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Towards an Understanding of the Use of Digital Media to Facilitate the Inclusion of Children with Learning Disabilities in Mainstream Primary School Classrooms

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Declaration

I hereby declare that this thesis is entirely my own work except where otherwise accredited. The thesis has not been submitted for an award at any other institution.

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Abstract

Róisín Garvey: Towards an understanding of the use of digital media to facilitate the inclusion of children with learning disabilities in mainstream primary school classrooms

Inclusion, or the integration into mainstream classrooms of students with learning difficulties, should strive to make the students' education sufficiently challenging while also making considerations for their particular capabilities and needs. A key aspect of inclusion is the requirement for appropriate support services and additional aids for both students and teachers. Digital media can be effective in helping to facilitate learning and can provide opportunities for engagement, peer learning, curriculum support and assessment. It can also promote collaborative and cooperative learning when the educational content is tailored to the capabilities of individual students. Finding teaching strategies that are suitable for an entire mainstream class, regardless of the format, is extremely difficult given that children with general learning disabilities can present with a broad range of characteristics and the amount and type of these characteristics that are present are unique to the individual.

This thesis outlines some of the issues encountered in facilitating inclusive schooling and offers some observations from a comparative study that sought to investigate the extent to which digital media could facilitate inclusion in mainstream classrooms compared to traditional teaching methods. The study aimed to determine the levels of collaboration and the potential for peer learning when participants completed tasks through both a traditional desk-based learning format (TDL) and interactive digital learning format (IDL). The findings contribute to a set of guidelines, which are discussed in this thesis with a view to informing the development of digital media for the inclusion of children with learning disabilities in mainstream primary schools. Additionally, the thesis offers some implications for practice and policy and for further research to expand this valuable research area.

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List of Abbreviations

TDL – Traditional, desk-based learning format

IDL – Interactive, digital learning format

MGLD – Mild general learning disabilities

LD – Learning disabilities

ICT – Information and communication technology

TUI – Tangible user interfaces

TEL – Technology-enhanced learning

Chapter 1: Introduction

1.1 Overview

Mild general learning disabilities (MGLDs) account for a large proportion of the learning disabilities present in mainstream schools (Carey, 2005). Yet, while specific learning disabilities can present a more defined set of characteristics, MGLDs are associated with a broader range of characteristics, the presence of which are unique to the individual (Lerner, 2005). This combination of broadness and the individual nature of disabilities accounts for one of the main difficulties when attempting to design teaching strategies that are suitable for these children with MGLD. In addition, many children will present with some characteristics of learning disabilities (LD) despite not receiving an official diagnosis (ASHA, 1994; Torgesen, 2001, Fletcher, in Wong & Butler, 2012). Some strategies for supporting children with LD in a mainstream classroom include differentiation of the curriculum and inclusion (Stainback & Stainback, 1996; Ball et al., 2005; Griffin & Shevlin, 2007). Inclusive classrooms encourage collaborative group work that supports all learners by helping children to build tolerance and social skills (Karagiannis, et. al, 1996; Rose & Howley, 2006). Strategies for facilitating inclusive classrooms can vary but often include recommendations to support different learning preferences that children may have through the use of multi-sensory instruction. Digital media and games can be extremely beneficial for collaborative work and by extension, inclusion, by allowing more learners to be involved in the creative learning process. Digital games allow learners to collaborate in different ways, explore other skills and support other abilities (De Freitas, 2006; Bonanno & Kommers, 2008).

While digital media can facilitate learning it also provides affordances for a range of pedagogical approaches across all disciplines through the provision of collaborative, learner-centred, information-rich environments (Newhouse, 2002). Digital media has

specific benefits for rote learning with fairly effortless integration of motivational elements, feedback and multi-sensory supports (Bruckman, 1999). Digital media supports the learning theories of behaviourism by providing opportunities for repetition and reinforcement (Bruckman, 1999; Weegar & Pacis, 2012), constructivism by offering learner-centred active learning environments, and cognitivism by supporting the development of memory structures (Sorden, 2005). Crucially, with regard to the use of digital media, is the requirement to support the fundamental theoretical processes of traditional learning while offering additional benefits (Mayes & de Freitas, 2007, in Beetham & Sharpe). While computers can be used in a structured and creative way in the classroom, the benefits of technology are not limited to conventional computer systems.

Although there is still a tendency to use traditional computer-based educational software, research has offered the benefits of using virtual reality and tangible user interfaces to positively engage students and facilitate the use of new learning environments (Xie, 2008, Antle, 2007, Fails et al., 2005). They also offer the potential to support all learners, although this is an extremely difficult concept given the range of abilities and competences of children in mainstream classrooms. While more interactive, immersive and tangible technologies offer great potential for their use in education, or particularly for children with disabilities, the reality tends to be that it is rarely feasible to integrate this in the classroom (UNESCO, 2011). Despite the fact that today's Digital Natives (Prensky, 2001) have the opportunity to take advantage of the various types of personal technologies that are now available at relatively low costs, it is often teachers that need support to implement these tools in their classroom with barriers existing due to a lack of time, budget and often space.

In order to determine the best solution for teaching children with LD, an understanding of the difficulties faced by children in mainstream classes is crucial. This includes an examination of the most common characteristics of LD and the teaching strategies that are often applied to address these difficulties as not all children will be officially

diagnosed with a general or specific disability despite presenting with some difficulties (ASHA, 1994; Torgesen, 2001; Fletcher, 2012). Further to this, an understanding of the potential of digital media to facilitate inclusion along with an investigation of the most cost-effective method of facilitating such an approach.

An additional consideration relates to research that has been done on the use of interactive media for collaborative learning, often due to the advances in and improved access to technology (Ullmer & Ishii, 2001; Maher & Kim, 2005; Scott et al., 2003; Speelpenning et al, 2011) but questions have been raised over the effectiveness of using this technology for learning compared to traditional desk-based teaching methods when studies have shown that the collaborative behaviour of children tends to be quite similar across both formats (Scott et al., 2003; Antle, 2007). Various exploratory studies have been conducted in order to determine the effectiveness of interactive or tangible user interfaces in education, for enjoyment or engagement, over traditional computer based interfaces (Xie, 2008, Antle, 2007, Fails et al., 2005). Historically, many traditional educational games that have been used in the classroom are single-player, requiring a turn-based system of collaboration (Johnson et al., 2010), which although useful for supporting independent parallel play, can be exclusionary to academically weaker students. If considering using digital media to facilitate inclusion, a range of solutions have the potential to support this but any digital solutions such as tangible user interfaces, come at a significant cost currently in terms of the time and money required for the setup and maintenance of integrating this approach in a classroom.

In light of this, this thesis describes in detail a comparative study to determine the potential of affordable digital media to facilitate inclusion in a mainstream primary school classroom by observing the ways in which the children interact and collaborate while undertaking tasks in both traditional, desk-based (TDL) and interactive, computer-based (IDL) learning formats. This thesis contributes to the area of inclusive education by offering some recommendations for the development of highly collaborative and cooperative learning formats that can support students with a wide range of abilities. The

findings contribute to a set of guidelines for the development of digital media for the inclusion of children with LD in mainstream primary schools.

1.2 Research question

The research presented in this thesis aims to offer some valuable insights into the potential of digital media to support inclusion for primary school aged children through the use of learning activities that are applicable to the curriculum. As such, I pose the following research question, which will be addressed in this study:

To what extent can digital media help to facilitate the inclusion of children with cognitive disabilities into mainstream primary school classrooms compared to traditional teaching methods?

1.3 Thesis structure

An outline of the structure of the thesis is provided by way of an overview of the chapters that follow.

Chapter Two presents an overview of the theoretical background that informs this research study. Beginning with a view to understanding the classification of Mild General Learning Disabilities (MGLD), followed by an attempt to outline the history of LD in Europe and the US and of the characteristic difficulties that present with LD. Following this, an overview of the main learning theories and teaching strategies related to children with LD in mainstream classrooms are presented. This then leads to an outline of the learning theories related to digital media and towards an explanation of the benefits of using digital media for education, with a particular view to its potential for educating children with LD. Additionally offered in this chapter are some considerations and theories related to the design of digital media for education.

Chapter Three offers a description of the study that was designed to address the research question. The chapter begins with an overview of the research style (section 3.2) and the data gathering methods used (section 3.3). What follows is an overview of the research instruments developed for the study (section 3.4) and the participants that were chosen (section 3.5). Section 3.6 offers detailed description of the study implementation, and finally, the ethical issues that were addressed during the study are offered in section 3.7.

Chapter Four presents the largely qualitative findings of the study. This chapter offers a description of the detailed data analysis, outlining the first and second order coding, that was conducted in order to generate the findings related to the experiences of the children during the study. The chapter concludes with an offering of some of the broader themes that were extrapolated from the study findings.

Chapter Five begins by offering some further thoughts on the main themes that emerged from the study with a view to addressing the research question. Based on this, some guidelines are offered for the development of digital media to support the inclusion of children with LD in mainstream primary schools. The second part of this chapter, section 5.2, concludes with discussion of the contributions from the study. The limitations of the study are outlined followed by some suggestions for future related research and implications for the design of collaborative digital media as well as for practice and policy.

Chapter 2: Background

2.1 Overview

The research question and the study designed to address it are based on a gap in the empirical research related to the potential of affordable digital media over traditional collaborative teaching methods to support as many learners as possible in an inclusive primary school classroom. The study considerations include, but are not limited to, the varying learning difficulties present in primary school aged children in mainstream schools, the teaching strategies used to address these, the potential of digital media in general as a learning tool and the most common barriers to the integration of digital media in the classroom.

In section 2.2.1, by way of exploring the complexities of LD, the various definitions and classifications used to identify learning disabilities (LD) are offered, in particular Mild General Learning Disabilities (MGLD). This section also outlines the difficulties in diagnosing general learning disabilities. Following this, section 2.2.2 offers an historical perspective of the treatment and response to LD in Europe and the US. Section 2.2.3 outlines the most common difficulties affecting children with MGLD and the characteristics that are generally present in children with learning difficulties regardless of prior diagnosis. In section 2.2.4, the learning theories that are most relevant to the teaching of children and those with MGLD are discussed. Section 2.2.5 introduces the first of two teaching strategies used to support children with LD in mainstream classes, differentiation of the curriculum. This is followed, in section 2.2.6, with an outline of the practice of inclusion, which can refer to a number of contexts but here refers only to the integration into mainstream classes of students with LD. Additionally, an overview of the particular research topics covered in this chapter with regard to the Irish context (section 2.2.7) is offered.

The second half of this chapter considers the role of digital media in education with a particular view to its potential in supporting children with LD. As such, an overview of the role of learning theory with regard to educational digital media (section 2.3.1) is presented along with some of the benefits of the use of digital media for children with LD (section 2.3.2). Section 2.3.3 outlines the main barriers to the integration of digital media in classrooms, including the use of poorly designed digital tools. Section 2.3.4 brings forward the strategies of differentiation and inclusion, as mentioned earlier in this chapter, by way of exploring the potential of digital media to support these strategies. In section 2.3.5, some considerations for the design and development of educational digital media are outlined. These considerations, including various instructional design models, helped to inform the design of this study described in Chapter Three. Finally, the research motivation and research question (section 2.4) are offered as a result of this theoretical background.

What follows, in Chapter Three, is a detailed description of the media that was developed to act as research instruments and the methodology used to address the research question.

2.2. Teaching children with learning disabilities

2.2.1 Introduction

Learning disabilities (LD) are complex and wide-ranging but the term is generally used when referring to a deficiency or difficulty in one or more of the basic processes needed for traditional learning (IDEA, 2004). Lerner (2005) more specifically defines the term as a "neurobiological disorder" affecting an individual's understanding of "spoken or written languages". This presumption that the disability is caused by a disorder in the nervous system is included in two further popular definitions of the term, one from the National Joint Committee on Learning Disabilities (NJCLD, 1991) and the other from the Interagency Committee on Learning Disabilities (ICLD, 1987). These committees

also refer, in their definitions, to LD as a "heterogeneous group of disorders" that are "intrinsic to the individual" highlighting the complications in finding an all-encompassing definition of the term or indeed classifying an individuals particular learning difficulty. Fletcher et al. (2003, p30) acknowledge this challenge by referring to studies that took into account the unexpected nature of "intraindividual variability". The Individuals with Disabilities Education Improvement Act (IDEA, 2004) offers an important caveat that the term is used when the problem is not primarily the result of another difficulty or disadvantage such as sensory impairments, social, economic or emotional disadvantage (IDEA, 2004). The World Health Organisation has defined LD, or more specifically, mental retardation although this is now seen to be an out-dated term, as "a state of arrested or incomplete development of mind" (WHO, 2010). However, the WHO notes in the same report that "intellectual abilities and social adaptation may change over time" and "may improve as a result of training and rehabilitation". More recent research argues of further complexity in defining learning disorders. Green and Chee (1997) outlined the issue of comorbidity, particularly prevalent in children with ADHD, Autism and Down Syndrome, where these conditions present along with other specific LD. The key factor of special needs is perhaps that, above all else in terms of classification, it indicates that a person possesses individual characteristics that require special provision (Emanuelson, 2001).

When defining LD, the difficulty arises in that "learning disability" is an umbrella term that includes varying categorisations and degrees of such disabilities. Historically, one of the methods used to classify LD is by IQ, although while it is found to be useful for sub-categorising LD, few of the popular definitions refer to IQ being an effective measure due to variances that can occur in the measurement through intellectual and social development over time (Fletcher et al, 2003; Siegel, 2006; BILD, 2011). The IQ measure should not be wholly discredited, but should not be the main focus when planning for teaching intervention. The generally accepted classification of LD based on IQ range notes that a cognitive functioning range of 50-70 standard score is classified as a mild learning disability, 35-50 is a moderate learning disability, 20-35 is a severe

learning disability and below 20 is a profound learning disability (Carey, 2005; BILD, 2011).

One approach to take when classifying, identifying and defining LD is to apply a variety of models. While historically the standard method to identify LD was to apply the IQ-Achievement Discrepancy model, this has been strongly opposed in recent years (Fuchs & Fuchs, 2006). This model sought to highlight any difference between a student's results on a general intelligence test and a standard achievement test to determine if there was a severe discrepancy between IQ and achievement. An achievement score of less than two standard deviations from the IQ score pointed to a LD. A large problem with this model was that it failed to identify a student's particular learning need, it was not applied to younger children when they would have benefitted most from a diagnosis and it was not seen to be fair to children from culturally diverse backgrounds (Fontana, 1995). This model was replaced by the Response-to-Intervention model, which allows for early intervention and produces results to aid appropriate instruction. Fletcher et al. (2003) point to other models of defining and identifying LD. The intra-individual model, for example, focuses on the use of intervention by tracking progress and seeing where intervention is needed. The authors recognise the general unpredictability of LD in that children generally have strengths in some areas and weaknesses in others, as such, they acknowledge the importance of Gardner's Multiple Intelligence theory although this model highlights many skills and talents that are often not recognised in schools or the curriculum (Gardner, 1996).

While specific LD, such as Dyslexia, present a more defined set of characteristics, MGLD are associated with a broader range of characteristics and the amount and type of these characteristics that are present are unique to the individual (Lerner, 2005). This intraindividual variability (Fletcher et al., 2003 p30) and the potential for children with LD to improve academically over time make the application of rigid teaching strategies virtually impossible. The following section outlines a history of LD as an introduction by way of offering of a more comprehensive view of the difficulties faced by both the

children with LD and the teachers who are educating students of varying abilities in mainstream classes.

2.2.2 History of Learning Disabilities

The history of the treatment and classification of learning disabilities has its roots in medicine, particularly in research of brain injuries and behaviour. Given the scope of this thesis the focus will mainly centre on the history of cognitive disabilities in Europe.

The Foundation Period (Hallahan & Mercer, 2001; Lerner, 2005; Mercer & Pullen, 2009), roughly extended from 1800 to 1930 and concentrated on both reading disabilities and links between brain injuries and behaviour difficulties. Key findings in this period were Franz Joseph Gall's initial observations on particular mental and physical functions being controlled by specific areas of the brain (Wong, 2004), and Broadbent and Kussmaul's focus on speech and language and reading disabilities. These studies led to further exploration in the late 1800s of reading difficulties occurring without the presence of brain injuries, along with the use of the term "dyslexia" by Berlin (1887) when discussing specific reading difficulties, and, the still relevant links between reading difficulties and visual memory by Morgan in 1896 (Hallahan & Mercer, 2001) and by Hinshelwood in the early 1900s (Hinshelwood, 1917). Both Morgan and Hinshelwood conducted studies on people who had normal brain function and it was Hinshelwood whose studies lead to the still widely held belief that reading disabilities can be inherited and that such disabilities are difficult to diagnose and characterise.

These findings, which focused on reading difficulties in "normal children" and links with visual memory, a sort of "word blindness" as it was known, led to the move by US teachers in the 1920s to develop diagnostics, assessment tools and interventions for those with reading difficulties in the Transition Phase (Lerner, 2005). Many of the findings from this period are still particularly relevant today. Key researchers in this period were Grace Fernald, Samuel Orton, Marion Monroe, Samuel Kirk and William Cruickshank (Rotatori, et al., 2014). Some important revelations and discoveries were

Fernald and Orton's multi-sensory teaching methods and Orton's observation that a person's IQ does not reflect their intellectual capacity and his conflicting opinion on Hinshelwood's theories of the percentage of the school population with reading difficulties (10% to Hinshelwood's 0.1%). Orton held the belief that mixed cerebral dominance was the cause of many reading difficulties including a reversal of letters, palindrome confusion, mirror reading, etc. (Hallahan & Mercer, 2001; Rotatori, et al., 2014) and his remediation practices using phonics and a blended learning approach using multisensory instruction are still relevant today. While Fernald generally concurred with Orton's approach to learning using kinaesthetic styles and a multisensory approach, in fact Fernald and Keller's VAKT (Visual-Auditory-Kinaesthetic-Tactile) method pre-dates Orton's multisensory approach, but she did not propose the teaching of phonics (Fernald, 1943). Monroe, in testing the methods of Orton, Fernald and Keller developed diagnostic tests, which used the results to guide instruction (Hallahan & Mercer, 2001; Rotatori, et al., 2014). Monroe's developments have had significant impact on teaching children with LD, namely a reading index that indicates the discrepancy between actual and expected achievement as a means of identifying students with reading disabilities; and diagnostic prescriptive teaching, which promotes the analysis of the specific reading errors that children make in tests in order to guide further instruction. As such, Monroe has been said to have introduced the concept of diagnostic prescriptive teaching, an approach that is still in use today. Monroe was also able to estimate from this reading index that close 12% of the population had a reading disability, much closer to Orton's estimation than Hinshelwood's perhaps out-dated presumption.

The Emergent Period that followed, from 1960-1975 (Hallahan & Mercer, 2001), saw legislation and the education system begin to take notice of learning disabilities with the term "learning disability" being introduced by Samuel Kirk in his book Educating Exceptional Children (1962). It was during this period that Governments began introducing legislation on LD and organisations and support groups were set up by parents and professionals.

Despite the initial research into LD largely focusing on the link between behaviour and brain injuries, some of the findings from the period were carried through with continuing relevancy today, including the benefits of multisensory learning and the prevalence of LD in schools.

2.2.3 Common difficulties for children with cognitive disabilities

Empirical research shows that the most common problems affecting people with LD, regardless of pre-existing brain injury, are perception and discrimination problems (Goldstein, 1936; Baddeley and Hitch, 1974; Westwood, 2003); working memory deficiencies (Baddeley and Hitch, 1974; Swanson, 2003) and phonological processing difficulties (Green & Chee, 1997; Wolf & Bower, 1999; Fletcher et al, 2003). Kavale and Forness (2003) argue that since 1963, one of the main reasons found for LD is related to a process disturbance, i.e. perceptual motor functioning, and recognise the importance of phonology, processing skills, auditory processing, memory and encoding skills. For the purpose of this research, the common difficulties will be discussed in terms of deficiencies in visual processing, comprising discrimination, figure/ground, memory; and auditory processing, which includes phonological difficulties and memory. Separating these deficiencies in this way does not suggest that children face difficulties with either exclusively; it merely offers a classification and many children present with a variety of difficulties associated with both. The Individuals with Disabilities Education Improvement Act (IDEA, 2004) refers to these auditory and visual processing difficulties under the classification of disorders in psychological processing, which also separately includes language and memory difficulties.

Memory problems play a large part in the overall difficulties of children with LD. Swanson and Sáez (2003) note that deficiencies in working memory are an issue in terms of word recognition, processing skills and comprehension; and mathematics. Much of Swanson's work refers to the role of memory and cites Baddeley's model of working memory as a theoretical framework. Where memory problems are present in children with MGLD, particularly in areas of short term and working memory, common

tasks such as sequencing is made more difficult. Baddeley and Hitch (2000) discuss the accuracy of specific models, which highlight working memory in children. The models debated are the Baddeley and Hitch multi-component model (1974) and the Pascual-Leone model (1970). Nicholson et al. (1991), in a study of issues with working memory and phonological discrimination for people with dyslexia, demonstrated that the child's working memory improves with age and that the issue lies with "an impairment of control processes rather than an underlying disorder of the working memory architecture".

As outlined in section 2.2.2, much of the research into the common difficulties or characteristics of LD has come from the historical, more scientific studies into brain injury and resulting disabilities. Kurt Goldstein studied many cases of brain injury in soldiers and found what he termed to be "forced responsiveness to stimuli", a "seeming inability to distinguish essential from inessential" which in turn showed some deficiency in figure/ground perception, i.e. the discrimination between figures and their background which brings with it problems of focusing on individual words on a page when reading; and this "abnormal distractibility" makes "extraneous stimuli" a hindrance (1939). One recommendation resulting from this and related research focused on providing a distraction-free environment (Hallahan & Mercer, 2001), a concept that can be applied to instruction for children with visual processing or spatial awareness disorders.

It was during the 1960s that saw an increased focus on the varying characteristics of LD as schools began to adopt policies for identifying and teaching children with these characteristics, an exercise that remains challenging. Teaching strategies for children with LD generally require regular revisions, as different learning approaches may be unsuitable for particular children. This challenge is outlined in the following section, through a discussion of three main schools of learning, behaviourism, cognitivism and constructivism, and their relevance with regard to educating children with LD.

2.2.4 Educating children with learning disabilities

This section offers a discussion of the application of behaviourist, cognitivist and constructivist methods in educating children with LD. Educating children with LD requires attention and planning with focus on individualisation and the need for developing independence and social function.

Behaviourism focuses on the noticeable changes in behaviour (Schuman, 1996), of the learner in response to external stimuli and concerns itself with passive, automatic reactions that occur, e.g. Pavlov's dog. Examples include direct recall of facts, repetition and performance of procedures. Behaviourism, which is not generally recommended for high level processing or procedures due to fewer opportunities for improvement (Bailey, 1998; Ertmer & Newby, 1993, pp56), is well suited to Special Needs education. This is particularly the case for direct instruction and explicit teaching (Lerner, 2005) for children with lower potential for advancement, more severe disabilities or more specific retention, behavioural or IQ problems, including children with autism, Down Syndrome and Attention Deficit Hyperactivity Disorder (ADHD) who are learning social behaviours. According to Bailey (1998), acceptance and integration of behaviourist theories was followed by a reduction in the use of the controversial (Swain et al., 2003) medical model of disability as a guideline for the provision of education for children with special needs. Bailey links this move with the integration of special needs children in mainstream schools as teaching methods can be adapted to suit the child using these theories. Key figures in the area of Behaviourism are Pavlov, Thorndike and Watson, who developed and expanded theories of conditioning and reinforcement; and Bandura who developed the social learning theory whereby reinforcement occurs through social learning, although it is not always immediate.

Cognitivism refers to the process of strategising to best organise information for learning and is concerned with best use of short-term memory to organise, store and understand new information. In essence, cognitivism focuses on internal mental process and the assimilation and application of knowledge to support learning (Merrill, 1987).

Cognitivism and constructivism lay a great deal of importance on the design of instructional material and information as theorists believe learning is dependent on a learner's processing capacity, the effort and depth of processing (Craik & Lockhart, 1972; Craik & Tulving, 1975). As such, cognitivist theories such as the Cognitive Load Theory (Chandler & Sweller, 1991) and the Schema Theory and Mental Models should be considered in the design of content for children with LD . From a cognitivist point of view, theorists such as Piaget and Vygotsky emphasised the role of play in developing skills such as problem solving, creativity, communication and social skills and offering meaningful and open ended experiences to aid assimilation and reuse of knowledge. Cognitivism places much emphasis on the role of memory, in particular the sensory register, short term or working memory and long-term memory (Lerner, 2005). It is Mayer's cognitive theory of multimedia learning (2009) that is of particular relevance to this research and will be discussed in section 2.3.1.

Constructivism takes the position that learners are active in how they interpret information and build meaning and knowledge through prior experiences using observation and processing (Cooper, 1993; Wilson, 1997; Ertmer & Newby, 1993). Constructivism takes into consideration the influence of content and context in learning to be a truly individual process. Vygotsky, who believed strongly in the power of social interactions for learning, in particular language development, devised the Zone of Proximal Development which focuses on the importance of scaffolding, a relevant area in special needs where learning is to be matched to the child's abilities. The Zone of Proximal Development refers to the zone or gap between that which a child can do on their own and what they can do with help. In this sense he believed that a child's ability to learn depended on their ability to take instruction. Vygotsky's references to scaffolding and assisted learning are particularly relevant in terms of special education needs (Woolfolk, 2010). Another key figure in the area was Piaget who, while also outlining four stages of intellectual development (sensorimotor, preoperational, concrete operational and formal operational) believed that teaching should match the needs of the children, and was one of the earliest proponents of the individualised approach to

teaching. While Piaget believed in the individualised, social and active learning process for children, it is not a guaranteed learning method for children with particular cognitive disabilities. Fontana (1995), however, finds problems with Piaget's theory as it does not accurately gauge children's abilities and progression.

Some lesser known researchers whose work is linked to the field of social theories using multimedia, relevant topics to this research, include Froebel who believed strongly in the integration of play and sensory experience to learning; Comenius and his examples of multisensory learning and the role emotion plays in development; and Dewey who follows Froebel with his theory of learning by doing. The work of Comenius, Froebel and Dewey was mirrored in the work of Montessori, an influential figure in children's education, who despite placing little value on the role of play in learning, believed in learning through the senses, through tangible environments and social learning. Physical and social stimulation play a key role in cognitive development (Woolfolk, 2010) lending the theory that active learning is effective for children's development.

Due to the nature of LD and the complexity of teaching children with possible multiple learning difficulties, many methods and models, including the controversial medical model (Bailey, 1998), the social model, the divergent individualistic model (Allan et al., 1998) and the psychological model, have been created, adapted and often discarded for use with students with MGLD. Woolfolk (2010) notes that there is no perfect solution to answer all learning problems and as is particularly relevant to the scope of this research project on the various disabilities in a mainstream primary school classroom, many theories could apply to one child as people develop gradually at different rates. Fontana (1995) also notes the importance of factors within the learner themselves that can influence how well they learn and can be more important to teachers, including but not limited to emotional factors, motivation, memory and social background. There are, however a number of teaching strategies that are commonly used when educating children with LD, including differentiation of the curriculum, as outlined in section 2.2.5, and inclusion, in section 2.2.6.

2.2.5 Differentiation of the curriculum

Curriculum adaptation or differentiation, as noted by Carey (2005), is fundamental in ensuring that "all children have equal opportunities" and it essentially requires a student-centred approach to teaching. Westwood (2003) defines it as "learning things differently according to observed differences among learners". Ball (2006) describes differentiation as a "process whereby teachers select appropriate teaching methods to match an individual student's learning strategies within a class group". This is a crucial approach when teaching children with different abilities in a mainstream classroom as, when done correctly, it can make the curriculum appropriately flexible yet challenging to suit all students (Stainback, et al., 1996). Griffin and Shevlin (2007) note that children with special needs require a broader range of opportunities and approaches in order to reach their potential. The authors acknowledge the need for these students to access a similar diverse curriculum to their peers. In a discussion paper produced by the NCCA (1999), the need for all students to access an "appropriate broad and balanced curriculum" with minimal differences in the methodologies used was listed as a main aim for the education of children with special educational needs. The NCCA (2002) defines differentiation as the manner by which a teacher "varies content, activities, methodology and resources when taking into account the range of abilities, interests, needs and experiences of students". By this definition, all children, irrespective of their educational needs, culture, or abilities are capable of requiring an adapted curriculum (Lapkoff & Li, 2007).

But barriers and challenges exist in terms of providing a suitable differentiated curriculum. One problem with differentiated teaching is in the amount of effort and time required by teachers to implement this approach effectively, as noted by Tomlinson (2000), differentiation is "not a recipe for teaching". Coffey (2004), in a study of curricular differentiation, outlined that strategies were best used at lower primary levels where learning focused more on activities whereas at the higher level, with the integration of more complicated topics, textbook learning was used more ultimately

making differentiation more challenging. An oft-cited quote from Gardner, when discussing his theory of multiple intelligences, highlights the issue at hand, “The biggest mistake […] in teaching is to treat all children as if there were variants of the same individual and thus to feel justified in teaching them all the same subjects in the same way.” (Siegel & Shaughnessy, 1994)

Research notes (Stainback, et al., 1996) the need for a “good match between learning objectives and student attributes” and suggest building on activities that address individual abilities rather than developing completely different objectives can help to ensure the student or group of students feel involved in the class. The authors consider that each student, despite working towards the same educational goal “and learning together”, had varying objectives leading to that goal. They offer some strategies for differentiation to ensure that all students feel included and work together towards a common goal. Techniques suggested by the authors include use of flexible learning objectives, activity adaptation by allowing students with particular abilities use their strengths to achieve these objectives. Ball (2006) suggests the utilisation of visual and auditory skills through various media for students with more prominent visual spatial abilities. Carey (2005) offers the notion of differentiation by a variety of methods including differentiating the learning environment, content and teaching process. Despite the general encouragement for inclusive schooling for children with LD as outlined in section 2.2.6, considerations should be made for the likelihood that some students may need a quieter environment, additional resources, a variety of media or a different method of demonstrating learning in order to develop independent learning skills.

One popular strategy for differentiation is a revised version of Bloom’s Taxonomy (1956), which allows teachers to categorise and measure learning objectives. This revised version by Anderson et al. (2001) incorporates the Taxonomy with Gardner’s Theory of Multiple Intelligences and seeks to support both the gifted child and the child with special needs (Noble, 2004). Bloom’s original taxonomy noted six categories in the cognitive domain, Knowledge, Comprehension, Application, Analysis, Synthesis, and

Evaluation. Krathwohl (2002) acknowledged the need to redefine the structure of the original taxonomy and to rename the categories, moving from nouns to verbs, to ensure clarity in terms of the learning objectives. The new categories are Create, Evaluate, Analyse, Apply, Understand and Remember. By broadening the scope of the categories, the authors hoped to prevent "missed educational opportunities" and help teachers to improve the delivery of instruction to all children. Another technique for differentiating the curriculum is the notion of tiered activities or assignments (Kingore, 2004; Levy, 2008). While less frequently used for daily tasks, this technique allows the teacher to develop three different tasks for a given objective or concept, a core task, an extended task and a modified task in order to make the instruction more student-centred. . As the names suggest, the core task will apply generally to the majority of the class. An extended task is devised to suit students who may need an additional challenge and the modified task is developed for those students that require support.

Schumaker and Deshler (2003) reference standards developed by the University of Kansas Center for Research on Learning (KU-CRL) by which to design interventions. Any designed intervention was required to be feasible within their classrooms, easy to learn by both teacher and student, yield meaningful, measured outcomes, broad enough to impact students without learning difficulties, and have a positive impact on the student with learning difficulties to enable competition within a classroom. The National Council for Curriculum and Assessment (NCCA, 2007) guidelines for children with MGLD offers some strategies including differentiating by level and pace, by student interest, by access and response, by structure, sequence and teaching style. Another model for differentiation, the REACH framework (Rock, et al, 2008), uses quality indicator - teacher, content, learner, instruction and assessment - based on variables to help teachers to integrate a differentiated curriculum. The authors hope that by using their step-by-step approach, it will enable all students to "have cognitive access, be active participants, progress […] and achieve their educational outcomes".

2.2.6 Inclusion

A second popular teaching strategy for educating children with LD is inclusion. While inclusion generally refers to the integration into mainstream classes of students with learning difficulties, those from disadvantaged backgrounds or those for whom English is not their first language, for the purpose of this research inclusion will be discussed in relation to the former only. More specifically in this case, inclusion can be defined as "the process of providing services to students with disabilities in local mainstream schools in age-appropriate general education classes with necessary support services and supplementary aids for pupil and teacher"(Ball et al. 2005). A key aspect of this definition is the integration of a requirement for support mechanisms for students in order to successfully achieve this inclusion. In addition, in their report, Inclusive Education in Action - Project Framework and Rationale, the European Agency for Development in Special Needs Education (2010) concluded that inclusive education refers to "the presence (access to education and school attendance), participation (quality of the learning experience from the students' perspective) and achievement (learning processes and outcomes across the curriculum) of all learners". By all accounts, inclusion should take every student's needs into consideration and strive to make their education sufficiently challenging but suited to their capabilities and needs (Stainback & Stainback, 1996).

Inclusion is generally regarded as an important part of teaching students with disabilities where possible, particularly those with MGLD. Although the inclusion method has had little opposition, particularly in the past twenty years, advocates are quick to outline concerns that should be addressed. Inclusion for children with MGLD is rarely opposed but some question how effective it can be for children with moderate or severe general and specific disabilities where the children may benefit more from one-on-one teaching (Westwood, 2003). This movement towards inclusive schooling for all was initially developed in the 1960s when advocates sought to "normalise" education environments for people with disabilities (Stainback & Stainback, 1996). It would take several years,

and a variety of legal battles, including the anti-segregation victory from 1954's Brown v. Board of Education (Rotatori, et al., 2014) in the United States, and the Rehabilitation Act of 1973 to see a significant shift in education policy internationally.

Karagiannis, et. al (1996) argue that inclusive schooling helps to prepare all children to live in a supportive community by gaining social skills, values and positive attitudes. As Swan (2000) notes, much has been learned "from our years of trial and error in breaching the long impassable frontier of educating the 'ineducable' and including the excluded in order to realise that every child can learn if they are appropriately helped to do so". But teachers need the support of the whole school in order to successfully integrate children with special needs in the classroom to ensure that all children benefit and can learn effectively. Rose and Howley (2006) highlight this requirement to prevent any individual from being disadvantaged and note that "singling out pupils for treatment that is differential may simply draw attention to their difficulties and exacerbate the discrimination which comes with a focus upon perceived deficiencies". The authors also warn that focusing on any particular difficulty or disability can mean that the individual's "strengths, personality, interests or abilities become secondary to the challenges that they face in learning". The issue at hand, however, is that children are individuals and particularly in the case of children with MGLD, they can have quite varying educational needs and learning preferences. By applying Gardner's theory of multiple intelligences and using specific teaching approaches that focus on each student's strengths and preferred learning style (Schaffner & Buswell, 1996) teachers can create meaningful experiences and facilitate learning for all children (Falvey et al., 1996).

King (2006) suggests some strategies that help students learn including control of task difficulty and group work. Group work, as echoed by Kirby and Drew (2003) should be in small groups with peer tutoring and cooperative learning (Johnson & Johnson, 1999) being used as an aid in successfully integrating children with special educational needs in the classroom. Typically these exercises can promote positive attitudes amongst

students, help to facilitate learning and improve social skills. Individualised Education Plans are useful tools created with the aim of addressing an individual's specific learning need (Griffin & Shevlin, 2007). These plans can be crucial in deciding on the most appropriate method of teaching a particular student as they require the teacher to consider the particular strengths and needs of the child along with a reference to the motivation and interests of the child (NCSE, 2006).

2.2.7 Learning disabilities in an Irish context

While the research presented in this chapter offers an overview of the history and classification of LD from Europe and the US, due to the context of this research study, the following section briefly outlines some history of LD from an Irish perspective.

Currently, the number of children with diagnosed special needs in mainstream classes is 3,421 (CSO, 2014), but a study by the Economic and Social Research Institute (ESRI) estimates that 25% of children in Ireland "have a special education need [although] not all of them need support at school" (Cradden, 2014). It is quite likely that a majority of this estimation comprises children who have presented with at least one characteristic of general learning disabilities and may not be officially diagnosed due to difficulties with diagnosis (ASHA, 1994; Torgesen, 2001, Fletcher, in Wong & Butler, 2012).

The history of LD in Ireland is far shorter than the US context, as it was in the 1960s that services were put in place in Ireland for special education. While early legislation acknowledged special needs, including imposing fines on people who took advantage of those with disabilities, the classification of people with disabilities was not without prejudice. Griffin and Shevlin (2007) note that the use of the words "amadán" and "óinseach" developed into derogatory terms in formal schooling. The authors outlined the significant difficulties brought about by both the integration of asylums and workhouses for the learning disabled, and the establishment of compulsory national system of education in the 1800s. The founding of the Association of Parents and

Friends of Mentally Handicapped Children, which eventually became St. Michaels House, saw the moving of special education in the right direction.

With a newly established Department of Health Commission in the 1960s came a recommendation for the increased use of special schools for the mentally handicapped. It was in the department's 1965 report on the issue that the views of Special Education in Ireland began to improve, despite the fact that such segregated teaching was being questioned in other countries at the same time (Griffin & Shevlin, 2007). A critical inclusion in the report was the allocation of special classes for children with MGLD in mainstream schools, a practice that is still used today. Other significant milestones were the introduction of remedial teachers in classrooms in the 1960s, the creation of the New Curriculum in 1971 that was more child centred and focused and on individual differences.

The National Council for Curriculum and Assessment (NCCA, 2007) guidelines for children with MGLD support the definitions and classifications of other countries' policies, as outlined in sections 2.2.1 and 2.2.2, that "students with mild general learning disabilities are not easily distinguishable from their peers. Their learning needs are often difficult to define, due to the multiplicity of factors that can contribute to their learning disability". The NCCA also notes some challenges that students with mild general learning disabilities may face, including:

- delayed conceptual development and limited ability to generalise
- difficulty expressing ideas and feelings in words
- limited attention span and retention
- clumsiness and difficulties with motor skills
- underdeveloped sense of spatial awareness
- difficulty adapting to new situations.

~ The National Council for Curriculum and Assessment Guidelines (2007)

Additionally, with respect to Irish policy on inclusion, it was the government's support of UNESCO's Salamanca Statement and Framework for Action on Special Needs Education, along with 91 other governments at the 1994 World Conference on Special Education Needs, that ensured the country's commitment to providing equal education for all. This commitment ultimately led to the Education for Persons with Special Educational Needs (EPSEN) Act 2004 which states that, where possible, "a child with special educational needs shall be educated in an inclusive environment with children who do not have such needs".

2.2.8 Summary

This research has outlined the strongly individual nature of LD and how they present in children, resulting in complexities with regard to designing or employing teaching strategies to address the difficulties faced by many of these children. Differentiation of the curriculum and inclusion offer children with LD an opportunity to learn and develop with their peers, albeit often at a different rate. The following section looks at the potential of digital media to facilitate learning with a particular focus on children with LD.

2.3 The role of digital media in education

2.3.1 Introduction

Digital media lends itself well to the learning theories and teaching practices laid out in section 2.2.4 related to pedagogy. Digital media also seeks to aid the teaching of skills and techniques that are frequently deficient in children with MGLD, such as memory, and auditory and visual processing skills, etc. (Ulman, 2005). The term digital media is used in this research to cater for the advances in affordable technology and the wide range of multimedia, software, tangible interfaces, peripherals and personal technologies that are available and that allow for the integration and engagement of learners (Beetham, 2007). The term is also noted to specifically include the terms Information

Communication Technology (ICT) and technology. Digital media is particularly suitable to the provision of education along the behaviourist route, where more automatic, rote learning is required and motivation, feedback and visual and auditory stimulants are an important feature of educational software (Bruckman, 1999). Sorden (2005) argues, however, that these visual and auditory elements can be counter-productive to learning if more focus is paid to using them to stimulate rather than educate.

A main aim of digital media for learning is to allow for the teaching of the curriculum, whether differentiated or standard, in the most pedagogically effective manner possible. Mayes and de Freitas (2007, in Beetham & Sharpe) suggest that when applying learning theories to digital media that "the challenge is to describe how the technology allows underlying processes common to all learning to function effectively". When considering the teaching of children with LD it is very difficult to pinpoint which learning theory, approach or model is best. As was suggested in section 2.2, a combination approach or certainly an individualised approach is often the preferred option.

While considerations are made for pedagogical theories in the design and integration of instructional content, digital media can influence teaching strategies in classrooms. Newhouse (2002) argues that digital media can create opportunities for teaching that supports active learning, is learner-centred, collaborative and allows greater access to information. When considering the traditional pedagogical theories, behaviourism, cognitivism and constructivism, some key elements emerge as being easily applied through the use of technology. Skinner and Gagné's behaviourist approaches of "drill and practice", integrating consistent feedback and repetition, is frequently utilised in digital games and software to facilitate reinforcement for subjects such as Maths and languages (Bruckman, 1999; Weegar & Pacis, 2012). Vygotsky's constructivist perspective and Papert's constructionist perspective, that teaching should be matched to the needs of the learner and that learning should be active is used in digital games involving puzzles and sequences, and in children's programming tools such as LOGO

and Scratch (Woolfolk, 2010; Read & Markopolous, 2013). Piaget and Athey's work on schema, and the various cognitive theories including the theory of Multimedia Learning, Paivio's Dual-Coding Theory and Baddeley's Working Memory Model, play a role in digital assessments and the development of e-learning solutions (Sorden, 2005).

While some of these frameworks for differentiating the curriculum with the integration of digital media are based on instructional design principles from a largely behaviourist position (Owen, 2008), Mayes and de Freitas (2007) follow the research of Greeno et al. (1996) in order to identify three distinct perspectives for understanding learning, that is the associationist perspective, which came from a behaviourist tradition, and the cognitive and situative perspectives. The associationist approach focuses on strengthening associations, on the process of learning through structured sequences or activities and the integration of feedback. It involves the analysis of tasks and the arrangement of activities based on complexity to form learning objectives. The cognitive perspective stresses the importance of other areas of the cognitive domain such as processing in memory, schema theory, and metacognition in the acquisition of knowledge. Learners complete activities in order to construct their own knowledge and meaning through reflection and discovery. The situative perspective acknowledges the influence of society and culture on learning in terms of the environment and the learning outcomes, and focuses on the patterns of learning. Authenticity is a key element to learning in this approach and collaborative learning activities are scaffolded with the integration of real-world scenarios. Problem-based learning and cognitive apprenticeships are examples of situated learning (Barab & Duffy, 2000). Mayes and de Freitas (2007) suggest that in most cases a blended approach of the three perspectives may be most suitable and acknowledge the importance of each perspective to learning. Indeed this may be the case when integrating digital media for children with learning difficulties due to the vast array of potential presentations of these difficulties in children.

Mayer (2009) offers a range of evidence for the application of multimedia learning, learner-centred design and requirements for instructional design. Learner-centred design and the pedagogy of digital media concerns itself with the belief that some teaching practitioners integrate such media without due regard for their pedagogical effectiveness (Beetham & Sharpe, 2007; Mayer, 2009) or whether they can have negative effects on the learning of children with cognitive disabilities. Digital media supports a multisensory method of learning (Barron & Orwig, 1997), an approach that has been championed by key figures such as Orton, Montessori and Fernald since the early 1900s. Digital media also successfully incorporates elements of Vygotsky and Piaget's methods, linking play and learning, supporting scaffolding and peer learning. Sharma and Hannafin (2007) acknowledge the link between scaffolding and Vygotsky's Zone of Proximal Development (ZPD) and note that they provide frameworks for design and study, with the ZPD's conceptual framework being used to select learning tasks and scaffolding's strategic framework used to determine the most appropriate strategies for specific learning. But like traditional teaching methods, incorporating digital media in the classroom requires careful planning to ensure that it is suitable for the child's needs (Draffan, 2002) and will not impede their learning. Jonassen et al (1999) suggested that digital media should be thought of like teachers in that it does not teach students but rather facilitates learning by allowing students to construct their own knowledge, develop problem solving and critical thinking skills and learn through their experiences.

But learning theories are not limited to offering the best approach to take when using digital media in teaching children with cognitive disabilities, Gagne's nine instructional events, for example, can help in the selection of media for a general audience regardless of the learner's ability. And in terms of the pedagogy of digital media, one could look at it in terms of the way the child is allowed to interact with the technology, passively, or actively, or as Druin and Solomon (1996) suggest, whether the computer has control over the student or vice versa.

2.3.2 Benefits

There has been an increased interest in the use of digital media in schools due in part to the increasing dependencies that people place on these technologies (Beetham & Sharpe, 2007) and the need for young people and jobseekers to be digitally literate (Burgstahler, 2003). Schools have also seen an increased focus on using digital media in educating people with disabilities over the last number of years (Dept. of Education and Science, 2008). This increase is due to advances in and improved access to this technology, focused training initiatives for educators, increased funding for ICT in schools and the generally lower cost of integrating these technologies (Shiels & O'Flaherty, 2006). And the use of digital media is not limited to assistive technologies or even conventional computer systems, it also includes the use of the multi-faceted technologies available today, including software, alternative hardware, web and immersive technologies, tangibles, video and audio, etc. that can be quite easily integrated in the teaching curriculum.

Digital media, when designed and integrated with the learner in mind, has the potential to be highly pedagogically effective. The potential benefits of using a combination of different senses for learning was first suggested in the 1920's by Samuel Orton. His subsequent work with Anna Gillingham and the development of the Orton-Gillingham method, which involves the combined teaching of how a word looks, sounds and feels (Gillingham & Stillman, 1970) introduced the idea of multi-sensory instruction. Fernald later used this research as a cornerstone of his VAKT (visual, auditory, kinesthetic, tactile) teaching style (Fernald, 1943), a method that is easily facilitated using technology (Kátai et al., 2008) and an important factor in teaching students with cognitive disabilities (Shams & Seitz, 2008). Digital media can be extremely beneficial for collaborative work, by using interactive technology and games, for instance, to include more learners in the creative learning process. Digital media and games allow learners to collaborate in different ways, explore other skills and supporting other abilities (De Freitas, 2006; Bonanno & Kommers, 2008). Burgstahler (2003) notes that

access to digital media can offer people with disabilities "the potential to maximize independence, productivity and participation in academic programs, employment, recreation and other adult activities". Digital media, as argued by Alexander (1999) and Jonassen (1999) in Smeets (2005), can facilitate "active learning and higher order thinking" by providing authentic learning environments. Digital media can support meaningful learning (Liu, et al 2013), which can be demonstrated through transfer (Sorden, 2005) and can be used effectively for assessment and exploratory learning (Florian, 2004). Jonassen et al (2003) suggest that meaningful learning is achieved when appropriate technology is used, which engages learners through "(a) knowledge construction, not reproduction; (b) conversations, not reception; (c) articulation, not repetition; (d) collaboration, not competition; and, (e) reflection, not prescription (p. 15)". Larcher (2000) suggests that the context of use of digital media can determine its success more so than the technology itself. He argues, that "collaborative play with computer games can provide an opportunity for children to apply interactive communication and language skills […] that they have been taught elsewhere".

Williams, et al. (2006), in a review of literature on the topic, noted a few of the benefits found for the use of digital media for children with LD. One such report claimed that digital media can facilitate "access to learning which increases motivation, fosters self-competition and confidence and improves self-esteem" (Thomas, 1992, in Williams et al, 2006). When one considers the range of difficulties that can accompany a MGLD, including but certainly not limited to motor, sensory and memory impairments (Westwood, 2003) it is understandable that digital media created for people with severe disabilities has the potential to be beneficial for people with MGLD to help in the areas of listening, reading, memory and language skills. At its root, digital media should not be seen as a replacement for good teaching practice but rather as an enhancement. From the perspective of LD, this enhancement can come in the form of reinforcement, motivation, skills development (cognitive, motor, etc.) and simulations (Ulman, 2005) which is of particular relevance to children with processing and memory skills, allowing them to recognise consequences and plan routines. Traditional digital media "drill and

practice" activities can be beneficial for children with attention, memory or processing deficiencies by providing immediate and automatic feedback and encouragement (Draffan, 2002; Behrmann, 1994; Besio, 2004), and much needed repetition.

Crucially, while many benefits are noted for the integration of digital media for education, barriers still exist with regard to its use in classrooms and particularly its use for children with LD. Some of these barriers are addressed in the following section.

2.3.3 Common barriers

Of the most common barriers to the integration of digital media in schools, at an initial stage, poorly designed instructional technology can in itself prevent some children with LD from accessing learning (Burgstahler, 2003). When considerations are not made for working memory and cognitive load, for instance, visuals or interactive elements do little more than stimulate the learner (Cook, 2006). Attention should also be paid to the usability of the digital instruction in order to allow the learner access to the critical information contained within. While many children these days have the opportunity to take advantage of the ubiquitous nature of technology, falling into the category of Prensky's Digital Natives (Beetham, in Beetham and Sharpe, 2007), it is often teachers that need the extra incentive in order to integrate digital media in the classroom, through good practice examples, guidelines and empirical evidence.

But an individual's own circumstances can result in impeded access to learning, which should also be considered with regard to this research as it affects the type of digital media that may realistically be integrated in the classroom. A UNESCO report on digital media in education for people with learning disabilities (UNESCO, 2011) categorised the barriers for learning as social, economic, and physical. Issues related to these categories can include a digital divide in terms of student access to technologies at home, inappropriate use as a collaborative tool, limited funds, lack of policies to support integration, inaccessibility due to poor design of digital systems and inaccessibility due to an individual's deficiencies in motor skills or abilities.

Brown (2000) argues that the issues of access, instruction and recognising barriers are key to integrating digital media for learning. Access relates to the location, quality and equal share of digital media; instruction relates to the ability to match the digital media to the student and the curriculum and teachers attitudes to digital media; and barriers lists the main difficulties that educators may face when trying to integrate digital media in classrooms, including teacher attitudes, lack of time, gender, fear, lack of role models and lack of supervision. Newhouse (2002) categorises Cradler's requirements for effective use of digital media into five general areas of impact:

- provision of both software and a hardware infrastructure
- support for teachers related to the integration with the curriculum and to technical issues
- school-wide policies, practices and design for the integration of ICT
- professional development and training for teachers
- management support for the teachers and students

Teacher attitudes towards the use of digital media can often play a large role in the lack of digital resources or interventions being used in classrooms. Newhouse (2002) notes that the integration of digital media in classrooms often inevitably results in an alternate teaching and learning model. This can be a somewhat daunting concept for teachers, particularly if they have little prior experience with digital media. The reality is that unless guidance, guidelines and good practice examples are provided to the teachers for particular scenarios or interventions, the scale of the task can seem overwhelming, regardless of how small a change it is in reality. In a study on the contribution that digital media can make to learning environments in primary education, Smeets (2005) cites related studies (Niederhauser & Stoddart, 2001; Pisapia, 1994; Demetriadis et al., 2003) in order to address how variances in teacher styles, skills and attitudes can affect the type of digital resources being used and the probability of its use. These studies found that teachers with a traditional teaching style chose skill-based instructional software while teachers following a constructivist approach chose skill-based and open-

ended software. In learner-centred classrooms, drill and practice, simulations and problem-solving activities were chosen, while teacher-centred teachers chose technology-enhanced learning (TEL) to reinforce skills, for motivation or incentives. The study by Demetriadis et al. highlighted a notion that teachers are influenced by the desire to meet school targets and goals and, as such, have a tendency to ignore innovations.

This conclusion suggests that an important potential barrier is attitudes of school management. Some observations and strategies suggested at a university level but applicable in all education levels, teachers can benefit from a school policy or teaching plan regarding TEL, that a support infrastructure is put in place at a school-wide level and that teacher training is provided for continuing professional development (Siemens & Tittenberger, 2009; Blackmore & Owens, 2003). Funding is also a large issue from a school management perspective whereby schools may find they are sacrificing traditional teaching resources for digital resources. Schools in areas that are classified as underprivileged are further disadvantaged by a lack of available funding from the local communities for a technology infrastructure or for staff development for the teachers (Blackmore & Owens, 2003).

For those teachers that have the ability to use digital media in the classroom, the benefits of its use to facilitate particular teaching strategies is outlined in the next section.

2.3.4 Inclusion and differentiation issues and strategies

With the current drive for inclusion of most children with LD into mainstream schools and efforts to facilitate individualised learning (Williams, et al. 2006; Scherer, 2003), digital media could be of enormous help to both children and teachers (Swanson et al., 1999). As previously mentioned in section 2.2.6, a key aspect of the definitions of inclusion is the reference to the use of appropriate support services and additional aids for both students and teachers to facilitate an inclusive classroom (Ball et al., 2005). While the benefits of using digital media for learning has been addressed, it is important

to note how it can specifically aid in integrating children with disabilities in the mainstream classroom as literature points to a lack of attention to the area currently (Williams, et al. 2006).

Crucially, in terms of this research, digital media can be engaging, can facilitate peer learning and can be used for supporting the curriculum and for assessment. It can provide a differentiated learning environment whereby the educational content is tailored to the capabilities of individual students (Smeets & Mooij, 2001). Kozma and Anderson (2002) suggest some strategies to facilitate the inclusion of students with LD in schools through the use of technology:

- Engage students through activities that feature collaboration, project-based learning, and authentic environments.
- Help students to develop digital skills that include information literacy and communication skills, and self-expression.
- Consider students' needs, interests and capabilities in order to facilitate individualised instruction
- Provide access for students who lack the facility of ICT and digital technologies, and address issues of equity for students of different genders, ethnic or social groups.
- Expand the potential of the classroom through re-organisation of the class.

Smeets (2005) stresses the importance of educating teachers in the benefits of using digital media to engage students and create opportunities to facilitate active and self-directed learning. He notes that computers are generally used to complement existing instruction rather than promote new pedagogical practices and highlights the importance of using digital media when differentiating the curriculum and structuring it to support co-operation and collaboration. Bryant et al. (1998), when referring to inclusive strategies for higher-level education, offer some suggestions to increase the understanding and commitment of faculties for incorporating technology in the classroom. Many of these suggestions are applicable in primary level education,

including the need to develop a digital media development plan for the school, offer staff development training in digital media, and obtaining funding for the integration of the digital media. Crucially, the authors note the need to integrate the digital media without disrupting the potential to facilitate learning. Research suggests that if teachers can claim ownership of digital media it encourages them to use it more often as they can invest time and energy in planning its incorporation in the classroom (Robinson & Sebba, 2010; Higgins, 2003). Istenic Starcic & Brodnik (2010) cite research that acknowledges a need for teachers to focus more on competences in directing their own professional development rather than their technical competences in order to allow them to be innovative in their teaching.

Burgstahler (2003) outlines some specific ways in which digital media can help facilitate independence and participation for children with various disabilities. Digital media can maximise independence for students with motor deficiencies through the use of assistive technology such as hands-free keyboard; allow students with speech difficulties to participate in classroom discussions through digital communication; and allow students with physical disabilities to participate in experiences through simulations and virtual reality. For less severe disabilities, strategies such as slowing down the speed of a mouse can be a useful technique for people with dexterity issues, concentration issues or coordination issues. Subtitles included for the hearing impaired can be integrated into lessons easily to help with reading difficulties (Ulman, 2005). Grabinger, et al.(2008) point to the opportunities afforded by media applications to “improve learning accessibility for all students, not just those with disabilities”.

Educators, however, should be advised on the most effective ways of integrating digital media to reduce the learning curve as “mastering the ever-changing technology leaves little time for reflection on the best way to use it” (Allen, 2001).

2.3.5 Design considerations

In order for digital media to be used in the classroom, it needs to be pedagogically effective and suited to an individual's needs. Special attention needs to be paid to the design of interactive or instructional material for children with LD. Instructional designers cannot overlook the end user when it comes to designing content or concepts that are to be used by people with special needs. Keeler and Horney (2007) believe that it is the responsibility of instructional designers "to intentionally create courses that address needs and styles of all individuals, including those students with disabilities". Just as accessibility and usability features are called for in modern design, there is a requirement for learning needs to be facilitated and supported by design and technology, rather than causing learning to be hindered by these elements.

Research, particularly Paivio's Dual-Coding Theory (Paivio, 1986) and Baddeley's Working Memory Model (Baddeley and Hitch, 1974), suggests that information is processed through dual channels - visual and auditory. Each channel has limited processing capacity (Sweller, 1994), and as such, is in danger of being overloaded when attempts are made to teach with digital media without considering the learner. Mayer (2009) notes that efforts should be made to design effective instructional systems that can "[reduce] extraneous processing, [manage] essential processing and [foster] generative processing". His Cognitive Theory of Multimedia Learning argues that systems can be developed that appropriately make use of auditory and visual working memory without overloading the processing capacity of the learner, thus effectively facilitating their learning. This is a crucial consideration when designing or using educational media for children with LD who may present with deficiencies in visual or auditory processing that could further limit their capacity to process information effectively. Paas, et al (2004) highlight some important factors for consideration that can impact on cognitive processes, including the characteristics and restrictions of working memory, and the various implications of intrinsic, extraneous and effective cognitive load.

The variety and range of LD highlights not only the requirement for design considerations but also the complexity of such a task. Grabinger, et al (2008) add strength to this notion by acknowledging that, in addition, each individual is unique in how they present with symptoms and the intensity of these symptoms. As such, the authors admit that the task of designing for these distinct characteristics seems "practically impossible". As a strategy, designers can create solutions that follow certain models, principles or guidelines to ensure that products are suitable for and accessible to people with varying abilities or disabilities. One such framework is Universal Design, defined as the "design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people, regardless of their age, size disability or ability" (Disability Act, 2005). Universal Design, as noted by Bergman and Johnson (1995), argues that while design was traditionally focused on addressing the needs of the average person in order to potentially be suitable for the largest ratio of people, this focus is exclusionary as "the average user is a fictitious construct". Of the seven principles of Universal Design, key concepts include requirements for the design to accommodate a wide range of individual preferences and abilities; to be easy to use and understand, regardless of the user's experience, knowledge, language skills, or current concentration level; and to communicate necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities (Center for Universal Design, 1997).

Further to this, Universal Design for Learning offers a set of principles specifically for use in the design of instructional content for learners with cognitive impairments (Grabinger, et al., 2008). Universal Design for Learning (UDL), developed by the Center for Applied Special Technology (CAST) is defined as "a research-based framework for designing curricula […] that enable all individuals to gain knowledge, skills and enthusiasm for learning", which is accomplished by providing "rich supports for learning and reducing barriers to the curriculum, while maintaining high achievement standards for all students" (CAST, 2011). The three main principles of UDL suggest that instructional material provides multiple means of representation, of action and

expression and of engagement (CAST, 2011). Grabinger, et al (2008) outline that the premise of UDL is essentially that all students are different and cannot simply be categorised as either average or disabled. Essentially it is anticipated that, through the application of the UDL guidelines, all aspects of the instructional process will be covered allowing for the facilitation of learning for all students.

Instructional theories are principles of instruction derived from learning theories or empirical studies (Driscoll, 2005) that will provide the conditions for learning goals to be achieved (Reigeluth, 1983). The key to this theory is that learning occurs when conditions are favourable, when various mental processes transform information as it passes through memory. Instructional design is concerned with the optimal organisation and presentation of learning materials in order to achieve learning objectives (Siemens, 2002). Gagne identified the mental conditions that are required to be activated for this transformation of information and outlined nine processes or events that optimally address these conditions. His nine events of instruction are presented below in the order that he believes is most effective (Gagne et al., 1992):

1. Gain attention by activating receptors with stimuli
2. Inform learners of objectives in order to set out expectations for the learner
3. Stimulate recall of prior learning by activating short-term memory
4. Present the content in a meaningful way, in chunks and with variation of style
5. Provide “learning guidance” by helping learners to encode information for storage in long-term memory
6. Elicit performance (practice) to enhance retention and demonstrate understanding
7. Provide feedback to reinforce and assess performance
8. Assess performance through retrieval and reinforcement of knowledge
9. Enhance retention and transfer to the job through retrieval and generalisation of the knowledge

The popular ADDIE instructional design model provides a framework for the design of instructional material according to an iterative process that consists of five phases - Analysis, Design, Development, Implementation and Evaluation, which is carried out in a cyclical manner (Molenda, 2003; Gustafson, 1991). Another popular model is Merrill's Component Display Theory (CDT), which outlines the effectiveness of chunking information into microelements (Merrill, 1987). Siemens (2002) notes that many of the popular frameworks for instructional design promote the use of an iterative design process with considerations for user-centred design and the chunking of information to facilitate effective learning.

In terms of accessibility, which essentially holds as a central aim to make systems, environments and objects easier to use, it has been seen that all people, regardless of ability, can benefit from these measures. What is often seen as an accessibility feature exclusive to a particular disability can be beneficial to others, for instance, slowing down the speed of a mouse can be a useful technique for people with dexterity issues, concentration issues or coordination issues. Subtitles included for the hearing impaired can be integrated into lessons easily to help with reading difficulties (Ulman (2005). Dagger et al (2005) note, that "Accessibility and inclusion are also issues that have moved beyond the 'special needs' agenda. Now the aim is to make all learning facilities adaptive to individual needs". Nesset and Large (2004) outline the importance of considering some design theories that have been tailored to children's needs including User Centred Design and Learner Centred Design. Both of these theories place the user at the centre of the design process with Learner Centred Design, as the name suggests, considering learning as a core aim of the design. Beetham (2007) argues that the main challenges that arise from a learner-centred approach are (a) determining what variances in the ways that learners differ from one another are important to the specific learning in question, and (b) how can these variances be addressed in order to be effective for the individual learner. Read and Markopolous (2013) note the contribution of Allison Druin in advocating for the active involvement of children as stakeholders in the design of games and media as part of her cooperative inquiry method.

2.4 Research question

As addressed through the research in this chapter, the use of digital media for learning has long been a topic of discussion and investigation due to its potential to support learners in an engaging way regardless of their individual differences (Mayer, 2009; Gardner, 1996). Digital media, when designed correctly, can enhance how we process new information based on existing schema (Sweller, 2005). Recently, there has been a drive to explore how more interactive, tangible and augmented reality systems can further expand the potential of digital media for education due to their ability to engage learners (Antle, 2007; Ullmer & Ishii, 2000; Stanton, et al. 2001). Tangible interfaces certainly offer more benefits with regard to cooperative learning compared to traditional, graphical user interfaces largely due to the requirement for asynchronous, turn-based collaboration. However, empirical research has also pointed to a lack of evidence with regard to tangible interfaces offering any improvement in collaborative style over traditional, desk-based activities (Scott et al., 2003). This, along with the cost still associated with integrating such digital media in a classroom, has suggested that there are other solutions available, which can engage learners and facilitate collaboration.

Recent research has certainly suggested the benefit of conducting exploratory comparative studies with children (Xie, 2008, Antle, 2007, Fails, et al. 2005, Zaman & Abeele, 2004) in order to determine the potential affordances of particular media. Considering the associated costs and various studies conducted with regard to tangible user interfaces (TUIs), this research study integrates part of the framework used for TUIs and adapts it to suit this context. Sequencing tasks were chosen to aid in addressing the research question, as sequencing skills are an important part of the National Curriculum, transfer well across learning formats and are suitable for collaborative, problem-solving activities.

The research question that I will address in this study looks to determine:

To what extent can digital media help to facilitate the inclusion of children with cognitive disabilities into mainstream primary school classrooms compared to traditional teaching methods?

Additionally, based on the research outlined in this chapter, the developed media will also include considerations for the design of an affordable, collaborative learning resource that can also support the class teacher by allowing for more autonomous activities to be undertaken during class periods to reduce the amount of time required by the teacher to facilitate the collaborative activities and offer support to all learners. This thesis also contributes to the area of inclusive education by offering some recommendations for the development of highly collaborative and cooperative learning formats that can support students with a wide range of abilities.

2.5 Summary

Through this research, a number of gaps were identified with regard to the potential of digital media to support the widest range of children possible through collaborative, cooperative learning in an inclusive classroom. Despite the fact that there are complexities involved in developing teaching strategies for children with disabilities due to the range of ways in which they can present, the importance of supporting all children and helping them to develop social skills is apparent in order to prepare them for their future.

The following chapter, Chapter Three, outlines in detail the learning formats that were developed as instruments to address the research question and the methods used in conducting the study.

Chapter 3: Research Methods

3.1 Overview

A number of issues were raised in the research, in Chapter Two, including but not limited to, the difficulties encountered when defining or classifying learning disabilities (LD); the various difficulties commonly associated with many disabilities; the benefits of inclusive schooling for children with LD; the various barriers encountered by teachers when attempting to integrate technology in the classroom; and the strategies for teaching children with LD, particularly differentiation of the curriculum and inclusion. When aiming to determine the benefits of inclusion in mainstream schools, research has often focused on specific learning disabilities, such as Autism; on physical disabilities and assistive technologies specific to those disabilities; or on the inclusion of children from various different economic and cultural backgrounds. However, there is a lack of information specifically related to general learning disabilities and inclusion.

By facilitating an inclusive classroom, teachers can help children to develop positive attitudes and gain important social skills and values (Karagiannis, et. al, 1996). As such, the development of core skills and attitudes, as well as fostering a general supportive atmosphere, can be key outcomes of this approach. Inclusion is crucial to minimising discrimination and helps to build self confidence and self esteem by employing teaching strategies that will be suitable for the child, can highlight their strengths and prevent them from being excluded or singled out in a class (Rose & Howley, 2006). Strategies for integrating children with cognitive disabilities in the classroom often involve dividing children into small groups to encourage peer tutoring, facilitate learning and create a supportive, unprejudiced environment (Johnson & Johnson, 1999; Kirby & Drew, 2003). By grouping children with a mix of abilities, different strengths can be highlighted and promoted to encourage all children to participate.

This study required the design of two research instruments, which were developed to address the research question, one traditional (TDL) and one interactive using participative digital media (IDL). As the study was comparative in nature, the content and structure of the formats was designed to be similar while still offering some element of challenge for the participants. In this respect, the style of image, type of sequencing task and amount of tasks remained similar across both formats. The tasks were initially designed with the TDL in mind, with considerations continuously made for how it could be applied to the IDL. The study, as outlined in this chapter, compared the experiences of four groups of five children, aged 7-9 years, across the two learning formats.

Based on the research presented in Chapter Two, a number of assumptions were made prior to the development of the research instruments, all of which informed the design. Particular considerations include the lack of time available in classes, the lack of time available for teachers to learn or implement a new technology and the cost involved in developing digital media, that is, with regard to any requirements for the integration of commercial products in the design or development, such as Microsoft's Kinect to track movement. Further considerations drawn from the research included the requirement to include some element of challenge while keeping the varying abilities of children in a mainstream classroom in mind. In this regard, different types of challenge were considered, from the imagery used to the design of the tasks or the amount of opportunities for repetition included.

Assumptions were also made with regard to the perceived effect of the different learning formats on the children's enjoyment. It was assumed that an interactive, computer-based format would be more enjoyable for the children than a traditional, desk-based format, largely due to the novelty of such an approach. As this was a comparative study, it was important to keep the tasks as similar as possible in order to conduct a fairer comparison.

The following chapter outlines the material and the research method that was developed to address the research question based on the theoretical background outlined in Chapter Two. Section 3.2 offers an outline of the research style used in the study followed by an

overview of the data gathering methods used in section 3.3. In section 3.4, a description is offered of the materials used as research instruments. The study participants are introduced in section 3.5, followed by a detailed description of the study in section 3.6. The chapter concludes with an overview of the ethical issues and how they were addressed in section 3.7.

3.2 Research style

The study was largely qualitative as it sought to determine the experiences of the participants and as such it was designed to be somewhat "exploratory, fluid and flexible" (Mason, 2002, p24). As was discussed in Chapter Two, children with LD present with characteristics that are unique to the individual and, along with the small sample size, qualitative research was deemed appropriate to analyse their responses to each learning format in the study in order to determine their experiences and their individual contribution in a collaborative environment.

Qualitative analysis was conducted through:

- Observation of the participants to investigate their level of collaboration and engagement.
- Focus groups with the participants following the completion of the tasks in order to gain further insight into their experience of the two formats
- Post hoc reflection of the tests with the teacher to determine the possible affordances of digital media as an alternative or an accompaniment to the face-to-face learning environment.
- Two stage coding was conducted following the study in order to analyse the data gathered in an honest and comprehensive manner (Saldana, 2013)

3.3 Data gathering methods

As mentioned in section 3.2, the study was qualitative with observation being used as the main data gathering method during the study itself. Quantitative measures were also used during the observations (Appendix A), with specific attention paid to various performance metrics (e.g. task completion time, error rate, etc.). A key element of this performance test was to determine if children employ peer learning while working in their groups or if the teacher is more inclined to intervene to offer assistance to the children. This was important as inclusion is better fostered when there are opportunities for peer tutoring and a child's strengths can be highlighted and utilised regardless of their abilities.

Focus groups were carried out with each of the participant groups immediately following their completion of the study in order to gain further insight into their experience and behaviour. Research with children shows increasing use of focus groups, despite common beliefs that children are too immature or unfocused, as they can generally participate in discussions and offer feedback in groups (Davis, 2001). In order the answer the research question, some considerations were necessary to be made with regard to the focus group with these participants as noted in Davies (2007), including encouraging all participants to contribute to the discussion and ensuring that no one participant dominates the discussion.

An interview was conducted with the class teacher, following the completion of the study by all groups, in order to gather further information on the teachers thoughts of the study, how the children managed, any difficulties, etc. This interview with the teacher was incorporated as a potentially valuable source of data as the teacher knows the children, their abilities and difficulties. The main aim of this semi-structured interview was to contextualise the qualitative data gathered throughout the study and collect further information and insights from the teacher largely related to the performance and

behaviours observed of the children but including information on technology use in the classroom.

Audio recordings were made of the entire study, including focus groups and post-hoc interview, and screen recordings were made of the IDL format as an additional data gathering method. Additionally, a number of measures were employed to ensure that threats to the reliability and validity of results could be reduced. As one of the methods of data gathering used was observation, there was a possibility that there would be some level of bias as one individual gathered the data. However, methodological triangulation was employed in an effort to address this and to ensure that the combination of data gathering methods, including performance test and focus groups, would aid in maximising validity rather than guaranteeing complete validity (Cohen et al., 2007), as it was anticipated that any findings from one method would increase confidence in the findings in any cases where data agreed across two or more methods (Denzin, 1970).

The study was conducted in one school with one teacher to reduce the extraneous variables that could reduce the reliability and validity of the study. By keeping both the independent and dependent variables as similar as possible across the study, it allows clearer analysis of the data. For instance, the prior experience of the teacher or participants, the use of digital media in the school or indeed the range of abilities of similarly aged children in another school could all bias the study.

The following section details the material that was developed for the study in order to address the research question.

3.4 Developed material

3.4.1 Overview

As outlined in Chapter Two, empirical research states that the most common problems affecting children with LD include perception problems (Baddeley & Hitch, 1974;

Westwood, 2002) and working memory deficiencies (Baddeley & Hitch, 1974). Sequential memory is one of the seven main components of visual perception as noted by Gardner (1996). Sequencing skills are key elements of the National Primary Curriculum for subject areas such as Communication and Language, Mathematics, Physical Education and Music. Sequencing is relevant not only to spelling but reading, in terms of forming words, sentences and scenarios. By developing their sequencing skills, children can better comprehend what they read, particularly in terms of developing an understanding of a narrative (Williams, 2003). In other subjects like Maths, sequencing is of great importance and poor sequencing skills can lead to the transposition of numbers to alter a value, much like how the rearrangement of letters can change the meaning of a word entirely. As such, it is important to teach or reinforce sequential memory skills; these are core skills that have applications to the real world.

Additionally, digital media can be extremely beneficial for collaborative work, by using interactive technology, games, etc. to include more learners in the creative learning process. Games allow learners to collaborate in different ways, explore other skills and supporting other abilities (De Freitas, 2006; Bonanno & Kommers, 2008).

The following sections outline the materials that were developed in order to address the research question. As mentioned in section 3.1, the study required the development of two learning formats, TDL and IDL, to compare children's experience across both formats.

3.4.2 Tasks

In total, twenty separate tasks were designed for the study to be completed across two learning formats, which are outlined below in section 3.4.3 and 3.4.4. Following consultation with the class teacher and initial piloting, the time required to complete all of these tasks was not deemed feasible within a dedicated timeframe, largely due to the school's scheduled breaks, and the tasks were reduced to six for the TDL format and six for the IDL format. The tasks for the study were designed to incorporate a range of

sequencing activities that are applicable to a number of subjects. They required the students to match and complete image and symbol sequences of increasing difficulty. The aim of the tasks was to provide students with a variety of objects to also incorporate, on a lower level, other visual perception skills such as pattern recognition, and memory tasks. As the groups consisted of children with different abilities, the tasks needed to have some element of challenge to attempt to maintain the interest and engagement of all students (Tudge, 1990).

As mentioned above, in order to conduct as fair a comparison of the two formats as possible, both followed the same structure with regard to the tasks. Each format began with sequencing tasks that incorporated memory skills; this required the participants to study a sequence of images for 5 seconds before it is removed from their sight. The participants were required to match the sequence with the images in their possession. Challenge was incorporated here with an increasing difficulty in the imagery used, from more distinctive graphics to abstract symbols. These tasks were followed by pattern recognition tasks where a pattern with a missing image was displayed to the participants requiring them to decide which of their images completed the pattern. The pattern recognition tasks were included as another challenge for the participants as they would need to identify that it was a pattern before trying to solve it. The imagery used for these pattern tasks were abstract for some and more distinctive for others, also adding to the challenge. The final tasks were aural sequential memory tasks, which required the participants to match the sequence of events in a story that was read aloud to them. When they heard the story they created the matching sequence with the graphical representation of some key events in the story.

The expectation, from the combination of these tasks and the formats used, was an enjoyable, challenging group activity that supports the majority of learners, regardless of their ability. The development of each format is outlined in the following sections.

3.4.3 Traditional desk-based learning format (TDL)

The design of this format considered the layout and dynamic of a regular classroom and the activities that are typically carried out in this environment. Traditionally, children would use printable material and carry out tasks at their desks or at a table in a dedicated space, for instance, a learning support classroom. As each group consisted of five participants the sequential memory tasks comprised five images so that the participants could complete the sequence if they had one corresponding image each. While background colours were included for some of the sequences, they generally included at least two different shades of the same colour to slightly increase the challenge. Symbols were also used in these sequential memory tasks to increase difficulty. Examples of the images and symbols used in the initial tasks of the study are shown in Figure 1 and Figure 2.

The pattern recognition tasks only required one correct corresponding image, and comprised a three-image pattern repeated once. As such, two additional images of similar style were also included so that each child had an image and there would appear to be more possible solutions. An example of one of these pattern recognition sequences is included in Figure 3. While this was the pattern presented to the children, the group had one graphic each that resembled the style of the graphics in this pattern. Only one graphic offered the solution to this task, the full set of individual graphics that the group had are also included in Figure 4.

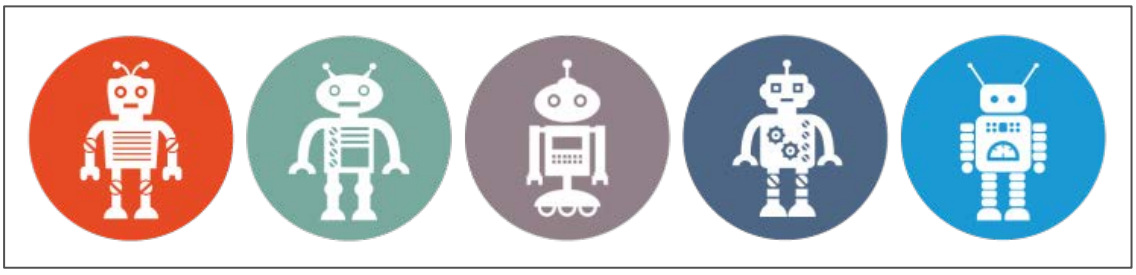


Figure 1 Traditional (TDL) format imagery, icon example

Figure 2 Traditional (TDL) format imagery, symbol example

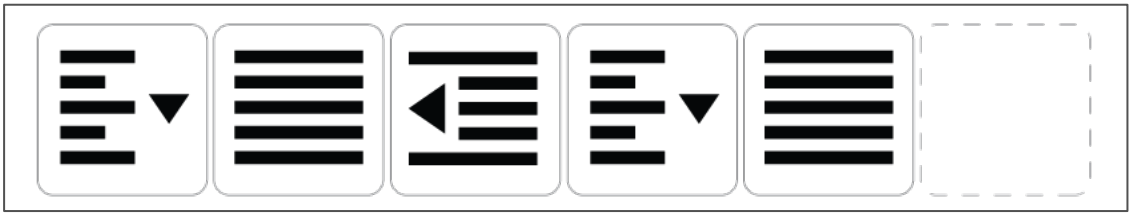


Figure 3 Traditional (TDL) format imagery, pattern recognition

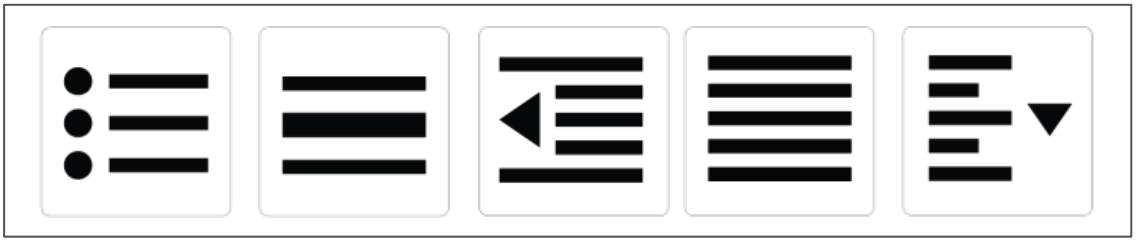


Figure 4 Traditional (TDL) format imagery, available images for participants

The sequences of graphics were printed in colour on A4 paper (as shown in Figure 1, Figure 2 and Figure 3) and the individual graphics for the participants were printed in colour on A5 paper. All of the images were laminated for re-use throughout the study. The particular format was allocated a 20 minute time slot in the study schedule based on prior testing, with an estimated 10 minutes of actual play time for each group.

3.4.4 Interactive digital learning format (IDL)

The IDL made use of fiducial markers (see Figure 5), which are commonly used in Tangible User Interfaces (TUIs) as the physical objects that interact with and control digital representations (Ullmer & Ishii, 2001). In order to address the research question,

which sought to determine the extent to which digital media could facilitate inclusion, and to develop a format similar to the TDL format, a number of considerations were made. This format required the physical movement of the participants to recreate the sequences in order to consider those children whose difficulties include coordination issues, as these are not limited to those with diagnosed dyspraxia. This physical requirement was also incorporated to address Gardner's Multiple Intelligence Theory, whereby academically weak children may show signs of increased ability in a different format. While collaborative activities on desktop computers were considered, any use of one mouse in a group, regardless of the group's size, limits the amount of collaboration as it can result in unequal participation (Rogers, et al. 2009).

Figure 5 Fiducial marker

The fiducial markers are typically used to manipulate elements in augmented reality systems or multi-touch surfaces (Owen, et al, 2002) while the markers used for this format were the amoebas developed for use with the reacTIVision framework (Kaltenbrunner, 2009). This opensource reacTIVision framework and TUIO protocol integrated with ActionScript3 (AS3) in Adobe's Flash formed the basis for the development of this format. This system was developed for fiducial tracking, finger tracking and blob tracking with the fiducial tracking solely used for this project enabling the manipulation of onscreen graphics with these markers. The reacTIVision framework tracks the marker through TUIO messages sent through UDP to the application, in this case Flash. As the format was developed and used with Flash on a Mac OSX, the laptop's integrated camera was used to enable the tracking, and the UDP connection

through a dedicated port to the Flash Local Connection was initialised using FlashBridge.

In order to facilitate the possibility of further scaling or customisation of the tasks, the images for each sequence were loaded into Flash from an external folder to display at random positions on the screen for each task. As each fiducial marker has a unique identification number in the framework, it was possible to assign particular images to each marker. As with the tasks in the TDL format, there were five participants in each group so five fiducial markers were used which corresponded to the graphics on the screen (see Figure 6). Space was provided for the participants to line up their images according to the sequence they were shown and feedback appeared as to whether they were correct or incorrect. The graphics and tasks for this format were in keeping with the style used in the TDL format for consistency and to aid in the comparison of the two formats. Although some feedback was included in each task, feedback and instruction in general was limited by way of comparison with the TDL.

Figure 6 Interactive (IDL) format imagery, available images for pattern recognition task

The fiducial markers allow the children to physically move to interact with the application and interact with other children as they were initially developed to track and map objects. The markers were printed on A4 sized paper and laminated, which ultimately gave the participant more control and more of a connection between the physical action and the movement on screen. Figure 7 shows a screen capture of one of the tasks in the IDL format as the participants completed the task. In this particular task, a story sequence was shown on screen for fifteen seconds and the participants used their markers to move the corresponding images to match the sequence of the story.

3.4.5 Iterative design

An iterative design process was followed insofar as the IDL required internal testing and refinement prior to its use with the children in a classroom setting. Some revisions were made as a result of this testing prior to the study being implemented in the school, including but not limited to the following:

- Initially, the fiducial markers were designed to be attached to the individuals by printing the markers on vests/t-shirts that the children could wear over their uniform. As mentioned above, it was decided that having physical markers that the participants could hold would allow for a feeling of more control
- The number of tasks was reduced following consultation with the teacher and initial testing, largely due to the time limitations in the school with regard to scheduled breaks. As such, the tasks were reduced to 6 for each format and considerations were made to ensure that the tasks retained an increase in difficulty and sufficient challenge.
- A straightforward task with no timing was included at the start of the interactive study by way of an interactive tutorial in order to help reduce the learning curve.
- The reacTIVision framework required calibrating, which included a purposeful calibration of the y-axis to cause movement along this axis to be reflected, increasing coordination challenge.
- Initial testing also highlighted a need to allow time for the participants to check which image their marker corresponded to in the tasks where the sequence was timed to show for 5 seconds before disappearing. Participants in the initial testing phase indicated a significant difficulty in remembering sequence before taking the time for each participant to check the images.
- Various iterations of the tasks were developed and discussed with the class teacher to ensure that they were sufficiently challenging for the particular class while also including suitable content for their age group. One particular early

task called for decimals to be sequenced, although this was found to be too advanced for the children.

Figure 7 Graphical representation of fiducial markers on the screen

3.5 Participants

A small, purposefully selected sample of twenty, second class children from a primary school in the South-west of Ireland participated in the study. The participants were chosen from a class of twenty-five using maximum variation sampling for the specific purpose of addressing the research question (Teddlie & Yu, 2007). It was determined that the remaining five students were not representative of the case being investigated in the study, for instance, due to the specific nature of a disability or their similarity to other participants in terms of demographic or ability.

The participants had a range of abilities, including some presenting with MGLD. Only participants with prior written informed consent and parent/guardian consent were

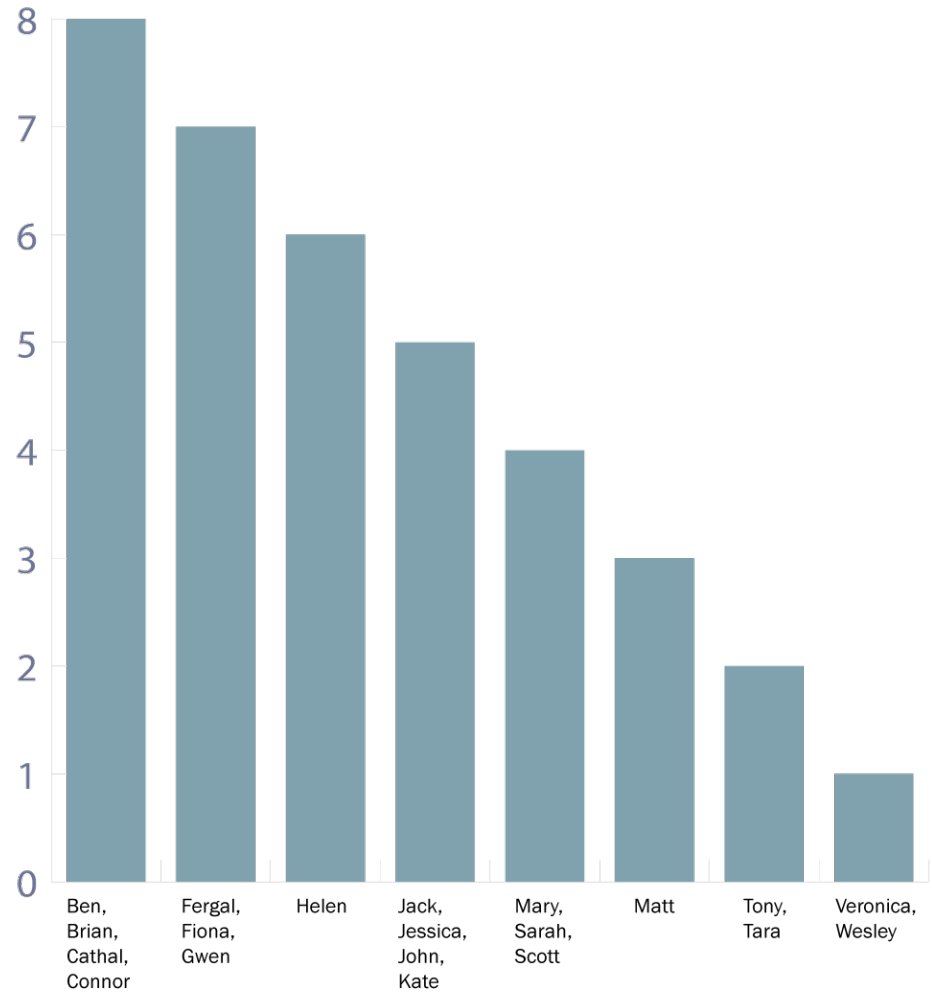
included in the study. A relatively homogenous group was formed in terms of the participants being in the same age group of 7-9 year olds from one school. A small sample was chosen as, when well organised and planned, they could call attention to "feelings, prejudice and subliminal ideas that is difficult to tap into by more structured methods" (Davies, 2007, p140).

Maximum variation sampling (Teddlie & Yu, 2007) was applied to this study for the specific purpose of addressing the research question. The participants comprised eleven boys and nine girls. The pupils were divided into groups of five by the class teacher based on their abilities. The children in each group were then sub-categorised further whereby the teacher identified the abilities of the children according to points on a scale ranging from weak to academically strong. This scale was based on a number of criteria, at the discretion of the class teacher, including but not limited to any presence of MGLD or specific disabilities, the pupil's level of competency, their strengths in curricular activities, social ability, etc. As such, each group comprised participants with a diverse range of abilities and strengths.

The participants have been given pseudonyms in this chapter to protect their anonymity. These pseudonyms were adopted to highlight their cognitive ability alphabetically, as categorised by the class teacher, with the academically stronger children placed earlier in the alphabet than the academically weaker children. Figure 8 highlights the range of abilities of the children, and the presence of learning or other difficulties at virtually every stage of the graph.

While the sample size was small the study activities were carried out four times with groups of five participants each, a feasible number of participants given the nature of the activities to be observed. These observations were conducted with the use of additional quantitative data gathering methods, in particular a set of performance metrics from which initial data codes were developed, and were triangulated further through the use of focus groups and a post hoc interview with the teacher. In addition, despite the range of abilities, due to the relative homogenous nature of the sample and the activities to be

studied, it was deemed a suitable number to reach theoretical saturation of the data (Glaser & Strauss, 2009) in order to eventually, through thorough data coding, extrapolate broad themes of relevance.



Legend:
8. Described variously by the teacher as "extremely able", "highly competent" and "extremely capable".
7. Identified as quite able with few or minor issues in some subjects.
6. Identified as well able but with some issues identified in terms of ability to follow instructions, coordination, etc.
5. Described by the teacher as "able" with some issues.
4. Identified as "weak" in some subjects.
3. Identified as weak and with some issues identified in terms of ability to follow instructions, coordination, etc.
2. Identified as "very weak".
1. Identified as extremely weak and in need of support in many subjects.

Figure 8 Perception of range of abilities of the participants prior to study

3.6 Study implementation

3.6.1 Overview

The facilities in the school allowed for the TDL format tasks to be undertaken at a desk in a classroom, similar to the typical setting that these tasks would be undertaken with a teacher on a regular school day; and the IDL format tasks were carried out in the school hall. The study took place over two days in the school in order for sufficient time to be available to complete all of the tasks with the four groups and to facilitate the school's scheduled breaks. As the class teacher was required to be present at all stages of the study, suitable supervision was arranged for the remainder of the class group. This helped in isolating the research instruments as it was anticipated that the interactive, computer based format in particular would be distracting for the other students. Most importantly, however, it allowed me to keep the study as similar as possible across all groups and to avoid any unfair advantage being given to the other groups if they were to see the task content.

The signed consent forms (Appendix C) from the children's parents were gathered to ensure that full approval had been given for the class to participate. Prior to the study, I introduced myself to the class and explained my research study, thanking the children for taking part. Included in this introduction was an explanation that the children could withdraw at any time and without any repercussions, and I reiterated that if they should feel uncomfortable or unhappy that they should let me, or their teacher know so that we could address any issues to ensure the welfare of the child was prioritised. The groups were already established prior to the beginning of the study and the children created their own nametags to help in identifying themselves to me.

A counterbalanced approach was taken with the four groups, as demonstrated in Figure 9. This method was employed in order to eliminate the presence of confounding variables, for instance, the participants' experience with the first task influencing their performance in the second task. As such, Group A and Group B began with the TDL,

and finished with the IDL and Group C and Group D began with the IDL and ended with the TDL. Each group completed the study with a short focus group, as outlined in the next section.

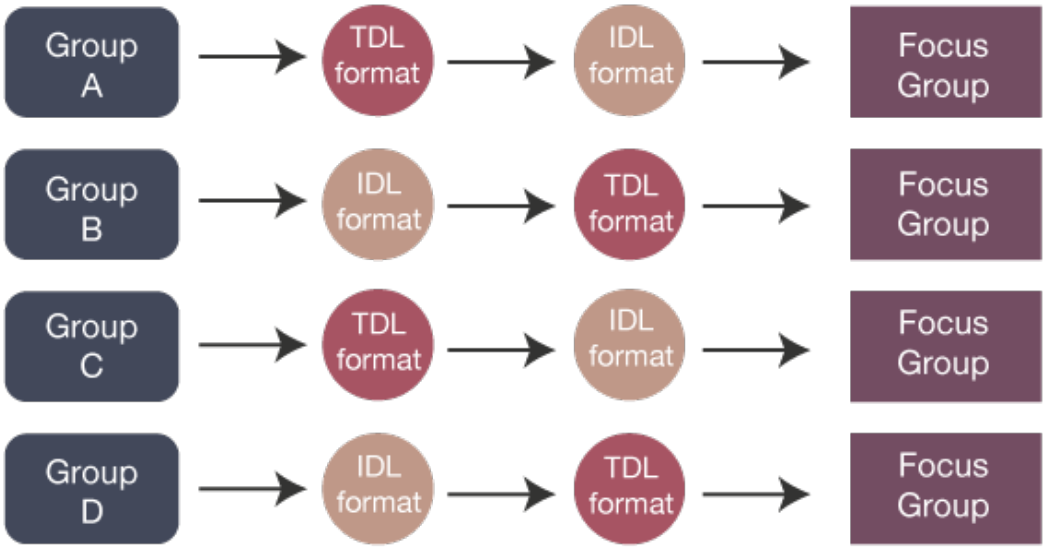


Figure 9 Study schedule incorporating counterbalance

The following outline was typical of the structure of the study for groups A and B, as such, detail will be provided for the group A.

3.6.2 TDL Format

Group A began with the TDL format while the rest of the class were supervised. Each child in the group was given a stack of six images for use in these tasks. The first three tasks incorporated memory skills as well and the class teacher, using a timer, showed each sequence to the group for five seconds before taking it away. The group then, working together, matched the sequence that they had been shown. The fourth and fifth task were pattern recognition tasks, requiring the group to identify and complete the pattern shown, so for these tasks the teacher left the pattern sequence on the table so that the group could decide how to complete it. The final task used aural skills and memory whereby the teacher read aloud a story to the group and required the children to recreate the sequence of events of the story with their images. The particular format was

allocated a twenty minute time slot in the study schedule based on prior testing, with an estimated ten minutes of actual play time for each group. Immediately following the completion of this format, a short, informal discussion took place with the class teacher and the children to determine which of the tasks they found the most difficult or the easiest, with the teacher encouraging all of the children to respond. This helped to contextualise some of the observations that were made during the task time. It was particularly useful with regard to the children that were observed as quiet during the tasks, as some of these children were equally quiet when asked a direct question by their teacher.

3.6.3 IDL Format

It was assumed that the group would carry forward some insights gathered from the TDL format to the IDL format, in particular, some strategies for dealing with the more difficult tasks such as the patterns. In the school hall, the children were given one fiducial symbol each, which would correspond to one image on screen for each of the tasks. Small, circular coloured mats were placed at a sufficient distance from the camera to allow for the symbols to trigger the images on screen, and to allow each child ample space to stand in a line in front of the camera. These mats acted as marks when the children moved position, so that there was little interruption to the flow of the tasks when repositioning. As part of the instructions presented to the children at the beginning of this format, and by way of explaining the concept to the group, a straightforward, un-timed sequence task was presented to the group to give them an opportunity to reduce the learning curve. Following this, the group completed sequences similar to those in the TDL format, i.e. timed, memory sequences, pattern sequences and an aural, memory sequencing task. The particular format was allocated a thirty minute time slot in the study schedule based on prior testing, with an estimated fifteen to twenty minutes of actual play time for each group. As with the TDL format, in order to contextualise some of the observations from the tasks, a small discussion took place, prior to the focus groups, to determine the children's perceived performance in the tasks and the tasks that

they found most difficult. As a lead in to the focus groups, the children were asked to complete a very short 'This or That' form (Appendix B) to focus their thoughts having completed the two formats.

3.6.4 Focus groups

The focus groups themselves were conducted immediately following the completion of the two formats for all groups. The focus groups were limited to a maximum of twenty minutes for each of the groups for a number of reasons. The participants were children under ten years of age and in order to keep their attention, particularly after completing the study, and keep the discussion relevant it was felt the timing was sufficient (Vaughn et al., 1996). A certain amount of flexibility was incorporated, particularly related to these focus groups, and the decision regarding the time limitation was upheld following the completion of the tasks due to the fact that the children had generally verbalised their thoughts quite well during the study. The focus groups for Group A and Group B took place separately in the school hall as these groups had completed the tasks in the IDL format last. The focus groups for Group C and Group D took place in the classroom setting where they completed their tasks, in the TDL format, last. Although the focus groups were run in two different settings, the children were comfortable in both environments and their teacher was present during the focus groups. It was for this reason in particular that the questions posed in the focus group aimed to reduce possible acquiescence bias (Cohen et al., 2007) and instead a key focus of the discussions was the extrapolation of any differences between the two formats. The focus groups were semi-structured in that a small amount of questions were pre-defined and simulated retrospective recall was used to gain further insights from the children, based on their 'This or That' responses and some comments and observations made during the tasks.

3.6.5 Post-hoc interview

At the end of the study, an interview was conducted in private with the class teacher. This interview was estimated to take twenty minutes but the actual interview was

approximately thirty-five minutes in length. The results of this interview are outlined in the findings, in Chapter Four, and aided particularly in the theme development phase of the data analysis. The interview was semi-structured, whereby some questions were predefined before the study took place, and other were included based on brief analysis of the observation notes. The teacher brought some notes taken during their own informal observation of the children while undertaking the tasks, which further aided the discussion.

3.7 Ethical issues

The very nature of the research question generated a number of potential issues to be addressed, particularly with regard to research carried out with individuals under the age of 18, and those with any cognitive difficulties. There were no foreseeable risks for the participant in taking part in the study, but in order to appropriately address this particular ethical issue, a number of mechanisms were employed. The class teacher was present at all times during the study as participants were under 18 years of age and the study was carried out in the school. The participants were advised to inform their class teacher should they experience any problems. Information on the study was provided to potential participants and their parents/guardians in advance to allow for informed consent. Informed consent is a key requirement that helps to ensure that participants, in this case with the approval of the parents/guardian, are partaking voluntarily in a study that they fully understand and have the freedom to withdraw from (Diener and Crandall, 1978). Written informed consent was obtained from both the participants and the parents/guardians who agreed to take part in the study. The study and evaluation procedure was explained to the participants to ensure they had been fully informed. Participation was voluntary, there was no coercion to participate and both the participants and their parents/guardians were informed that they could withdraw consent and discontinue their participation in the study at any time without repercussions. The school headmaster and the class teacher had given their permission for the study to be

conducted with prior written informed consent from parents/guardians in order to ensure compliance with school policies and protocols.

With regard to matters of privacy, anonymity and confidentiality of participants, data protection procedures have been strictly adhered to ensure participants' anonymity in the thesis or any published literature. Participants were debriefed at the end of the research in order to comply with my duty of care obligations in accordance with the policies and regulations of the awarding institute and the school. All focus group, interview and performance data have been coded to ensure anonymity and are only identifiable by me. All data stored on or collected on computer has been password protected to ensure protection from unauthorised access. Data has been encrypted for storage on a secure, password protected hard drive and will be retained securely and confidentially for a period of three years after the completion of the thesis to allow sufficient time for review or further reference and the data will be disposed of securely once the retention period has expired. Following the retention period, or in the event of the withdrawal of a participant, all data will be disposed of in a manner suitable for the format of the data.

In terms of equality, inclusion or exclusion, children with learning difficulties who attend the mainstream school have participated in the study and have been included in the evaluation of results. No child was identified or singled out based on any disability they may have or in terms of the activities they were asked to complete. The activities were group tasks, no child was interviewed individually and there was no one-on-one data gathering that would make any participant feel excluded. While the class teacher was involved in the study, and the children participated in small groups, appropriate supervision was organised for the other students who were not participating at each session. Although five students were eliminated from the study based on purposeful sampling as outlined in section 3.5, they were given an opportunity to carry out the tasks following the conclusion of the official study to prevent any feelings of exclusion.

A performance test was conducted during the study whereby the participants' performance was overtly observed and measured in accordance with performance

metrics, e.g. task completion, error handling, etc. The participants were informed of this method of data collection and the class teacher was present during this test.

3.8 Summary

The theoretical background outlined in Chapter Two has highlighted how different children are with regard to their learning preferences and abilities (Griffin and Shevlin, 2007; Gardner, 1996), and the benefit of collaboration and peer learning for the development of social skills and for general cognitive development (Stainback & Stainback, 1996; Rose & Howley, 2006). There is a particular gap in the research, however, regarding the potential of affordable digital media over traditional collaborative teaching methods to support as many learners as possible in an inclusive primary school classroom.

The main aim of the study was to address the research question by comparing the two learning formats, TDL and IDL. The following chapter, Chapter Four, presents the findings of the study, which were gathered and analysed using the methods outlined in this chapter. The findings are presented in two stages, based on two phases of data coding, which aimed to generalise the findings by way of developing guidelines for the further development of digital media to facilitate inclusion.

Chapter 4: Findings

4.1 Overview

This study saw data being gathered in a structured way through the use of overt observation partly based on performance metrics, focus groups and a post-hoc interview with the class teacher. Although the performance metrics were used as the basis of the first phase of codes, additional codes were derived from the observation and subsequent discussions in order to present the data as comprehensively as possible (Miles & Huberman, 1994, p56). The data coding was cyclical, involving the analysis of the content using multiple methods including descriptive, in vivo, process and simultaneous coding in the first phase and largely pattern and focused coding during the second phase (Saldana, 2013). The first phase of coding generated 43 codes although some codes were deemed redundant during analysis of later participant groups and results were often similar given the semi-structured nature of the data gathering. Of these 43 first-order codes, 13 of these were high frequency codes, that is they were present with all four groups and in the teacher interview although it should be noted that the performance of the children and the observation in general was discussed at length in the interview in order to contextualise the data gathered through observation and focus groups with the participants.

While over 40 codes were established during this first phase of coding, the codes that were analysed were those that were present at least twice in the entire study. The results are presented in the following chapter for each of the formats in order to highlight any comparisons or differences in the performances or experiences of the groups. As mentioned in Chapter Three, two groups began with the TDL format at a desk and the other two groups began with the IDL format. First phase codes are highlighted throughout this chapter with the use of italics. Following this initial phase, a second phase of coding took place, which sought to develop some larger themes to carry

forward to the next chapter. These themes were generally established through clustering and the application of both pattern and focused coding (Saldana, 2013). These second phase codes are highlighted throughout the chapter with the use of uppercase letters.

4.2 First-order coding

The highest frequency codes that were generated in the initial phase of coding, that is the codes that occurred more than four times for each group across the entire study, are outlined below. These codes may differ slightly in the text due to the format of a particular sentence in the description of the findings, for instance, *support from the teacher* could be referenced as *teacher gave support;* or *reiterate instructions* could be referenced as *reiterating instructions*.

As outlined in the previous chapter, the TDL format was carried out by the participants, in groups of five, at a desk and the IDL format was carried out by the participants in the groups in a larger space in the school hall. Two of the groups carried out the tasks in the TDL format first and the other two groups carried out the tasks in the IDL format first. The findings from this qualitative data gathering are summarised in section 4.2.1 on a format-to-format basis. Some of the voices of the students included below were recorded during the tasks themselves while others arose from the focus groups with the individual groups, which were carried out as a means of contextualising the issues or points observed in the tasks.

4.2.1 TDL format

Group A

Generally, there was a low frequency of the teacher needing to *reiterate instructions* for this group in comparison to the other groups and a higher frequency of *peer support* was observed. Interestingly, counter to the predictions prior to the study, the *leadership* fell to both Connor, the most academically strong student in the group, and Tony, the

academically weakest child. Similarly to the other groups when completing the pattern task, this group applied some *logic* to the task, suggesting that the missing piece at the end of the series of images "could be the end of the line on a computer, with the full stops", before *noticing* that it was a pattern. The group moved between *referring* to the order of the sequence by the images themselves or their colours and by the other participants' names, i.e. "Green, orange, turquoise, grey and who has blue?" and "Mary, then Fiona, then…"

Group B

This particular group included two children described by the teacher as having Occupational Therapy (OT) needs, with another child identified by the teacher as being the "weakest academically" in the class, all of which could account for the frequent need to *reiterate instructions* to this group. While there was a lot of *discussion* observed in the group, the two most academically strong students, Ben and Helen, were the more dominant voices throughout the tasks. The group also applied *logic* to the tasks, particularly the story whereby they argued the sequence of events based on what would make sense rather than with a greater focus on remembering, "first you go to the shop and then you get milk". Jessica also argued that she though the animal images "would be in alphabetical order". Both the most academically strong children and the most academically weak children, Ben and Wesley, were in agreement that the pattern was the "hardest of them all".

Group C

There was marked contrast in the performance of Group C in this TDL format, which they completed second, as they were more vocal from the beginning and showed an improvement in *confidence* compared to the first task in the IDL format. More *peer support* was observed in this format although they required *help from the teacher* whereby they were reminded of the instructions on two occasions. The symbol task predictably caused the group more difficulty, "this is going to be tough" and they tried to

find some *logic* to the pattern by the direction the arrows were displayed "there's one of each of these so they're in the right order". They were quick to decide on a good *strategy* for the pattern task with Sarah suggesting, "let's see each others" in order to try to solve it. Tara noted that the story task was the most difficult as they had no images and instead had to use aural skills, but that it was helpful "that they all worked together" to solve it.

Group D

The participants showed *improvement* from the first TDL format in that they were quicker to settle into the tasks and required very little *support from the teacher* in the form of instructions. As with the other groups, the pattern task caused some difficulty and took a considerable amount of time to complete compared to the other tasks, despite the group having completed two pattern tasks in the IDL format. "Veronica has the right one", "But what about Scott's?". "Are you happy with that?". "I'm not sure". A breakthrough came, however, when the teacher asked one of the most academically weak children if he was satisfied with the solution, that his image was correct as stated by two of the students. Scott, who was quieter than the others during this task, declared *confidently*, "No, because it's a pattern" and showed the pattern to the other students, "Oh yeah, it's a pattern". Following the completion of all of the tasks the children appeared to be more vocal when discussing the tasks.

4.2.2 IDL Format

Group A

This format resulted in similar amount of *discussion* amongst the group, with the same participants comfortably assuming *leadership* roles. This task saw more *references* to their physical position, "the guitar was next to me", suggesting that there was an acknowledgement of the physical space and their position in it. *Peer support* and *communication* was observed as particularly strong during the tasks in this format. When Fiona and Mary had difficulty, at two separate stages, moving their image into the box

on the screen they received *support from the teacher* by way of suggestions to make it easier. Both of these examples of teacher support were immediately followed by additional support and encouragement from the other group members. Rather than the teacher offering hints to check the images individually to see which symbol corresponded to which image, Connor suggested that they check the symbols one by one, “Fiona, what one are you?”

Group B

Group B showed little improvement in terms of their grasp of the tasks and they were particularly lively throughout all of the tasks in this IDL format. As such, the teacher regularly *reiterated instructions* frequently during the tasks. On two occasions, Wesley physically moved position immediately to get into the correct order while most of the other children hesitated and they needed *support from the teacher* by way of being asked, “does anyone have to move position?” Another participant, who knew she needed to change position, resorted to asking the group if they could move for her, “Can I switch with you, Matt, because it will be better” and “Can I switch with you because I need to go there”. Matt displayed a noticeable difficulty with *coordination* in controlling the image on the screen with the symbol but received lots of *peer support* from Ben who regularly offered the advice “you go like this to go up and this to go down”. Ben offered a lot of *encouragement* to the other children throughout the task, “you’re good at it!” and demonstrated examples of *prior experience* with games by suggesting, “Helen, go down a bit, up in real life”. This use of specific terminology was commonplace in all groups and not surprising given the age group of the children.

Group C

As was the case with both of the groups that began with the IDL format, there was a slightly slower progression with the tasks as the participants needed some time to grasp the concept and instructions. While there was no significant negative impact as a result of this, it was noticeable compared to the groups that began with the other TDLformat.

The children were observed to be more hesitant to experiment or *play* with the symbols, particularly at the beginning, leading to some minor issues with their control over the images on screen "Mine won't move down". While Cathal was quick to provide *peer support*, he wasn't observed to be as helpful to the other students in the later tasks, particularly when making more passive declarations such as "I'm in my place". Later, another suggestion from him was deemed as more impersonal compared to the direct *communication* displayed in the first two groups, "Whoever is swimming is second". Fergal was very vocal throughout the tasks in terms of offering *peer support* and, as with Group A, the most academically weak child, Tara, also contributed to offering this support.

Group D

Similarly to Group C, this group took a small bit of time to get comfortable with the IDL format, as it was the first set of tasks they completed in the study. However, Brian, the most academically strong student was very quick to offer *peer support* when demonstrating how to control the images with the symbols, "you have to go up to go down". As with Group C, the most academically strong student used a more indirect form of *communication* with the group, with similarly passive declarations, "I'm in the right place" and quite frank guidance to the other students, "you're there". The same child appeared to somewhat reluctantly take on a *leadership* role during the later tasks with this generally quiet group, "okay, you go here, you're here…". The three most academically weak participants, John, Scott and Veronica, all received *support from the teacher* related to their coordination, controlling the image, and their physical movements, "Do you remember where you should be?", "Do you think you need to move, Scott? So you need to move your body".

Timing

The groups were recorded completing the tasks and their actual time spent on each format was extracted from this recorded data. It was predicted that they would spend

slightly longer completing the tasks in the IDL format due to a small learning curve, and that they would apply some experience from the first set of tasks they completed, regardless of the format, to the second set of tasks. The results are outlined in Table 1 and Table 2.

Group	**Overall play time – TDL format**	**Overall play time – IDL format**
Group A	8mins 55sec	13mins 25sec
Group B	9mins 48sec	14mins 16sec

Table 1 Overall playing time, per format, for Groups C and D

Group	**Overall play time – IDL format**	**Overall play time – TDL format**
Group C	17mins 11sec	6mins 32sec
Group D	14mins 32sec	8mins 03sec

Table 2 Overall playing time, per format, for Groups C and D

The learning curve for Group C was particularly evident and they required more instruction than the other groups, in contrast, their TDL tasks were completed quite quickly and they were more vocal during this task.

Extracted from these overall times, the pattern tasks stood out as being more difficult than the others, with the various completion times outlined in Table 3. Generally, this particular task took more time to complete compared to the other tasks. It was predicted that there would be a slight reduction in time taken to complete this task as the participants progressed through the study as noticing it is a pattern can significantly reduce the time needed to solve the task. It was also predicted that their experience with

the first pattern task IDL format would inform the second pattern task in the IDL format and thus equate to slightly less time spent completing this particular task. This wasn't necessarily the case, however, as some groups failed to make the connection. When moving from one format to the other, there was a slight improvement in time taken by three of the groups, even though Group A got their first pattern wrong. Group B showed improvement moving from the TDL format to the IDL format in terms of recognising the pattern but some children spent a significant amount of time playing with the symbols and images before completing the task.

Group	**Pattern task (TDL)**	**Pattern task 1 (IDL)**	**Pattern task 2 (IDL)**
Group A	1min 11sec (incorrect)	59sec	1min 46sec
Group B	2min 38sec	1min 13sec (attention issue)	32sec
Group	**Pattern task 1 (IDL)**	**Pattern task 2 (IDL)**	**Pattern task (TDL)**
Group C	1min 49sec	1min 59sec	1min 45sec
Group D	1min 12sec	57sec	2min 14sec

Table 3 Completion time, per pattern recognition task, across both formats

Although Group D improved from task to task in the IDL format, they failed to apply this to the pattern task in the TDL format later, when only one child noticed the pattern but didn't verbalise this until some time had elapsed.

Group A improved when moving from one pattern task to the other in the IDL format although it's not evident in the results in Table 3. For Pattern task 2, the group indicated the correct answer after 13 seconds, a significant improvement, but it took an additional 1 minute and 33 seconds for them to finish the task as all of the participants checked their individual images and then the child with the correct image had to coordinate the movement of the image into the allocated space through various negotiations with the other students and the physical movement of the symbol.

4.3 Second-order coding

Following the development and analysis of the first phase of codes, a second round of coding was completed in order to expand the findings to highlight some broader themes, generally those that were frequently referenced in the focus groups and post hoc interview, leading to the establishment of three larger categories. These categories generally absorbed or helped to clarify some of the first phase codes and allowed for the findings to be carried forward to the discussions and ultimately address the research question. In keeping with the style of analysis carried out in the first phase of coding, this second phase was also cyclical but was largely carried out by means of pattern and focused coding, along with clustering of the initial developed codes. These three themes which arose from this second phase of coding have subsumed the first phase descriptive and in vivo codes which covered analysis of both the behaviour and performance of the groups as well as observations related to the learning formats, both TDL and IDL. The broad themes that were established through the second phase of coding are COMMUNICATION, INDIVIDUALITY and CHALLENGE. The nature of the tasks, particularly the IDL allowed for some observations from the teacher's perspective, which were gathered as part of the final interview. These observations allowed me to contextualise some of the findings and gain further insight into the behaviour of the children and their capabilities, and thus informing the coding at both stages.

4.3.1 COMMUNICATION

The largest theme to emerge from the findings is COMMUNICATION. As the study sought to determine the extent to which digital media could facilitate inclusion, the level of COMMUNICATION taking place was of significant interest. Through the first phase of analysis, a pattern emerged from the data presenting numerous codes related to different aspects of COMMUNICATION, all of which were clustered to form this theme. Moving from the first phase of coding to this second phase, the high frequency codes from the first phase that fell into this theme include, but are not limited to, *reiterate instructions, discussion, encouragement, negotiation, peer support* and *language.* Another code absorbed by this theme was *collaboration*, referring in this case to the interaction among the children (Dillenbourg, 1999). As it is a large theme, and the particular contents are somewhat varied, it has been further broken down into three subcategories, Authoritative Communication, Peer Communication and Digital Communication to present more abstract, applicable information.

Authoritative Communication

Authoritative Communication, in this instance, deals primarily with any COMMUNICATION from the teacher, the authoritative figure in the study. The role that the teacher played in the study highlights the time required by the teacher to progress tasks, *reiterate instructions, reiterate feedback* or generally offer help to students. One area in particular where a teacher's role is crucial is in the design of the groups, as the level of support from academically strong students can vary depending on their personality. As such, the particularly academically weak students would probably need to be grouped with more tolerant, helpful students. As it stands, the children seemed comfortable in groups and noted that they sit in groups in the classroom and often work in groups, although the mix of students in these groups depends on the subject. For instance, some subjects allow the teacher to group them with more of a mix of abilities whereas for Maths they are grouped based on their abilities with strong, mild and weak groups. While no student explicitly asked for help during the study, the

teacher or I addressed any noticeable confusion in case clarification was required. The support from the teacher ranged from offering small hints on how to proceed with the task, to a reaffirming positive feedback. This COMMUNICATION was also not limited to being directed at academically weak students as, for instance, one child who was identified as quite able has other characteristics that meant she required more reminders of the instructions for the tasks. While it could be said that Authoritative Communication could also include advice or suggestions from the academically strong students in the groups who would be deemed reliable by the teacher, in this instance it refers mainly to the various *instructions, encouragement* or *support* which was received from the teacher. This is primarily due to the fact that, from the observation, advice from the most academically strong students was not always dependable and as such falls into the subcategory of Peer Communication.

Peer Communication

Peer support can help to facilitate learning and improve social skills (Johnson & Johnson, 1999). The level of Peer Communication was noticeable throughout the study and produced interesting data regarding the characteristics of this method of COMMUNICATION. The academically strong students tended to offer the most *peer support* to the students within the groups, although there was a considerable amount of *discussion* and *negotiation* amongst all students regardless of their ability. This resulted in a far more collaborative approach to the various tasks. The majority of this Peer Communication was direct, with only a few observed incidents of indirect COMMUNICATION, mainly in the interactive tasks where, more often, an academically weak child would talk to the screen rather than to the person. While no student explicitly asked another for help, academically strong students in some cases offered help but this was found to be characteristic of the individual and was not limited to academically strong students though, as one group in particular saw both the academically strongest and academically weakest children offering regular support to the group. The teacher agreed that the students seemed to be very good to each other,

"nobody got frustrated or annoyed with the others if they got something wrong, it's a nice trait [that the students have]". Of the academically strong students, a few in particular were observed to be very helpful and tolerant towards the others, which was supported by the teacher who noted that they would be very good at explaining things to the academically weak students, "like a teacher explaining, not condescending", with one child in particular who "just gets that [the academically weak children] don't know what to do". Some children took it upon themselves to *reiterate instructions*, although with less frequency and in all cases it was an academically strong student who was observed clarifying these instructions. Most of the children were observed offering verbal encouragement to other students, particularly in the interactive pattern task, which required only one child to place the image in the correct place.

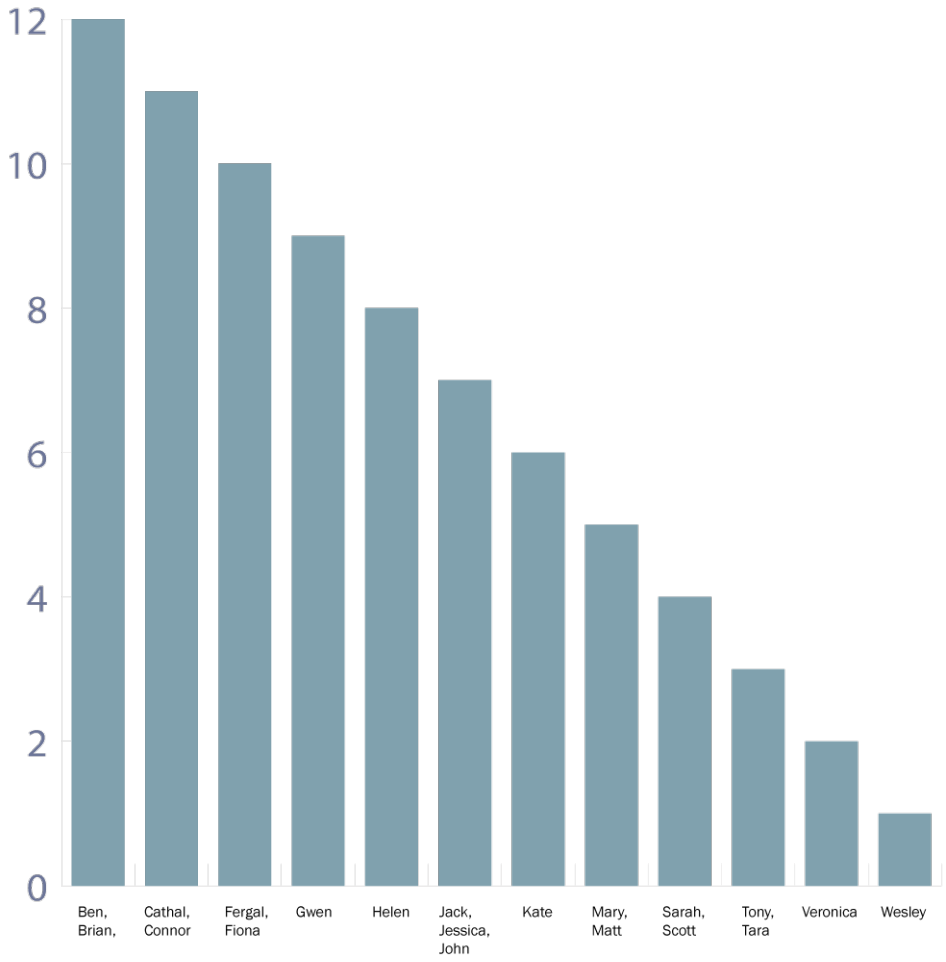
Digital Communication

Digital Communication refers to the instructions and *feedback* available digitally, through the IDL format. Digital feedback and instruction that is well planned and consistent can help to reduce the cognitive load for the user (Mayer, 2009) and keeps the user informed of their progress (Gee, 2005). Purposefully limited instruction was included in these tasks in order to help with the observation of the collaborative nature of the tasks, i.e. to determine if this would prompt the children to encourage each other or *reiterate instructions* themselves. The findings from this study point to opportunities for repeated and customised feedback as a means of encouraging students who may require it. The study also pointed to the importance of allowing students the opportunity to see the correct solution when a task has been completed, regardless of whether they themselves were correct, by way of confirmation or as a learning tool. The teacher noted that the children "love seeing [positive feedback], they see it instantly on the computer". In addition, the importance of self-efficacy for children with LD in particular can play a large role in the design of feedback for learning systems. But this is not limited to those children with LD as was shown in the study where some children described as quite able demonstrated a lack of confidence in some of their decisions during the tasks.

4.3.2 INDIVIDUALITY

INDIVIDUALITY refers to, amongst others, any *personality traits*, *self-esteem issues, learning preferences*, *abilities* and *prior experience* that were clustered to form this theme. Children with learning difficulties or general LD can present with such a broad range of characteristics that designing a general teaching strategy can be extremely difficult. In addition, regardless of ability, personality traits can play a large role in how children interact with their peers or with digital media. While the previous section outlined the breakdown and distribution of abilities across the twenty students prior to the study, following the study, analysis of the findings and recall from the observations suggest that the actual ability range of the students, particularly in relation to these tasks - or at least taking into consideration all of the possible issues that could affect the undertaking of the task, is closer to that shown in Figure 10. This attempts to highlight the variety of abilities that can be present in any one class and the sheer complexity of applying any generalisation.

The behaviour of some of the children and their performance in the tasks not only contradicted any prior assumptions I had, it also surprised the class teacher who noticed improvements in their performance compared to regular classroom interactions and results. Two students who were identified by the teacher as being particularly academically weak while undertaking classwork and participating in class were observed as displaying a level of confidence that was greater than normal when discussing and undertaking the tasks. One student was acknowledged to seem “more confident in the smaller group and more confident to speak”. With regard to one extremely academically weak student who was observed moving into position immediately for the interactive tasks, the teacher noted that he “wasn’t reliant on somebody else because he always is and would be so unsure of himself…[yet]…he was the first person to move, he had followed the instructions and knew what to do”.



Legend
12. Described variously by the teacher as "extremely able", "highly competent" and "extremely capable".
11. As above, with slight variances based on collaboration, attention, communication, etc.
10. Identified as well able with little or no issues academically.
9. Identified as well able with mild issues in some subjects.
8. Identified as well able but with some issues identified in terms of ability to follow instructions, coordination, etc.
7. Described by the teacher as "able" with some issues.
6. Identified as "able" but with some issues (identified in observation and post-hoc interview) that could affect their progress or their results within a group.
5. Identified as "weak" in some subjects.
4. Identified as "weak" in some subjects with particular issues that may affect how they interact or progress within a group.
3. Identified as "weak".
2. Identified as "very weak".
1. Identified as extremely weak and in need of support in many subjects.

Figure 10 Perception of range of abilities of the participants following the study

As mentioned above with regard to the COMMUNICATION of the children, not all academically strong children assumed leadership roles. Of the four most academically strong children, only two were observed to be quite consistently both helpful and tolerant. The other two children were more hesitant to offer peer support and were described by the teacher as "less tolerant" with the academically weak students, possibly thinking "that they can do it by themselves". Observation of one group in particular saw the most academically weak child in the group display a great deal of confidence in helping others and strategising over the pattern tasks in particular. This, however, was not the norm for the groups and was clearly a characteristic of the child. Sometimes children were observed to have the "characteristics" or behaviour of a child with different abilities or capabilities, for instance some quite academically strong children had particular difficulties that attributed to them seeming academically weaker than they are, particularly in the case of their coordination.

In terms of behaviour, no child was so disruptive as to interrupt the study but certain differences in levels of attention resulted in some groups being reminded of instructions numerous times. One student in particular was more excitable than the others, which was characteristic of the child. It was observed that when the child was given their cards in the correct order for the desk-based tasks they immediately mixed them up. Their behaviour was not disruptive but may have had a bearing on the responses of the students in the group and the time taken in completing the tasks. Another child was observed inadvertently blocking an academically weak child during the desk-based tasks.

4.3.3 CHALLENGE

Another theme emerging from the analysis is CHALLENGE. This theme absorbs some of the related codes, including some high frequency codes such as *strategy, coordination* and *physical* from the first phase of coding. The key aspect of this theme is the frequency with which the element of *challenge* was coded during the first phase of coding both from descriptive and in vivo codes. Various challenges were purposefully

included in the tasks, in keeping with Vygotsky's Zone of Proximal Development and the integration of scaffolding to attempt to maintain the interest and engagement of all students (Tudge, 1990).

In terms of coordination, five students were observed as having some difficulty with their coordination irrespective of their position in the range of abilities. For instance, these coordination issues were noticed in Fiona, John, Matt and Veronica in the IDL format, while Helen displayed coordination issues in the TDL format. Three students made reference to their physical exertion during the IDL format, "I'm already sweating!" and "this is like an arm workout", indicating a possible additional challenging aspect of the format. Although, one student noted that it was particularly tough for him to keep his image in place on the screen, this was due to the height difference between him and the others in his group where he needed to stretch his arms more to control the images.

The children, when asked of ways to make the tasks better, variously offered suggestions that would make the game more challenging. When one child suggested having two symbols per child, that is two symbols displayed on one card, similar to the game *Dominos*, it was in order to "make it a bit tougher, a bit more fun". In fact, many of the suggestions offered by the children included references to mechanisms typically found in computer games, such as additional "lives", "dying" when colliding with another player's image" and "starting again from a saved point".

Although no specific measure was established prior to the study with regard to engagement, the category has emerged through first phase codes such as *enjoyment*, *attention* and *curiosity.* While the term, engagement has a variety of definitions, Skinner and Belmont (1993) state that it can be evident through a learner's behaviour and emotions. Although the pattern tasks were generally found to be the most difficult, the challenge maintained their attention, and increased their engagement. When presented with the first pattern task of the study, in this case during the TDL format, one child noted, "this is fun but this is going to be so hard".

4.4 Summary

While both formats can be seen to facilitate inclusion, one format, the IDL, certainly affords more opportunities for autonomous learning while still supporting the students; and could reduce the time required by the teacher to implement this approach. The TDL format proved to be very time consuming for the teacher, as they were required to control the images and give instructions and feedback.

The findings presented some interesting observations, through pattern coding in particular, and some themes surfaced quite early with the second phase of coding helping to further clarify and refine these themes. It's clear that none of the themes brought forward from this are intended to be considered separately, as they all influence each other. For instance, from a broad perspective the level of communication can be determined by the individual characteristics of the children involved, and it's the characteristic abilities of these children that determines the amount or design of the challenge that can be introduced in order to ensure that it is engaging for all students. As outlined above, the largest theme to emerge is COMMUNICATION, but this is not wholly surprising considering the study attempted to observe communication and collaboration practices across all tasks. The sub-categories attempt to link the various elements of the theme, Authoritative Communication, Peer Communication and Digital Communication.

All of these sub-categories are influenced by the theme of INDIVIDUALITY, that is, the varying characteristics and abilities of the children involved. While some conclusive statements can be made regarding individual differences and their effect on communication in group work, one cannot assume that the observations from this study are applicable to another class, even another class in the same school. As such, the opportunities offered by particular teaching or learning formats should be considered.

The third theme to emerge from the study is CHALLENGE, which once again influences the other themes. While CHALLENGE is important in learning, regardless of

ability, it should be considered in terms of the individual characteristics of the learners and the level of COMMUNICATION offered. As demonstrated with Vygotsky's ZPD, scaffolded learning can benefit all learners but key aspects of this are *peer support* and varying levels of personal development.

Figure 11 offers a visualisation of this relationship between the themes, and highlights that, for this context in particular, i.e. the facilitation of inclusion for children with LD, an overlap of all three themes is important.

These broad themes are carried forward to the discussions in Chapter Five with a view to developing guidelines for the design of interactive digital media for inclusion. The second part of that chapter offers some limitations of the study and implications for future research and for policy and practice.

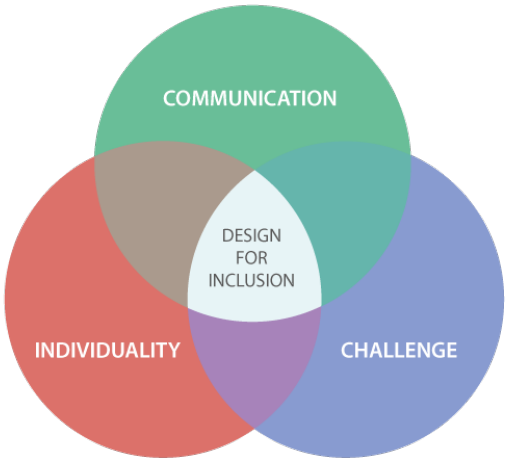


Figure 11 Visualisation of the relationship between themes extrapolated from the findings

Chapter 5: Discussions and Conclusions

5. 1 Discussions

5.1.1 Overview

While there is no conclusive evidence that one format was better than the other in terms of the various aspects that help to facilitate successful inclusive teaching, for instance, engagement or communication, having completed the study it has become clearer that the IDL format affords more opportunities than the other for children to work autonomously and collaboratively while also supporting the various strengths and weaknesses of the individual students. This in turn offers teachers an opportunity to integrate inclusive practices in the classroom without being consumed by a requirement to give their full attention to the participating group. The key areas for discussion related to the potential of the IDL format are outlined in this chapter and will cover the collaborative and communicative potential, the opportunities for challenge and supporting individual learners, as laid out in Chapter Four. Further related elements will also be included along with their potential impact. As mentioned in the last chapter, these areas and themes are so interlinked that it is impossible to discuss them separately. This chapter offers an overview of the most important findings as they relate to the research question posed in Chapter Two. The chapter also offers some implications for design of collaborative digital media for students with special education needs and more specifically for inclusion based on the findings from the study. The chapter concludes by outlining some limitations of the study and implications for future research and for policy and practice.

5.1.2 Communication & Collaboration

Research has outlined the importance of well-planned feedback on motivation, performance, achievement and self-efficacy (Elliott & Dweck, 1988; Hattie &

Timperley, 2007). While a purposefully limited amount of digital feedback was included in the IDL format, the study highlighted the importance of such feedback in digital media to allow children to work somewhat autonomously. A large amount of time was required of the teacher to give instructions, reiterate instructions or offer hints throughout both formats during the study. While the inclusion of verbal and written feedback in digital media not only provides two methods for children to receive this information, addressing any potential issues they may have with regard to reading or hearing, it also reduces the amount of time the teacher needs to spend progressing or facilitating the task during class time. Scaffolded feedback in particular has also been seen to improve memory and recall, and shows significant benefits for children with regard to self-generated corrections based on this feedback (Finn & Metcalfe, 2010).

With regard to collaboration, empirical research has found that collaboration and cooperation among school-aged children is important for a variety of reasons including but not limited to increasing social skills, tolerance and engagement (Tolmie et al., 2010). The findings revealed that the children behaved quite similarly across both formats, which while in keeping with the design of the study, also supports the suggestion of Scott, et al. (2003) that collaborative behaviour is generally similar across paper-based and interactive formats when the interactive format allows multiple children to interact concurrently. Counter to this is the way in which children would collaborate when using a standard desktop computer, a method that generally requires a turn-taking strategy due to the availability, in the majority of cases, of only one input device.

The coordination of groups for collaborative tasks is crucial to the level of collaboration amongst the participants of a group (Wang, 2009) and this was particularly evident in this study, where the groups were formed primarily to represent a diverse range of abilities. As such, the findings demonstrated the benefits of having a tolerant and supportive child with good academic ability in a group. Two of the groups countered this with children who presented as less supportive despite being academically extremely able. This coordination will be discussed further in section 5.1.3, on individual

differences, but with regard to collaboration, a well-coordinated group can ensure that each child can make an equal contribution, or at least be presented with the opportunity to provide an equal contribution, regardless of their ability.

5.1.3 Individual differences

The findings of this comparative study demonstrated the range of abilities of the children in the class, irrespective of, in some cases, their academic ability. Research, particularly in the past twenty years, acknowledges the unpredictability of LD and the variety and strength of characteristics that can present as unique to individual children (Fletcher, et al., 2003; Lerner, 2005). This study supported the research through observation of these twenty children. Although some of the children were deemed extremely able, academically, characteristics such as tolerance towards others and leadership was seen to play a large role in the dynamic of the groups. As mentioned above, the study certainly pointed to the importance of the teacher in choosing groups for activities designed to support inclusion as while this grouping was based on ability, it highlighted the need to balance other personality traits of individuals within the group. In addition, the performance of some of the children in the formats was counter to my perception of their competence suggesting the importance of the role that learning preferences can play in achievement or performance (Bryant and Bryant, 2003). Three children indicated a preference to carry out the tasks on their own suggesting that learner preferences move beyond considerations for the format of delivery to the method of collaboration, if any, particularly for so-called solitary learners (Ke & Carr-Chellman, 2006).

5.1.4 Challenge

Quite structured and specific challenge was included, in the tasks themselves but also through the use of the fiducials as controls in the IDL tasks. Although the majority of children spoke positively of the challenging aspect of the tasks, often linking this to the notion of the tasks being enjoyable, some academically weak students were observed acknowledging that although the tasks were challenging, they were achievable because

they worked as a group to accomplish them. In addition, despite various observations of the participants simplifying tasks by, for instance, referring to colours rather than icons when sequencing the images, the more difficult tasks were generally observed to be more engaging for the participants. As such, the findings suggest the importance of the requirement for a balance between task achievability and challenge (Xie, 2008).

This balance was also observed to be important with regard to the interactive nature of the IDL format. While the IDL incorporated an element of physical challenge, it also added to the cognitive load by including the requirement for coordination skills and a potential distraction for the participants through the use of the fiducial markers. These interactive elements are likely to be more challenging to some children than others and require considerations in the design and development to prevent a negative impact on the processing capability of some children due to an increase in the cognitive load (Mayer, 2009).

The study also supported research into scaffolded learning with regard to some of the experiences of the children. That is, while some children were able to successfully carry out the challenging tasks with minimal help, other children relied on the academically strong children in order to progress through the tasks. Scaffolding is particularly important for children with LD whose ability for self-directed learning may be compromised (Eriksson et al., 1997) but who still require a challenge in order to increase engagement and facilitate learning. It should be well planned regardless of the format in which the learning is delivered, to ensure that it is sufficiently challenging for all capabilities and needs (Stainback & Stainback, 1996).

5.1.5 Engagement and Motivation

Research notes the importance of engagement and motivation for learning (Belland et al., 2013; Price et al., 2003; Csikszentmihalyi, 1990) and by applying novel approaches, such as unusual technologies or media, in a classroom children can be motivated through their curiosity provided that the approach is not overly complex (Malone, 1980). As with

Xie's study, which compared children's engagement and enjoyment across three learning formats, there's no evidence to suggest that one format was more engaging than the other with an exception that results of the 'This or That' method showed most children indicating their preference for the IDL format. The children were told to mark both formats if they couldn't choose and three children expressed equal preference for both formats. Both formats encourage equal participation by giving an element of control to all children. The 'This or That' method, although a secondary data gathering method, only sought to trigger responses and would not be deemed to be a particularly reliable indication of a child's preferences. However, if engagement is to be taken as an observed measure of the combination of enjoyment, positive attitudes and interest (Skinner & Belmont, 1993), then the IDL format resulted in more positive responses.

While efforts were made to make the tasks equally appealing to both the boys and girls, including considerations for the imagery used, differences in performance may have occurred based on gender due to the children's prior experiences. The girls variously described the tasks as mysteries and puzzles where some of the boys suggested making them more difficult with reference to gaming concepts such as effects of on-screen collisions and losing lives. However, there was no evidence to indicate that boys would generally do better in any of the tasks given the varied personality traits and social interaction of the children in the study.

5.1.6 Considerations for the design of interactive digital media for inclusion

This study highlighted a number of considerations with regard to the design and development of an interactive, computer-based learning format to facilitate the inclusion of children with LD in a mainstream classroom. What is offered here, in Figure 12, is a preliminary guideline for further design of such a solution, based on the observations from this study, which have been supported by the research. While further investigations are recommended and the difficulty of addressing such a task are, as outlined in this

thesis, quite significant, the guideline offers a visual representation of some of the key auxiliary considerations. While Universal Design outlines that designing for the average user is near impossible, elements can be included in digital tools that can be adapted for different users, enabling more autonomous learning and reducing a teachers time required to help in facilitating this collaborative work.

This iterative guideline, primarily, outlines the importance of the learning content used in the output. The content used in this study, sequencing and pattern recognition, was generally applicable to all primary school students based on the importance of the skill in various subjects according to the National Curriculum. These skills are also reinforced for children with visual perception difficulties outside of the regular classroom, for instance in learning support classes. In order to make the content suitably engaging for all users in order to facilitate learning, some element of challenge should be incorporated, for example an increase in task difficulty over time. When incorporating challenge, however, the unique capabilities of the children should be assessed with due regard also to the type of communication included. Communication here, as noted in the last chapter, includes considerations made for the requirements of authoritative, peer and digital support. Scaffolded feedback can take into account some of the varying abilities and requirements of children, offering frequent direct, specific, structured feedback where necessary. Control in the framework refers to the potential of the tool for interaction and cooperation among the students.

As mentioned previously in this chapter, certain formats allow for different collaborative styles, for instance, traditional computer based learning facilitates a turn-based strategy of collaboration while tangible user interfaces and traditional desk-based learning formats allow for more concurrent collaboration. This study demonstrated the potential for multi-user simultaneous collaborative learning.

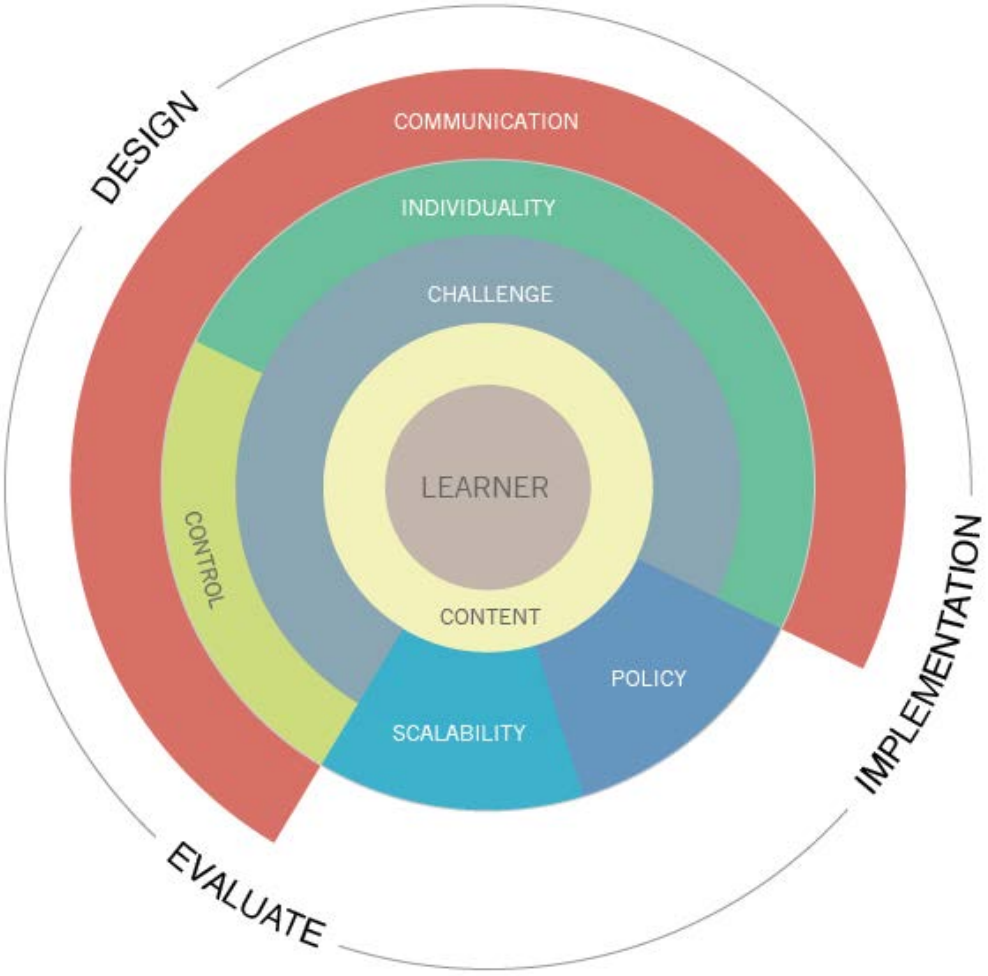


Figure 12 Visualisation of the iterative guidelines for the design and development of interactive digital media for inclusion

In addition to the considerations outlined here, it is recommended that the scalability or customisation of the content should be considered with regard to the design and development. For instance, the inclusion of dynamic content that could be updated external to the developed tool could allow a teacher to change or include additional imagery or content for use with other groups or subjects. This would aid in the application of such a tool in a variety of classrooms or contexts. Considerations should also made with regard to any policies in place in schools related to inclusive practices,

content or procedures and may also include budget allocations from external sources for digital media.

Finally, although the guideline is designed with a view to allowing for more autonomous collaborative activities for children in mainstream classes, a key element of this study, and the supporting research, is the importance of the teacher in the design, development and implementation of such as solution. The study has pointed to the requirement for planning with regard to the grouping of children for such activities, the inclusion of challenge, choice of content and various methods of support. Having said that, further investigations into the design and development of a digital tool for inclusion can offer further solutions in order to help in reducing the time required by teachers to supervise and support children using a digital format for inclusion. And freeing up teacher time does not have to take them away from the students in question, as Dewey (1938) noted the importance of teachers observing their students in order to help in their development by highlighting any unknown strengths a child may have (Gardner, 1996) and more autonomous learning formats allow teachers the opportunity to do this unlike many traditional classroom activities.

In the following section, I offer some conclusions in the form of limitations of the study and suggestions for further research.

5.2 Conclusions

5.2.1 Overview

This study offered an opportunity to investigate the potential of different learning formats for facilitating inclusive practice in schools. I found that although the participants demonstrated similar engagement with both formats, facilitating inclusion with the use of interactive, computer-based formats offers more opportunities to support children with varying learning abilities through scaffolded, direct feedback and integrating digital supports. This, in turn, offers teachers the opportunity to implement

such interactive aids in the classroom without the time pressures required when constantly supporting learners through traditional activities. I found that despite children's high level of competence in academic activities, their ability to offer substantial support to others through scaffolded learning methods can vary considerably. In addition, some children with low academic abilities but strong social skills can be beneficial in motivating the participation of other children with poor social skills. I also found that the use of fiducial markers in this format, rather than with tangible user interfaces, offers opportunities to encourage concurrent cooperative learning by requiring the simultaneous participation of all of the children in the group thus adding to the potential of this format to facilitate a fully inclusive environment.

In the following section, by way of concluding the findings and discussions in the thesis, I outline some of the additional considerations related to this work, namely in the limitations, reflexivity and generalisability of the study. I also offer some thoughts regarding the potential future research in this specific area and some implications for design, policy and practice.

5.2.2 Limitations

While the individual differences of the participants was a key element of the study, some caution should be applied with regard to grouping children of mixed abilities for collaborative tasks due to the range of supports required by children with LD and the variety of levels of support that academically strong children feel comfortable in giving. The participants of this study are accustomed to working in groups, although at the time of the study, were a part of self-assigned groups for other class activities.

Another limitation refers to the novelty of the approach and the possible influence that this can have on the level of enjoyment or engagement. As mentioned in section 5.1.5, by applying unusual approaches in a classroom, children's curiosity can increase their motivation, provided that the approach is not overly complex (Malone, 1980). This in

turn can have an effect on the observation, depending on the elements that are important to the study.

A third possible limitation is the potential for acquiescence bias due to the suggestion that children are more likely to acquiesce, particularly with regard to questions that support simple 'yes' or 'no' answers (Breakwell et al, 1995). This wasn't determined to be an issue with regard to the validity of this research due to the methodological triangulation applied to the study and the strategies employed in the focus group to minimise the possibility of acquiescence through the discussion. It is, however, a factor to consider in future research.

The sample size used for the study is quite small, in keeping with a qualitative research style that seeks to understand the experiences and behaviours of participants. While this was not deemed to be an issue due to the application of analytical generalisation, the repetition of the study across four groups and the application of counterbalance, the sample size should still be considered a limitation.

Generalisability

Due to the largely qualitative nature of the study, the generalisability of the study should be addressed. Given the small sample size of the study but also the theoretical differences noted in how characteristics can present in children, a generalisation to theory, or analytical generalisation (Firestone, 1993; Yin, 2003), is deemed to be more suitable. As such, the findings have been compared to theory rather than attempting to generalise from the sample to a larger population. This is supported by the two-stage coding process, which was applied to the study data by way of expanding the findings to a more abstract format in order to present implications for the design and development of educational media for inclusion.

Reflexivity

A final limitation relates to reflexivity. With regard to my own background, I have a personal interest in the use of multimedia technologies in primary level education, particularly for individuals with disabilities, regardless of their severity. Previous research that I have carried out for my primary degree involved the development of a computer game to help children with learning difficulties, particularly visual perception issues. I believe that this thesis is an expansion of that research with particular attention paid to developments in technology in recent years and the variety of strategies available to facilitate learning for children with general LD. This research differs, however, in that the review of literature, outlined in Chapter Two, has identified a gap in the theory, particularly related to inclusion and interactive media, which led me to the research question that I posed in Chapter Two. I have also been involved in a number of funded research projects in the area of Game-Based Learning through my work.

While this background could offer bias towards the use of digital media for learning, it influenced my ability to find solutions for issues or limitations observed in the study through largely qualitative analysis using methodological triangulation to increase the validity of the study. In addition, much of the findings were based on thorough analysis of the data which included the application of various methods of coding with a large focus on the voice of the participant in order to present the findings as accurately as possible.

5.2.3 Implications for practice and policy

Research into the use of digital media and interactive technologies for education is growing with increasing focus on the benefits of tangible and interactive technologies to support learning (Ullmer & Ishii, 2001; Maher & Kim, 2005; Smeets, 2005; Newhouse, 2002; Bonanno & Kommers, 2008). Teachers, however, need to be supported in integrating such resources in the classroom with barriers still in existence, such as lack of time, lack of funding and lack of training (Burgstahler, 2003; Brown, 2000). In order

to provide these supports, some initiatives are aimed at offering training, case studies, resource toolkits and tutorials for the integration of digital games for learning, computer programming and the use of Information and Communication Technology (ICT) in the classroom but this should be expanded to include supports for advancing, affordable technologies.

Digital media that supports a wide range of uses has particular potential given the time constraints in schools. Various Game-based learning (GBL) initiatives aim to help teachers in using Commercial off the shelf (COTS) games in a variety of ways in the classroom. This is particularly relevant to primary school teachers who teach numerous subjects, as digital media or digital games that can be customised and applied across more than one subject has real, practical benefits.

Additionally, while this study aimed to determine ways by which digital media could better facilitate inclusion by supporting children with LD, it also enabled the teacher to observe the children in a new context, thus offering the opportunity to detect any strengths and weaknesses that may not be picked up in a day-to-day classroom environment. This may have implications in terms of developing new methods of assessment for children in mainstream classes.

With regard to the policies that shape the practices in schools, there has been an increased drive to integrate ICT in the classrooms. But rather than focusing on providing support for the use of ICT and digital media as a tool for learning or reinforcement, this move has been spurred by a new strategy to educate the future workforce for careers in IT. This has not been without its share of controversy, and was particularly evident with the development of the new computing curriculum in the UK (Passingham, 2013; Dredge, 2014). While the introduction of this curriculum is a positive step for children's digital skills development, there is a danger that the potential of digital media to support the development of more general academic skills may be overlooked.

While the funding may have improved in the grants allocated, barriers are still in place in terms of the permissible items that can be purchased and schools generally prioritise baseline ICT resources, including projectors and wireless peripherals, as the technology generally has to have a clearly defined educational value and be appropriate to the stage of ICT development in school. This study considered the availability of digital resources in developing an affordable interactive learning format but regardless of the feasibility of the use of these resources, as mentioned throughout this section the importance of supporting teachers in the integration of these resources cannot be underestimated.

5.2.4 Implications for further research

While the study offers contributions to the design and development of collaborative digital media for children with LD with specific emphasis on the use of affordable, interactive technologies to support inclusion, some suggestions for further research are offered below.

It may be valuable to consider further the various characteristics of learning difficulties independently in order to address their potential impact on the design of appropriately challenging aspects of activities, for instance, poor attention skills, lack of confidence or low self-efficacy may affect the design of instruction, feedback and interaction.

Further investigation of theories such as of embodied cognition could progress research in this specific area, particularly with regard to the potential for the social interaction of the children in this physical space to aid in their learning processes (Antle, 2007; Kirsh, 2013). While the children were very active with their hands during the study, the presence of physical marks on the floor to highlight an appropriate distance from the camera for the interaction may have played a part in some of the children appearing more rigid with their body while their hands were very active. Further study of embodied cognition in this regard could look to the placement of the fiducial when used as controls.

In addition, as mentioned earlier in this chapter, by incorporating more problem-solving tasks and facilitating more autonomous activities, it offers teachers the opportunity to observe the social interactions of the children in a different context, observing their strengths in other areas and helping to highlight weaknesses, for instance, in coordination.

5.2.5 Implications for design

During the IDL format, the children were required to have all of their markers displayed on the screen simultaneously for the result, whether correct or incorrect, to register. This made the participants more reliant on others in a way that wasn't as necessary with the TDL format. In traditional desk-based formats, or indeed when using tangible user interfaces, very often there is a strong possibility that an individual could take control of the images and place them in order by themselves if the tasks were not monitored. Tangible user interfaces, variously, register the correct fiducial when it has been placed in a certain area on the table, but even with multiple tangibles it does not require concurrent cooperative use. In this study, the use of physical space and the requirement for the symbols to be in the correct order and on the screen simultaneously makes it difficult to work independently of the group. I believe there's more investigation possible to the use of physical space and controls in this manner rather than through tangibles on table-top style surfaces as the physical space between the participants strengthens the requirement for concurrent cooperative collaboration without the need for turn-taking, allowing the children to play concurrently but requiring the full input of all children to complete the task. This prevents unequal participation or any issues related to synchronous shared control as observed by Antle (2007) in the application of the CTI framework to the Aibo trials.

While the findings revealed that collaborative styles were quite similar across both formats, the study supports the research by Antle (2007) that when designing tangible user interfaces for children, their varying abilities and development must be considered. The range of abilities of a small group of children can be unpredictable but attempts can

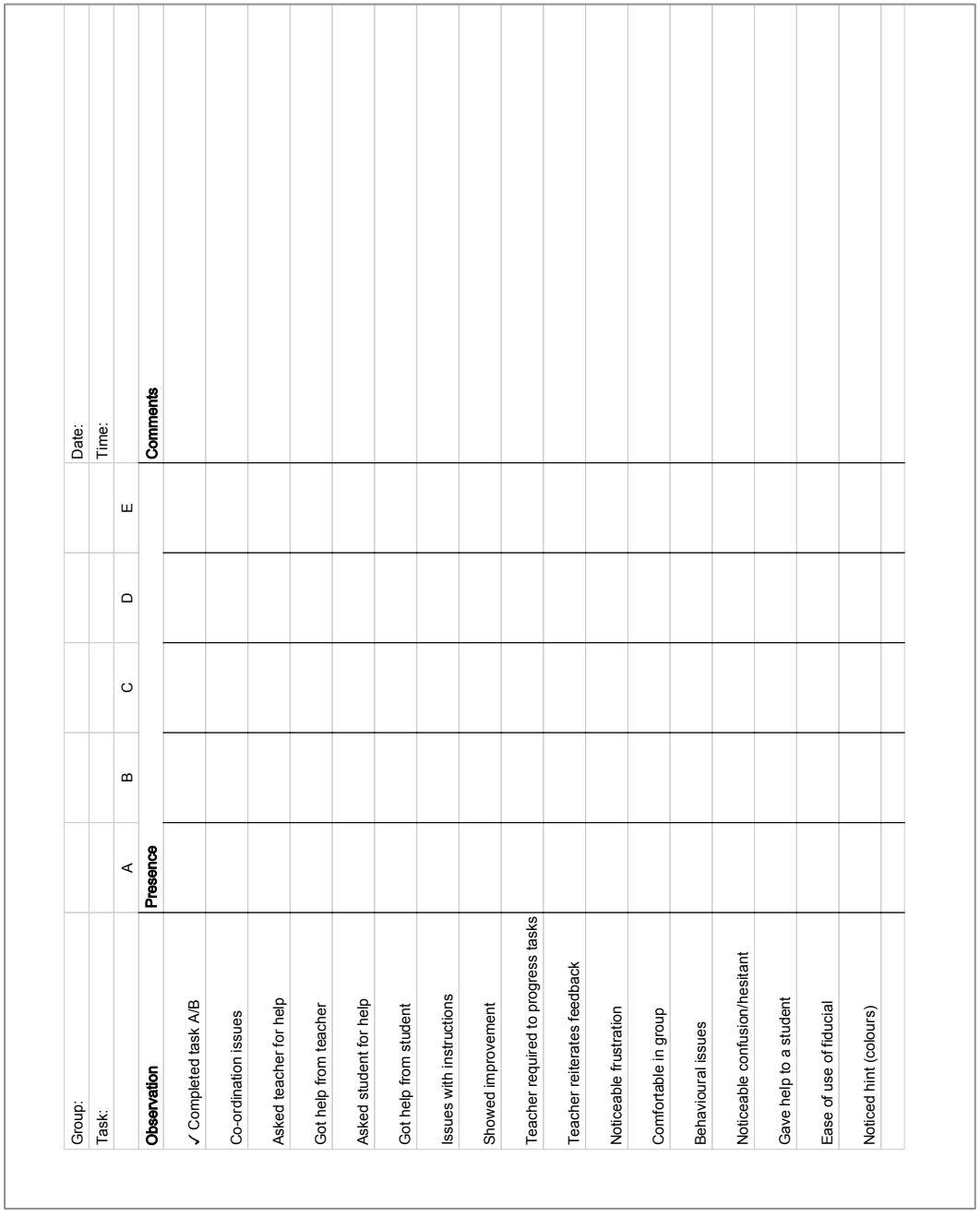
be made to address some key areas such as social, attention and reading or aural issues through structured feedback and digital cues. Lack of self-confidence and self-efficacy was an observation of the study and a common characteristic of children with LD (Schunk, 2012). By offering feedback individually, based on tracking the markers for instance, it offers encouragement to students who may require more support. Research undertaken regarding scaffolded feedback in educational software for children with LD (Whitelock, 1999; Dean et al, 2000) supports the findings in this study that highlighted the different functionality, frequency and type of feedback that would be required for children with different abilities. Learner differences and preferences also suggest the potential value of involving children in the design of educational digital media (Read & Markopolous, 2013).

The integration of more gameplay mechanics could help to motivate and engage digital natives (Prensky, 2001) while making use of the physical space offered by the IDL format to provide a complex, collaborative learning environment. As mentioned previously, digital games allow learners to collaborate in different ways, explore other skills and support other abilities (De Freitas, 2006; Bonanno & Kommers, 2008).

5.2.6 Summary

While this thesis puts forward some recommendations for future exploration, it offers some contributions to the growing body of research aimed at determining the educational benefits of digital media, particularly with regard to children with LD. It offers a set of guidelines for the development of affordable, scalable digital media for use in mainstream primary schools. Finally, it contributes to the exploratory research conducted with regard to the potential of different interactive media for collaborative learning and, in turn, to the area of inclusive education.

Appendix A – Observation sheet



Group: Date:

Task: Time:

	A	B	C	D	E	Comments
Observation	**Presence**					
✓ Completed task A/B						
Co-ordination issues						
Asked teacher for help						
Got help from teacher						
Asked student for help						
Got help from student						
Issues with instructions						
Showed improvement						
Teacher required to progress tasks						
Teacher reiterates feedback						
Noticeable frustration						
Comfortable in group						
Behavioural issues						
Noticeable confusion/hesitant						
Gave help to a student						
Ease of use of fiducial						
Noticed hint (colours)						

Appendix B – 'This or That' form

Which game was the most fun?	Game 1 (table) 	Or	Game 2 (computer) 
Which game was the most boring?	Game 1 (table) 	Or	Game 2 (computer) 
Which game was the most difficult?	Game 1 (table) 	Or	Game 2 (computer) 
Which game was the easiest?	Game 1 (table) 	Or	Game 2 (computer) 
Which game would you most like to play in a group?	Game 1 (table) 	Or	Game 2 (computer) 
Which game would you most like to play on your own?	Game 1 (table) 	Or	Game 2 (computer) 

Appendix C – Parental consent form

Research Study Information

Your child is being asked to participate in a research study to determine the extent to which digital media can facilitate inclusion in mainstream classrooms. This comparative study of two learning formats - traditional and interactive - will involve the completion of a series of sequencing tasks using both traditional and interactive methods. Sequencing tasks are being used in the study as they are core skills, contained in the national primary school curriculum, that are important in a variety of subjects.

Your child's participation will take approximately 1 hour and will be carried out during school time, with their class teacher present at all times, and will involve the following:

- Complete sequencing tasks in a small group with their classmates including completing patterns and matching sequences using cards with images/symbols. An audio recording will be made while the group carries out the tasks and this data will be saved to a computer database for later analysis.
- Complete some sequencing tasks in a small group with their classmates by interacting with a computer. The participants will be given cards, which correspond to images on the screen. When they move the marker, the image on screen moves. The students will arrange themselves, and as a consequence the images on screen, in a sequence to match the sequence of images shown. An audio recording will be made while the group carries out the tasks and this data will be saved to a computer database for later analysis. A recording will be made of the computer screen using screen-recording software, but your child will not be shown on this screen as they will be represented on screen by an image corresponding to the marker on the card they are given.
- Following the tasks, your child and their group will be asked some questions with regard to their experiences of completing the tasks as part of a short focus group. An audio recording will also be made during this focus group and this data will be saved to a computer database for later analysis.

This research is being conducted as part of a masters programme I am undertaking in the Cork Institute of Technology and the data from this study will be included in my final thesis and may be published in educational journals at a later date. All information collected about your child during this study will be kept strictly confidential and all identifying information will be removed so they cannot be recognised from it. The recordings and data produced as a result of your child's participation in this study will be safely and securely stored.

There are no foreseeable risks for your child as a result of taking part in this study. Your child may withdraw from this study for any reason, at any time, without any need for explanation and without penalty. If they withdraw from the study at any time, any data that they have contributed or produced will be destroyed.

If you require further information please contact:

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Consent Form for Parents/Guardians and Children

I have read and understood the description provided above. I understand that my child can withdraw from this study at any time.

If you agree, please tick the box:
I agree to allow my child to take part in the study described above. ☐

Print name of child: _____

I (the child) agree to take part in the study described above.

Mark / colour the box: Yes ☐ No ☐

Parent/Guardian Signature: _____ Date: _____

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