet.
OB4C	They also had to fill in their log book.

Code	Observation Comments
OB4D	Icon mostly used by the children was the 'back icon' and they understood what that did.
OB4E	Also, the 'print icon' was used quite often and when questioned they said they understood what it meant because they had seen it somewhere else.
OB4F	The stop icon was misunderstood and when they clicked on it they were confused on what it had done and thought the Internet had crashed.

Code	Software	Static Icon Functionality	Frequency	Tasks Executed Accurately	
				Yes	No
OB4G	Internet Explorer	Back	5	✓	
		Print	1	✓	
		Stop	2		✓
OB4H	Microsoft Excel	Save	8	✓	

Observation Code: OB5 (Main study – session 5)

Date of observation: 18/11/05

Where children observed: ICT Lesson

The Chalfonts Community College

No. of children observed: 26

Classroom teacher: Mrs Bhudiya

Time/day to check back: 10.15am till 11.05am (50 minutes)

Code	Tasks Set by Teacher for the ICT Lesson
OB5A	Time spent by the teacher on instruction and explaining the differences between quiz and questionnaires.
OB5B	Lesson time was given to children to do some research on the Internet about their town.
OB5C	Using Microsoft Word they had to prepare a quiz on where they live.
OB5D	They also had to fill in their log book.

Code	Observation Comments
OB5E	All the formatting and text alignment icons such as underline, bold, centralise etc. used efficiently by the children and when questioned they were easily able to tell me what each of the icons did.
OB5F	While searching on the Internet most of the children used the 'back icon'.
OB5G	When I questioned some children on their icon usage I found that they were unable to understand the following icons within Internet Explorer: 1. Stop 2. Refresh 3. Home

Code	Software	Static Icon Functionality	Frequency	Tasks Executed Accurately	
				Yes	No
OB5H	Microsoft Word	Font Type	10	✓	
		Font Size	8	✓	
		Font Colour	9	✓	
		Bold	4	✓	
		Underline	2	✓	
		Text Alignment	8	✓	
		Bullet points	1		✓
		Numbering points	2		✓
OB5I	Internet Explorer	Back	4	✓	
		Stop	1		✓
		Refresh	1		✓

APPENDIX B.1

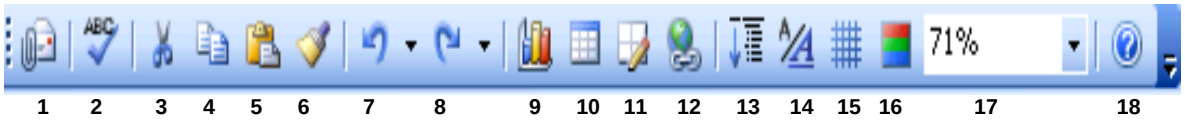
Sample Interview Static Icons

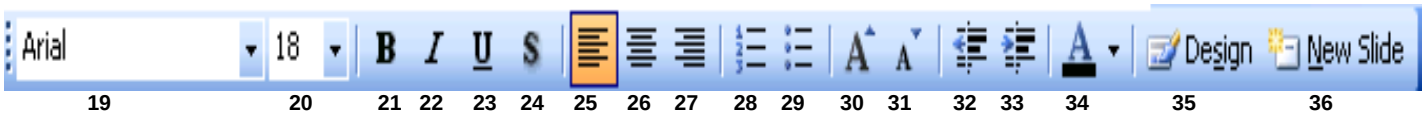
A sample of static icons were selected from each of the software packages that were most commonly used by the children and functionality was selected on the basis of the observations made. These static icons were used to verify the children's understanding of selected functionality they were required to use during their lessons. Each of the software packages was given a unique code and each icon was also given a unique number to make it easier to record the icon functionality that subjects were unable to understand when questioned during the interview sessions. The coded approach is similar to the process outlined in Miles & Huberman (1994) and approach outlined by Strijbos et al. (2006). For example, for Microsoft Word the code of MSW has been applied to stand for "Microsoft Word" and then each icon has been given a number.

Microsoft Word (MSW)

Microsoft Word - Drawing (MSWD)

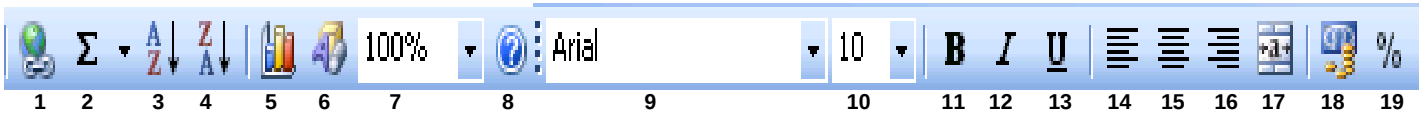
Microsoft PowerPoint (MSPP)





Microsoft Internet Explorer (MSIE)

Microsoft Excel (MSE)



APPENDIX B.2

Sample Interview Static Icon Functionality

This section details the icon functionality that was selected to be shown to subjects during the interview sessions. Icon selection was based on the series of observations during the pilot and main study. Children were only shown the static icon image as shown in appendix B.1. This appendix is for information only.

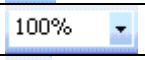
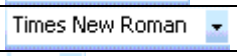
MSW ICONS		
Icon No.	**Functionality**	**Static Icon Image**
1	File Search	
2	Print	
3	Print Preview	
4	Spelling and Grammar	
5	Cut	
6	Copy	
7	Paste	
8	Format Painter	
9	Undo	
10	Redo	
11	Insert Hyperlink	
12	Tables and Border	
13	Insert Table	
14	Zoom	
15	Microsoft Office Word Help	
16	Style	
17	Font	
18	Font Size	
19	Bold	
20	Italic	
21	Align Left	
22	Centre	
23	Align Right	
24	Justify	
25	Numbering	
26	Bullets	
27	Decrease Indent	

Table B.1: Defining the functionality of each of the sample static icons shown to children from Microsoft Word

MSWD ICONS		
Icon No.	**Functionality**	**Static Icon Image**
1	Rectangle	
2	Oval	
3	Textbox	
4	Insert WordArt	
5	Insert Diagram or Organisation Chart	
6	Insert Clipart	
7	Insert Picture	
8	Fill Colour	
9	Line Colour	
10	Font Colour	
11	Line Style	
12	Dash Style	
13	Arrow Style	
14	Shadow Style	
15	3-D Style	

Table B.2: Defining the functionality of each of the sample static icons shown to the children from Microsoft Word – Drawing Toolbar.

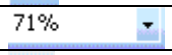
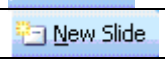
MSPP ICONS		
Icon No.	**Functionality**	**Static Icon Image**
1	E-mail (as attachment)	
2	Spelling and Grammar	
3	Cut	
4	Copy	
5	Paste	
6	Format Painter	
7	Undo	
8	Redo	
9	Insert Chart	
10	Insert Table	
11	Tables and Border	
12	Insert Hyperlink	
13	Expand All	
14	Show Formatting	
15	Show/Hide Grid	
16	Colour/Greyscale	
17	Zoom	
18	Microsoft Office PowerPoint Help	
19	Font	
20	Font Size	
21	Bold	
22	Italic	
23	Shadow	
24	Align Left	
25	Centre	
26	Align Right	
27	Justify	
28	Numbering	
29	Bullets	
30	Increase Font Size	
31	Decrease Font Size	
32	Decrease Indent	
33	Increase Indent	
34	Font Colour	
35	Slide Design	
36	New Slide	

Table B.3: Defining the functionality of each of the sample static icons shown to the children from Microsoft PowerPoint

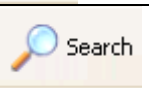
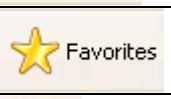
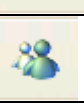
MSIE ICONS		
Icon No.	**Functionality**	**Static Icon Image**
1	Back	
2	Forward	
3	Stop	
4	Refresh	
5	Home	
6	Search	
7	Favourites	
8	History	
9	Mail	
10	Print	
11	Edit with Microsoft Office Word	
12	Messenger	

Table B.4: Defining each of the sample static icons shown to children from Microsoft Internet Explorer

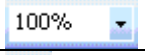
MSE ICONS		
Icon No.	**Functionality**	**Static Icon Image**
1	Insert Hyperlink	
2	Autosum	
3	Sort Ascending	
4	Sort Descending	
5	Chart Wizard	
6	Drawing	
7	Zoom	
8	Microsoft Office Excel Help	
9	Font	
10	Font Size	
11	Bold	
12	Italic	
13	Align Left	
14	Centre	
15	Align Right	
16	Justify	
17	Merge and Centre	
18	Currency	
19	Percentage Style	

Table B.5: Defining each of the sample static icons shown to children from Microsoft Excel

APPENDIX B.3

Interview Transcripts

This section presents the interview transcripts for the 20 interviews carried out during the main study. The aim of the interviews was to develop an understanding into children's static icon usage patterns, object understanding and investigate the children's ZPD levels. The interview followed a semi-structured approach. This enabled questions to be tailored depending on each subjects understanding and having the flexibility to re-phrase when required. The approach enabled a more valid response from the subject on their understanding of static icons (Burns 2000). Each interview subject has been applied a unique code and differentiated by the sequence number. The coded approach is similar to the process outlined in Miles & Huberman (1994) and approach outlined by Strijbos et al. (2006). For example, Interview subject 1 will have a code applied to it of IS1. Similar to the observation coding technique, a letter has been applied after each code for a particular segment of data to enable clustering of information and aid in identifying patterns across different interviewees.

Code	Interview Subject 1 (IS1)
(Q1) What type of software packages do you use?	
IS1A	Microsoft Office – Word, Notepad, Paint, Games and Internet
(Q2) Do you use those packages quite often?	
IS1B	No not really, only use the computer at school or at home for homework.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS1C	Yeah I use them quite often – save, print (MSW3), print preview (MSW4) and formatting icons such as colour, text size (MSW18) etc. Insert Picture (MSWD7) in Word and Internet – favourites (MSIE7), back (MSIE1) etc.
IS1D	I also use icons such as colour (MSW10), word art (MSW4), insert pictures (MSW7) and favourites (MSIE7) – they help me. I use these icons because I understand what they mean. Such as favourites (MSIE7) I understand what it means cause of the text I also have Google on my favourites at home.
IS1E	For clip art I know which icon to click on it's the one at the bottom of the page in Word.
IS1F	But spelling I don't know I mostly go through the menu. But most times when I spell something wrong a red line comes underneath the word and I just right click.
IS1G	Some icons stand out but I don't know what they mean if they had a bit of writing underneath it might help.
(Q4) Do you understand what they mean?	
IS1H	Yeah, they help you get to what you want to do and find out what you want to get.
IS1I	Help you in your studies such as the Microsoft Word 'help icon' (MSW15).
IS1J	You have to find out what you want and then click on the icon to get it.
IS1K	You have to try and find out for yourself on what the pictures mean sometimes.
IS1L	The pictures can give ideas on what they might be.
(Q5) When you look at the pictures do they help you understand what the icons mean?	
IS1M	Yeah, colour gives you colour, picture and word art are quite obvious. The text ones help as well.
IS1N	Font styles help because it does the same thing that it shows. The font icons are really good as they do the same things as they say like the bold icon (MSW19) and the font type icons (MSW17).
IS1O	The pictures that are used for the icons sometimes do give an idea of what do and the text is guide.
IS1P	But you have to find out for yourself as the small pictures can be confusing.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS1J	• MSW4, MSW6, MSW8 and MSW11. • MSWD5, MSWD14 and MSWD15. • MPP1 • MSIE3, MSIE4, MSIE5, MSIE8 and MSIE12.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS1K	Sometimes, but I don't use static icons that I don't understand.
IS1L	I put the mouse over the icon sometimes and look at what the text says but sometimes it isn't always clear on what the icon does and doesn't make sense.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS1M	Yes, only when I understood what they meant.
IS1N	If I don't understand what an icon means I won't probably use it and the pictures can be confusing. **PROMPT: Pointing to the paste icon on sample 1 – do you know what that means by just looking at it?**

IS1O	I don't know what it means but is it paints? **PROMPT: Is that because it has a brush?**
IS1P	Yeah because that's what you would paint with.
(Q9) How can we make icons better for you?	
IS1Q	Bolder pictures Clearer on what the icon does. Add bolder pictures that are clearer. Bigger More colours Add text
(Q10) Do you think you would use the icons more if they improved?	
IS1R	Yeah, I would use the icons more as they would catch the eye.
IS1S	I only use the icons most because they stand out also they have text with it. Icons such as favourites (MSIE7), new slide (MSPP36) I use a lot because they stand out and the text helps me understand what they do.
IS1T	The picture used and a bit of writing helps.
IS1U	The print icon (MSW2) I find it easy now and it's used in different packages as well.
IS1V	The icon next to it - Print preview (MSW3) I didn't understand what it did and I clicked on it one day at home and figured it out.

Code	Interview Subject 2 (IS2)
(Q1) What type of software packages do you use?	
IS2A	Microsoft Word, Internet Explorer, PowerPoint and Publisher only sometimes and is only used at home.
(Q2) Do you use those packages quite often?	
IS2B	I use the computer mostly at home and once a week at school.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS2C	Yeah, I mostly have used print (MSW2), save, the format options such as bold (MSW19), italic (MSW20) and which way the text should go (MSW21-24). I've also use the icon with the abc (MSW4) on it.
	Prompt: Do you understand what they mean such as the abc icon (MSW4)?
IS2D	No, but I have used it before but I'm not sure what it means.
	Prompt: By just looking at the abc icon (MSW4) do you know it means by the picture they have used?
IS2E	Is it like in bullet points with the abc (MSW4) – that's what I think it might be.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS2F	Yeah, I guess most of the time I know what they might mean. But I only know what they mean as I'm guessing what they might do.
IS2G	The text changing ones are easy to understand but not the other ones.
(Q5) Do you use the icons much for things such as file open/save?	
IS2H	Yeah, I use the icons but I prefer to go through the menu at most times.
IS2I	I think it's easier to go through the menu I think.
	Prompt: Why do you think the menu structure is easier?
IS2J	I prefer using the menu as I find the icons confusing sometimes.
IS2K	I just think its easier going through the menu – I don't know why it's just the way I do things and have got use to it and always go through the menu.
IS2L	I stay away from them and stick to the menu as it tells you what it is doing.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS2M	• MSW6, MSW7, MSW8, MSW9, MSW10, MSW11 and MSW12. • MPP35 and MSPP36. • MSIE3, MSIE4, MSIE8 and MSIE11.
IS2N	• Note: guessed that the refresh Icon in Internet Explorer was recycling!
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS2O	I think I have but it doesn't always help as sometimes I still don't understand what the icon does.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS2P	No not really as I like going to the menu structure. I find that the icons are confusing and not clear.
(Q9) How can we make icons better for you?	
IS2Q	Better pictures
IS2R	Colour

Code	Interview Subject 3 (IS3)
(Q1) What type of software packages do you use?	
IS3A	Microsoft Office – Word, PowerPoint, Games, Internet and MSN.
(Q2) Do you use those packages quite often?	
IS3B	Yeah, at school and at home.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS3C	I do use print (MSW2), the ones that make your writing bigger, change the font and colour (MSW17/18).
IS3D	In Internet Explorer I mostly use the back (MSIE1) and forward buttons (MSIE2).
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS3E	Some of them I don't know what they are and then I don't click on them.
IS3F	The picture is not clear on what it does.
IS3G	The pictures don't help they are confusing and I don't click on them ones.
IS3H	Need to have better pictures first. **PROMPT: Show me an icon on the sample 1 sheet that you really don't understand?**
IS3I	The abc icon (MSW4) I don't understand it's not clear and I can't guess what it does and the picture doesn't tell me and also I haven't clicked on it to try it out.
(Q5) Do you use the icons much for things such as file open/save?	
IS3J	Yeah, I'll use some of them at school. Mostly use the icons that I have been told to use and been taught in school.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS3K	• MSW4, MSW25 and MSW26. • MSE2, MSE3 and MSE4. • MSIE3, MSIE4, MSIE5 and MSIE8.
(Q7) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS3L	Yeah I would use them more only if I understood them.
(Q8) How can we make icons better for you?	
IS3M	Clearer icons
IS3N	More understanding.

Code	Interview Subject 4 (IS4)
(Q1) What type of software packages do you use?	
IS4A	Microsoft Office and Internet Explorer.
(Q2) Do you use those packages quite often?	
IS4B	Yeah, I use the computer quite a lot at home and at school.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS4C	Yeah, I use things like Cut (MSW5), Paste (MSW7), WordArt (MSWD4), Save and Print (MSW2).
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS4D	Yeah most of them as the pictures are easy to understand and I know most of them anyway.
IS4E	I try most of them out anyway.
IS4F	I use to have an Apple Mac computer at home and the icons on that were hard to understand and not clear as you had to highlight the icon and wait to see what they did.
IS4G	The pictures are much easier to understand on Office and Internet Explorer than the Apple Mac.
IS4H	Also, the text helps find out what the icon does.
IS4I	Sometimes the pictures can be hard to understand on what they do.
IS4J	The icons that I do use are those that I understand and have used for a long time.
(Q5) Do you use the icons much for things such as file open/save?	
IS4K	I sometimes use icons and sometimes use the menu structure. But I do prefer to use the menu structure to do things as it has writing that helps me understand what it does.
IS4L	It feels better to use the menu structure.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS4M	• MSW4, MSW25, MSW26 and MSW27 • MSWD5, MSWD6, MSWD7, MSWD8 and MSWD9 • MSE1, MSE2, MSE3 and MSE4. • MPP1, MPP32 and MSPP33. • MSIE3, MSIE4, MSIE5 and MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS4N	Sometimes, but I would rather click on it to try it out.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS4O	If icons were clearer on what they did they would use them more often.
(Q9) How can we make icons better for you?	
IS4P	Simplify icons
IS4Q	More colours
IS4R	Clearer

Code	Interview Subject 5 (IS5)
(Q1) What type of software packages do you use?	
IS5A	Microsoft Office – Word, PowerPoint, Excel, Internet.
(Q2) Do you use those packages quite often?	
IS5B	Yeah, at least once a week. I don't use the Internet at home at all as it has been locked at home.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS5C	Yeah, I use like save, print (MSW2), formatting i.e. size, fonts (MSW17/18) etc. WordArt (MSWD4) and Clip Art (MSWD6) – that's really it.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS5D	I didn't really understand some of the icons when I first saw them.
IS5E	When I first saw the print icon I thought it looked like a fax machine. I wasn't sure of what it did and had to try clicking on it to find out what it meant.
IS5F	After I tried it I found out what it did and I've used since then. But it was a bit confusing for me.
IS5G	With the save icon someone had to tell me what it did before I used it.
IS5H	When I look at the pictures I try to guess what the icon does.
IS5I	Sometimes after I've clicked on it and tested to see what it does I've understood what they do but it doesn't always mean the same thing as the picture.
IS5J	With some of the pictures they are clear on what the icon does but not all of them are and I get confused.
(Q5) Do you use the icons much for things such as file open/save?	
IS5K	I go to file and then choose the option I want to have.
IS5L	I would rather go to the menu structure to make sure I am doing it right.
IS5M	I trust the menu structure more as I don't always fully understand what the icon does and I don't want to loose my work by pressing the wrong button.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS5N	• MSW1, MSW2, MSW3, MSW4, MSW5, MSW6, MSW7, MSW8, MSW25, MSW26 and MSW27. • MSE1, MSE2, MSE3, MSE4, MSE17, MSE18 and MSE19 • MPP1 and MSPP18. • MSIE3, MSIE4 and MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS5O	No not really.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS5P	Yes only if I was sure of what they did.
(Q9) How can we make icons better for you?	
IS2Q	Clearer icons
IS2R	Use pictures that are more for children.

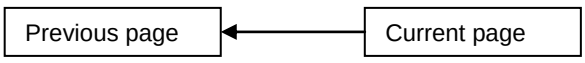
Code	Interview Subject 6 (IS6)
(Q1) What type of software packages do you use?	
IS6A	Microsoft Office – Word, PowerPoint, Internet.
(Q2) Do you use those packages quite often?	
IS6B	I use the Internet mostly at home and use the other packages while I'm at school.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS6C	Yeah, I use cut (MSW5), paste (MSW6), save, formatting i.e. size, fonts, colour etc (MSW17/18), Text Alignment (MSW21-24), Print (MSW2) and Preview (MSW3) – that's probably about it.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS6D IS6E	Yeah, most of the time like the save icon I understood quite quickly what it did. The pictures give you a clue on what it does such as the grid (MSW12) but doesn't clearly tell you I mostly guess by looking at the picture.
(Q5) Do you use the icons much for things such as file open/save?	
IS6F	I go through the menu structure and I've now got into the habit of going through the menu structure at home and school.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS6G	• MSW1, MSW4, MSW6, MSW7, MSW11, MSW12, MSW13, MSW25, MSW26 and MSW27 • MSWD13. • MPP10, MPP11 and MSPP18. • MSE1, MSE17, MSE18 and MSE19. • MSIE3, MSIE4, MSIE6, MSIE8 and MSIE12.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS6H	Sometimes, I use the mouse over text to tell me what it does but I sometimes still am not clear.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS6I	I probably would.
(Q9) How can we make icons better for you?	
IS6J	More icons along the top rather than going through the menu all the time. It would make it quicker.

Code	Interview Subject 7 (IS7)
(Q1) What type of software packages do you use?	
IS7A	Microsoft Office – Word, PowerPoint, Excel, Internet.
(Q2) Do you use those packages quite often?	
IS7B	Yeah, most of the time.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS7C	I use the Undo (MSW9) sometimes, Graphs (MSPP9), Print (MSW2), Preview (MSW3), formatting icons (MSW17/18) and Text Alignment (MSW21-24). Also, the abc icon (MSW4).
	PROMPT: what does the abc icon (MSW4) do?
IS7D	I'm sure I have used it. I think it changes something like grammar or is it thesaurus - actually I'm not sure but it does check something.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS7E	The pictures don't really tell you much about what the icon does and they are confusing.
IS7F	Sometimes you look at the picture and think what do they mean. I then click on it and find that they don't actually do anything like they have shown on the picture.
IS7G	The pictures don't always link to what the icon does.
IS7H	They make me more confused and lost.
(Q5) Do you use the icons much for things such as file open/save?	
IS7I	I only use the icons that my sister in Year 9 has taught me as I know what they mean because of my sister.
IS7J	I don't use any others because I don't understand them and I don't want to loose my work by clicking on the wrong one and then having to do all my work again.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS7K	• MSW1, MSW4, MSW5, MSW7, MSW8, MSW9, MSW10, MSW12, MSW13, MSW25, MSW26 and MSW27 • MSWD4, MSWD5, MSWD7, MSWD8, MSWD9, MSWD10, MSWD11, MSWD12, MSWD13, MSWD14 and MSWD15. • MSIE3, MSIE4, MSIE5, MSIE6, MSIE7 and MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS7L	No I don't because if I don't understand what an icon does I won't use it and would rather go through the menu structure.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS7M	Yeah, I probably would use them.
(Q9) How can we make icons better for you?	
IS7N	Clearer icons
IS7O	Cartoons

Code	Interview Subject 8 (IS8)
(Q1) What type of software packages do you use?	
IS8A	Microsoft Office – Word, PowerPoint.
(Q2) Do you use those packages quite often?	
IS8B	Yeah at least once a week.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS8C	I mostly use the icon for save, print (MSW2) and formatting i.e. size, fonts, colour etc. (MSW17/18)
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS8D	I know what some of the icons mean by looking at the picture but not all of them.
IS8E	Most of the time I guess.
(Q5) Do you use the icons much for things such as file open/save?	
IS8F	I'm not sure. I would probably go up to file or something. **PROMPT: Say you wanted to save a file now, what would you click on?**
IS8G	I'd go to file and save. **PROMPT: Even though there is a save icon that you could click on. Do you know which one is the save icon?**
IS8H	Yes, it's that one (pointing at the screen towards the save icon on Microsoft Word).
IS8I	I understand it as it looks just like a floppy disk that I would use. But I would still go
IS8J	through the menu structure as that's the way I have always done it.
IS8K	I find it easier to do it that way and I've been taught that way.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS8L	• MSW6, MSW7, MSW8, MSW11, MSW15, MSW25, MSW26 and MSW27 • MSWD5. • MPP2, MPP3 and MSPP4. • MSE1, MSE2, MSE3, MSE17, MSE18 and MSE19. • MSIE3, MSIE4 and MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS8M	No, not really. I would rather use the menu.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS8N	I might use them.
(Q9) How can we make icons better for you?	
IS8O	Words are better than pictures as it explains what it does, pictures are confusing.

Code	Interview Subject 9 (IS9)
(Q1) What type of software packages do you use?	
IS9A	Microsoft Office – Word, PowerPoint, Excel, Internet.
(Q2) Do you use those packages quite often?	
IS9B	I mostly use the computer at school.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS9C	I use save, print (MSW2), preview (MSW3) and formatting i.e. size, fonts, colour etc. (MSW17/18). **PROMPT: Do you icons quite often?** Yeah most of the time to save and stuff. **PROMPT: Do you find them quite useful for the work you do?** Yeah, they are much quicker to use.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS9D IS9E IS9F	I understand most of the icons just by looking at the pictures. If I already know what the icon is then I will use it. If I don't know what the icon means then I won't take any chances by using it. **PROMPT: How do you know what the icon does?** Cause I've used it before in previous times. **PROMPT: How about if you have not used it in previous times but the picture looks familiar?** If I am school I will ask someone what it means otherwise I just won't use it.
(Q5) Do you use the icons much for things such as file open/save?	
IS9G	I use icons for things like saving my work or printing. As going through the menu to do things like that takes too long.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS9I	• MSW1, MSW3, MSW4, MSW5, MSW6, MSW7, MSW8, MSW11, MSW12, MSW13, MSW15, MSW25, MSW26 and MSW27 • MSIE3, MSIE4, MSIE5 and MSIE8. **PROMPT: Do you understand what these two icons mean? (Pointing at MSW9/10)** Is it zooming in and out? I've never used those ones.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS9J	No, I just stick to the ones I know.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS9K IS9L	Yeah I would use them more but I would try them out first before using it on my work. **PROMPT: Could they be made easier for you?** Yeah, definitely they could be made much better.
(Q9) How can we make icons better for you?	
IS9M	Pictures need to be more to the point so you know straight away when you look at them. Like you really know what it is and does.

Code	Interview Subject 10 (IS10)
(Q1) What type of software packages do you use?	
IS10A	Microsoft Office – Word, Internet.
(Q2) Do you use those packages quite often?	
IS10B	Only at school.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS10C	No not that much. I only use the ones that change the letters on the page. (Formatting (MSW17/18)). **PROMPT: Say you wanted to save your work now – what would you do?** I would go to file and then go down onto save and click. **PROMPT: Do you know which icon you could click on to save your work?** No.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS10D IS10E	I find the pictures confusing and don't want to use them. **PROMPT: So, you hardly ever use them then?** Yeah, I never use them and always go through the menu.
(Q5) From sample 1 **– which static icons don't you understand?**	
IS10F IS10G	I don't understand any of the icons on the sheet. Apart from the formatting text icons. • MSW1-MSW27 • MSWD1-MSWD15 • MSPP1-MSPP36 • MSIE1-MSIE12 • MSE1-MSE19. **PROMPT: How about this icon in Microsoft Word (pointing at MSW2)?** No I don't understand what that means. **PROMPT: What do you think it might mean?** I'm not sure maybe a fax machine or something but what it does I don't know. **PROMPT: Why do you think you don't understand many of these icons on sheet 1?** It's because of the pictures I am not sure on what they do – so I don't want to use them and stay away from them. **PROMPT: Do you find using the menu easier?** Yeah **PROMPT: Why?** It has text and it tells me what it does.
(Q6) How can we make icons better for you?	
IS10H	Clearer pictures Adding more text

Code	Interview Subject 11 (IS11)
(Q1) What type of software packages do you use?	
IS11A	Microsoft Office – Word, PowerPoint, Excel, Internet.
(Q2) Do you use those packages quite often?	
IS11B	Yeah, I use them a lot at home and school.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS11C	I use the print one (MSW2), formatting i.e. size, fonts, colour etc. (MSW17/18), word Art (MSWD4), clip art (MSWD6), favourites (MSIE7), search (MSIE6) and e-mail (MSIE9) sometimes. I use them a bit for underlining, bold and sometimes I use print. I use the print one at home but at school it is more important so I go to file and then print.
	PROMPT: Why do you not use the print icon at school as well?
IS11D	Just in case it doesn't work and I might loose my work. So I don't just use it.
	PROMPT: Why do you think it might not work or do something wrong?
IS11E	I don't know.
	PROMPT: Is it because it is a shortcut?
IS11F	Yeah and it might mess up.
	PROMPT: So you would rather go through the menu structure at school and at home you would click on the icons.
IS11G	Yeah as I have more time at home in case something goes wrong and I loose my work. At school it is harder as I only have lesson time.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS11H	Some of the icons I understand by looking at the pictures but not all of them.
(Q5) Do you use the icons much for things such as file open/save?	
IS11I	I would go to file and then find save on the list. I would probably print by clicking on the button on the top. I also know the open one as well it's the one that looks like an open folder and if I wanted to open something I would click on it.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS11J	• MSW4, MSW5, MSW6, MSW7, MSW8, MSW11, MSW12 and MSW13 • MSWD5. • MSIE3, MSIE4, MSIE5, MSIE8 and MSIE11.
(Q7) How can we make icons better for you?	
IS11K	A few of them could be made easier and be less confusing.
	PROMPT: How do you think they could be made easier for you?
IS11L	I'm not sure really. Like this Internet icon for back have maybe one page with an arrow going back to a previous page – it would make it clearer.
IS11M	Example provided by a child for the Internet Back Icon.
	

Code	Interview Subject 12 (IS12)
(Q1) What type of software packages do you use?	
IS12A	Microsoft Office – Word, PowerPoint, Internet.
(Q2) Do you use those packages quite often?	
IS12B	Yeah, I use them at school and the Internet mostly at home.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS12C	I use them for formatting i.e. size, fonts, colour etc. (MSW17/18), favourites (MSIE7) and Search (MSIE6)
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS12D	Some of the pictures help me in understanding what the icons do but some of them are confusing and I prefer to use the menu anyway.
IS12E	It feels like I understand things on the menu and it the text helps me a lot.
(Q5) Do you use the icons much for things such as file open/save?	
IS12F	Sometimes, but I've got use to going to file and doing things now.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS12G	• MSW7, MSW8, MSW9, MSW10, MSW11, MSW12, MSW13 and MSW15 • MSWD5. • MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS12H	Sometimes at home I do to just to find out what the icon does. **PROMPT: Do you think the text helps to explain what the icon does to you? And if yes do you then use that icon?**
IS12I	The text does help but not all the time as sometimes the words can be too complicated and I don't understand what they mean.
IS12J	But if I do understand what the icon does I will use it at home but not at school. **PROMPT: Why wouldn't you use the icon at school?**
IS12K	It's just that I'm scared that I might loose my work.
IS12L	At home I'm mostly messing about and it doesn't matter if something goes wrong but at school it does and I might get told off.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS12M	I probably would use them more but I have to know what they do first as I don't want to loose my work.
(Q9) How can we make icons better for you?	
IS12N	I think they could be better if they had interesting pictures on them and if they were clearer in what they did.

Code	Interview Subject 13 (IS13)
(Q1) What type of software packages do you use?	
IS13A	Microsoft Office – Word, PowerPoint, Excel, Internet.
(Q2) Do you use those packages quite often?	
IS13B	Yeah, I use them at school and at home for homework and stuff.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS13C	The ones I use mostly is the changing text ones (Formatting (MSW17/18)) and save.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS13D	Some of the ones are really easy to understand and I can tell what they do. **PROMPT: Which ones are they?**
IS13E	Like print (MSW2) is really easy to understand and things like the clip art (MSWD6) one in Microsoft Word. The mail (MSIE9) one on the Internet and MSN (MSIE12) are really good as I've seen them in other places such as at home or in school. **PROMPT: How about the others, how do you find the pictures used on them?**
IS13F	I find them confusing sometimes and I try to guess what they do by looking at them but sometimes when I try them they do something different.
IS13G	I don't use them icons as if I don't know what they do I don't use them unless I am at home messing about then I do!
(Q5) Do you use the icons much for things such as file open/save?	
IS13H	Yeah I use the save icon quite a lot at school and the teacher normally tells us to click on it as well.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS13I	• MSW1, MSW4, MSW5, MSW6, MSW7, MSW8, MSW9, MSW10, MSW11, MSW12, MSW13 and MSW15. • MSWD5. • MSIE3, MSIE4 and MSIE8
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS13J	No, I don't really do that not on purpose.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS13K	Yeah
(Q9) How can we make icons better for you?	
IS13L	Make them more interesting with more colours and better pictures.

Code	Interview Subject 14 (IS14)
(Q1) What type of software packages do you use?	
IS14A	Microsoft Office – Word, PowerPoint, Excel, Internet.
(Q2) Do you use those packages quite often?	
IS14B	Yes, at least once a week.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS14C	The static icons that I use are save, open, print preview (MSW3) and format ones (MSW17/18).
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS14D	The pictures are confusing and I think that it is made more for my parents or adults.
IS14E	The pictures are not always clear and can be too complicated. Like why does the favourite's icon (MSIE7) have a star as the picture – I don't understand who it relates together. **PROMPT: Pointing at the refresh icon (MSIE4), do you know what it means?**
IS14F	I think it means something like recycle.
(Q5) Do you use the icons much for things such as file open/save?	
IS14G	No not really as I prefer to use the menu structure. Using the menu is easier and I understand it more as it has text.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS14H	• MSW6, MSW7, MSW8 and MSW11. • MSWD5. • MPP13, MPP14 and MSPP15. • MSE1, MSE2, MSE3, MSE17, MSE18 and MSE19. • MSIE3, MSIE4 and MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS14I	No not really.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS14J	Yeah I would probably use the icons more only if I clearly understood what the icons did as I don't want to loose my work.
(Q9) How can we make icons better for you?	
IS14K	If the icons were simple and snappy.

Code	Interview Subject 15 (IS15)
(Q1) What type of software packages do you use?	
IS15A	Microsoft Office – Word, PowerPoint, Excel, Internet, Encarta.
(Q2) Do you use those packages quite often?	
IS15B	Yes at least once a week.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS15C	Yeah I use them sometimes. The ones I use are save icon, open and print icon (MSW2).
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS15D	Only with some of the icons but I find most of the pictures confusing.
IS15E	The pictures don't tell me what the icons do.
(Q5) Do you use the icons much for things such as file open/save?	
IS15F	I like to use the menu structure.
IS15G	I'm scared to click on the icon as I am not always sure on what it does and I might loose my work.
IS15H	If I want to understand what an icon does I first mess around with the icon by clicking on it to find out what it does before I use it or be told by someone else of what the icon does.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS15I	• MSW1, MSW4, MSW5, MSW6, MSW7, MSW8, MSW9, MSW10, MSW11, MSW12, MSW13 and MSW15. • MSWD5. • MSE1, MSE2, MSE3, MSE17, MSE18 and MSE19. • MSIE3, MSIE4, MSIE5, MSIE7 and MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS15J	Sometimes, depends on what I am trying to do.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS15K	Yes, as long as they were much clearer.
(Q9) How can we make icons better for you?	
IS15L	They could be made better by having clearer pictures and telling me what it does.

Code	Interview Subject 16 (IS16)
(Q1) What type of software packages do you use?	
IS16A	Microsoft Office – Word, PowerPoint, Excel, Internet.
(Q2) Do you use those packages quite often?	
IS16B	Yeah, not all of them though.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS16C	Most of the time I use new document, open, print (MSW2) and formatting (MSW17/18).
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS16D	Some of the pictures used for the icons are really good and I understand them. They are the ones I mostly use.
IS16E	But some of the pictures are not clear and do not give that much information on what they do.
(Q5) Do you use the icons much for things such as file open/save?	
IS16F	I would rather use the menu structure than the icon especially for school work. **PROMPT: why would you prefer to use the menu structure for school work?**
IS16G	I trust it more with school work and don't want to end up clicking on the wrong icon and doing my work all over again.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS16H	• MSW1, MSW2, MSW3, MSW4, MSW5, MSW6, MSW7, MSW8, MSW9, MSW10, MSW11, MSW12, MSW13, MSW15, MSW25, MSW26 and MSW27 • MSWD5. • MSIE3, MSIE4 and MSIE8.
(Q7) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS16I	Yeah I probably would.
(Q8) How can we make icons better for you?	
IS16J	Clearer pictures
IS16K	Explain what it does – rather than the one word you get when you put your mouse over it doesn't explain much.
IS16L	Icons need to be made easier for us so that we can use them.

Code	Interview Subject 17 (IS17)
(Q1) What type of software packages do you use?	
IS17A	Microsoft Office – Word, PowerPoint, Internet.
(Q2) Do you use those packages quite often?	
IS17B	Yes, mostly at school.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS17C	I mostly use save, open, print (MSW2), undo (MSW?) and formatting icon (MSW17/18).
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS17D IS17E	Some of the pictures I understood really quickly such as the print icon. But other pictures can be confusing for me and sometimes when I look at an icon and then click on it something different happens as to what is shown on the picture.
(Q5) Do you use the icons much for things such as file open/save?	
IS17F	I do use the icons I understand but I mostly use the menu structure.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS17G	• MSW1, MSW3, MSW4, MSW6, MSW7, MSW8, MSW11, MSW12, MSW13, MSW25 and MSW26. • MSWD5. • MSIE3, MSIE4, MSIE5, MSIE7 and MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS17H	No
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS17I	I think I would still like to use the menu structure as I know what I am doing as the text tells me what the icon will do.
(Q9) How can we make icons better for you?	
IS17J	They could use clearer pictures.

Code	Interview Subject 18 (IS18)
(Q1) What type of software packages do you use?	
IS18A	Microsoft Office – Word, Excel, PowerPoint and Internet Explorer.
(Q2) Do you use those packages quite often?	
IS18B	Yes, at least once a week.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS18C	I sometimes use them mostly in Microsoft Word for changing how the text looks like making it bold (MSW19) or italic (MSW20). I use the back (MSIE1) button on the Internet a lot as well.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS18D	I understand the ones that I use but the others I don't really understand.
IS18E	The ones that have text with them help me as well because they tell me what they do but there aren't many of them.
(Q5) Do you use the icons much for things such as file open/save?	
IS18F	Yeah I use them sometimes when the teacher tells me to. But I like to go to file and then save. **PROMPT: Why do you prefer to go to the menu to do things like save?**
IS18G	It's something that I have done since I have used computers and have got use to it.
IS18H	It feels like when I go to the menu it will save my work as if I click on the icon it might not always work and I might loose my work.
(Q6) From sample 1 **– which static icons don't you understand?**	
IS18I	• MSW1, MSW2, MSW3, MSW4, MSW5, MSW6, MSW7, MSW8, MSW9, MSW10, MSW11, MSW12, MSW13, MSW15, MSW25, MSW26 and MSW27 • MSWD5. • MSIE3, MSIE4, MSIE5 and MSIE8.
(Q7) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS18J	No not really.
(Q8) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS18K	Maybe I would but I need to know what they do.
(Q9) How can we make icons better for you?	
IS18L	Better pictures Text with the pictures Colour

Code	Interview Subject 19 (IS19)
(Q1) What type of software packages do you use?	
IS19A	Microsoft Office – Word, Excel, PowerPoint and Internet Explorer.
(Q2) Do you use those packages quite often?	
IS19B	Yeah when I am school and sometimes when I am at home I use the Internet for games and chatting to friends
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS19C	Yeah I use them quite often when I'm at school in lessons and at home when I'm doing my homework. **PROMPT: Which static icons do you use?** I use the print (MSW2), preview (MSW3), the formatting ones (MSW17/18) and some of the Internet icons like back & forward buttons (MSIE1/2).
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS19D	Yeah some of the pictures are really good and help me understand what they do and mean.
IS19E	But some of them I try to guess what they do but I don't understand.
IS19F	Then I mess about and click on them to see what they do only at home not school.
(Q5) Do you use the icons much for things such as file open/save?	
	Yeah
(Q6) From sample 1 **– which static icons don't you understand?**	
IS19G	• MSW4, MSW6, MSW8 and MSW11. • MSWD5, MSWD14 and MSWD15. • MPP1 • MSIE3, MSIE5, MSIE8 and MSIE12.
(Q7) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS19H	Yeah they are much easier and quicker as I don't have to go through the menu to find what I want to do.
(Q8) How can we make icons better for you?	
IS19I	I'm not sure really but I think better pictures would help and text.

Code	Interview Subject 20 (IS20)
(Q1) What type of software packages do you use?	
IS20A	Microsoft Office – Word, Excel, PowerPoint and Internet Explorer.
(Q2) Do you use those packages quite often?	
IS20B	Yeah at school as I don't have a computer at home.
(Q3) Do you use any static icons at all such as save, print? (Those small little pictures at the top of packages such as Word).	
IS20C	Yeah, only when the teacher tells me to click on it in the class during the lesson. **PROMPT: Which ones do you use in class then?** Like save and print (MSW2) **PROMPT: Would you still use the icons if the teacher didn't tell you to use them?**
IS20D	No because I don't know what most of them do and I would be too scared as I might click on the wrong one and I might loose my work.
(Q4) When you look at the pictures do they help you understand what the icons mean?	
IS20E	Looking at them now I find them confusing.
IS20F	The ones I do use are because the teacher has told me what it does like saving my work or print.
IS20G	The pictures that are really good are those ones that have text like I find the ones that change the text style or make it bold.
(Q5) From sample 1 **– which static icons don't you understand?**	
IS20H	• MSW1, MSW2, MSW3, MSW4, MSW5, MSW7, MSW8, MSW9, MSW10, MSW12, MSW13, MSW25, MSW26 and MSW27 • MSWD4, MSWD5, MSWD7, MSWD8, MSWD9, MSWD10, MSWD11, MSWD12, MSWD13, MSWD14 and MSWD15. • MSIE3, MSIE4, MSIE5, MSIE6, MSIE7 and MSIE8.
(Q6) When you are using a package such as Word – do you put the mouse over the icon to find out what it does?	
IS20I	No not really.
(Q7) If you knew what some of the icons shown on sample 1 **meant – would you use them more?**	
IS20J	I think I might use them more.
(Q8) How can we make icons better for you?	
IS20K	Add text to the pictures that tells you what they do.

APPENDIX B.4

Teacher Interview Transcript

This section presents the interview carried out with the teacher of the ICT lesson in the main study. The aim of the interview was to develop an understanding from the teacher's perspective of the type of functionality that the children used as part of their lessons at school. The interview also enabled a deeper understanding of the ICT curriculum and the type of functionality that they may have been using for tasks or coursework. The interview used a semi-structured approach, enabling questions to be tailored and providing the flexibility to re-phrase when required. Each line in the interview has been given a unique code and differentiated by letter. The coding approach is similar to the process outlined in Miles & Huberman (1994) and approach outlined by Strijbos et al. (2006).

Code	Teacher Subject 1 (TS1)
(Q1) What type of software packages are children most likely to use?	
TS1A	In lesson time the tasks and coursework that they have gets them mostly to use Microsoft Word, Internet Explorer for research and Microsoft PowerPoint. Also, to fill in the log book they use Microsoft Excel.
(Q2) When they are trying to do simple things like save their work or print – do they use static icons to execute this action?	
TS1B TS1C TS1D	Well, from what I have noticed most of the children go through the menu structure. But when I am reading out instructions I do tell them which icon to click on to save their work as it is much simpler as many of them do not understand what icons do. However, during the duration of their course we do prepare material for the children giving them specific tasks to do which involves clicking on icons and tell them which ones to click one. But if they carry on using the icons I'm not sure.
(Q3) What type of functionality are they mostly likely to use during a normal lesson?	
TS1E	They are most likely to use the simple ones like save, print, formatting, bullets, numbering, cut, copy, insert table and aligning text.
(Q4) Do you think the icons that are available to the children help them understand what they do?	
TS1F TS1G	No, not really. The icons that have text with them help the children and are much easier as they are able to read the text and understand from their what they do. **PROMPT: How about those icons that do not have text?** These icons can be quite tricky for the children as they are unable to identify what the icon does. Those icons that are represented with pictures that children are familiar with can help.
(Q5) How do you think the icons could be designed better for children to aid their understanding?	
TS1H	I'm not sure really as it can be difficult due to the nature of which these icons are presented to children. Maybe by using more pictures that relate to things in a child's environment may increase their usage and understanding.

APPENDIX B.5

Focus Group Transcript

This section of the appendix presents the results collected during the focus group study. The aim of the focus group study was to develop an understanding into the type of objects that children between the ages of 11-12 relate to the functionality selected to be animated. This part of the study phase aided in designing animated icons. A total of 14 animated icons were developed. The focus group, consisting of six subjects, enabled an understanding to be developed into the types of object that the participants related to certain functionality and that could be applied to the icon functionality. Each icon functionality was given a unique code and differentiated by sequence number. The coding approach is similar to the process outlined in Miles & Huberman (1994) and approach outlined by Strijbos et al. (2006). For example, the 'Undo' icon had the code applied to it of U1. Similar to the observation/interview coding techniqu,e a letter has been applied after each code to denote a particular segment of data, enabling the clustering of information.

Code	Focus Group Transcript – Undo Icon Functionality (UN)
(Q1) What does the Undo functionality mean to you? *(Interviewer: points at the undo picture shown on Appendix B.1 – MSW9)*	
UN/1	It means going back as you have made a mistake and want to go back to how it was before.
(Q2) How could we make this icon better?	
UN/2	By telling us what it does and a better picture – the arrow doesn't tell you much.
(Q3) What type of pictures could we use to make these icons easier for you to understand?	
UN/3 UN/4	I think the rubber the one they use in Paint would be good thing to use. You could have a hand coming onto the screen and rubbing out a mistake that might have been typed like we do on paper when we do something wrong. The text will help us understand what it does.
(Q4) Any other ideas on how we could make it better?	
UN/5	No not really.

Code	Focus Group Transcript – Redo Icon Functionality (RE)
(Q1) What does the Redo functionality mean to you? *(Interviewer: points at the redo picture shown on Appendix B.1 – MSW10)*	
RE/1	Does it mean going forward or something like that? I'm not sure. **PROMPT:** An example of redo can be doing something again.
(Q2) How could we make this icon better?	
RE/2	Not sure really.
(Q3) What type of pictures could we use to make these icons easier for you to understand?	
RE/3	By having a teddy bear walking across with a redo board in his hands would make it more interesting. It would also look better and be funny. Also the text will help understand what it means.
(Q4) Any other ideas on how we could make it better?	
RE/4 RE/5 RE/6	I'm not sure really what you could have to make it look like redo. I know the rewind button they have on dvd players is useful as it means going forward and the redo button also means forward. **PROMPT: So, do you think that's a good idea of having a rewind picture for the redo icon?** Yeah, I think that makes sense – *agreement from all.* But I still think my teddy walking across the screen holding a banner with redo on is better – *comment made from one child.*

Code	Focus Group Transcript – Copy Icon Functionality (CO)
(Q1) What does the Copy functionality mean to you? *(Interviewer: points at the copy picture shown on Appendix B.1 – MSW6)*	
CO/1	I'm not sure what the picture is trying to say but by what you said the text means that you are trying to copy something.
(Q2) How could we make this icon better?	
CO/2	By having it showing something being copied.
(Q3) What type of pictures could we use to make these icons easier for you to understand?	
CO/3	I think if we had a picture being copied like say it went from one to two, that would be very good.
(Q4) Any other ideas on how we could make it better?	
CO/4	No

Code	Focus Group Transcript – Help Icon Functionality (HE)
(Q1) What does the Help functionality mean to you? *(Interviewer: points at the help picture shown on Appendix B.1 – MSW15)*	
HE/1	Does it mean questions **PROMPT: It actually means help.**
HE/2	I wouldn't have known that if you hadn't told me but what I don't get is why they have got a question mark there then. That doesn't make any sense to me.
(Q2) How could we make this icon better?	
HE/3	By using text instead of a picture that says help on it.
(Q3) How about if we only could use pictures to show this functionality – what type of pictures could we use then?	
HE/4	Not sure really. **PROMPT: Try and think of those things you relate to help.**
HE/5	You could have a man scratching his head and looking confused as he walked through a room.
HE/6	Or a man looking really sad and then really happy like he had found the answer to something.
HE/7	You could have a man with a question mark bubble over his head or I think instead a question mark you could have the words help in a bubble. Both of them ideas would be good.
HE/8	A light bulb could be useful as well I always think of that means when someone has got an idea or got the answer to something.

Code	Focus Group Transcript – Refresh Icon Functionality (REF)
(Q1) What does the Refresh functionality mean to you? *(Interviewer: points at the refresh picture shown on Appendix B.1 – MSIE4)*	
REF/1	Don't know maybe recycle as its green with two arrows. **PROMPT: This icon actually means to reload the Internet page.**
(Q2) How could we make this icon better?	
REF/2	Don't know really it's a hard one.
(Q3) What type of pictures could we use to make these icons easier for you to understand?	
REF/3	We could have a man who has long hair and is smelly and then in the next picture he has had a bath and a hair cut and doesn't look smelling anymore. **PROMPT: How will that tell us what the icon does?**
REF/4	In the middle of the icon you could have gone and then he is back again all nice and clean. **PROMPT: Any other ideas?**
REF/5	Have a stick man with refresh in a bubble hanging over his head. Or maybe not having refresh there as some people might not understand what that means you could have reload. **PROMPT: How about without any text at all?**
REF/6	You could have a stick man appearing really big first and then going smaller and smaller nearly disappearing but then coming back to his normal size again as it was in the start.

Code	Focus Group Transcript – History Icon Functionality (HI)
(Q1) What does the History functionality mean to you? *(Interviewer: points at the history picture shown on Appendix B.1 – MSIE8)*	
HI/1	I don't know you are going to have tell us what it means. **PROMPT: If you click on this icon it will show you the history of all the web sites you have visited over a period of time.**
(Q2) How could we make this icon better?	
HI/2	I'm not sure. If it means history they should show a picture that relates to it.
(Q3) What type of pictures could we use to make these icons easier for you to understand?	
HI/3	We could have people from the history for this icon. There could be pictures of different people from history. I'm not sure that would work it could confuse some people who don't recognise who those people are. **PROMPT: So, what else do you think would be good idea?**
HI/4	Maybe a timeline as this shows history and going back and we've done that in school as well in our history lesson. But you would have to have the times in text so we can tell its going back in time.

Code	Focus Group Transcript – Favourites Icon Functionality (FA)
(Q1) What does the Favourites functionality mean to you? *(Interviewer: points at the favourites picture shown on Appendix B.1 – MSIE7)*	
FA/1	This one means favourites and it's easy to tell because of the text it has next to it. **PROMPT: If it didn't have the text next to it would you be able to tell looking at the star icon that it meant favourites?** No, not at all. **PROMPT: Why?** Can't really see the link between star and favourites. Also why don't they label it as bookmarks as that's what favourites are really.
(Q2) How could we make this icon better?	
FA/2	I think this icon is okay but only because it has text.
(Q3) What type of pictures could we use to make these icons easier for you to understand?	
FA/3	Have chocolates as the picture as everyone I know likes chocolates. **PROMPT: That's a good idea. Any one else have any ideas on what they would think means favourites to them?**
FA/4	Thumbs up always means something people like.
(Q4) Any other ideas on how we could make it better?	
FA/5	No not really.

Code	Focus Group Transcript – Stop Icon Functionality (ST)
(Q1) What does the Stop functionality mean to you? *(Interviewer: points at the stop picture shown on Appendix B.1 – MSIE3)*	
ST/1	I'm not sure what this one does. The picture doesn't tell you much. **PROMPT: This icon means stop loading the Internet page.**
(Q2) How could we make this icon better?	
ST/2	I would like to know what it actually does.
(Q3) What type of pictures could we use to make these icons easier for you to understand?	
ST/3	It means stop so you could have a small hand appearing which gets bigger and bigger meaning stop. That would be good and I would understand that.
ST/4	You could have traffic lights with the end being the red light.
ST/5	Or a lollipop lady helping small kids crossing the road and holding a banner saying stop and making all the cars on the road stop. It would be like a small cartoon like they have on television.

APPENDIX C.1

Animated Icon Design Underpinned with Concepts from Theories of Learning

Internet Explorer Home Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Schemas	The concept of schemas was reflected in the design of this animated icon with the object selected for animation being a familiar physical object which exists within the child's environment.
Assimilation	The object chosen for the animation aims to aid children in identifying the activities associated with it. The animation aim to assist children to assimilate and identify the functionality by drawing on their previous experiences.
Accommodation	Accommodation was taken into account to ensure that the object selected to represent the function was an object that the children were able to understand and identify in real-life.
Sociocultural Theory	
Culture	The culture concept was reflected in the design of this animated icon as the home object is dependent on the child's cultural setting – depending on which location this icon is designed for, the object attributes may differ. For this thesis, the focus was on children based in the UK and a generic graphic image of a house was selected for animation.
Activity Theory	
Object orientedness	This concept is reflected in the design of the animated icon as the 'home' object is something that objectively exists in the child's world. The child should be able to identify the functionality of the icon as they are able to relate the object back to the activities they carry out in everyday life.
Mediation	'Mediation' of the functionality should be supported by the choice of object that means that the children are able to link back to how they use the object in real-life.

Table C.1: Outlining each concept underpinning the design of the 'home' animated icon.

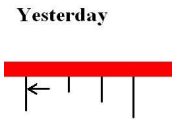
Internet Explorer History Function	
Theory/Concept	**Justification**
Sociocultural Theory	
ZPD	This concept was taken into account in the design of the history icon functionality by taking into account the types of objects that children are able to relate to abstract icon functionality of this type. The children's actual level of development was established during the observation and interview sessions as majority of the children were unable to identify the static version. During the focus group studies, the children suggested the time line may be a useful way in which the history functionality could be presented (See Appendix B.5 –HI/4) as they were able to relate it to activities they had previously carried out with the teacher in the classroom. With the use of the object selected by the focus group and animation, it can be suggested that the children should now be able to identify the icon functionality successfully and achieve their potential level of development.

Table C.2: Outlining each concept underpinning the design of the 'history' animated icon.

Internet Explorer Refresh Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Developmental Stages	The developmental stage in focus for this study was the formal operational stage where suggestions have been made that children are able to understand abstract information presented to them. A focus group was set-up in order to develop an understanding into the types of objects and activities the children may associate to icon functionality of this type (See Appendix B.5). This concept was reflected in the design of the animated icon by aiding in developing an understanding into how children may interpret the object and the associated animation to the functionality. The concept provided an overall understanding of how children in the selected age group understand and acquire new information presented to them.

Table C.3: Outlining each concept underpinning the design of the 'refresh' animated icon.

Internet Explorer Favourites Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Developmental Stages	The developmental stage in focus for this study was the formal operational stage where suggestions have been made that children are able to understand abstract information presented to them. A focus group was set-up in order to develop an understanding into the types of objects and activities the children may associate to icon functionality of this type (See Appendix B.5). In the session the children selected the object to be applied for animation for this functionality (See Appendix B.5 – FA/4). This concept was reflected in the design of the animated icon by aiding in developing an understanding of the type of objects and activities the children may associate to the functionality.

Table C.4: Outlining each concept underpinning the design of the 'favourites' animated icon.

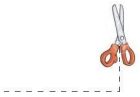
Microsoft Word Cut Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Schemas	This concept was reflected in the design of the cut icon functionality with the object selected for animation. The object used to represent the functionality was a pair of scissors something which physically exists within the child's environment and they are familiar with.
Assimilation	This concept underpins the design of the animated icon as the object used to represent the function aims to help children assimilate the meaning and identify the functionality based on their previous experiences with the object in their environment.
Accommodation	This concept was taken into account to ensure that the object selected to represent the function was an object that the children were able to understand and identify with. The animation is able to provide a means by which they are able to view the associated activities linked to the object and in turn may be able to accommodate the functionality.
Sociocultural Theory	
Context	The concept of context was taken into account whilst designing this icon by ensuring the object applied to represent the function closely matched the representation of scissors the children may use in real-life. The animation for the functionality followed the same sequence of using a pair of scissors to cut along a dotted line (Figure C.3 outlines the animation sequence).
Culture	The culture concept was reflected in the design of this animated icon as the scissors object may have different attributes depending on which location this icon is designed for. For this thesis, the focus was on children based in the UK.
Activity Theory	
Object orientedness	This concept is reflected in the design of the animated icon as scissors are something that objectively exists in the child's world. With this concept the child should be able to identify the functionality of the icon as they are able to relate the object back to the activities they may carry out with the object.
Mediation	This concept was taken into account during the design of the animated icons as the object used to represent the function physically existed within the child's environment. They should be able to 'mediate' the functionality as they are able to link it back to the activities they may have carried out with the object in real life.

Table C.5: Outlining each concept underpinning the design of the 'cut' animated icon.

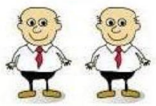
Microsoft Word Copy Function	
Theory/Concept	**Justification**
Sociocultural Theory	
ZPD	This concept was taken into account in the design of the copy icon functionality by taking into account the types of objects that children are able to relate to abstract icon functionality of this type. The children's actual level of development was established during the observation and interview sessions as majority of the children were unable to identify the static version. A focus group was set up to investigate the types of objects that might be useful in illustrating this function (See Appendix B.5). Based on the feedback provided by the focus group the object and sequence of animation was designed (See Appendix B.5 – CO/3). It can be suggested the animation acts as a scaffold assisting the child in identifying the icon functionality successfully and achieve their potential level of development.

Table C.6: Outlining each concept underpinning the design of the 'copy' animated icon.

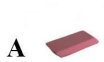
Microsoft Word Undo Function	
Theory/Concept	**Justification**
Sociocultural Theory	
ZPD	This concept was taken into account in the design of the undo icon functionality by taking into account the types of objects that children are able to relate to abstract icon functionality of this type. The children's actual level of development was established during the observation and interview sessions as majority of the children were unable to identify the static version. A focus group was set up and it was suggested that a physical object that already exists in the child's environment be used in the animation i.e. a rubber (See Appendix B.5 – UN/4). This approach enabled the children to link the activities the object carries out in their environment to the functionality being offered. With the use of the object selected by the focus group and animation, it can be suggested that the children would now be able to identify the icon functionality successfully and achieve their potential level of development.

Table C.7: Outlining each concept underpinning the design of the 'undo' animated icon.

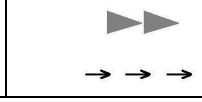
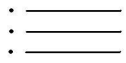
Microsoft Word Redo Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Schemas	This concept was reflected in the design of the redo icon functionality with the object selected for animation. The aim of the object used to represent the functionality was of a rewind image used on DVD players and remotes. This was a suggestion made by the focus group (See Appendix B.5 – RE/5). The object was something of which the children were familiar with in their environment.
Assimilation	This concept underpins the design of the animated icon as the object used to represent the function aims to help children assimilate the meaning and identify the functionality based on their activities the children may associate to the functionality.
Accommodation	This concept was taken into account to ensure that the object selected to represent the function was an object that the children were able to understand and identify with. The animation is able to provide a means by which they are able to view the associated activities linked to the object and in turn may be able to accommodate the functionality.
Sociocultural Theory	
Culture	The culture concept was reflected in the design of this animated icon as the rewind object may have different attributes depending on which location this icon is designed for. For this thesis, the focus was on children based in the UK.
Activity Theory	
Object orientedness	This concept is reflected in the design of the animated icons as the rewind object is something that that the children are familiar with due to their use of DVD players (as suggested by the focus groups – see Appendix B.5). With this concept the child should be able to identify the functionality of the icon as they are able to relate the object back to the activities the object carries out in their environment.
Mediation	This concept was taken into account during the design of the animated icons as the object used to represent the function existed within the child's environment. They should be able to 'mediate' the functionality as they are able to link it back to the activities they may have carried out with the object in real life.

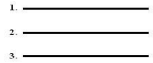
Table C.8: Outlining each concept underpinning the design of the 'redo' animated icon.

Microsoft Word Bullets Function	

Theory/Concept	**Justification**
Genetic Epistemology Theory	
Schemas	This concept was reflected in the design of the bullets icon functionality with the object selected for animation. The static icon object used to represent this function was also used in the animations. The object (though not physically in the environment) should have already been familiar to the children.
Assimilation	This concept underpins the design of the animated icon as the object used to represent the function aims to help children assimilate the meaning and identify the functionality based on their previous experiences with the object in their environment.
Developmental Stages	The developmental stage in focus for this study was the formal operational stage where suggestions have been made that children are able to understand abstract information presented to them. The static icon object used to represent the function was used in the animation and enabled the children to view step by step illustration of what the icon functionality provides. The concept was reflected in the design of the animated icon as it provided assistance in developing an understanding of how children may view and interpret the icon functionality being presented to them.
Sociocultural Theory	
ZPD	This concept was taken into account in the design of the bullets icon functionality by taking into account the types of objects children are able to relate to abstract icon functionality of this type. The children's actual level of development was established during the observation and interview sessions as majority of the children were unable to identify the static version. However, the use of animation may aid the children in identifying the functionality as for this function they are able to see what happens if they use this icon functionality. With the use of the static object and animation, it can be suggested that the children would now be able to identify the icon functionality successfully and achieve their potential level of development.
Scaffolding	The concept of scaffold underpinned this concept as the animation was able to provide the children with a step by step visualisation of the icon functionality. It could be suggested the animation is acting as a scaffold to understand and identify the icon functionality successfully.
Context	The concept of context underpins the design of this animated icon as the animation is able to clearly illustrate to the children the activities associated to the functionality.
Culture	The culture concept was reflected in the design of this animated icon as the bullets object is dependent on the child's cultural setting – depending on which location this icon is designed for, the object attributes may differ. For this thesis, the focus was on children based in the UK.

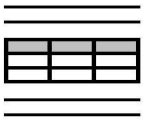
Activity Theory	
Hierarchical Structure of Activity	This principle underpins the design of this animated icon as it can be argued that the activities that a child associated to an object are in order to achieve a desired outcome in a task. By using a familiar static icon object and applying animation the children were able to view the series of activities associated with the functionality and identify it successfully.
Development	The principle of development may be reflected in the design of this animated icon if the children are able to identify and apply the animated icon functionality successfully in the future. It was found during the interviews and observations that the children were unable to identify the static version of the functionality.
Internalisation/Externalisation	This principle underpins the design depending on the whether the children are able to identify the functionality, be able to understand how the functionality works and apply it successfully in the future.

Table C.9: Outlining each concept underpinning the design of the 'bullets' animated icon.

Microsoft Word Numbering Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Schemas	This concept was reflected in the design of the numbering icon functionality with the object selected for animation. The static icon object used to represent this function was also used for the animations. The objects (though not physical) should have already been familiar to the children.
Assimilation	This concept underpins the design of the animated icon as the object used to represent the function aims to help children assimilate the meaning and identify the functionality based on their previous experiences with the object in their environment.
Developmental Stages	The developmental stage in focus for this study was the formal operational stage where suggestions have been made that children are able to understand abstract information presented to them. The static icon object used to represent the function was used in the animation and enabled the children to view a step by step illustration of what the icon functionality provides. The concept was reflected in the design of the animated icon as it provided assistance in developing an understanding of how children may view and interpret the icon functionality being presented to them.

Sociocultural Theory	
ZPD	This concept was taken into account in the design of the numbering icon functionality by taking into account the types of objects children are able to relate to abstract icon functionality of this type. The children's actual level of development was established during the observation and interview sessions as majority of the children were unable to identify the static version. However, the use of animation may aid the children in identifying the functionality as for this function they are able to see what happens if they use this icon functionality. With the use of the static object and animation, it can be suggested that the children would now be able to identify the icon functionality successfully and achieve their potential level of development.
Scaffolding	The concept of scaffold underpinned this concept as the animation was able to provide the children with a step by step visualisation of the icon functionality. It could be suggested the animation is acting as a scaffold to understand and identify the icon functionality successfully.
Context	The concept of context underpins the design of this animated icon as the animation is able to clearly illustrate to the children the activities associated to the functionality.
Culture	The culture concept was reflected in the design of this animated icon as the numbering object is dependent on the child's cultural setting – depending on which location this icon is designed for, the object attributes may differ. For this thesis, the focus was on children based in the UK.
Activity Theory	
Hierarchical Structure of Activity	This principle underpins the design of this animated icon as it can be argued that the activities that a child associated to an object are in order to achieve a desired outcome in a task. By using a familiar static icon object and applying animation the children were able to view the series of activities associated with the functionality and identify it successfully.
Development	The principle of development may be reflected in the design of this animated icon if the children are able to identify and apply the animated icon functionality successfully in the future. It was found during the interviews and observations that the children were unable to identify the static version of the functionality.
Internalisation/Externalisation	This principle underpins the design depending on the whether the children are able to identify the functionality, be able to understand how the functionality works and apply it successfully in the future.

Table C.10: Outlining each concept underpinning the design of the 'numbering' animated icon.

Microsoft Word Insert Table Function	

Theory/Concept	**Justification**
Genetic Epistemology Theory	
Schemas	This concept was reflected in the design of the insert table icon functionality with the object selected for animation. The static icon object used to represent the insert table functionality was also used in the animations. The object (though not physical) should have already been familiar to the children.
Assimilation	This concept underpins the design of the animated icon as the object used to represent the function aims to help children assimilate the meaning and identify the functionality based on their previous experiences with the object in their environment.
Developmental Stages	The developmental stage in focus for this study was the formal operational stage where suggestions have been made that children are able to understand abstract information presented to them. The static icon object used to represent the function was used in the animation and enabled the children to view a step by step illustration of what the icon functionality provides. The concept was reflected in the design of the animated icon as it provided assistance in developing an understanding of how children may view and interpret the icon functionality being presented to them.
Sociocultural Theory	
ZPD	This concept was taken into account in the design of the insert table icon functionality by taking into account the types of objects children are able to relate to abstract icon functionality of this type. The children's actual level of development was established during the observation and interview sessions as majority of the children were unable to identify the static version. However, the use of animation may aid the children in identifying the functionality as for this function they are able to see what happens if they use this icon functionality. With the use of the static object and animation, it can be suggested that the children would now be able to identify the icon functionality successfully and achieve their potential level of development.
Scaffolding	The concept of scaffold underpinned this concept as the animation was able to provide the children with a step by step visualisation of the icon functionality. It could be suggested the animation is acting as a scaffold to understand and identify the icon functionality successfully.
Context	The concept of context underpins the design of this animated icon as the animation is able to clearly illustrate to the children the activities associated to the functionality.
Culture	The culture concept was reflected in the design of this animated icon as the insert table object is dependent on the child's cultural setting – depending on which location this icon is designed for, the object attributes may differ. For this thesis, the focus was on children based in the UK.

Activity Theory	
Hierarchical Structure of Activity	This principle underpins the design of this animated icon as it can be argued that the activities that a child associated to an object are in order to achieve a desired outcome in a task. By using a familiar static icon object and applying animation the children were able to view the series of activities associated with the functionality and identify it successfully.
Development	The principle of development may be reflected in the design of this animated icon if the children are able to identify and apply the animated icon functionality successfully in the future. It was found during the interviews and observations that the children were unable to identify the static version of the functionality.
Internalisation/Externalisation	This principle underpins the design depending on the whether the children are able to identify the functionality, be able to understand how the functionality works and apply it successfully in the future.

Table C.11: Outlining each concept underpinning the design of the 'insert table' animated icon.

Microsoft Word Spell Check Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Schemas	The concept of schemas was reflected in the design of this animated icon as the object selected for animation was a familiar object and the animation followed the same sequence for when a word is spelled incorrectly in Microsoft Word. This approach was taken as it would seem that the children would be familiar with the object and the activities it carries out.
Assimilation	This concept underpins the design of the animated icon as the object aims to aid children to identify the activities associated to it. The animation will be able to assist children to assimilate and identify the functionality based on their previous experiences.
Accommodation	This concept was taken into account to ensure that the object selected to represent the function was an object that the children were able to identify and the animation illustrated the activities associated to it.
Sociocultural Theory	
Culture	The culture concept was reflected in the design of this animated icon as the spell check object is dependent on the child's cultural setting – depending on which location this icon is designed for, the object attributes may differ. For this thesis, the focus was on children based in the UK.
Activity Theory	
Object orientedness	This concept was reflected in the design of the animated icon as the animation aimed to illustrate to the children the activities associated to the functionality. The animation showed the same sequence that Microsoft Word carries out and is something the children are already familiar with. With this concept the child should be able to identify the functionality of the icon as they are able to relate the object back to the activities it carries out.
Mediation	This concept was taken into account during the design of the animated icons as the object used to represent the function was something that was within a child's environment. They should be able to 'mediate' the functionality as they are able to link it back to the activities the object carries out in real-life.

Table C.12: Outlining each concept underpinning the design of the 'spell check' animated icon.

Microsoft Word Help Function	
Theory/Concept	**Justification**
Genetic Epistemology Theory	
Developmental Stages	The developmental stage in focus for this study was the formal operational stage where suggestions have been made that children are able to understand abstract information presented to them. A focus group was set-up in order to develop an understanding into the types of objects and activities the children may associate to icon functionality of this type (See Appendix B.5). In the session the children selected the object to be applied for animation for this functionality (See Appendix B.5 – HE/8). This concept was reflected in the design of the animated icon by aiding in developing an understanding of the type of objects and activities the children may associate to the functionality.

Table C.13: Outlining each concept underpinning the design of the 'help' animated icon.

APPENDIX C.2

Animated Icons Storyboard

This section outlines frame by frame the sequence of animation for each of the animated icon functionality.

Icon Functionality 1: Internet Explorer Stop Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.1: Illustrating the sequence of animation for the ‘stop’ icon

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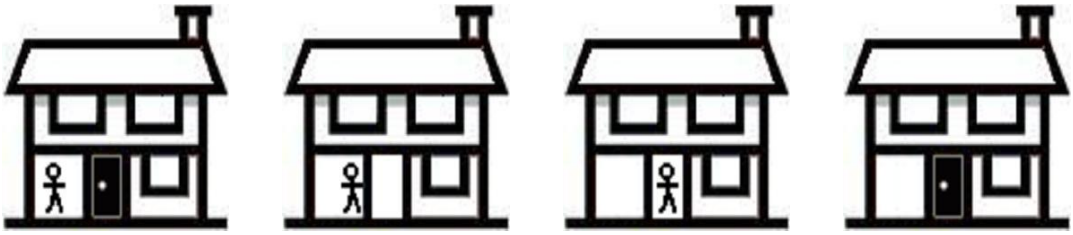
Icon Functionality 2: Internet Explorer Home Function



FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.2: Illustrating the sequence of animation for the ‘home’ icon

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Icon Functionality 3: Microsoft Word Cut Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.3: Illustrating the sequence of animation for the ‘cut’ icon

Icon Functionality 4: Microsoft Word Copy Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.4: Illustrating the sequence of animation for the ‘copy’ icon

Icon Functionality 5: Microsoft Word Bullet Points Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.5: Illustrating the sequence of animation for the ‘bullets’ icon

Icon Functionality 6: Microsoft Word Numbering Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

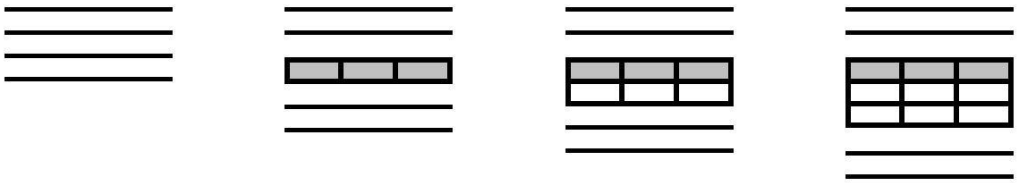
Figure C.6: Illustrating the sequence of animation for the ‘numbering’ icon

Icon Functionality 7: Microsoft Word Spell Check Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.7: Illustrating the sequence of animation for the ‘spell check’ icon

Icon Functionality 8: Microsoft Word Insert Table Function



FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.8: Illustrating the sequence of animation for the ‘insert table’ icon

Icon Functionality 9: Microsoft Word Undo Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.9: Illustrating the sequence of animation for the ‘undo’ icon

Icon Functionality 10: Microsoft Word Redo Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.10: Illustrating the sequence of animation for the ‘redo’ icon

Icon Functionality 11: Microsoft Word Help Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

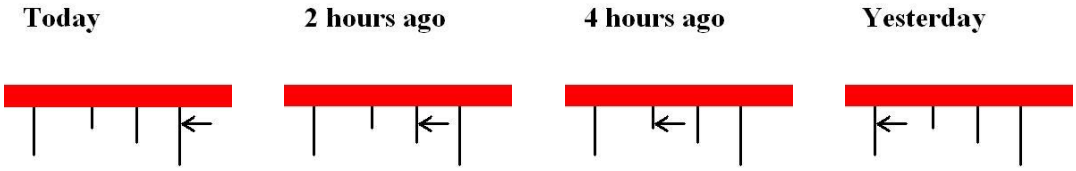
Figure C.11: Illustrating the sequence of animation for the ‘help’ icon

Icon Functionality 12: Internet Explorer Refresh Function

FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.12: Illustrating the sequence of animation for the ‘refresh’ icon

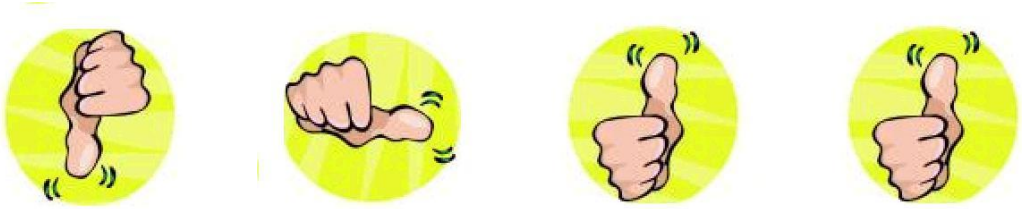
Icon Functionality 13: Internet Explorer History Function



FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.13: Illustrating the sequence of animation for the ‘history’ icon

Icon Functionality 14: Internet Explorer Favourites Function



FRAME 1 FRAME 2 FRAME 3 FRAME 4

Figure C.14: Illustrating the sequence of animation for the ‘favourites’ icon

APPENDIX D.1

Worksheet Design

The first thing for this task is I need you to go to the following website:
http:www.geocities.com/mandy_gill/Main.htm

Once the page has loaded click on the link labelled – "Click here to start". A new page should appear with a picture in the middle and Icon 1 label at the top of the page. If, this page does not load or you have problems let the teacher know.

To make a start you will need to click on the "Play" button on each page to watch the animation. Once the animation has finished playing it will stop. At this point I want you to write down in one sentence what you think that icon might mean or what it might do. If, you want to see the animation again, please click on the "Play" button.

After you have finished writing down what you think the icon might mean. Please click on the "Next" button to see the next page. If you could go through all of the 14 icons and write down what you think they mean. For example, for Icon 12 on the screen write down what you think it means on the worksheet next to the space labelled Icon 12.

Could you please make sure you have an answer for each of the icons that are shown to you. Also, remember you are unable to go back once you have clicked next on the screen.

Once you have finished let Mandy know and she will come around to talk to you.

WHAT DO YOU THINK THESE ICONS MEAN?

ICON 1

ICON 2

ICON 3

ICON 4

ICON 5

ICON 6

ICON 7

ICON 8

ICON 9

ICON 10

ICON 11

ICON 12

ICON 13

ICON 14

Questions:

1. What did you think of the icons you just saw?

2. Did you think these icons were useful in telling you what they mean?

That's it! Thanks for your help.

Please let Mandy know that you have finished. .

APPENDIX D.2

Worksheet Analysis

This section of the chapter presents the results gathered during phase three of the practical studies. This phase involved children viewing a series of animated icons and completing a worksheet in which they describe what they thought each of the icon functionalities meant. A table was prepared for each icon functionality and the types of responses have been included along with the frequency of those responses. To be able to discuss the results gathered during phase three, the responses have been allocated into broad categories. The reason for using such categories is to help us to look into the common responses received from the children and place them into the appropriate groups. This enabled responses to be grouped, as a similar response may have been received from the children for an animated icon though described in a different way. Each of the categories are discussed in depth in section 5.7.1.

Internet Explorer Stop Function Responses							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Stop	27	Go, slow down, stop	4	Ready, steady, go	1	Something to change	1
		Stop, ready, go	4	Go, steady, go	1		
		Stop, think, go	2	Yes, maybe, no	1		
		Go, stop	2	Green, orange to red	1		

Table D.1: Grouped Responses for the 'stop' function

Internet Explorer Home Function Responses							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Home	7	Go home	7	Get out of house	1	Save	1
				Gone	1	Don't know	1
				Closing door to house	1		
				Open the door	2		
				Shutting the door	2		
				Enter	3		
				Go inside	20		
				Man going inside	1		
				Go into house	6		

Table D.2: Grouped Responses for the 'home' function

Internet Explorer History Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
History	4	Back	8	Temperatures changing	1	Calendar	5
				Presenting a graph	1	Table line	1
				Changing time	2		
		Back in time	8	Line moves down timeline	1		
				Record of days	1		
				Time chart/line	19		
				Time travel	1		

Table D.3 Grouped Responses for the 'history' function

Internet Explorer Refresh Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
				A man reloading	1	Editing	1
				Man coming from the distance	1	Font size	2
				Man shrinking	2	Magnifies	1
				Moving closer (forward)	1	Bigger	3
				People walking away	1	Enlarge	4
				Standing close & moves away	4	Grow	4
				Changing size	7	Resize	4
				Enlarge & make small	1	Size	1
				Getting bigger & smaller	3		
				Getting closer & closer	1		
				Small, bigger, bigger	3		
				Small, medium, bigger	3		
				Reducing picture	1		
				Zoom in & out	6		
				Back, forward again	1		

Table D.4 Grouped Responses for the ‘refresh’ function

Internet Explorer Favourites Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Favourites	2			Bad to good	2	Don't know, know I do	1
				Bad, alright, good	8	Find out what something does	1
						Don't know	4
						Congratulations	1
				Getting better	1	Correct	3
				Good or bad	1	Okay	3
				Make it better	1	Well done	2
				No, ok, yes	2	Good	11
				Thumbs down	1		
				Thumbs up	9		

Table D.5 Grouped Responses for the 'favourites' function

Microsoft Word Cut Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Cut	50			Make an outline	1	Forgetting about somebody	1
						Cutting a 90 angle	1

Table D.6 Grouped Responses for the 'cut' function

Microsoft Word Copy Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Copy	9	Clone	10	1 man revolves into 2	1	Everyone has 2 sides	2
		Copy & Paste	4	2 people	1	Friends	1
		Doubling	6	Man split into 2	1	Multiply	2
		Mirror Image	1	Twins	8	Paste	3
		Reflection	1	Two same people	1		
		Symmetry	2				

Table D.7: Grouped Responses for the 'copy' function

Microsoft Word Undo Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
		Correcting mistakes	1	Change the word	1	Being bullied & lonely	1
		Correcting something	1	Take away letters	1	Delete	4
						Erase	22
						Mistakes	1
						Rub out	20
						Wrong	1

Table D.8: Grouped Responses for the 'undo' function

Microsoft Word Redo Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
						Play	3
				Arrows moving	3	Don't know	1
				Arrows pointing right	1	Throwing someone out	1
				Fast forward	12	People/things passing	1
				Follow arrows	1	Play forward	2
						Playing a film	1
						Move on	1
						Moving in two roads	1
				Go right	4	Moving straight	1
				Go round	1	Arrows	1
				Go that way	2	Forward	10
				Going in a certain direction	1	Continue	1
				That way	1	Go	3

Table D.9: Grouped Responses for the 'redo' function

Microsoft Word Bullet Points Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Bullet points	39	A list of things	1	2 lines	1	Don't know	2
		Adding lines	1	Line	1	Copy	1
		Been added	1	Paragraph picture	1	Swap	1
		Different points	1	Writing more	1		
		Making points	1				
		New point	1				

Table D.10: Grouped Responses for the 'bullets' function

Microsoft Word Numbering Points Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Numbered points	25	Adding number & lines	1	3 key points	1	Paragraph	1
Insert Numbers	2	List	2	2 lines	1	Sentence	2
				Writing in steps	1	Don't know	2
				Writing more & more	1	Again	1
				Writing up questions	1	Been copied	1
						Test	1
						Questions	5
						Answer question	1

Table D.11: Grouped Responses for the 'numbering' function

Microsoft Word Insert Table Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Insert Table	33	Cells	2	4 bold lines	1	Don't know	2
		Grid	5	9 boxes appear	1	A broken heart	1
				Building something	1	Graph	4
				Doing boxes	1		
				Lines put into blocks	1		
				Drawing pictures in sentence	1		

Table D.12: Grouped Responses for the 'insert table' function

Microsoft Word Spell Check Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Spell Check	22	Changed to make sense	1	A,B,C	3	Change	2
		Correct	2	Alphabet	3	Helping each other	1
		Correcting something	2	Arranging	1	Move writing	1
		Correction	4	Changing letters around	2	Order	1
		Mistake checker	1	Rearranging	3	Swap around	1
				Start of the alphabet	1	Don't know	2

Table D.13: Grouped Responses for the 'spell check' function

Microsoft Word Help Function							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
		Ask a question	1	A idea	34	Changing sad to happy	1
Help	5	Question mark	1	Brain switched on	2	Hope	1
				Clue	1	Don't know	2
				Confused to an idea	1		
				No ideas – then think of one	1		
				Think of something	1		
				Was confused & now understand	1		
				I understand now	1		

Table D.14: Grouped Responses for the 'help' function

Q1. What did you think of the icons you just saw?							
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*	*Category 4*	*Freq.*
Clear & Useful	4	?	3	Easy & hard	8	Shows things in weird ways	1
Easy & useful	5	Confusing	2			Weird & hard	1
Good	12	Didn't like them	3			Weird but simple	1
Interesting to work out	1					Weird, fun	1
OK	5					Weird, helpful	1
Quite good & understandable	2						
Useful as relate to object	1						
Reliable	1						

Table D.15: Grouped Responses for Q1

Q2. Did you think these icons were useful in telling you what they mean?					
Category 1	*Freq.*	*Category 2*	*Freq.*	*Category 3*	*Freq.*
?	3	Easy to understand	1	More detailed	1
I don't know	1	I think they do	1	Most of them, some confused me	1
No	11	Most were useful	2		
Quite young to understand	1	Quite, obvious	1		
		Some hard & easy	2		
		Some need tweaking but they were useful	1		
		Some useful	6		
		Doubling & bullets	1		
		OK	1		
		Useful, bold, easy to see	1		
		Yes	18		

Table D.16: Grouped Responses for Q2