THE EFFECTIVENESS OF AN ALLIANCE BETWEEN EDUCATIONAL PSYCHOLOGISTS AND TEACHING ASSISTANTS IN DELIVERING NATIONAL NUMERACY STRATEGY INTERVENTIONS

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ABSTRACT

This research investigates the impact of collaborative work between an Educational Psychologist (EP) and teaching assistants (TAs) delivering a wave 3 National Numeracy Strategy (NNS) intervention. The aim was to decipher whether EPs can play a distinctive role in addressing the stubborn and significant tail of underachievement in numeracy and, indirectly, the associated risks to an individual's life opportunities, health, employability and social cohesion by providing consultative support for TAs.

A multiple case study approach was adopted involving three case studies, each comprising one TA and three underachieving children, at different schools in the North of England. The EP modelled the use of the wave 3 NNS materials and supported/trained TAs in delivering this and other jointly agreed input over one academic term. Initial consultations were held with TAs to explore their experiences of mathematics and delivering numeracy interventions. Thereafter, joint planning and discussions took place on a fortnightly basis to identify what was working well and what input from an EP may be of use; EP input was provided as and when appropriate. Outcomes from the research were assessed using a standardized numeracy test, attitude questionnaires completed by TAs and children, interviews with TAs before and after the intervention and a research diary. The quantitative data gathered through the numeracy test and attitude questionnaires were compared pre and post intervention using descriptive statistics. The qualitative data from interviews and the research diary was analyzed using a thematic analysis approach.

The results indicate that consultative support from EPs is welcome by TAs and schools and can be associated with positive outcomes for the children involved. TAs felt EP support was reassuring and acknowledged that it increased their knowledge and confidence and this directly affected the way they thought, felt and behaved in relation to the children's numeracy difficulties. TAs reported positive observable changes in the children's attitudes to numeracy lessons and there was a positive correlation between children's scores on the numeracy test and the final attitude scores allocated to them by TAs, indicating that the intervention had a substantial impact on children's attitudes and attainment in numeracy. TAs, parents and teachers attributed the positive changes seen in children to participation in the intervention and children's progress was clearly linked to the numeracy topics covered by the NNS materials. A model for EP-TA collaboration with NNS interventions is proposed and significant factors include: consultation; modelling resources; conducting diagnostic assessments; shaping TAs' pedagogical practice and providing training on instructional psychology methods.

The research indicates that there is a potential distinctive role for EPs in raising the numeracy attainment and attitudes of children working with TAs on NNS interventions. The key element is successive EP consultations that target specific numeracy needs, effectively consider contextual factors and provide ongoing support for TAs. The proposed model could be applied to other numeracy interventions and provides an economical alternative to expensive SEN provision that EPs could usefully contribute to. Further research will be needed to ascertain more precisely the value added by the factors identified in this study to be associated with positive outcomes for children.

DECLARATION

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

COPYRIGHT STATEMENT

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SECTION 1: INTRODUCTION

The author's individual and collective experience within a Northern Educational Psychology Service of providing support for 'dyscalculic' children and background in teaching mathematics have featured in developing an interest in this area of research. Although the term 'dyscalculia' has served to give children's numeracy difficulties a prominence in the minds of teachers and teaching assistants in a similar way to that created by the term 'dyslexia', it has also served to provide a social construction through which a number of children can be identified as unable to learn mathematics without additional special support and resources. There is often so much more that could be done to support such children within the class room instead of searching for 'excuses' to explain away their difficulties or insist on expensive additional provision and the author's view is that ongoing consultation sessions with staff working directly with these children should help to structure such support.

Numeracy difficulties have been shown to have far reaching negative consequences for the individual and high cost for society in the long term. The UK has a stubborn and significant 'tail of underachievement' with numeracy (Basit, 2003; Dowker, 2009; Frederickson *et al.*, 2008) which has remained consistent over a number of years despite the efforts of many professionals. The National Numeracy Strategy (NNS) is the most focused attempt to raise standards in numeracy and a number of modifications have been made since its inception in 1999 to accommodate the needs of low achievers. The latest of these is the wave 3 intervention, *Supporting Children with gaps in their Mathematical Understanding*, used in this study (DfES, 2005c). However, the guiding principles of the NNS materials are not always transferred satisfactorily into the classroom and Gross (2007) points out that the materials are in need of further evaluation beyond the anecdotal evidence provided so far. One of the outcomes of this research will be to provide further evaluation of the NNS wave 3 materials following supported use in three English Primary Schools.

It could be argued that without Teaching Assistants (TAs) the NNS would have been unworkable. The number of TAs in English schools has risen sharply in recent years yet large scale longitudinal studies have questioned the usefulness of this costly government backed policy and concluded that TAs have a negative impact on pupil

attainment. However, there is one exception: TAs have been shown to deliver successfully interventions for which they are trained and supported. Much research shows that teachers cannot or do not perform this supervisory role adequately due to time and work load demands and also lack of confidence in dealing with numeracy difficulties. It is also clear that TAs will continue to be the main providers of support for children with numeracy difficulties but remain relatively untrained and unsupported in dealing effectively with the needs of the children they are expected to work with; often providing 'alternative rather than additional support' (Blatchford *et al*., 2009).

In the author's view, there is a potentially distinctive role for Educational Psychologists (EPs), as external professionals with specialized knowledge, in providing the necessary support for TAs. The focus should be on reducing anxiety, increasing expectations and experiences of success and identifying specific teaching approaches that work for the child in the classroom. This research aims to explore the role of the EP in raising numeracy standards for children with difficulties through collaborative work with TAs in the form of successive consultations.

The underpinning premise for this study is to test the ideas put forward by various researchers that TAs could deliver interventions satisfactorily given appropriate training and support (Blatchford *et al*., 2009; Alborz *et al*., 2009; Williams, 2008; Dowker, 2004; Ofsted, 2002) and that there may be a role for EPs in facilitating this process with regard to numeracy interventions (Muijs, 2003; Gross, 2007 and 2009; Mackenzie, 2007). A number of researchers have implied that consultative support from EPs would make a useful contribution to raising numeracy attainment for children experiencing difficulties but only Gross (2007 and 2009) appears to have explicitly suggested this as a possible unique EP role. This research specifically involves ongoing consultative support from an EP: modelling NNS materials and providing targeted support with diagnosing and addressing numeracy difficulties.

The intention is to use the results of this study to potentially inform a more systemic approach to tackling numeracy difficulties which EPs could usefully engage in. In this sense, the distinctive contribution to knowledge of this research is an investigation of the impact of an alliance between EPs and TAs with regard to addressing the numeracy difficulties of children using wave 3 NNS resources. Understanding the effectiveness of

ongoing consultations within an EP-TA alliance will be the primary aim of this research with addressing numeracy difficulties using NNS resources serving as an exemplar of the consultation process in action.

In order to assess the current state of knowledge in this area, a literature search was conducted to identify relevant articles and studies. Some of the references included in the literature review (chapter 2) were obtained through searches of electronic data via the *Google* and *Google Scholar* search engines using search terms such as 'consultation', 'teaching assistants', 'adult support', 'numeracy', 'numeracy interventions', 'National Numeracy Strategy', 'Primary National Strategy', 'mathematical interventions', 'educational psychologist', 'school psychologist' and various combinations of these. Similar terms were used to search electronic databases such as *PsycInfo* and *Medline*, accessed via the University of Manchester website, and the *EBSCO host* database provided through the Association of Educational Psychologists.

Some references were sourced directly from books, presentations, DCSF research reports and literature produced by interested or related third parties such as the Every Child Counts trust. Studies were selected for inclusion on the basis of their appropriateness to inform research into the role of teaching assistants, their impact on numeracy attainment and potential collaboration with EPs. None of the studies found involved EP involvement with TAs or matched the methodology of the current research but the few that targeted specific children for trained TA support and measured changes in pupil attainment came closest.

SECTION 2: LITERATURE REVIEW

2.1 Aims of the literature review

This literature review aims to describe recent research that points out the significance of adequate numeracy skills to an individual's success in a number of spheres and highlights the long term impact that poor numeracy is expected to have on society. It outlines theories concerning the development of mathematical understanding and describes the nature and prevalence of numeracy difficulties, based on recent research. The attempts made to tackle such difficulties by the National Numeracy Strategy (NNS) in England and Wales are considered with a focus on the effectiveness of Teaching Assistants (TAs) in their implementation. Finally, a case is made for the involvement of Educational Psychologists (EPs) in supporting TAs to deliver NNS interventions and assist them in addressing the needs of children with numeracy difficulties.

2.2 The impact of poor numeracy within education and society

Knowledge of and fluency with basic numeracy is essential for effective functioning in our world. It enables us not only to perform calculations and appreciate number concepts but also to organise our lives. A basic grasp of numeracy allows us to budget our time and finances to meet the demands every day existence makes upon us. Amongst other things, it helps us to purchase food and clothing, read calendars, follow recipes, locate addresses, play games and even monitor our own health and fitness.

Despite this prime importance of arithmetic and mathematical skills in general to every day life, children (and adults) with difficulties in this area have been relatively neglected. The research base for mathematical development and difficulties is much smaller in comparison to other developmental difficulties, such as literacy difficulties, but there has been a recent increase in interest in this area (Dowker, 2007; Shalev 2004). The reasons for this growing interest are varied but all related to changing social and educational attitudes to numeracy problems (Munn and Reason, 2007). This, at least, is a step in the right direction in supporting children with difficulties in mathematics and the education professionals who work with them.

Munn and Reason (2007) state that education systems around the world have increased their emphasis on the successful acquisition of numeracy skills based on a coordinated international demand for numeracy skills. In England and Wales, the National Numeracy Strategy (NNS), now part of the Primary National Strategy, has had an impact on the way numeracy is taught in primary schools and also shaped the perception and expectations of teachers with regard to children's numeracy development. It incorporates 'waves' of intervention strategies, much like those associated with tackling literacy difficulties, and is one of a number of intervention strategies reviewed by Dowker (2004) on behalf of the government.

The Every Child a Chance Trust, a charity whose stated aim is to 'unlock the educational potential of socially disadvantaged children through the development and promotion of evidence-based, early intervention programmes' (Gross, Hudson, and Price, 2009) commissioned a report which reviewed research on the long term costs of poor numeracy. Figure 1, below, illustrates the five different types of costs identified by the report as incurred by children who have not learned to understand basic number concepts by the age of 7.

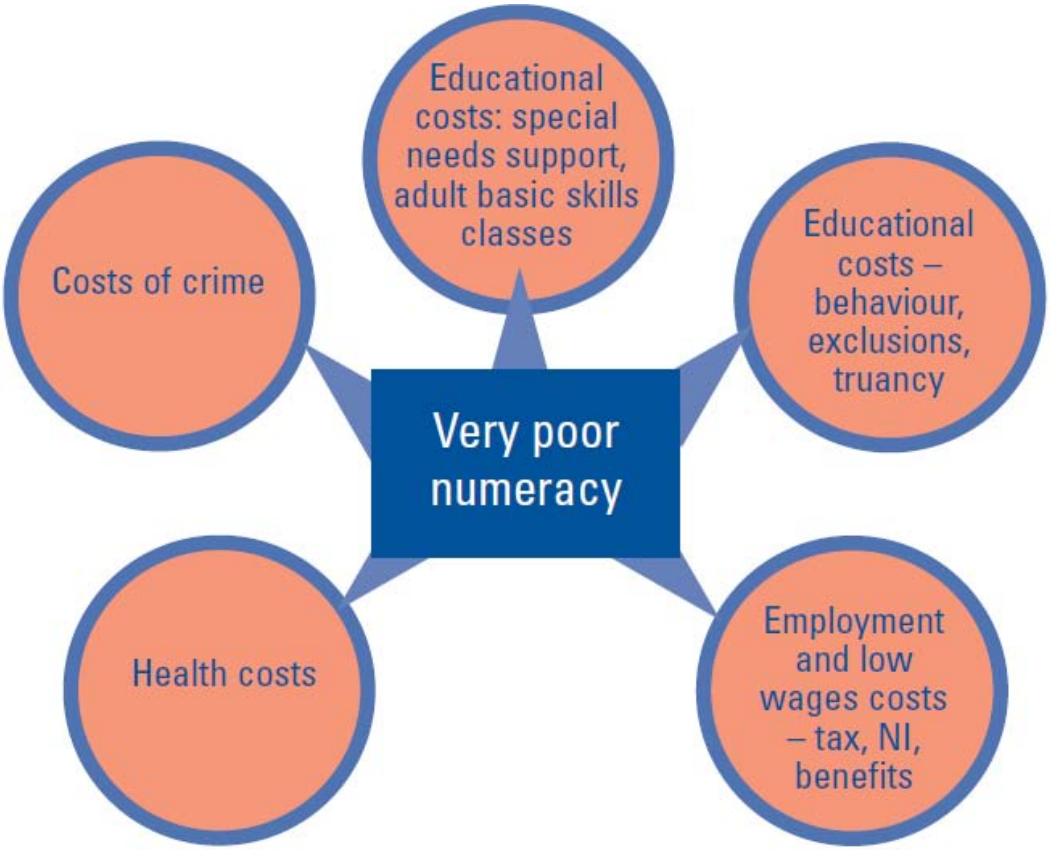

Figure 1: Five types of costs incurred by children with very poor numeracy at age 7 (taken from Gross *et al*., 2009)

The research reviewed by Gross *et al.* (2009) showed that numeracy difficulties are linked to expensive special educational needs provision, truancy, exclusion from school, significantly reduced employment opportunities, increased health risks and an increased risk of involvement with the criminal justice system. Many of these increased risks operate over and above those associated with general social disadvantage, those associated with parallel literacy difficulties, and those associated with lack of qualifications. Therefore, the research appears to suggest that numeracy difficulties play a distinctive role in restricting opportunities throughout a person's lifetime and that competence with numeracy does not just facilitate employability and benefit the economy but also acts as a protective factor in maintaining social cohesion (Gross *et al.*, 2009).

Gross *et al* (2009) estimate that the cost to society of failure to master basic numeracy skills at primary school is up to £2.4 billion every year, for all individuals with numeracy difficulties. The cost for individuals with just numeracy difficulties, without parallel literacy difficulties, is estimated at up to £763 million each year. The report explains that its estimation of the five types of costs illustrated in figure 1 are derived from four critical pieces of data:

1. **Population numbers** – 35,843 per year group which equates to 5.9% of children leaving primary school in 2005 with attainment below National Curriculum Level 3 in Maths (19,686 boys and 16,157 girls). 2005 was the last year group for which there are published data on the breakdown of pupils attaining below Level 3 by gender, SEN status, and whether the pupil also has concurrent literacy difficulties.
2. **Prevalence rates** – based on the percentage of the population that have these problems and incur these costs. The report claims that wherever possible these relate to numeracy difficulties alone and have been calculated using the data provided in the Parsons and Bynner (2005) Study. This cites separate incidence figures for poor literacy/poor numeracy, and poor numeracy/competent literacy groups, with competent numeracy/competent literacy groups serving as the population baseline. Where this data could not be used, the report authors cannot be clear about the extent to which differential incidence is due to poor numeracy or general low skills.

3. **Typical frequency and/or duration of the problem** – The report authors identified or assumed a frequency and/or duration for each problem and identified typical associated costs which were used to work out a total cost to the public purse for that problem or event. Where they were unable to predict frequency only one episode was counted e.g. exclusion from school.
4. **Unit cost information, actual or proxy, for each specific type of social cost -** Unit costs are taken from: other published cost-benefit studies; national sources for health and social care services; criminal justice and benefit receipts or derived from first principles using agencies' data. Price levels were applied for services as they would have been provided in 2008.

Gross *et al* (2009) describe the difficulty in establishing the extent to which very poor numeracy operates over and above other factors such as poverty, lack of parental involvement in learning, or slow cognitive development. They suggest that separating out those with poor numeracy/competent literacy and comparing them with those competent in both numeracy and literacy skills resolves the problem by enabling us to see numeracy-specific effects rather than general low skills linked to disadvantage. They also mention that the differential frequency methodology used in the report has limitations as it assumes that the impact of different factors on outcomes is additive, and does not take into account potential interactions. The report acknowledges that just because a factor or event occurs more frequently in those with poor numeracy it does not necessarily follow that if the numeracy difficulty were addressed the factor or event would not occur. For these reasons, Gross *et al* (2009), state that the estimates in their report are indicative and therefore should be treated with caution. A prospective longitudinal study is planned which, according to the report authors, will help to 'reality-test' the estimates and hypotheses generated by the differential frequency method used in their research.

Furthermore, the report goes on to say that providing effective numeracy intervention at age seven to all of the 35,843 pupils who currently leave primary school each year with very low numeracy skills would save the public purse an estimated £1.6 billion each year. This is based on a 79% success rate and a unit cost of £2,600 per person. The benefits of early intervention seem to far outweigh the long term costs and this message is being heeded by the government. It is commissioning and funding research into the

much neglected area of numeracy difficulties and seeking to back numeracy interventions with a proven evidence base. These should not only facilitate the development of competence with numeracy amongst children but also allay the anxieties of adults who work with them – some of whom are reluctant to participate in numeracy interventions (Gross, 2007).

2.3 The development of mathematical understanding in children.

The process of cognitive development is important in the development of mathematical understanding and thus the work of two major theorists in this area: Piaget (1896-1980) and Vygotsky (1896-1934). Piaget is often regarded as the most influential educational psychologist although he described himself as a 'genetic epistemologist'. He wrote little about the teaching of mathematics but his theories have had an immense influence on those involved in shaping mathematical education (Thompson, 1997).

Piaget believed that children were initially egocentric, in that they were 'centred' on their own 'concrete' world and the effects of their actions within it. He believed they were unable to comprehend the viewpoints of others if they differed from their own. Piaget argued that children passed through a series of developmental stages as they freed themselves from the constraints of their own perspective and the concrete objects around them and became capable of more abstract mental operations. Piaget maintained that children progressively constructed this more abstract and general capacity to solve problems in the world in an independent and solitary manner. This view supports the pedagogic principles of discovery learning, whereby teachers simply facilitate children's learning and thus cognitive development by providing a rich, stimulating environment rather than through direct teaching. The driving force is cognitive conflict, which occurs when children are forced to modify familiar theories in the face of tasks that demand more of them and in doing so achieve greater competence to tackle future problems (Nunes and Bryant, 2004).

One of the contributions of Piaget's theory is on children's quantitative development and this provides important insights into how children learn mathematical concepts and ideas (Ojose, 2008). Piaget maintained that children did not understand number by counting or learning number labels but through realising that a set of objects was

invariant unless objects were added or removed and simply spreading them out did not change their number value. This discovery of invariance of number despite spatial displacement was such an important step in children's intellectual development for Piaget that it became the second stage in his theory (Nunes and Bryant, 2004). Piaget (1952) believed that children discovered the notion of numerosity through the development of logical concepts and reasoning and this view needs to be contrasted with recent researchers who hold that infants appear to respond to the numerical properties of their visual world without much opportunity to manipulate their environment or benefit from language and abstract reasoning (Butterworth, 2005a).

The four main stages of Piaget's theory with specific regard to numeracy development are outlined below (Ojose, 2008; Das Gupta, 1994):

- ***Sensori-motor stage*** *(birth to approximately 18 months)* - infants explore and recognise objects using the senses and develop cognitive structures that enable increasingly complex patterns of actions. Object permanence is acquired at this stage as well as the ability to link numbers to objects (Piaget, 1977).

- ***Pre-operational stage*** *(approximately 18 months to 7 years)* - Actions begin to be represented by symbols, the most symbolic activity being represented by the rapid acquisition of language. The child has an egocentric perspective and limited logic: linking unrelated events, seeing objects as possessing life, inability to see another's point of view, inability to reverse operations and focussing on only one dimension of an object. A child at this stage can understand that three add four equals seven but cannot reverse this to find what seven take away three is. Piaget showed that children at this stage cannot conserve number, length or capacity.

- ***Concrete operations stage*** *(approximately 7 to 12 years)* – Acquisition of language and basic skills accelerate dramatically and children become capable of 'logico-mathematical thought' (Piaget, 1991). Now they can focus on more than one dimension of an object and are able to conserve and reverse operations as a result. They are most successful with concrete problem solving activities and find abstract or philosophical concepts difficult. Two logical operations

necessary for understanding number concepts are developed (Piaget, 1977): *Seriation* (ordering objects by increasing or decreasing length, weight or volume) and *Classification* (grouping objects based on a common characteristic). 'Hands on' experiences are invaluable at this stage in making abstract mathematical concepts concrete so that they can be used to solve problems and lay the foundations for more advanced mathematical thinking. They boost children's mathematical confidence by providing a way to confirm and test their reasoning.

- ***Formal operations stage*** *(approximately 12 years upwards)* - thinking in abstract and hypothetical ways is now possible. The child can now construct his or her own mathematics by forming hypotheses and deducing possible consequences based on his or her accumulated knowledge. Abstract thought patterns are executed using pure symbols, without the need to refer to concrete examples, allowing mastery of highly abstract areas of mathematics such as algebra.

These fixed stages are a key feature of Piagetian theory and each one depends upon the one before it. Piaget holds that adults can do little to propel children onto the next stage. He recognized that a child may perform at different stages on different tasks and he called this uneven development *décalage.* However, the existence of *décalage* poses problems for the idea that certain stages of development characterize certain modes of thought. In Piagetian theory, children actively contribute to their own learning by acting upon the environment and constructing internal structures that control the way they think. These mental structures develop as the child constructs increasingly complex ways of thinking to make sense of their environment in an attempt to achieve *adaptation.* This can be achieved through two processes: *assimilation* (internalizing and adapting new knowledge through existing structures) *and accommodation* (modifying existing schemes to incorporate new knowledge) (Das Gupta, 1994; Piaget, 1991).

Piagetian theory has contributed to current approaches to the study of children's mathematical thinking but some aspects have been criticized. The main one being his idea that children's intellectual structures determine how they think over and above any other influence. Recent research on mathematical reasoning shows that children with

the same intellectual structures function differently if the *content* of the problem, the particular *mathematical representation* being used or the *social situation* in which they are engaged is altered (Nunes and Bryant, 2004). Piaget also says little about the role of language and social interaction in development. He viewed language as a reflector of cognitive achievement as opposed to a controller of it and this has led researchers to question the validity of his experimental findings, accusing him of requiring children to use 'disembodied thinking'. Modifications of Piaget's experiments showed that context and language influenced children's responses as they tried to make 'human sense' of the situation (Light, Sheldon and Woodhead, 1991; Donaldson, 1978). It may be worth noting that, following criticism of his theory in later years, Piaget accepted the importance of peer collaboration to produce *socio-cognitive conflict* but still maintained that formal teaching was a hindrance to the child's cognitive development (Nunes and Bryant, 2004; Das Gupta, 1994).

Unlike Piaget's emphasis on individual constructivism, Vygotsky emphasized social constructivism. He differed most from Piaget in the importance he attributed to the role of social interactions in cognitive development. He argued that children acquire (or appropriate) *cultural tools* during the course of their development so that they can be used to achieve things in the individual's life as well as be passed onto future generations. These *cultural tools* could be physical (such as a computer or other technology) or psychological (such as language or shared number systems). The social rules and traditions of the child's culture will 'explain' how these are to be used and the child gains this knowledge through social interaction (Nunes and Bryant, 2004; Das Gupta, 1994; Vygotsky, 1978). Bandura (1925- present) proposed a similar process in his *social learning theory* which posits that learning by observation and imitation of a 'model' person forms the basis of much behaviour. Children are more likely to imitate warm and powerful models who possess objects or exhibit characteristics they value and by acting like their models, children hope to obtain these valued characteristics (Das Gupta, 1994).

Vygotsky (1978, 1991) stressed the importance of direct teaching as a force for driving cognitive development. The social interaction between teachers and pupils or between more able and less able peers provides the basis for developing new ways of thinking. Vygotsky believed children possessed a *zone of proximal development* within which

more able people, usually teachers, could *scaffold* them. The zone of proximal development represents the difference between what a child can achieve independently and what they can achieve with the help of a more able adult or peer. The metaphor of a scaffold, which is gradually withdrawn as the learner gains the ability to work with less support, stresses the significance of the social support of learning and development. Vygotsky accepted that some aspects of development could be achieved by the child through everyday experience but purely abstract modes of thought, such as those required for complex numerical problem solving, could not be achieved without instruction in abstract sign systems. Vygotsky suggested that children may use the socially constructed knowledge systems they are exposed to without initially understanding their significance but with time and experience will begin to understand them through a process of *reconstruction*. An example of this is children's playful engagement in counting without an appreciation of the purpose of quantification. Even though some children count accurately and extensively, it is still an imitative social activity supported by adult language and goals. After considerable joint experience, children internalize the cultural practice of counting and it becomes a more conscious cognitive activity directed according to adult principles (Munn, 1997).

The significance of Vygotsky's theory for mathematical understanding becomes apparent after the age of 2 years, until which time, Vygotsky accepts that the Piagetian notion of children developing through maturation and self discovery may dominate. After this 'natural line' of development, Vygostky argues that cognitive structures are greatly influenced by the 'cultural line' of development. This involves the cultural sign systems of written language and mathematics and Vygotsky believed human thought would be impossible without the interaction between human speech and these sign systems (Nunes and Bryant, 2004; Das Gupta, 1994; Vygotsky, 1991).

In summary, for Piaget, mathematical understanding develops through children's facilitated interactions with their environment and is closely linked to their progress through a series of fixed stages of intellectual development. Children may not be able to grasp certain mathematical concepts, no matter how well explained, until they are developmentally ready to *assimilate* or *accommodate* them. Whereas Vygotsky, emphasized the role of direct instruction by those with greater knowledge finding some common ground between their knowledge and that of the learner in order to *scaffold*

them through their *zone of proximal development*. The *cultural tools* associated with mathematical understanding are encountered initially through social interaction between people (inter-psychological) and then *internalized* by the child so that they become part of them (intra-psychological). These theories have had a significant impact upon the view of the child as learner and the nature of mathematical instruction, especially for children experiencing atypical developmental or instructional pathways.

2.4 The nature of numeracy difficulties in children

Children possess an innate capacity for acquiring numeracy skills such as counting, adding and comparing quantities without any formal instruction (Starkey, Spelke and Gelman, 1990; Ginsburg, 1997; Shalev, 2004, Butterworth 2005a). Very young infants have been shown to recognize and mentally manipulate small numbers and some species of animals have also been shown to have an innate number sense (Dehaene, 1997). This implies that children already possess some level of numerical ability before they are introduced to the cultural tools of their society and learn to count formally. Butterworth (2005a) summarizes the principal milestones in the development of arithmetic by age and these are illustrated below in table 1. The table shows the ages at which most children tested reliably demonstrated the given numeracy abilities but it should be borne in mind that different children can reach the milestones at very different ages.

Age	Milestones
Birth	Can discriminate on the basis of small numerosities.
4 months	Can add and subtract one.
11 months	Discriminates increasing from decreasing sequences of numerosities.
2 years	Begins to learn sequence of counting words.
2 ½ years	Recognises that number words mean more than one.
3 years	Counts out small numbers of objects.
3 ½ years	Can add and subtract one with objects and number words. Can use cardinal principle to establish numerosity of set.
4 years	Can use fingers to aid adding.
5 years	Can add small numbers without being able to count out sum.
5 ½ years	Understands commutativity of addition and counts on from larger. Can count correctly to 40.
6 years	Can conserve number.
6 ½ years	Understands complementarity of addition and subtraction. Can count correctly to 80.
7years	Retrieves some arithmetical facts from memory.

Table1: Milestones in the early development of arithmetic (adapted from Butterworth, 2005a).

Butterworth (1999 and 2005a) reminds us that these milestones are based on American and European contexts and there is evidence to show that children acquire arithmetical concepts more quickly in cultures with very regular number word systems such as Chinese or Japanese.

As mentioned above, there are large individual differences in numerical ability. The Cockcroft report (1982) found that there was a large variation in numerical ability between children of the same age and emphasized tailoring methods to meet the needs of individual children and discouraged an age based approach where some methods become regarded as 'babyish'. Dowker (2004) reports that studies conducted some twenty years later similarly concluded that a large gap in numerical ability existed – almost seven years at the age of 11.

Augustyniac, Murphy and Phillips (2005) note the wide range of variation in the characteristics of students with numeracy difficulties and also the wide range of expression in performance deficits. For some children mathematics is one of many subjects with which they struggle and for others it is the only area of difficulty. Some children have specific delays with numeracy development which may eventually be resolved whilst others have specific problems that persist despite intervention. The causes of these difficulties are also varied and tend to overlap: they can include individual characteristics such as unusual brain development; inadequate or inappropriate teaching and poor preschool experience of mathematical activities and language (Dowker, 2004).

Numeracy is a multi-dimensional entity made up of many components including: knowledge of counting and numerical combinations (or 'number facts'); number production and comprehension; ability to execute numerical procedures and estimate appropriate magnitudes; understanding numerical principles such as the laws of commutativity and associativity; application of mathematical knowledge to solve word and practical problems and so on (Dowker, 2004; Augustyniac *et al.,* 2005; Adams, 2007; Munn and Reason, 2007). Moreover, each of these cognitive demands requires inherent and experiential factors. For example, counting requires mastery of the principles of one to one correspondence (only one word tag is assigned to each counted item), stable order (the order of the word tags must not change across counted sets), cardinality (the value of the final word tag represents the quantity of items in the counted set) and abstraction (objects of any kind can be collected together and counted). Number production and comprehension requires the ability to translate between verbal and written Arabic forms and produce semantic representations of these forms to enable comprehension of magnitude and place value (Augustyniac *et al.,* 2005; Geary, Hoard and Hamson, 1999).

Dowker (1998) and Ginsburg (1997) have shown that it is relatively easy to find children with marked discrepancies in either direction between virtually any two components of numeracy. Geary, Hamson and Hoard (2000) found that many children exhibit mathematics difficulties that are not stable over time and therefore a longitudinal approach to studying the nature of their difficulties should be adopted. It is possible for children to outgrow developmental delays with numeracy, respond well to intervention

or be misidentified using a test located at one point in time. The fact that patterns of numeracy difficulties can be so variable between individual children means that diagnostic interviews are an appropriate method of extracting relevant information as opposed to standard tests which may mask difficulties in specific areas. In this way the numeracy strengths and weaknesses of a child and the reasons behind their thinking, intuitions, errors and strategies can be better understood (Dowker, 2004).

There is a consistent finding that children with numeracy difficulties have deficits in the retrieval of basic numerical combinations and employ less sophisticated counting strategies (Gersten, Jordan and Flojo, 2005; Geary *et al.*, 2000). Simple combinations, such as number pairs totalling 10, only become routine 'facts' with repeated use and reinforcement. The ability to memorize and readily retrieve these combinations helps to build conceptual and procedural knowledge of abstract mathematical principles such as the commutative and associative laws. Immature counting strategies serve to limit the opportunities to learn these principles (Gersten *et al.*, 2005). However, to complicate matters, even though these issues are common amongst children with numeracy difficulties, not all children who exhibit numeracy difficulties have these problems (Dowker, 2004).

Research has shown that children with combined numeracy and reading difficulties (ND+RD) show a different pattern of cognitive deficits compared to children with numeracy difficulties only (ND). Children with ND only have an advantage over those with ND+RD in mathematical areas that can be mediated by language such as word problem solving and verbal counting but not in areas that require numeracy competence such as estimation of numerical magnitudes and rapid retrieval of number combinations. Competence with reading appears to ameliorate numeracy difficulties and it has been hypothesized that there is a relationship between deficits in processing sounds (a factor in dyslexia) and accessing numerical facts in long term memory (Jordan, Hanich and Kaplan, 2003; Geary *et al.*, 2000). Although reading difficulties have a negative impact on numeracy development, numeracy abilities do not influence reading development (Gersten *et al.*, 2005).

The role of working memory in numeracy difficulties has been identified as a central deficit by a number of studies (Holmes and Adams, 2006; DeStefano and DeFevre,

2004; Gathercole, Pickering, Knight and Stegmann, 2004; Temple and Sherwood, 2002; McLean and Hitch, 1999; Geary, 1993). Working memory refers to our ability to coordinate mental operations with transiently stored information during cognitive activities such as performing complex mental arithmetic (Hitch, 2005). Working memory is composed of three interacting subsystems that include specialised stores for verbal (phonological loop) and visuo-spatial material (visuo-spatial sketchpad) along with an attentional component (central executive) that controls activity within it (Baddeley, 2000). Gathercole and Alloway (2008) explain how despite its usefulness, working memory has a limited capacity and this capacity varies substantially between individuals. Children with poor capacities struggle to meet the demands of situations with a heavy memory load such as numeracy problem solving. Gathercole and Pickering (2000a) showed that a combination of phonological loop and central executive measures were significantly associated with poor performance in National Curriculum numeracy tests. Six and seven year old children who achieved poorly on these tests also showed deficits on central executive tasks involving the processing and storage of verbal material for brief periods of time and less marked deficits on phonological loop measures. Central executive and visuo-spatial sketchpad scores have been related to National Curriculum mathematics attainment at age 7, 11 and 14 years and phonological loop scores at ages 7 and 11 (Gathercole *et al*., 2004; Jarvis and Gathercole, 2003; Gathercole and Pickering , 2000b).

Deficits in phonological loop and central executive functioning are seen to impair numeracy ability as the phonological loop supports counting processes and the central executive is involved in the co-ordination of multiple tasks involved in counting and solving numeracy problems (Bull, Johnston and Roy, 1999). Poor working memory may also impair children's ability to commit number facts to long term memory as the information in working memory decays too rapidly for associations to be formed. This is particularly important in building an efficient cognitive network that can be rapidly drawn upon for solving numeracy problems which in turn facilitates the acquisition of more complex numeracy skills (Geary, 1993). This evidence points to a significant role for working memory in the processing and retention of numerical information and Gathercole and colleagues (ibid) advise educational psychologists to assess the working memory functioning of children that have been referred to them with numeracy difficulties.

Gersten *et al*. (2005) also note that a different development research tradition primarily conducted by psychologists interested in the cognitive development of children focuses on the concept of *Number Sense*. Definitions vary amongst researchers but generally refer to a conceptual structure that relies on many links among mathematical relationships, principles and procedures. This includes fluency in estimating and judging magnitude, ability to recognize unreasonable results, flexible mental mathematics and ability to switch between and use appropriate representations. Number sense development can be enhanced through teaching and creating links between the various components (Case, Harris and Graham, 1992). Askew, Rhodes, Brown, William and Johnson (1997) found that 'highly effective' teachers possess knowledge, understanding and awareness of conceptual connections within and between different areas of mathematics which they are able to share with children by drawing on their experiences and facilitating them in making the connection with curriculum topics.

Dowker (2004) reviewed research that showed that numeracy difficulties often co-occur with dyslexia and other forms of language difficulty. Aspects involving verbal memory such as learning number facts are often an area of difficulty for dyslexics but some also have fundamental problems with number sense (though this can also occur in non-dyslexics). Children with language difficulties tend to have particular difficulty with general arithmetic, symbolic understanding, organization, memory, 'talking through' problems and benefiting from oral or written instruction. Certain forms of brain damage and genetic disorders can lead to disproportionate numeracy difficulties. However, people with even severe intellectual impairment tend to show similar numeracy performance and strategies to typically developing individuals of the same mental age (Baroody, 1988). In her review, Dowker (2004) notes the difficulty in generalizing about all people with numeracy difficulties due to the very heterogeneous forms they can take but evidence suggests that the majority of such difficulties can be seen as representing the lower end of a continuum. However, there are exceptions to the general evidence that numeracy difficulties are part of a continuum of ability.

There are a few individuals with specific numeracy learning difficulties whose difficulties are both severe and rare. These individuals are thought to have *dyscalculia* which is sometimes called number blindness and affects the ability to acquire numeracy

skills. A range of terms have been used to describe this condition including: 'developmental dyscalculia'; 'mathematical disability'; 'arithmetic learning disability'; 'number fact disorder' and 'psychological difficulties in mathematics' (Butterworth, 2003). There is still much debate as to whether the term dyscalculia should be used at all and whether it is the lower end of a continuum or a separate disorder. Some people prefer to define it in functional terms, involving specific and severe numeracy difficulties without reference to cause while others see it as a brain based disorder involving abnormality or underdevelopment of number processing regions (Dowker, 2009). The complexity of numerical processing makes it difficult to define dyscalculia but the DfES (2001) provides the following definition:

> *Dyscalculia is a condition that affects the ability to acquire arithmetical skills. Dyscalculic learners may have difficulty understanding simple number concepts, lack an intuitive grasp of numbers, and have problems learning number facts and procedures. Even if they produce a correct answer or use a correct method, they may do so mechanically and without confidence.* (p2)

Some researchers claim that this definition does not explain why there should be a selective deficit of numeracy ability and moreover that it is a congenital brain based disorder (Butterworth, 2003 and 2005a; Shalev, 2004). Gifford (2005) in her 'review of research in relation to dyscalculia' puts the prevalence of dyscalculia at about 5%. This figure includes overlap with dyslexia (with some researchers claiming that a third of dyslexic children also have dyscalculia) and reflects an equal number of boys and girls.

Butterworth (2005a and 2005b) asserts that dyscalculic difficulties centre on an inability to understand and manipulate *numerosity*, which he describes as the cognitive counterpart to the mathematical term 'cardinality'. This is the innate ability to recognise that collections have a numerosity and that this can be manipulated by combining or taking items away and that one collection has either an equal, higher or lower numerosity to another. It also means understanding that collections do not need to be of visible things (they can be audible, tactile or abstract things like wishes) and recognizing small numerosities on sight (Butterworth, 1999 and 2005a). Dyscalculic individuals can master areas of mathematics that do not depend on manipulating numerosities such as algebra, geometry and topology and given plenty of time can

manage to manipulate numerosities in an abnormally time consuming manner. They tend to be of normal intelligence, emotionally stable and motivated to learn but do not appear to respond to remedial teaching. As mentioned above in this section, working memory difficulties are associated with numeracy difficulties, However, Butterworth (2005a) states that '*although various forms of working memory difficulty may well co-occur with math difficulties, there is no convincing evidence implicating any form of working memory as a causal feature in dyscalculia*' (p14).

Gifford (2005) emphasizes persistence of numeracy difficulties over time despite good teaching as an important factor in identifying dyscalculia as her review questions some of the causal links made by researchers in the area. The fact that dyscalculia co-occurs with disorders such as ADHD (attention deficit hyperactivity disorder) and epilepsy and has been linked to premature birth, and to deficits in language, spatial awareness, coordination and memory makes it difficult to establish that it is a specific learning difficulty affecting numeracy ability only. Geary (2004), highlights the variety of difficulties shown by dyscalculic children and suggests that a single deficit theory does not fit the evidence. He suggests that the development of a standardised diagnostic test that provides more precise information would be more useful in assisting teachers to target specific numeracy problems rather than one focussing on identifying cognitive deficits such as the *Dyscalculia Screener* developed by Butterworth (2003).

Gross (2007) adopts a more pragmatic stance on dyscalculia. She argues against labelling children because of the evidence of a continuum of difficulties and the risks of applying medical models where children either have dyscalculia or they do not. She argues this could inadvertently lead to differing levels of provision and valuable time being wasted on diagnosing children. She advises educational psychologists to take on the 'scientifically less interesting but educationally more useful approach' of assuming all children with numeracy difficulties are to some extent dyscalculic and working with teachers to develop practical interventions to overcome barriers to numeracy. The emphasis should be on using consultations with teachers to 'diagnose' what children already know and need to know rather than probing for cognitive causation.

Figure 2, below, uses a causal modelling framework proposed by Frith (1999), in relation to defining and explaining dyslexia, to summarize some of the research on

numeracy difficulties. This is a three level framework which considers factors at the biological, cognitive and behavioural levels and how these interact with the environment. Frith (1999) suggests that linking the factors at the three levels and considering the ameliorating or aggravating impact of environment and culture provides for a fuller understanding of dyslexia. I have used this framework to illustrate details of the factors that researchers have shown may cause numeracy difficulties at the various levels (Dowker, 2009; Williams, 2008; Adams, 2007; Augustyniac *et al.*, 2005; Buttterworth, 2005a; Gersten *et al.*, 2005; Gifford, 2005; Dowker, 2004; Geary, 2004).

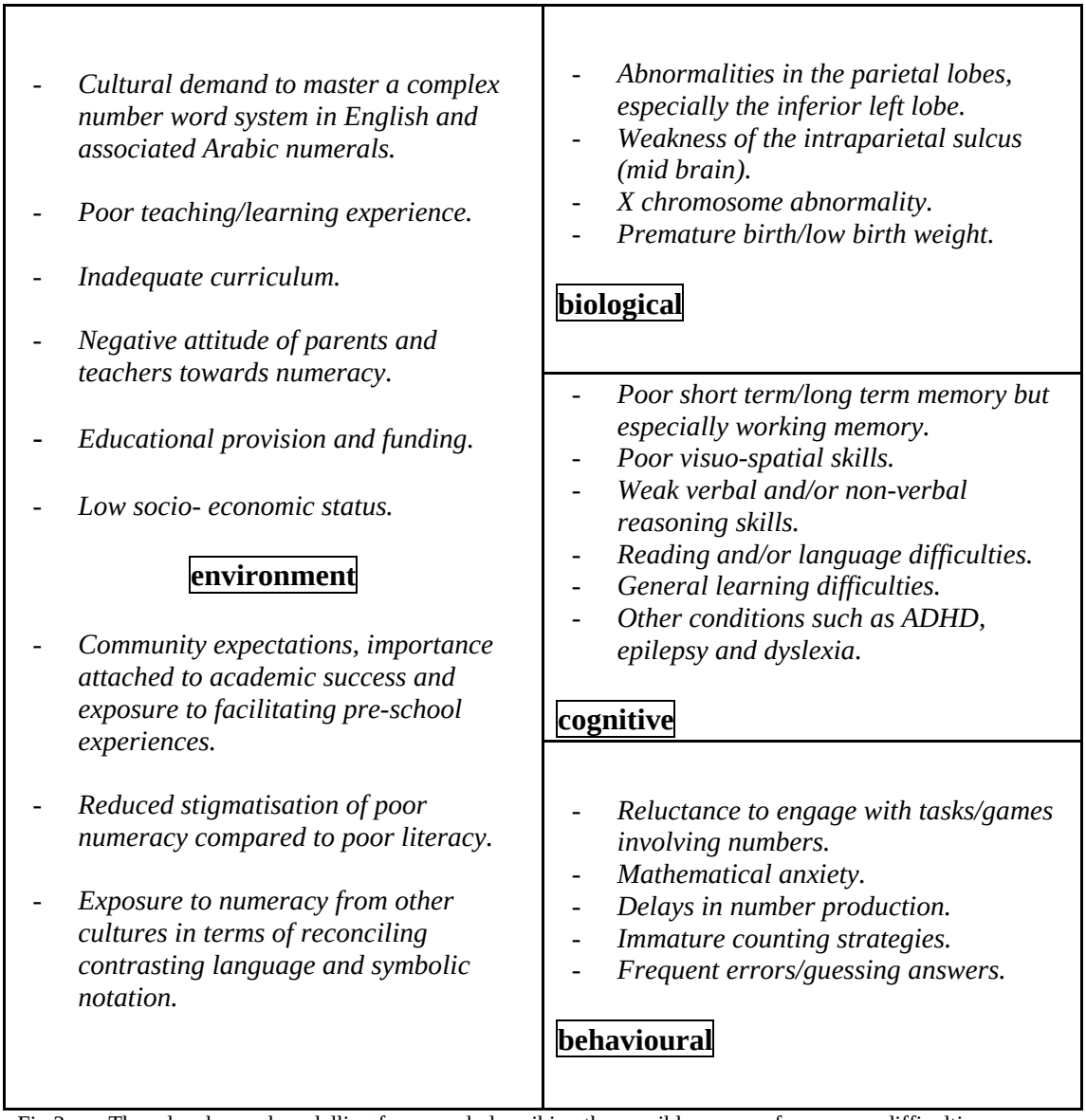

Fig 2: Three level causal modelling framework describing the possible causes of numeracy difficulties (model adapted by the researcher from Frith, 1999).

These three levels (biological, cognitive and behavioural) interact with the environment and are not mutually exclusive. Adams (2007) notes that psychological models of

numeracy difficulties tacitly imply an abnormal pathological origin as opposed to an educational perspective which tends to focus on developmental delay. How these diverse but complementary approaches conceptualise numeracy difficulties in future will have a profound impact upon the experiences of children who have numeracy difficulties and the way they are perceived by others. If at least some children with numeracy difficulties are seen as 'abnormal' then this would call into question the appropriateness of inclusive approaches advocated by the NNS.

Unlike literacy difficulties, there is a much wider variation in the characteristics of children with numeracy difficulties and the expression of their deficits. Teachers spending time, in collaboration with other professionals, discerning variations in performance deficits and learning impairments exhibited by individuals could be invaluable in developing interventions to tackle their difficulties (Augustyniac *et al.*, 2005; Gersten *et al.*, 2005; Dowker, 2004 and 2009). An educational psychologist, with specialized knowledge, could support teachers or teaching assistants by sharing ideas and working jointly on solutions designed to tackle an individual's numeracy difficulties.

2.5 Prevalence of numeracy difficulties and what works in tackling them

Gross *et al.* (2009) report that numeracy difficulties are very common in the adult population. Based on the results of maths skills tests conducted on 8000 adults as part of the government's skills for life survey, they estimate that 15 million adults have numeracy skills at or below those expected of an 11 year old and of these 6.8 million have numeracy skills at or below those expected of a 9 year old. These adults are likely to struggle with things like recalling multiplication tables and other number facts, converting between currencies and measures and working out percentages and fractions, making discounts, taxes and wage slips, amongst other things, difficult to understand. Most adults questioned, wished they had learned more maths at school and many felt they would have made further progress in their careers as a result. The survey found that maths difficulties were prevalent at all ages and amongst all social groups. Parsons and Bynner (2005) found that adults with poor numeracy were seriously disadvantaged in the work place and experience negative outcomes in adulthood on a number of measures. Interestingly they found that poor outcomes for men were due to a

combination of literacy and numeracy difficulties. However, for women, it was numeracy, independent of literacy, which predicted most of the negative outcomes.

The Confederation of British industry's (CBI) education and skills survey conducted in 2008 on 735 companies employing 1.7 million people found widespread concern amongst employers about the numeracy (and literacy) competence of their employees. The main concern cited with numeracy was the inability of employees to spot simple numerical errors or rogue numbers. About 25% of the employers surveyed were providing remedial numeracy (and literacy) training for their employees and more than 40% feared they would be unable to recruit suitably qualified staff in the future.

A DfES commissioned report, entitled 'What Works for Children with Mathematical Difficulties?' (Dowker, 2004) concluded that many children have difficulties with mathematics and a significant number have specific difficulties. Unlike literacy difficulties, these are as common in girls as in boys. It considered children working at level 1 of the National Curriculum at age 7 or level 3 at age 11 as having some degree of mathematical difficulty and those that fail to reach the above levels by these ages as having quite marked difficulties. It made clear that numeracy interventions work, at any time and do not have to be long in duration. However, it recommends early intervention in order to prevent numeracy difficulties from becoming entrenched and avoiding the potentially damaging development of mathematical anxiety. Individualised work is singled out as particularly significant in terms of positive impact on a struggling child's performance and this need not be very large to be effective. Even small amounts of individualised work can potentially bring a child to the point where they can benefit from normal classroom teaching.

Dowker (2004) recognises the need to address the extreme mathematical difficulties faced by a minority of children who fit the government's (DfES, 2001) definition of children with dyscalculia. However, she stresses that most children do not have such severe problems and their difficulties are better seen as a continuum of mathematical performance. The implication being that there is also a continuum of intervention needs, such as the three 'waves' of intervention integrated into the NNS. These waves of intervention are described in table 1, below:

Wave of intervention	Description
0	No specific intervention at this stage but the child may benefit from teachers and others who work with them being aware of their specific strengths and weaknesses.
1	Flexibly adapting activities within whole-class setting to ensure the effective inclusion of all children in high-quality learning and teaching of mathematics.
2	Additional time-limited provision in the form of small-group intervention to accelerate progress and enable children to work at age-related expectations.
3	Additional time-limited provision to enhance the progress of identified children where Waves 1 and 2 are not, on their own, having the desired effect. This will involve focused teaching activities which tackle fundamental errors and misconceptions that are preventing progress. This may range from: 1. Individualized provision of an infrequent and/or non-intensive nature. 2. Intensive individualized provision 3. Totally individualized programme and/or special educational setting.

Table 2: Waves of intervention integrated into the NNS, adapted from Dowker (2004) and DfES (2005b).

Dowker (2004) stresses the importance of recognising and addressing individual differences in numeracy ability. She notes the important influence of the school environment and teaching methods on the numeracy performance of children throughout the ability range. Appropriate teaching can prevent some forms of numeracy difficulty from ever becoming apparent and though individual differences within numeracy performance are not created by the school environment alone; they can be exaggerated by it. Some of the approaches used to tackle numeracy difficulties include: ability grouping, individualized and/or small group work and the use of teaching assistants.

Ability grouping can lead to some children being labelled as 'no good at maths' and can lower expectations. It often takes too little account of individual differences within the group and taking into consideration the multi-componential nature of numeracy may even make construction of ability groups impossible. How would you group children with widely differing profiles of numeracy strengths and weaknesses so that they are appropriately challenged and motivated to learn? (Dowker, 2004). The use of teaching assistants (TAs) to support children with numeracy difficulties has the potential to benefit them if carried out appropriately. The exact factors that determine whether or not TA support is successful are yet to be established but see section 2.7 for a discussion.

The Dowker (2004) review suggests that individual and small group work within class can be beneficial in tackling numeracy difficulties. The use of some or all of the following could assist the effective targeting of numeracy support for children within the classroom: **diagnostic tests** (rather than standardized tests which can mask difficulties with some aspects of numeracy), **pupil and parent interviews** (to provide information on history, experience, attitudes and plan for support), **teacher or teaching assistant observations** (to discover individual strategies, misconceptions, strengths and weaknesses in order to target support).

As mentioned in section 2.4, children with numeracy difficulties consistently have difficulty retrieving mathematical facts from memory and so rely on ineffective and time consuming counting strategies at an age when their peers are relying mainly on fact retrieval. Difficulties with other areas of cognition such as language, spatial awareness and memory have often been shown to concur with numeracy difficulties though these are not present in all children who struggle with numeracy. This can make word problem solving, multi-step arithmetic, using concrete or internal representations, written algorithms and monitoring their own mathematical thinking difficult for children. Teachers' knowledge of numeracy difficulties and their pedagogical response to this would logically illuminate any inquiry into numeracy learning difficulties but most studies focus on student variables and neglect the experiences and knowledge of teachers. This may be because for a number of years the view that 'teachers' autonomy is restricted to the classroom where he or she executes what others prescribe' has prevailed. However, a more extended view has emerged that considers the teacher 'as a thinking, decision making, reflecting and autonomous professional' (Van Steenbrugge, Valcke and Desoete, 2010).

Teachers' knowledge of the students, the school context, the social context, their mental models of mathematics and its teaching, knowledge of educational psychology as it applies to learning and instruction and their interpretation of curriculum materials all have a powerful impact on the classroom experience of children. They affect the choice of numeracy learning tasks, treatment of children's errors, acceptance of children's ideas and methods, curriculum decisions (what to focus on or revisit) and so on (Ernest, 1989). This knowledge and experience provides the foundation for teachers' and for that matter, TAs' pedagogical knowledge and numeracy teaching skills yet few studies

focussing on numeracy difficulties have tapped into this extensive body of knowledge (Van Steenbrugge *et al.*, 2010). Assessment of this knowledge would be a natural first step in any collaborative enterprise with teachers and TAs to address the numeracy difficulties of children and the present study aims to take this into account.

Askew *et al.* (1997) conducted a project that looked into the features associated with 'highly effective' teachers of numeracy. They found that highly effective teachers have knowledge, understanding and awareness of conceptual connections within and between different areas of mathematics and that this was not associated with their level of qualifications in mathematics. Teacher effectiveness was defined on the basis of pupil learning gain and the implication here is that teachers who modified their pedagogical style in order to promote conceptual development and connections between concepts managed to secure higher levels of attainment and retention amongst their pupils. This 'connectionism' depends on socially constructed mathematical meanings created through sharing understanding of ideas that children bring to the classroom and facilitating them in making the link with curriculum topics (Simon, 1995; Brown, McNamara, Hanley and Jones, 1999; Cobb, Wood, Yackel and McNeal, 1992a; Cobb, Yackel, Wood, 1992b; Cobb, 1988).

In a later update to her review, Dowker (2009), states that '*the broad components of arithmetical ability include counting, memory for arithmetical facts, the understanding of concepts and the ability to follow procedures*' (p6). Each of these broad components is made up of a number of narrower components and even though components correlate with one another, children can have weaknesses with one component relatively independently of weaknesses in other components. The situation is further complicated by the fact that it has not been possible to establish a strict hierarchy for the acquisition of these components and also that children with numeracy difficulties appear to show random variations in performance from day to day, making diagnosing difficulties more challenging. In all cases of numeracy difficulties there is considerable diversity of strengths and weaknesses and it is the nature of these that should form the basis of any intervention. If interventions are targeted at specific, identified, numeracy difficulties then most children will not need very intensive interventions (Dowker, 2009).

Dowker (2009) reviews the interventions currently being used within the UK since 2004. There has been a recent increase in individualised interventions largely due to government recommendations and financial support and in particular the introduction of the wave 3 NNS materials 'supporting children with gaps in their mathematical understanding' (now part of the Primary National Strategy). The review distinguishes between three main types of intervention but notes that there are overlaps between them and that some do not fall into any of these types. The three main types are:

1. Those involving the wave 3 NNS materials, usually with some modifications.
2. Those based mainly on detailed diagnostic assessments with activities targeted at specific needs.
3. Those that primarily involve multi-sensory apparatus.

The current research focuses on the first type which emphasizes individualised diagnosis of errors and misconceptions shown by children. Further details about the NNS are provided in section 2.6 along with the *Every Child Counts* programme which is currently being developed in response to the Williams (2008) review. This aims to target the lowest achieving children in Year 2 and support primary school children struggling with numeracy through the three waves of intervention model (see table 2).

2.6 The National Numeracy Strategy and Every Child Counts

The Third International Mathematics and Science Studies (TIMSS; Basit, 2003) concluded that 9 and 13 year old children in England performed relatively poorly in mathematics compared to other countries but performed better in science by comparison. This appears to indicate that educational rather than socio-cultural factors are the cause as it seems unlikely that the same home and community factors could be responsible for different levels of attainment in two related subjects (Basit, 2003). Some researchers have argued that educational factors are more important in mathematics than other core subjects (Reynolds and Muijs, 1999). Long standing concerns over national numeracy standards and their detrimental effect on economic competitiveness led to an increasing momentum for greater curriculum control from as early as 1976, culminating in the introduction of the National Numeracy Strategy (NNS) in September 1999 in all maintained primary schools (Brown, Millett, Bibby and

Johnson, 2000). The key features of the NNS (now part of the Primary National Strategy) were:

- *Increased emphasis on number, calculation and especially mental mathematics*, including estimation, recall of number bonds and times tables, delayed introduction of written methods and encouragement of pupils to select from a repertoire of strategies.
- *Three part template for daily mathematics lessons*, starting with 10-15 minutes of whole class oral/mental arithmetic practice, followed by direct interactive teaching of whole classes/groups and finishing with 10 minutes of plenary review.
- *Detailed planning using a week by week framework of detailed objectives*, specified for each year group and introducing many skills at an earlier stage than previously.
- *Systematic and standardized national training programme*, run locally by mathematics consultants and repeated by school mathematics coordinators in all schools, using videos and transparencies to demonstrate 'best practice' with in school support for schools perceived as needing it.

(adapted from Brown *et al.* (2000) and Brown, Askew, Millett and Rhodes (2003))

The prescriptive nature of the NNS framework is welcomed by many teachers, especially those with some level of anxiety about teaching mathematics. By detailing concepts in accessible form with accompanying terminology and examples, the NNS empowered practitioners the freedom to become teachers rather than administrators of the scheme by reducing responsibility for planning and developing mathematics programmes and activities (Basit, 2003). Although some have argued the reverse; that practitioners are not being treated as intelligent professionals whose teaching may have been enhanced by knowing the reasons behind the use of certain teaching approaches (Sutherland, 1999). The provision of videos, scripts, and approved artefacts could be seen as controlling what teachers see, hear and use but teachers will interpret and reconstruct what they see, hear and use through their own experiences, values and intentions (Brown *et al.*, 2000). Teachers' pedagogical styles are a personal response to the set of constraints under which they are expected to operate. Their beliefs, views and preferences about mathematics and its teaching significantly shape their instructional

practice and it is suggested that these are strongly affected by their own experience of schooling (Thompson, 1984; Ernest, 1989; Pepin, 1999). Teachers are likely to read the NNS materials with a specific audience in mind and adapt suggested activities to suit the children they work with and their own pedagogical needs (Remillard, 2005). Ultimately, teachers decide the fate of any educational enterprise and their attitudes, feelings and perceptions need to be recognised in advance for any innovation to transfer satisfactorily into classroom practice (Handal and Herrington, 2003).

Basit (2003) found that new teachers responded more positively compared to veteran teachers and regarded the NNS as having a number of pedagogical benefits: the rapid transition to mathematical thinking using the oral/mental starter; the review of learning allowed by the plenary and the opportunity to make connections with future learning; forcing teachers to take an alternative view, contemplate lessons as a whole and reorganise learning space; forcing to teachers to be clear about learning objectives and communicate positive attitudes to children as competent mathematics teachers. Furthermore, there was the belief that a more structured approach led to greater equality of opportunity for children who may otherwise have been disadvantaged by weak teachers. However, considerable gaps in children's mathematical knowledge were also highlighted. The NNS assumes that certain knowledge and skills have been acquired each year and the following year's framework builds on this but this is not necessarily the case for a number of weaker students and so it was felt the NNS did not take pupil differentiation into account adequately enough, at least in the first few years.

An independent review of Mathematics Teaching in early Years Settings and Primary Schools (Williams, 2008) recognized the positive impact of the NNS on the attainment of primary school children in England and Wales. It reports that the number of children attaining level 4 at the end of Key Stage 2 (age 11) rose between 1998 and 2007, from 59% to 77%. Brown *et al.* (2003) found that between 1998 and 2002, the greatest improvements were made by the middle 50% of pupils with only a small increase in the highest attaining groups and a small decrease in the lowest attaining groups. This may be because whole class teaching episodes and/or the topic of lessons do not always correspond to the low attaining pupils' greatest area of need. The areas where most improvement was made tended to be those where the NNS guidance increased the time

allocated to them and where the research findings clearly updated the manner in which they were taught.

Despite the stated positive impact of the NNS, the Williams' review (2008) also recognizes that there are about 30,000-35,000 children who achieve below level 3 at the end of Key Stage 2 and that this number, which equates to about 6%, has remained stable for the past few years. Gross (2007) notes how this largely static number of very low attainers has led the NNS to develop a number of initiatives to raise standards for these children and this includes improving the quality of inclusive teaching and working more effectively with teaching assistants (DfES, 2005a). Resources have deliberately been targeted at disadvantaged groups of children and more interactive whole class teaching coupled with carefully differentiated group work encouraged in supporting them. Children with mathematics difficulties have benefited from: being able to learn from their peers instead of relying on their own inadequate resources; opportunities for teachers to target appropriate learning objectives from a clearly defined progression; focus on oral mathematics and use of visual aids to develop mental representations; explicit teaching of key mathematical vocabulary and adoption of meta-cognitive strategies (Gross, 2007).

Most schools were not targeting children with numeracy skills as intensely as they were those with literacy difficulties and this led the NNS to develop support sessions for children at Key Stage 1 (5-7 year olds) in order to promote action in this area (DfES, 2003). Twenty-minute support sessions were built into existing teaching plans which enabled groups of struggling children to receive additional targeted tuition on a key concept covered in the main lesson.

A particular gap was exposed in the provision for Key Stage 2 children (7-11 year olds) so the DfES commissioned a review of research into 'what works for children with mathematical difficulties' (Dowker, 2004). This review made recommendations for effective interventions which stressed the multi-component nature of arithmetic ability; the variety of causes for numeracy difficulties and that they are best seen as one end of a continuum rather than a discrete disorder. In particular, it stressed the need to focus specifically on the precise components of mathematics that a child found difficult in order to accelerate their development of numeracy skills and knowledge. These

recommendations were used to develop the latest NNS wave 3 intervention materials for Key Stage 2 (DfES, 2005c).

These new materials take the form of diagnostic tools that enable class teachers to pinpoint the particular errors and misconceptions that are hampering a child's ability to make progress with their numeracy. These errors or misconceptions are then addressed using a series of booklets that focus on one to one teaching strategies with the child. The design of the materials draws on current psychological understandings of how all children learn and on recent investigations of appropriate pedagogies for children with special educational needs (Gross, 2007). These include focused one to one attention; overlearning; increasingly longer periods between reviews of new learning; meta-cognition; multi-sensory work; setting learning in familiar contexts; modelling key vocabulary; planned success; links to whole class activities and involvement of parents and carers with the child's learning (Lewis and Norwich, 2005). Details of children's errors or misconceptions are elicited through direct questioning and a collaborative approach, where the child is aware of the purpose of the activity and is actively encouraged to reflect on their learning, is adopted. This reflects best practice in assessment for learning as described by Black and William (2001).

Following teacher assessment to identify a child's conceptual and procedural difficulties, one of the booklets developed to address that need is used within or outside the daily numeracy lesson. Typically a child would receive a twenty minute individual session per week followed by five minute 'spotlight' sessions on each of the following days in addition to following the mathematics curriculum with or without support. However, the exact mode of teaching including who delivers it is up to the school. This flexibility is a useful feature of the NNS materials as it allows the intervention to be specifically targeted to an individual child's difficulties rather than dictating how things should be taught regardless of their particular needs. It enables adaptation of teaching style and approach to suit the child and the materials also include some suggestions on what to do if a child gives an incorrect response (Dowker, 2009).

Gross (2007) notes that these resources were well received by school staff and children though some schools could not manage to implement them in the way they were designed to be implemented. Some schools simply added them onto their medium term

planning for lower ability groups and used the materials when they coincided with the class work whilst more effective schools enlisted the support of specialist teachers to model use of the resources to staff. Many schools reported 'warm feelings' about children loving the resources and growing in confidence and motivation but there is still a need to evaluate the materials more rigorously.

Gross (2007, 2009) is also the director of the Every Child a Chance Trust which sponsors the Every Child Counts (ECC) programme. The ECC was announced in 2007 by the government to develop a numeracy intervention scheme for children aged seven with mathematical difficulties requiring wave 3 intervention. The ECC is backed by charities, businesses and the Department for Children, Schools and Families (DCSF) who realise how debilitating numeracy difficulties can be (Every Child a Chance Trust, 2009). The William's Review (Williams, 2008) endorses the Secretary of State's plans for the ECC programme and recognises the benefits to individual children and society as a whole.

The aim is to provide intensive individualized support to the 6% of children across the country who do not appear to be benefiting from the NNS as much as others. Highly trained teachers will teach three groups of four children (four children each term) for 30 minutes daily, for around 12 weeks. It is hoped that these low attaining children will make better progress towards expected levels of attainment in mathematics and achieve at least level 2 or better by the end of Key Stage 1. Following a '*research phase*' in 2007-08, and a '*development phase*' in 2008-10, it intends to provide, from 2010-11, intensive support in mathematics to 30,000 Year 2 children annually. It also expects the highly trained teachers providing ECC support to have a wider impact on learning and teaching in their schools, and help raise standards across the board. The government is spending £144 million between 2008-2011 into rolling out nationally the ECC programme and the already successful Every Child a Reader programme (Every Child a Chance Trust, 2009).

The use of highly trained teachers in delivering the ECC programme has obvious advantages for the schools involved and children should benefit immensely from expert assessment of their difficulties and tailored intervention. However, Williams (2008) recognises that costs could become prohibitively high and suggests more economical

alternatives are explored. The report cites evidence that highly trained TAs can successfully deliver intervention programmes and proposes that this option is considered, for less intensive interventions at least. It notes the anecdotal evidence that TAs are not as effective in delivering wave 3 interventions as qualified teachers and considers the following to be 'the best use of expensive human resources' (p53): intensive wave 3 interventions to be led by a qualified teacher; wave 2 and less intensive wave 3 interventions may be led by a suitable trained TA. The review further recommends that interventions should typically last for 12 weeks or one term and should preferably be given in Year 2.

Williams (2008) recognises the impact on the classroom environment of teachers' own enthusiasm for mathematics. Their knowledge (many primary school teachers are not mathematics specialists), beliefs about teaching and learning, attitude and self-confidence with numeracy will impact upon whether their practice is effective. This applies equally to TAs and the report recommends a 'robust pedagogy' as essential in improving the 'practice and performance of …teachers and teaching assistants' (p63).

2.7 The role of Teaching Assistants (TAs)

TAs are known by many names including classroom assistants, Non-Teaching Assistants, Special Support Assistants and Learning Support Assistants. In fact Balshaw and Farrell (2002) found eleven different names around the world but government guidance now advises the use of the term 'Teaching Assistants' only, rejecting names which implied TAs did not teach or were present only to support children with special needs (McVittie, 2005) .

There has been a significant rise in the number of TAs working in mainstream schools and a corresponding rise in the variety of tasks they undertake (DfES, 2005a). Farrell, Alborz, Pearson and Howes, (2009) put the figure at approximately 170,000 in January 2009. This is due to a number of factors including larger class sizes resulting from a shortage of qualified teaching staff; inclusive practice policies where children with SEN require support within mainstream classrooms and a move towards whole class teaching as opposed to individualised learning which leads to the need to provide one to one support for those that struggle to keep up (Muijs, 2003).

Former Secretary of State for Education and Skills, Estelle Morris, outlined an extension to the role of TAs in a speech to the Social Market Foundation (Morris, 2001). She said that TAs will be:

- supervising classes that are undertaking work set by a teacher, or working with small groups of pupils on reading practice.
- supervising lunchtime activities and invigilating tests
- giving pastoral and other individual support to pupils, and
- covering for teacher absence.

She stressed how nurses had taken on tasks which were previously the preserve of doctors and how this had helped reduce doctors' workloads and that extending the role of TAs could have a similar effect on teacher's workloads. Despite initial resistance from teachers and their unions, TAs routinely work with individual, groups or whole classes of children depending on their training and experience. However, some of the extra preparation, planning and assessment (PPA) time gained by teachers has been swallowed up by the extra work involved in managing and supporting TAs (McVittie, 2005).

The DfES (2005a) recognises the potential impact of the large number of TAs within schools and has produced materials to assist senior management teams in Primary schools and Early Years settings to deploy their TAs in the most effective way. They stress a key role for TAs in enabling schools to implement the workforce reforms set out in the National Agreement for raising standards and tackling workload. Based on evidence from HMI, the Primary National Strategy, university researchers and other sources, they claim that '*well-trained and well-managed teaching assistants can have an impact on inclusion, children's achievements and attitudes, and teacher workload'* (p2). They go on to say that TAs:

- foster the participation of all pupils in the social and academic practices of the school or setting;
- help raise the standards and achievement of all pupils;
- encourage independent learning.

However, where management and professional development are not as effective as they could be, this potential to make a difference may not be realised. The DfES (2005a) guidance stresses that 'the following levers need to be in place to ensure schools and settings benefit fully from the contribution of teaching assistants' (p2):

- Effective leadership and management
- Continuing professional development
- Focused support for children and the use of evidence-based intervention programmes
- Joint planning and reviewing progress
- Monitoring impact
- Performance management

In a large scale longitudinal study across many schools, Blatchford, Martin, Moriarty, Bassett and Goldstein (2002) investigated the effects of TAs on teaching and learning at KS1. They found that teachers viewed TAs support in a positive light and the most effective work was carried out when TA's training was integrated into classroom practice, connected with teaching plans and TA's views of their roles acknowledged. Teachers cited small group work as the most productive use of TAs and specifically how this increased curriculum time for mathematics. The study found that issuing TAs with written guidelines and modelling strategies to them was most effective in enabling them to support learning. The study suggests that it is important for TAs to transfer the knowledge they gain during training into effective classroom practice. The implications for practice could include TAs being encouraged to ask open ended questions and allowing more time for pupils to answer or investigating different ways of explaining a particular concept to small groups of pupils or working with TAs to devise activities that build on children's errors and misconceptions in numeracy.

In the Key Stage 2 part of their study, Blatchford, Russell, Bassett, Brown and Martin (2004) noted that TAs had much longer interactions with individuals and small groups of children compared to teachers due to TAs remaining static with their designated pupils and teachers generally moving around. This allowed for closer relationships and more individualised attention and indirectly supported the work of the teacher, especially through reiterating and repeating the message the teacher was trying to

convey. However, they raised concerns that the least qualified members of staff were being left to teach the most educationally needy pupils. They, in line with their KS1 study, did not find any direct link between the work of TAs and pupil attainment but warn against concluding that TAs have no effect. One limitation of this study was that the attainment of the whole class was measured rather than the attainment of the specific pupils with whom the TAs worked. They put this forward as a recommendation for future studies and also that more attention needs to be paid to TAs direct pedagogical role.

Blatchford, Bassett, Brown, Martin, Russell, Webster, Babayigit and Haywood (2008) reported on the Deployment and Impact of Support Staff (DISS) project, which they claim is the largest study of support staff yet undertaken and was commissioned by the DCSF and the Welsh Assembly Government in 2004. They include seven categories of support staff based on similarity of tasks performed and one of these categories is 'TA equivalent support staff'. For ease of reading and following government guidance, I will refer to them as TAs. They confirmed their previous findings that pupils were more passive with teachers, simply listening most of the time, but with TAs they were the main focus of attention and had more active, sustained interactions with them. Teachers felt that TAs supported them by taking on particular pupils and allowing them to teach the rest of the class, without neglecting their needs. The presence of TAs led to teachers being able to teach more and deal with negative behaviour less. There was more individual attention from TAs for pupils on School Action or with SEN but this also meant they had less interaction with the teacher. Generally, the presence of TAs increased adult interaction, classroom engagement and aided classroom management. The report noted the many opportunities TAs had to impact on pupil outcomes but the evidence was indirect and difficult to isolate from the other factors that may also influence outcomes. This makes it difficult to prove how TAs impact on pupil attainment, behaviour and attitude even though the perception that they do so is strong.

Blatchford *et al.* (2008) suggest a more detailed study of the 'wider pedagogical role' of TAs in terms of lesson and curriculum delivery would be valuable. There is still much to learn about the sequence of lesson planning, teaching, evaluation, feedback and further lesson planning with regard to TAs and how far the TAs understand the aims of lesson tasks and take into consideration pupil's previous knowledge. The pedagogical

and subject knowledge of TAs is also worth investigating as is a more detailed analysis of the manner in which they deal with pupil errors, the type and frequency of any 'scaffolding' and the processes through which they assess pupils' difficulties and misunderstandings. A systematic study of the amount of TA support received by a pupil and their attainment would assist in explaining the perceived link between TA involvement and academic outcomes.

In their final report, covering the DISS project over five years from January 2004 to April 2009, Blatchford, Bassett, Brown, Martin, Russell and Webster (2009) concluded that 'the more support pupils received, the less progress they made'. This is a damning assessment of huge government investment in expanding the numbers of TAs in schools to assist, amongst other things, the implementation of the National Numeracy and Literacy Strategies and the introduction of the National Agreement: *Raising standards and tackling workload*. However, Blatchford *et al.* (2009) also point out that their study uncovers the huge potential of TAs in helping teachers and pupils in the classroom. They raise serious concerns about the way TAs are currently deployed in schools and cite this as a reason why supported pupils may not be making expected progress. They mention other research (see below) that shows that pupils supported by TAs fair much better when they are prepared and trained for specific curricular interventions and receive support and guidance from teachers and schools about practice. They go on to say that the DISS project assessed the effect of TAs' support under different conditions to this more positive research. It examined the effect of the amount of support as it occurred under everyday conditions rather than with targeted interventions.

Blatchford *et al.* (2009) claim that the DISS study is the first to systematically address the deployment and impact of TAs across primary, secondary and special schools. The study covered all pupils who received support and was not restricted to those with SEN. Some of the recommendations they make include the following:

- Teachers need to develop skills to help them manage and prepare for the growing number of TAs they work with.
- TAs need to be prepared for their increasingly pedagogical, instructional role with pupils.

- More joint planning and feedback time should be made available for teachers and TAs.
- The deployment of TAs should be examined to ensure they do not routinely support lower attaining and pupils with SEN. These pupils should get more not less of the teacher's time.
- Teachers should take responsibility for the lesson-by-lesson curriculum and pedagogical planning for all pupils including those supported by TAs.
- More work on conceptualising the pedagogical role of TAs in their interactions with pupils is needed. This needs to be built into the management, support and monitoring of TAs.
- Schools should explicitly set out the quality and provision of TA support in relation to anticipated academic outcomes.

One of the few studies that explored the voice of the child found that children hold positive views of TAs and do not mind working as hard for them as they do for their teachers, inside or outside the classroom. They distinguish the role of TAs from those of their teachers and see them as supporting their teachers to do the job (Fraser and Meadows, 2008). However, there was concern that the schools which allowed research access were those that felt they had good relationships with their TAs and other schools may not have produced such positive results. Also, the children questioned were under the age of 12 and it may be that older children hold different views of working with TAs.

Farrell *et al.* (2009) conducted a review of research into the impact of adult support on pupils and mainstream schools. The majority of studies in their review focussed on the impact of TAs on literacy development. Others focused on their impact on children's social and emotional development, participation, attention and interaction in class with some studies focussing on more than one area. The review looked at 39 studies in depth of which only three looked at the impact on numeracy and two of these did so along with impact on reading. 30 studies looked at targeted interventions on children with SEN and measured the impact using a test of some kind. The TAs in these studies also received training and support in carrying out their role. Farrell *et al.* (2009) noted the high quality of these studies and the fact that they incorporated reliability checks on the interventions used. The results were promising in that virtually all found a positive

impact of TA support on the pupils they worked with. The two studies with negative or mixed findings did not withdraw pupils from classes and conducted much shorter interventions.

The non-targeted interventions were not as positive and produced mixed findings though anecdotal qualitative evidence was still as positive as the targeted studies. The smaller number of studies that did not measure impact using a test of some kind but relied on perceived impact on targeted and non-targeted interventions also found a positive impact of TA support. The general conclusion that can be drawn from these findings is that trained and supported TAs delivering targeted interventions have a positive impact on pupil's academic outcomes and they may be just as effective as qualified teachers. Educational Psychologists could play a role in providing professional development training for TAs, supporting teamwork between teachers and TAs and advising schools on working effectively with their TAs (Farrell *et al.*, 2009).

The above findings were presented by Professor Farrell at the Division of Educational and Child Psychology Conference at the University of Manchester in January 2009. Later that year, the final report on the review into 'the impact of adult support staff on pupils and mainstream schools' was completed by Alborz, Pearson, Farrell and Howes (2009). They point to the dearth of information on the impact of TAs on curriculum adaptation. Since this would probably be a substantial part of the work of TAs, it would be useful to analyze how TAs go about adapting materials and activities in order to make them more accessible to struggling learners. The review group suggest detailed case studies may shed more light on the impact of TAs on teaching. They also lend support to the recommendations made by Blatchford *et al.* (2009) by, amongst other things, emphasizing the need to:

- Train teachers to use their TAs effectively so that they are deployed as part of a wider strategy to enhance achievement of learning objectives across the class.
- Allocate time for teachers and TAs to collaborate in planning and assessment so that TAs' skills can be used to maximise pupil attainment. This should ideally take the form of a 'team teaching' approach.
- Keep 1:1 work between pupils and TAs to a minimum and provide supported group work that facilitates pupils' participation in class activities.

Cremin, Thomas and Vincett (2005) emphasize the importance of skilled coordination and management of TAs to ensure effective inclusive practice. Their research showed that successful teamwork within teacher-TA partnerships depended upon the clarity with which roles and expectations were discussed and defined. This appears to be echoed by later studies such as Blatchford *et al*. (2009) and Alborz *et al*. (2009). However, once again, time constraints were cited as the main barrier by teachers and TAs in adopting the teamwork models proposed by Cremin *et al.* (2005).

2.8 Teaching Assistants and numeracy interventions

Most studies into the impact of Teaching Assistants (TAs) on pupil attainment have focused on the acquisition of literacy skills (Blatchford *et al.*, 2009; Alborz *et al.*, 2009). Alborz *et al.* (2009) found three studies that involved TA support with numeracy in their systematic review of the impact of adult support on pupils and mainstream schools. These three studies focused on numeracy to varying degrees and produced contradictory evidence. Welch, Richards, Okada, Richards and Prescott (1995) and Frelow, Charry and Freilich (1974) found positive impacts of TA support with reading and maths. However, the Gatsby Mathematics Enhancement Project (GMEP; Muijs, 2003) which focused exclusively on numeracy intervention, found no benefit of TA support.

The GMEP involved specially trained Numeracy Support Assistants (NSAs) working with low achieving pupils identified through teacher judgement and testing to have numeracy difficulties. Three one day sessions of training were delivered covering: Classroom behaviour and management, interactive teaching (e.g. discussion and questioning techniques) and learning styles (visual, audio, kinaesthetic, multiple intelligences). The children were drawn from Years 1 and 2 in order to address numeracy difficulties early on and 180 children who received NSA support were matched with 180 controls that did not. The study found that children who received NSA support did not make any greater progress in maths compared to those that did not receive support. Muijs (2003) felt that the training given to the NSAs was adequate and more extensive than is usually provided to TAs but there was the possibility that the quality provided did not meet the needs of the NSAs. Also, a major weakness with the

quantitative methodology used in the study was that it did not allow closer examination of the underlying explanations for the results or the details of how NSAs differentiated the work for children. Using a case study method and following a smaller number of NSAs in depth using qualitative observations and interviews would enable a better understanding of these processes (Muijs, 2003).

Muijs (2003) also mentions that it is possible that additional or higher-quality training is needed over and above that which was provided and cites the work of Askew *et al.,* (1997) who found that, specifically for numeracy, *connectionist* teachers are more effective. These teachers believed effective and efficient numeracy involved being able to choose an appropriate problem-solving or calculation method; being able to make links between different parts of the curriculum and applying number skills to novel but realistic problems. These are the kinds of ideas being put forward by the NNS and TAs may be able to offer *connectionist* instruction with appropriate training. Interestingly, for the purposes of the current study, Muijs (2003) proposes that targeted help from educational psychologists may be beneficial and worth exploring in the future.

The Welch *et al* (1995) study also used trained TAs but in this case they provided assistance with reading and maths in mainstream classrooms to those children who needed it. TAs received extensive week long training in direct instructional techniques followed by opportunities to see those skills modelled by teachers and to be observed by them in order to receive feedback on their performance. Class teachers organized the TAs involvement and identified the pupils with whom they worked and like the Muijs (2003) study, the children with whom the TAs worked were not withdrawn from class. This may have had an impact on the perception of children and TAs as to the importance of the studies being conducted. Children in two out of the five year groups obtained significantly higher scores on reading and maths tests compared to similar peers attending a control school so although TA involvement showed some success, findings were mixed. The study also highlighted the critical role of teacher supervision, evaluation and collaboration with TAs.

Unlike Muijs (2003) and Welch *et al (*1995), Frelow *et al* (1974) did not use a control a group and the TAs were not assigned to work with particular pupils. This study looked at the academic and behavioural progress of children who scored in the lowest quartile

on standardized achievement tests. It also focussed on individual student attainment rather than overall effects in a class or year group as the other two studies did. Teachers and TAs were also unaware of the study and would therefore have given as much attention to the low achieving pupils as they would have done ordinarily. The scores of the children who received TA support were compared to the scores of similar low achieving pupils who had not received TA support in previous years. They concluded that additional TA support in mainstream classrooms led to low achieving pupils making more progress in reading and maths than would otherwise be the case.

Both Dowker (2004) and Williams (2008) support the use of teaching assistants (TAs) in supporting low attaining children with numeracy, though they still emphasize the input of qualified teachers. However, Williams (2008) notes the need to look at more economical methods of delivering mathematical interventions by training TAs to lead them rather than qualified teachers, especially when the interventions are not too intensive.

The DfES (2005a) reports that there is increasing evidence that focused, group intervention programmes delivered by trained teaching assistants have a significant impact on pupil achievement. They cite an unpublished study of trained TAs working with targeted children in Year 6 (over 56000 children in over 1100 schools). The KS2 results in maths rose by 2% (in English by 3%). LEA evaluations showed that the pilot schools improved their percentage of children gaining level 4+ in both English and maths more than that achieved by all the schools in the LEA as a whole. The conclusion was that training and support for TAs to carry out their new role and joint planning, evaluation and tracking progress of target children with teachers were the factors that led to the difference.

The DfES (2005a) state that significant impacts of TA led intervention programmes are only likely if the following factors are in place (p13):

- The programme is selected based on **evidence** of its effectiveness and its match to children's needs.
- It has a time-limited focus.

- There is planned time for the teaching assistant to feed back to the class teacher on progress and also to discuss any issues that have arisen.
- Its impact and use is regularly reassessed as part of provision mapping to identify whether teaching assistant time is justified in running particular programmes each year.
- It is part of whole-school provision to raise standards.

The NNS intervention programmes are time-limited programmes with evidence to support their effectiveness in accelerating children's progress up to age-related expectations. They can be delivered by teaching assistants working with small groups of carefully targeted children but specific training is a vital component in their successful use and should enable TAs to (DfES, 2005a, p13):

- develop their subject knowledge, pedagogical expertise and confidence;
- deliver the programme with high degrees of fidelity;
- understand how the programme links to the ongoing work of the class;
- develop a shared understanding of the programme with the class teacher.

Gross (2007) points out how intended outcomes from the NNS are not always achieved in reality. She notes how a stated goal of the NNS is for teachers to work with all ability groups but often they leave TAs to work with low attainers in mathematics. Another NNS goal is to have well trained TAs working with groups on appropriately differentiated tasks but, in reality, TAs may lack subject knowledge and have little time to liaise with the teacher. They often end up supporting children in completing inadequately differentiated tasks.

Ofsted (2002) found that the presence of TAs can improve the quality of teaching, particularly where the TA is working on an intervention programme for which they have received training and worked in close partnership with the teacher. Ofsted (2002) also acknowledge the important part they play in implementing the NNS and how this has affected the manner in which they are deployed. They conclude that trained TAs exhibit many of the characteristics of good teachers: an understanding of children's needs and behaviour and an ability to interact effectively with pupils in order to assess where they are with their learning and what steps to take to promote progress. Making

the most of these skills should not threaten the professionalism of teachers, say Ofsted, rather they should be encouraged and developed to the full.

Despite participating in raising standards, the role of TAs was initially overlooked by the originators of the National Literacy and Numeracy Strategies (NLNS). Schools welcomed the increasing numbers of TAs who brought extra support for children and collaborative back up for teachers with them. However the 'core' business of teaching as implicitly defined by the NLNS was the transfer of knowledge from one teacher to a whole class and therefore the activities of TAs became 'peripheral' (Hancock and Eyres, 2004). The advocated pedagogy and content of the NLNS was inadequate in enabling teachers to help all children to learn, even with skilled differentiation. So it became necessary to produce a variety of intervention programmes and finally acknowledge the contribution of TAs albeit at a peripheral level. Hancock and Eyres (2004) assert that because the contribution of TAs was overlooked by the evaluators of the NLNS they incorrectly suggested that teachers should improve their subject knowledge and practice rather than question the pedagogy of whole class interactive teaching that was failing a significant number of children. They go on to say that if it was not for the contribution of TAs then it is conceivable that schools would have rejected the NLNS as unworkable. Moreover, they claim that schools have been required to implement a pedagogy that views teachers as 'core' and TAs as 'peripheral' and this goes against the grain of inclusive pedagogies that promote collaborative practice

Much research points to the very limited collaboration between teachers and TAs and the fact that TAs often take responsibility for the lowest achieving pupils without much guidance and support (McVittie, 2005; Gross, 2007, Blatchford *et al.*, 2009, Alborz *et al.*, 2009). This often leads to insufficiently prepared TAs who have to 'tune in' to the teacher's introduction quickly in order to understand the learning objectives and too often concentrate on pupils completing the task rather than understanding it. In this sense thy provide 'alternative rather than additional support' (Blatchford *et al.*, 2009). This reality is unlikely to change quickly, if at all, and MacKenzie (2007) notes how TAs are increasingly likely to be the main providers of support for children with mathematics difficulties and that they may need particular assistance with understanding how to teach number concepts, or particular skills and strategies, in which case the best

'intervention' for Educational Psychologists (EPs) might be to provide specific training for TAs regarding the nature of mathematical development: key concepts, language, processing required and so on.

Much of the research related to teachers' pedagogical content knowledge and numeracy teaching skills cited in section 2.4 would almost certainly be applicable to TAs, even though there appears to be no research focussing specifically on TAs' knowledge, beliefs and attitudes about numeracy teaching. Large scale studies have shown that TAs are increasingly taking on a pedagogical role in much the same manner as qualified teachers albeit with smaller groups in many cases but the demands made upon them by the complex social and instructional environment are similar (Blatchford *et al.*, 2009; Alborz *et al.*, 2009). Therefore, it could be argued that the same factors that researchers like Thompson (1984), Ernest (1989) and Pepin (1999) have shown affects teachers' enacted models of teaching and learning numeracy; such as previous experience as a learner of numeracy, personal educational philosophy, assumptions about the teaching and learning of numeracy and response to instructional and societal constraints also affect TAs.

Table 3, below, shows a summary of the key details of the studies quoted in this literature review with regard to impact of TAs on pupil attainment.

Study	Method	School	Focus	Area	Impact
Blatchford et al. (2002)	Mixed	Reception, KS1 (Years 1 and 2)	All pupils	General	Negative
Blatchford et al. (2004)	Mixed	KS1 and KS2 (Years 1-6)	All Pupils	General	Negative
Blatchford et al. (2008) Blatchford et al. (2009)	Mixed	Primary Secondary	All pupils	General	Negative
Frelow et al. (1974)	Quantitative	Primary	Lowest attaining quartile	Reading and maths	Positive
Muijs (2003)	Quantitative	Primary	Numeracy difficulties	Maths	Negative
Welch et al. (1995)	Mixed	Primary	Literacy and numeracy difficulties	Reading and Maths	Mixed

Table 3: Summary of studies quoted in the literature review with regard to impact of TAs on pupil attainment.

2.9 A role for Educational Psychologists?

Munn and Reason (2007), assert that educational psychologists (EPs) work in the area between psychological theory and its applications in a variety of contexts. They are responsible for the 'direct application and…common understanding of psychology as it relates to children's learning and development' (p5). They note how the merger of two psychological research traditions: cognitive-developmental work and the psychology of maths education; has led to the widespread acceptance of constructivist theories to explain children's development and learning in mathematics. They argue that there is now enough research emanating from both traditions to allow psychological and educational theories to interact and educational psychologists can usefully employ their skills to form links at the point where theory and practice begin to inform each other.

They also point out that the adoption of the term 'dyscalculia' by Education from Neuropsychology and the publication of guidance by the government (DfES, 2001) on this issue highlights the increasing awareness of previously overlooked numeracy difficulties and is another good reason for EPs to get actively involved with work in this area.

MacKenzie (2007) notes the increasing likelihood of TAs' involvement with children who have numeracy difficulties and the requirement for good quality training to deliver individualised learning plans. She advocates a role for EPs in delivering specific training on mathematical development as the best 'intervention' they can provide in some cases. EP involvement may also help to overcome the challenges posed by the limited opportunities teachers have to liaise effectively with TAs or to provide them with appropriate guidance with respect to supporting the numeracy development of particular children (McVittie, 2005). Working directly with staff in classrooms is increasingly becoming an avenue through which EPs can promote and accelerate children's learning and indeed many EPs realise that to be effective, they need to work with adults who are regularly in direct contact with children (Love, 2009).

Farrell, Balshaw and Polat (2000) believe that EPs have the potential to play a key role in working with teachers and TAs in planning and monitoring teaching programmes and delivering training. This view is echoed by a number of later studies and researchers as

noted below. One of the implications for EPs put forward by Farrell *et al.* (2000) is that TAs prefer training to be directly related to their work and value the opportunity to be consulted about the planning and review of pupil's programmes. Muijs (2003) also mentions the potential benefit of EPs providing targeted help to TAs or teachers to support children with numeracy difficulties.

Gross (2007) provides an anecdotal example of how one local authority increased the confidence of TAs who were initially reluctant to participate in a numeracy intervention by modelling the use of the NNS materials before gradually handing over more and more of the teaching to them. She explains how the NNS materials have recently been developed to support children with gaps in their mathematical understanding following the principles set out in Dowker's (2004) report and how there is a need for further research into the impact of these materials that goes beyond the anecdotal 'warm feelings' being expressed by those who have participated in using them so far. She advocates a role for EPs in modelling these resources for teachers and teaching assistants in order to 'scaffold' later independent use. The consultation skills of EPs should be employed to encourage a teaching and learning response rather than searching for cognitive causes or over-investing time and energy in diagnosing and labelling children as 'dyscalculic' (Gross, 2007 and Gross, 2009)

The EP is well placed to deliver the kind of training described above as a level of psychological input may be called for that other professionals may not easily be able to provide. This can include methods such as Solution Oriented approaches and Positive Psychology, directed at children themselves or the professionals who work with them. Frederickson, Miller and Cline (2008) argue that EPs should attend to the learning environment, particularly the teaching methods and styles used to raise the attainment of underachieving children. They demonstrate how EPs have used *Instructional Psychology* to do this, throughout the history of their profession, at an individual casework level and through large scale educational interventions. Elements of instructional psychology include: behavioural objectives, task analysis, direct instruction and precision teaching. Some or all of which could be used to address the stubborn and significant 'tail of underachievement' with numeracy (Dowker, 2009; Frederickson *et al.,* 2008).

Not only are EPs knowledgeable about children's development and possess considerable training skills but they also have the benefit of a unique overview of practice within local schools gained, both directly and indirectly, through personal experience, links with other EPs and other professionals within multi-agency teams. EPs' knowledge of the development of children's mathematical understanding coupled with their access to contemporary research in the area of numeracy difficulties could be exploited to support TAs in shaping remedial teaching to benefit children with numeracy difficulties. Other psychological input could involve the application of learning theories, such as the Piagetian stages of cognitive development, the Vykotskian notion of *scaffolding* children through their *zone of proximal development* and Bandura's *social learning theory* (see section 2.3). Social and emotional aspects of learning numeracy including mathematical anxiety are another area that EPs could offer support in.

Many of the challenges associated with delivering successful numeracy interventions, as cited above, have been known to educational support professionals for a number of years. Yet the number of children underachieving with numeracy has remained relatively unchanged. This would imply that current methods are not working and it may be time to adopt an alternative approach. EPs could bring a level of expertise in consultative skills, research skills and psychological knowledge (as noted above) to address the barriers faced by children struggling with numeracy, which other educational support professionals have not been able to do so far.

Within the author's Educational Psychology Team, there is much anecdotal evidence that shows that teachers still request EPs' advice in 'diagnosing' children they believe have 'dyscalculia' in a similar fashion to the way they once did (and still do to some extent) for dyslexia. This may be due to the mistaken use of the word 'dyscalculia' to refer to all kinds of numeracy difficulties. EPs supporting NNS interventions (or other evidence based numeracy interventions) may be one way in which teachers could be encouraged to construct a teaching and learning response to address the needs of children with numeracy difficulties.

Prioritizing EP research into the individual and social psychology of numeracy difficulties would probably be valuable in terms of developing strategies with TAs (and

teachers) as to what interventions work best for children and ensuring that those with numeracy difficulties are still supported to achieve. This process would lend itself to the notion of consultation proposed by Wagner (2000) who states that the aim of consultations is to explore, with genuine curiosity, the perceptions and beliefs of the concern holder with a view to working collaboratively to explore patterns around the concern and address these in order to facilitate positive change. In line with Gross (2007 and 2009), one of the few researchers to explicitly suggest consultation skills as a possible unique contribution that EPs can make in this area, this research proposes that the EP has a valuable role to play in providing ongoing consultations as a means for structuring support for TAs in tackling children's numeracy difficulties. The multi-componential nature of children's numeracy difficulties and the individual characteristics of the TAs assigned to support them are likely to need a consultation approach in order for effective collaborative work to take place with EPs.

The definition of the term 'consultation' provided by Wagner (2000) is one of a number of definitions that exist and Farrell (2006) summarizes the main features of these definitions that EPs need in order to maximise their impact on helping children develop. These are summarized below with an indication of how they will be met by the current research:

- **To develop a detailed knowledge of the system where children live and work (school, family and community).** This research will seek to gauge this knowledge from Head teachers, SENCOs, parents, class teachers, TAs and the children themselves. A social constructionist stance will be adopted employing methods that will enable the researcher to acquire and understand the multiple social constructions of meaning and knowledge within the real world system of a school. This entails an understanding of educational systems, specifically with regard to the factors that serve to shape the role of TAs, the curricular tools (NNS) employed including the knowledge that informs their selection and the pedagogical practices that emanate from these. It will also require an understanding of children's mathematical development including atypical pathways and a sound knowledge of the nature of numeracy difficulties and evidence based practice with regard to what has been shown to work in tackling

them. Details of all these components of the system are provided in sections 2.2 to 2.9 above and will feed into the consultation process.

- **To develop mutually supportive trusting relationships with people who work in or with the system including the children.** This research aims to develop a mutually advantageous collaboration between EP, TA and the target children. The wholly supportive role of the EP will be emphasized and TAs and schools will be reassured that no judgments about their performance will be made or communicated to other parties. The exact nature of the intervention will be declared openly so that all parties are aware of the process they are agreeing to engage in and are working towards a common positive outcome. Mutually supportive relationships will be imperative in order to generate sufficient opportunities for discussion, training, intervention, reflection etc. needed to carry out the various aspects of this research within an established school system where the responsibility and time to deliver the curriculum and perform other duties have already been agreed and allocated.
- **To work jointly with others and negotiate their respective roles and responsibilities within the system in order to make their contribution effective.** This research will aim to negotiate and clarify roles and responsibilities from the outset. The consultation process lends itself to deciphering jointly with TAs and schools the most effective contribution that the EP can make and takes into account the expertise gained from their daily work within the system. Part of the EP role will involve carrying out a combination of standardized tests and diagnostic interviews, which Mackenzie (2007) suggests may be impractical for teachers or TAs to carry out, in order to extract useful information to support children's numeracy development. It will also involve providing access to psychological knowledge, theories and frameworks as well as training on aspects of Instructional Psychology in order to enhance the work being done. The EP role will evolve in situ as the challenges faced by schools, TAs and children are identified and jointly focused upon. Adopting the role of evidence base practitioner will be crucial to making an effective, accountable and ethical contribution.

Consultative approaches are entirely consistent with an inclusive approach and provide a flexible way of enabling mainstream schools to support children with a wide range of

diverse needs (Farrell, 2006). The ultimate aim of the intervention proposed by this research will be to boost the numeracy ability and confidence of the target children sufficiently to enable them to access the curriculum within their normal lessons and thereby promote their inclusion in mainstream classes.

Furthermore, as Farrell, Woods, Lewis, Rooney, Squires and O'Connor (2006) point out, the success of EPs and the services they provide are to be judged using the five outcomes from the Every Child Matters (DfES, 2004) agenda as benchmarks. These are to be healthy, stay safe, enjoy and achieve, make a positive contribution and enjoy economic well-being. Farrell *et al* (2006) recommend that EPs should actively consider how their day to day work is contributing to meeting these five outcomes and this contribution should be recorded and communicated appropriately to other stakeholders, such as parents. Competence with numeracy contributes to all five of these outcomes, either in the short or long term as evidenced in section 2.2, and therefore is a productive area for EP involvement. Farrell *et al.* (2009) propose that EPs could contribute to the professional development training of TAs and support teamwork between teachers and TAs. They also advocate a role for EPs in advising schools on working effectively with TAs and being clear and realistic about the aims of 'inclusive' placements.

In the present climate where confronting the causes of numeracy difficulties is seen by many, here and around the world, as a worthwhile investment of professional time and expertise, EPs would be well advised to demonstrate how their profession is relevant to major national developments and how their work is useful and valuable through actions and results rather than words and theories (Gersch, 2009).

2.10 Summary of literature review

Section 2.2 highlights recent research that describes the far reaching consequences to the individual and society of poor numeracy. Poor numeracy has become an international concern and tackling it early on has become a priority for the UK government. Section 2.3 describes the main psychological theories concerning the development of mathematical understanding in children that have impacted upon the way numeracy is taught in schools. Section 2.4 illustrates expected developmental

milestones with regard to numeracy but also emphasises that all children do not follow typical developmental pathways. It stresses the multi-componential nature of numeracy difficulties and the wide variation in the characteristics and performance deficits of children with such difficulties, highlighting the complexity of addressing needs in this area. The distinction made by many people between a continuum of numeracy difficulties and dyscalculia is also discussed with an emphasis on providing practical support for the children involved as opposed to searching for a causal label.

Section 2.5 explores the prevalence of numeracy difficulties in schools and workplaces. It focuses on recent research that identifies methods that work in tackling numeracy difficulties. One major aspect of this is the susceptibility of these difficulties to intervention, especially when it is individualized, specific and targeted early.
Large investments have been made, as noted in section 2.6, in exploring evidence based interventions that work and the wave 3 NNS materials have been developed and improved as a result. However, the practical reality of the use of these materials within the classroom falls short of the ideal for a number of reasons. The main one being that schools are still very much judged on their performance in tests and therefore teachers tend to leave the least able children to work with TAs. The support and liaison time given to TAs by teachers to carry out their role effectively is often limited or non-existent but the involvement of TAs is nonetheless crucial to the success of the NNS.

Section 2.7 discusses recent research into the effectiveness of TAs in schools with specific regard to their impact on pupil attainment. It notes that the large investment made by the UK government in increasing TA numbers has had little impact on attainment according to one large scale longitudinal study. However, other research indicates the success with which TAs can deliver interventions when they are properly trained and supported. Section 2.8 focuses specifically on TAs' involvement with numeracy interventions and notes that their sustained and individualised interactions with pupils in comparison to teachers can be a great facilitator in assessing and intervening with individual numeracy difficulties. However, teachers and other professionals may not possess the necessary knowledge of numeracy and child development, or the training skills necessary to provide effective support for TAs in developing their subject knowledge, confidence and skills in delivering numeracy interventions.

Section 2.9 argues that EPs could take on this training and supervisory role and notes that there appears to be no research into the role of EPs in such training and the subsequent impact this may have on TAs' capabilities and pupil attainment. EPs possess the necessary knowledge of children's numeracy development and a greater awareness of the social psychological factors that can affect it, making them more able to assist in tackling numeracy difficulties than other professionals.

2.11 The current research

The current research proposes to explore a way in which EPs might make a distinctive contribution to improving outcomes for children by providing ongoing consultative support for TAs in delivering NNS interventions. It has been noted above that poor numeracy has an effect on all five outcomes of the ECM agenda and since EP services are judged on how well they improve outcomes for children in these areas, it would be a productive use of EP time to get involved. The potential benefits of EP involvement in targeted numeracy interventions has been mentioned by Muijs (2003), who appears to be the only researcher to look at trained TA's effectiveness in delivering numeracy interventions. Gross (2007 and 2009) advocates a role for EPs in modelling the NNS resources to TAs in order to scaffold later independent use and is one of the few researchers to suggest consultation as a unique EP contribution to addressing the needs of children with numeracy difficulties and the adults assigned to work with them. She also notes that the NNS resources require further evaluation in addition to the positive, mainly anecdotal, feedback received so far and one of the outcomes of this research will be to provide this.

Furthermore, researchers who have investigated the impact of TAs on pupil attainment have found that specific targeted interventions for which TAs are trained yield the most positive results. However, the precise mechanisms through which this occurs are not known in any great detail and further research into the 'wider pedagogical role' of TAs and the manner in which they interact and scaffold children in order to raise their attainment is needed (Blatchford *et al.*, 2009; Alborz *et al.*, 2009).

This research aims to develop TAs' confidence, subject knowledge and teaching skills with regard to delivering NNS interventions. It also aims to measure any impact on the attainment and attitude of the target children that the TAs work with to see whether collaborative work with an EP has any effect on the successful delivery of NNS interventions. It will attempt to explain any impact of the NNS materials and any effect of EP collaboration with the children and TAs involved using established psychological theories. The research hypothesizes that modelling NNS resources for TAs and providing them with regular support through successive EP-TA consultations will boost their confidence, ability and motivation to successfully deliver NNS interventions. Therefore, this research aims to assess the impact of an EP supporting TAs (and indirectly, teachers) in delivering NNS interventions to children with numeracy difficulties in order to test the ideas put forward by the researchers mentioned above. Namely that TAs deliver interventions well when they are trained and supported and that EPs could play a role in facilitating this process with regard to numeracy interventions by providing ongoing consultative support. In particular, it aims to answer the following research questions:

2.12 Research Questions:

1. What impact do the NNS intervention materials, delivered by TAs with EP support, have on:
   a) the attainment in numeracy
   b) the attitude to numeracy
   of children with numeracy difficulties?

2. What features of the collaboration between EP and TAs may be associated with positive outcomes for the children involved?

CHAPTER 3: METHODOLOGY

3.1 *Overview of study*

In order to address the research questions stated in section 2.12, this study employed a multiple case study design incorporating a mixture of quantitative and qualitative methods. The underpinning premise for this study was to test the ideas put forward by various researchers that TAs could deliver interventions satisfactorily given appropriate training and support (Blatchford *et al*., 2009; Alborz *et al*., 2009; Williams, 2008; Dowker, 2004; Ofsted, 2002) and that there may be a role for EPs in facilitating this process with regard to numeracy interventions (Muijs, 2003; Gross, 2007 and 2009; Mackenzie, 2007). The intention was to use the results of this study to potentially inform a more systemic approach to tackling numeracy difficulties which EPs could usefully engage in. The rationale for adopting a multiple case study design and using certain data collection methods is given below.

3.2 *Multiple Case Study design*

A case study methodology was employed as it enabled a much more detailed examination of the interactions between TAs and the children they work with as well as shed light on the social psychological contexts within which they function. The case study approach was recommended by Muijs (2003), a previous researcher in the same area, as a better method for gathering precise information about how TAs assess and intervene with numeracy difficulties. The case study method was also recommended by researchers who have looked into the role of TAs in general as a means by which the factors affecting the attainment of children working with TAs could be better identified (Blatchford *et al.*, 2009; Alborz *et al.*, 2009).

Yin (2003, 2009) describes the case study approach as a common research strategy used in psychology. It is especially useful when attempting to answer ‘how’ or ‘why’ questions in situations where the investigator has little control over events. It can be used to gain knowledge about individuals, groups, organizations, society and other related phenomena. One major advantage of the case study approach is that it enables investigation of complex social situations by retaining the holistic and real life contexts

within which they occur. There is no attempt to control variables or impose any artificial constraints on the phenomenon being explored and so results and conclusions tend to have high ecological validity. Contemporary events are particularly suitable for case study research as direct observation and interviews with the people involved are possible. This, of course, does not preclude the study of historical records and documents that lead to the current situation as well. Yin (2009) provides an overall graphic of the entire case study process, illustrated as figure 3 below:

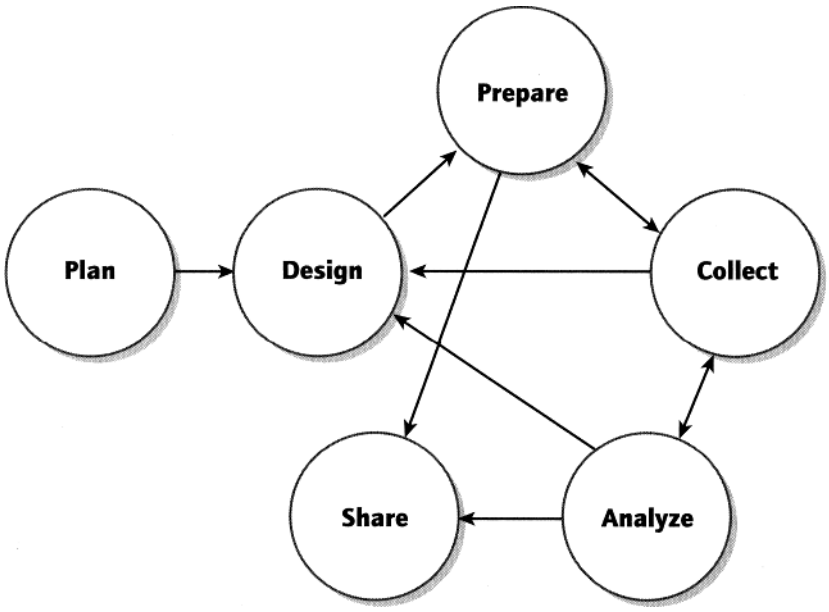

Figure 3: Doing Case Study Research: A linear but iterative process (taken from Yin, 2009).

The case study approach has a distinctive role in exploring contemporary interventions in their real life contexts, especially when the boundaries between the intervention and the context are not clearly evident. The most important use is to help explain presumed causal links in real life interventions that are too complex for other strategies and also where there may be more variables of interest than the actual points at which data is gathered (Yin, 2003). The current study fits this description as previous researchers have noted the difficulty in isolating the components of TAs' work on numeracy interventions that actually affect outcomes for children, using other approaches (see section 2.8). Moreover, useful data can be gathered from points in the study other than the pre and post testing of children and interviews with TAs.

In order to make evidence more compelling and the overall study more robust, Yin (2003) advises the use of a multiple case study design. Conclusions arising

independently from each of the cases will be more powerful than if they arose from a single case. Furthermore, the contexts of the cases are likely to differ in some form or other so arriving at similar conclusions based on these varied contexts increases substantially the external generalizability of the findings. Yin (2003) stresses the importance of a case study protocol, especially when adopting the multiple case study approach as it acts to keep the investigator focused on the subject of the case study. A case study protocol for the current research is outlined in section 3.3 and a summary is provided in table 4, below.

Overview of Case Studies	To inform research into the impact of EP support on TAs delivering NNS interventions and the features of this collaboration that are associated with positive outcomes for the children involved. Each of the three case studies comprised of three children and one TA at a particular school.
Field Procedures	Head teachers of the schools in the researcher's 'patch' received an invitation to participate (see appendix 1) and suitable schools were identified from those that expressed an interest to participate. Informed consent was sought from all adult participants and the parents/guardians of the child participants (see appendix 2). Child participants were tested using the revised Sandwell Early Numeracy Test (see section 3.5.1) and were assisted in completing the attitude survey (see appendix 3), pre and post intervention. TAs were interviewed using semi-structured interviews (see appendix 6) and completed a questionnaire (see appendix 4) for each of the children they worked with, pre and post intervention. Consultation with TAs was recorded using a Pro forma (see appendix 3) and a research diary was maintained throughout the research period. TAs kept a record of the work done in the absence of the researcher including any pertinent observations. The timeline described in table 4, below, was followed.
Case Study Questions	The research questions were: 1. What impact do the NNS intervention materials, delivered by TAs with EP support, have on: a) the attainment in numeracy b) the attitude to numeracy of children with numeracy difficulties? 2. What features of the collaboration between EP and TAs may be associated with positive outcomes for the children involved?
Guide for report	Analysis of data was conducted as detailed in table 6, below, and is included in sections 4 and 5. It will form part of the requirements for the author's Doctorate in Educational and Child Psychology degree award and the main findings will be presented to participating schools and interested third parties.

Table 4: Summary of the Case Study Protocol

3.3 *Procedure*

Based on the rationale provided in section 2.11 above for the need to examine more closely the factors which enable TAs to successfully deliver NNS numeracy interventions to targeted groups of children with numeracy difficulties and in order to address the research questions stated in section 2.12 and table 4 above, the timeline, illustrated in table 5 below, was followed:

Date	Action
September 2009 - October 2009	▪ Negotiate details with schools and recruit participants. ▪ Obtain informed consent from all participants. ▪ Agree timetable and action plan with schools/TAs.
October 2009 - March 2010	▪ Conduct pre and post intervention assessments and interviews with children and TAs. ▪ Conduct meetings, observations, work and agreed training with TAs. ▪ Maintain research diary
March 2010 – May 2010	▪ Analyze quantitative and qualitative data and write up thesis. ▪ Report main findings to interested parties

Table 5: timeline for the study.

Three case studies were conducted at separate schools within the researcher's Local Education Authority. A number of schools were invited to participate in the research and three chosen to take part based on their suitability/availability for the research. The unit of analysis was the EP consultation with TAs (and settings) in relation to the target children's mathematical difficulties and use of NNS strategies.

Each case study comprised three children, identified by their teachers as experiencing numeracy difficulties of a magnitude that would make them eligible to receive a wave 3 NNS intervention, and the TA designated to work with them on such an intervention. All nine children were tested individually using the Revised Sandwell Early Numeracy Test (SENT-R; Arnold *et al.*, 2009a) before and after a one term intervention. Since this test is standardized it provided age equivalents, standard scores and percentile ranks and therefore there was no need for a control group in order to make comparisons. The immense difficulty in 'controlling' what happens to a control group within the real life

context of this study in the period between pre and post assessments is a further reason why control groups were not used. The attitude to numeracy of the children was also surveyed pre and post intervention through direct questions posed to the children and perceived data from TAs obtained via questionnaires (see appendices 3 and 4). It is also worth bearing in mind that the sample children participated in their normal numeracy lessons in addition to receiving the NNS intervention and this might have some bearing on any observed changes.

The researcher was introduced as a trainee EP and ex-maths teacher conducting research into TAs delivering numeracy interventions to children with numeracy difficulties as part of his Doctorate in Educational and Child Psychology degree programme. The intention was to work in collaboration with TAs to ensure that NNS interventions were used effectively to accelerate children's numeracy ability towards age-related expectations. This involved modelling their use and supporting TAs in implementing them effectively. The materials used in this study were taken from the wave 3 materials: *Supporting children with gaps in their mathematical understanding* (DfES, 2005c) and the Year 2 addition and subtraction booklets were used.

The supportive context under which the research was to be conducted was made explicit to participants as well as its on going collaborative nature. It was made clear to TA participants that no judgements would be made about their suitability for the task or information related to competence passed onto line managers, senior staff or any other third party. Participants were assured that all interactions during the research would remain anonymous and confidential and no data would be passed to another party without their prior knowledge and consent. Other methodologies commonly used with this kind of research in schools, such as collaborative action research, were not deemed to take sufficient consideration of the unique contexts of each of the case study sites (schools) in terms of structure, management, ethos, culture and characteristics of staff, pupils and parents.

Precise details were negotiated with each case study site and all participants, involved directly or indirectly, fully informed of the nature of the study. Interviews were conducted and audio recorded with TAs to gauge their opinions and feelings about delivering mathematical interventions and to find out about their experience,

confidence, attitudes and beliefs about numeracy teaching and learning. These took the semi-structured format outlined in appendix 6 and were conducted before and after the intervention. An action plan was drawn up with TAs and settings as to how the collaborative work with pupils would be conducted.

Teachers helped to select the child participants in this study initially but their views were not officially sought at the post-intervention stage. There is the potential that bringing the teacher perspective into this research would have increased the opportunity to embed changes within the system and provide triangulation. However, part of the rationale for this research is that teachers lack the time to liaise effectively with TAs and the author's previous experience with conducting research in schools showed that teacher's views tend to be of limited value following an intervention where they have not been directly involved. There were also important time and resource related considerations that made it complicated to involve teachers more strongly. Furthermore, the perceptions of TAs in this research may have been adversely affected if their 'managers' were seen to be communicating too closely with the 'allegedly' supportive EP/researcher.

Six, approximately fortnightly, meetings were conducted with TAs throughout the one term period that this study spanned in order to discuss progress and next steps. The methods, psychological or otherwise, used by the EP (researcher) to facilitate TAs' work with children were analysed and discussed in terms of their possible impact on the TAs, the children they worked with and their attainment. These included issues around:

- Modelling and supporting use of the wave 3 NNS materials.
- Diagnosing areas of specific difficulty and agreeing methods to tackle these.
- Task presentation, adapting responses to scaffold children's thinking towards age-related expectations.
- Use of instructional psychology: precision teaching, setting behavioural targets
- Psychology of mathematical development: key concepts, consistent use of language and symbology.
- Knowledge of learning theories, especially with regard to the development of mathematical thinking.

- Providing links between contemporary theories about numeracy development and their application for remedial support.
- Approaches to developing meta-cognition and assessing working memory and learning preferences.
- Developing self-efficacy and building social relationships conducive to learning. Using methods incorporating planned success and praise.
- Solution focused/oriented approaches and positive psychology.

The exact nature of the intervention evolved *in situ* as the needs of TAs, children and schools/parents come to light and developed during the course of the research. The intention was to work within the established NNS provision within schools with Teachers and TAs doing what they would normally do. The additional factors were incorporating the wave 3 NNS materials into the numeracy teaching time for the target children and TAs having regular access to the researcher to discuss matters with and draw support from. A research diary was kept to record the session outcomes, observations and reflections after each meeting with TAs, log any interventions used and their perceived impact. The pro forma used for recording these key session outcomes is included as appendix 5.

In addition to the pre and post intervention testing of numeracy skills and survey of attitudes (see appendix 3), the 'voice' of the child participants was also heard during unstructured interviews conducted simultaneously with the numeracy assessment, both pre and post intervention. The emphasis was on finding out about their views of their numeracy ability, motivation and feelings about involvement with the intervention and what they felt worked. This interview was intentionally combined with the testing in order to create as natural a context as possible for dialogue with a virtual stranger (researcher) rather than induce anxiety in young children through direct questioning without the comforting focus of an activity. This interview was not formally analyzed but qualitative comments were reported in so far as they helped to put across the children's views and captured something related to the research questions.

To gather relevant evidence in order to answer the research questions, the data were analyzed as illustrated in table 6:

Event	When collected?	How analyzed?
TA interviews	Pre and post intervention	Thematic Analysis
TA meetings/collaboration	Research Diary kept over one term	
Child Interviews	Pre and post intervention	Pertinent comments reported
Child numeracy testing	Pre and post intervention	Standardized scores and descriptive statistics
Child attitude survey. TA questionnaire.	Pre and post intervention	Descriptive statistics and Content Analysis

Table 6: Methods of data analysis.

3.4 *Participants*

Three teaching assistants at three different schools worked with their own group of three children during this study. The researcher played an active part in the research as the common intervention in all cases was consultation with the EP/researcher. The age (in years: months at first testing) and the gender of each of the nine child participants involved in this study are illustrated in table 7, below:

Teaching Assistant 1 at School 1	Child A	6:9	male
	Child B	6:7	female
	Child C	6:9	male
Teaching Assistant 2 at School 2	Child D	6:10	male
	Child E	6:2	male
	Child F	6:3	male
Teaching Assistant 3 at School 3	Child G	6:3	female
	Child H	6:10	male
	Child I	6:8	male

Table 7: Details of participants.

The teaching assistants were all females aged 36 and over who classed themselves as coming from a white ethnic background. This fits with the profile of the majority of TAs in England found by Blatchford *et al.* (2009). One child participant came from a Bangladeshi background whilst all the others were from a white ethnic background and all had English as their first language.

The parents of one child declined to give consent for him to take part in the study for personal reasons, and so he was replaced by another child identified by the teacher as being just as eligible to receive a wave 3 numeracy intervention.

3.5 *Quantitative analysis*

Two instruments were used to gather the quantitative data for this study: the Sandwell Early Numeracy Test – Revised (SENT-R) and the questionnaires filled in by children and TAs. These are described in greater detail below.

3.5.1 *The Sandwell Early Numeracy Test - Revised*

All details included in this section have been obtained from documents contained within the Sandwell Early Numeracy Test – Revised version (SENT-R) (Arnold, Bowen, Tallents and Walden, 2009a) or from personal communication with Dr C. Arnold, one of the test authors.

The SENT-R was devised by SEN advisory teachers and EPs in response to the wave 3 NNS initiative which required schools to evaluate the interventions and teaching approaches used with pupils experiencing numeracy difficulties. It is designed for use with 4-8 year old children working between level P6 and 2a of the National Curriculum and is particularly suitable for this research as a result. The revised version of the test has been amended following extensive use in schools throughout the country and feedback from the government backed Every Child Counts Programme (Every Child a Chance Trust, 2009), who are using the SENT-R for their evaluations (see section 2.6).

The SENT-R is designed to be administered on an individual basis in order to assess pupil knowledge of early numeracy facts, help diagnose difficulties that can inform teaching, provide a means to compare skills with those of similar aged children and establish a finely graded scale to measure progress, particularly for children with special educational needs in Key Stage 2. The test consists of two parallel forms (A and B) each consisting of 68 child friendly items covering five strands which are referenced against the National Curriculum and have been derived from the descriptions of P level competencies contained in the DfES National Numeracy Framework.. These are:

1. Identification of number
2. Oral counting
3. Object counting
4. Value/computation
5. Language

Data from over 1700 children were collected but some samples had to be discarded for balancing reasons or because of unreliable data (such as no date of birth). The final standardization sample consisted of 1568 children (773 males, 748 females and 47 for whom gender details were not provided) from 17 schools, representing a diverse range of ethnic and linguistic backgrounds (Arnold, 2010). The schools selected had similar profiles of numeracy results as would be found nationally. Four year groups were used: The 2008/09 cohort for Reception, Year 1 and Year 2 (assessed in June and July 2009) and the new 2009/10 Reception cohort (assessed in September and October 2009).

Concurrent validity was assessed by comparison with National Curriculum tests for Year 2 pupils and the mathematical reasoning and numerical operations subtests from the Wechsler Individual Achievement Test (Wechsler, 2004). Content validity was ensured by drawing the test items from lists of skills cited in the PIVATs documentation and the National Numeracy Strategy. The items are referenced to the appropriate National Curriculum level and this represents the most reliable method of ensuring that the content of the test matches the materials and methods that the pupils will have encountered in their schools. The SENT-R has specifically been prepared for children following the NNS and all the items were referenced to the most up to date information from the national strategy teams (Arnold *et al.*, 2009a).

The SENT-R is particularly suitable for this research as it enables pre and post intervention measures to be taken easily using the parallel forms and is designed, amongst other things, to:

- Take a baseline of skills in number
- Identify specific number skills which require targeted teaching
- Monitor the impact of teaching interventions on rate of progress
- Group children with similar levels of number attainment to facilitate teaching.

(Arnold, Bowen and Walden, 2009b, p6)

3.5.2 *Questionnaires*

Two questionnaires were used in this study: Children's attitude questionnaire (see appendix 3 and 8) and TA questionnaire (see appendix 4 and 9). The questions in each were inspired by and expanded upon those used by the Every Child Counts Programme (Every Child Counts, 2008) in their evaluations.

The children's questionnaire consisted of seven questions using a five point likert scale (very good = 5; good =4; OK = 3; sad/not good = 2; very sad/ poor = 1). Van Laerhoven, Van der Zaag-Loonen, and Derkx (2004) have shown that child friendly likert scales are more reliable tools when working with children as they find it easier to understand and respond to, so the validity of their responses is increased. The questionnaire was placed in front of the children and they ticked the response they thought appropriate but the questions were read out to them as their reading levels were low and to ensure they understood what they had to do (see appendix 8 for a completed example). The children were reassured beforehand that this was not a test; there were no right or wrong answers and that they should just say what they think. The questionnaire aimed to assess the children's attitude to numeracy and their perception of the views of significant others with regard to their numeracy ability. It did not have any established validity or reliability but did have some face and content validity.

The TA questionnaire consisted of eight statements about the numeracy attitude and work of the three children they were working with. The TAs were expected to tick a box to indicate whether each statement was true always (5); mostly (4); sometimes (3); rarely (2) or never (1). The numerical scores allocated to each response were reversed for the final statement as it was negatively phrased (see appendix 9 for a completed example). An odd number of responses were deliberately used for each questionnaire to permit a neutral midpoint, which Robson (2002) describes as desirable. The TA questionnaire also did not have any established validity or reliability but did have some face and content validity. Already developed questionnaires covering similar content with established reliability and validity measures were not readily available for use in this study.

The total and individual item scores from both questionnaires were compared pre and post intervention to assess whether any significant changes had occurred. The qualitative comments invited at the end of both questionnaires were subject to a Content analysis. The essence of content analysis is identifying substantive statements or statements that really say something and putting them into categories (Gillham, 2002). Content analysis originated as a quantitative technique used mainly in the mass media but has recently been used in a wide variety of areas including the analysis of open ended questions within questionnaires or interviews (Gillham, 2002; Robson, 2002).

The 'count' style of analysis, widely used in the media, focuses more or less on the surface of the data at individual word level and descriptive categories can be formed with little inference. This quantitative count analysis is sometimes all that is needed to reflect the generality of the statements made by citing how many people made a particular point or one similar to it. This adds to the reliability of the approach as there is no interpretation involved on the part of the analyst (Gillham, 2002; Robson, 2002). A more sophisticated approach would be to examine the context of the statements made but this requires a level of inference that could call into question the reliability of the categorization. This is sometimes expressed in terms of *manifest* and *latent* content, corresponding to low inference items and high inference items respectively (Robson, 2002). For the purposes of this research, comments were analysed using individual words as the recording unit and where necessary the context of the sentence was taken into account in order to categorise the target word (see appendices 8 and 9).

3.6 *Qualitative analysis*

Qualitative approaches form the major part of the data collection in this study. This is in line with the recommendations of Muijs (2003) who concluded that case study approaches incorporating qualitative methods were necessary to decipher how TAs could help teachers and pupils effectively as well as study in more detail the differential behaviour of TAs in raising the attainment of children.

The ontological position of *constructionism* or *constructivism* has become influential and denotes the current state of much qualitative research. This position holds that social phenomena and our knowledge of them are not objective entities but constructs of

the mind created through social interaction (Dyer, 2006; Robson, 2002). The epistemological position of *interpretivism* provides an appropriate theory of knowledge for a constructivist ontology that specifies how the world may be validly and reliably known (Dyer, 2006). However, many labels are used interchangeably to denote similar aspects of qualitative research by different commentators and 'constructivism' is also commonly referred to as 'interpretive' (Robson, 2002). This research adopts a constructivist/interpretivist approach but in the interests of simplicity and to emphasize the socially constructed nature of reality, will refer to an epistemological position of *social constructionism* (Burr, 2003; Parker, 1994). It is worth noting that there is no one way to define social constructionism and the different descriptions provided by authors are best seen as exhibiting a kind of 'family resemblance'. There is no one characteristic borne by all family members but sufficient shared characteristics exist to identify them as family members (Burr, 2003).

Adopting the epistemological position of social constructionism means that this research views its human participants as endowed with the same qualities as the researcher. There is an acceptance that participants are self conscious social actors who can modify their behaviour to take into account both their internal states and external conditions. They can also use language to formulate, communicate and apply complex and various meanings to their experience which may or may not differ from those of the researcher. Moreover, this research views children's numeracy difficulties as a construction emerging through the interactions between the child, TAs and others (Dyer, 2006; Burr, 2003; Parker, 1994). Adopting a social constructionist stance takes into account the general acceptance amongst the psychology of maths education community that constructivist theories best explain learning and development in maths (Munn and Reason, 2007) and also the theories of Piaget and Vygotsky with regard to the development of children's mathematical thinking (see section 2.3).

Robson (2002) reminds us that in order to understand the multiple social constructions of meaning and knowledge prevalent in real world research, methods such as interviews and observations are best employed. These allow the researcher to construct the 'reality' with the participants and acquire multiple perspectives. The qualitative methods used in this research are described below in greater detail.

3.6.1 *Semi-structured interviews*

Interviews are probably the most frequently used method of gathering information both within and outside the social sciences. The most useful tend to be Semi-structured interviews which are a combination of two approaches: standardized or structured interviews and unstructured interviews (Dyer, 2006; Robson, 2002). With this approach the interviewer is guided by questions prepared in advance in an interview schedule but these do not dictate the progress of the interview. The questioning process is guided by the content of the interviewee's responses and the schedule acts as a checklist to ensure that all required areas are covered. This flexible approach balances the need for the interviewer to control the interview without denying the interviewee's experiential expertise in the area and their right to bring in new topics or alter the direction of the interview. Such an approach lends itself to entering, as far as possible, the psychological and social world of the interviewee. However, although it facilitates rapport/empathy and enables coverage of novel areas not initially thought of by the interviewer it also reduces interviewer control, takes longer to conduct and is more difficult to analyze (Dyer, 2006; Smith and Osborn, 2003; Robson, 2002).

Within this research, semi-structured interviews were used with the TAs pre and post intervention (see appendix 6) but also during the intervention itself. The interviews served to triangulate the data obtained through participant observation and questionnaires. Robson (2002) notes how observation is clearly a useful enquiry technique but asking participants directly about what is happening is an obvious shortcut to answering research questions. The benefits of interviewing include the opportunity to modify lines of enquiry, follow up interesting angles, investigate underlying motives and gain a richer understanding through noting non-verbal communication. However, the lack of standardization of interviewer skills and experience can raise concerns about reliability and bias (Robson, 2002).

The pre and post interviews with TAs in this study were audio recorded using a digital voice recorder. This had the added benefit of being relatively Unobtrusive by virtue of its small size and silent operation. It also allowed material to be directly uploaded into a computer for easier analysis. Robson (2002) offers an alternative to full transcription of interviews (which can take 10 hours for every one hour of recorded material) which is

to be selective, pick out relevant passages and note the counter numbers for particular quotations. Similarly, Gillham (2000) describes a short cut to transcription which is to listen to the recording and '*note down the substantive statements as they float along the stream of consciousness. There is a good deal of to-ing and fro-ing (with the recording) and, when you have abstracted the statements, you need to run through the (recording) again, listening for anything you might have missed.*' (p61). This approach provides a less time consuming, yet effective, approach to analysis and was adopted in this research. However, an example of a thematic analysis of an interview transcript is included as appendix 7 for illustrative purposes. All ethical issues concerning recording interviews were addressed (see section 3.7) and participants were told what would happen to their data from the point of recording to the point of destruction following a successful write up of the research.

3.6.2 *Research Diary*

Research diaries are also referred to as research journals (Borg, 2001). Although they are sometimes used as data they tend to differ from the data yielded by the research methodology. They contain information about the researcher and the main reasons for keeping them are to generate a history of the project, the researcher's thinking and the research process (Hughes, 2000).

Borg (2001) suggests that a research diary can be used to provide material for reflection that can serve to enhance researchers' thinking about research. The research diary can include procedural information such as describing events but more importantly includes information that enables articulating and rationalizing concerns and exploring solutions; acknowledging, expressing and examining feelings; establishing goals, formulating plans and deciding on actions; clarifying concepts and their implications for research; capturing, exploring and pursuing ideas; describing and evaluating progress and structuring thoughts. These reflective processes are particularly important during the writing of research diaries, according to Borg (2001) but he also highlights retrospective analysis of the research diary as beneficial in terms of providing an accessible record of actions and ideas that can deepen a researcher's understanding of their work. This can make the research diary an invaluable source of information when writing a thesis.

Nadin and Cassell (2006) remind us that research itself is a social encounter and therefore an interpretive activity where a variety of influences impact upon the interpretations generated. Research dairies are one way in which the time and space needed for reflexivity can be built into the research process. Action does not occur within a social vacuum and so the researcher needs to understand their own epistemological and ontological position and how this affects their interpretation but also bear in mind there is a fine line between interesting insights and self indulgence.

There is no set way of keeping a diary and some people use an actual diary while others use loose leaf paper. What is important is that developing thoughts and actions are recorded and reflected upon both at the time of writing and upon re-reading. The diary needs to be a personalized piece of work that enables the researcher to work in the style they find most useful and which is conducive to their own reflective practice (Hughes, 2000; Robson, 2002). Hughes (2000) advises that it is often useful to make entries under headings. For this research, the pro forma included as appendix 5 was used to record key session outcomes under the headings: 'comments from previous session'; 'Identified needs/focus'; 'Psychological principles employed/to be employed' and 'Observations and further comments'. The back of the pro forma was used to record thoughts and actions at a later time or date, as suggested by Hughes (2000). The use of a research diary was consistent with the epistemological position of social constructionism adopted by the researcher (a sample of a research diary is included as appendix 10).

3.6.3 *Thematic Analysis*

According to Braun and Clarke (2006), '*thematic analysis is a poorly demarcated, rarely acknowledged, yet widely used qualitative method within psychology*' (p77). They argue that it should be the first qualitative method that new researchers learn as it enables core skills to be developed that will be useful for conducting other more complex qualitative approaches. Whilst some researchers have positioned thematic analysis as a tool to use across various methods, Braun and Clarke (2006) argue that it should be considered a method in its own right.

Whilst not seeking to limit the valuable flexibility of the approach, Braun and Clarke (2006) provide a six phase guide to performing thematic analysis. These phases are summarized in table 8 below and form the basis for the method used in this study.

Phase	Description of the process
1. Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Table 8: Phases of thematic analysis, taken from Braun and Clarke (2006).

Thematic analysis is a method for identifying, analysing and reporting patterns or themes within data (Braun and Clarke, 2006). Contrary to the accounts given by some researchers that themes 'emerge' from the data or somehow 'reside' in the data awaiting discovery by a determined researcher, Braun and Clarke (2006) point out that the only place themes exist are within individual researcher's heads and these are constructed through a process of thinking about and creating links from the data as they understand it. Researchers need to acknowledge the decisions they make in selecting and editing data to render it meaningful to them, even when they claim to be 'giving voice' to their participants.

This study used inductive thematic analysis to identify themes within data and as such data was coded without attempting to fit it into a pre-conceived coding frame. Themes were identified on the basis that they captured something important in relation to the research questions rather than whether they appeared a specific number of times within the data item from one participant or were common amongst the data items of all

participants. The aim was to provide a rich thematic description of the entire data set so that important themes could be identified, coded and analyzed.

However, as Braun and Clarke (2006) note, data are not coded in an epistemological vacuum and the research questions played an important part in focusing my attention on certain data extracts that were felt to capture something important in relation to the research questions. The thematic analysis was conducted at a latent level in line with the social constructionist paradigm adopted by the researcher. In this sense, attempts were made to identify the underlying ideas, assumptions and conceptualizations that were seen to shape the semantic content of the data (see appendix 7).

The flexibility of thematic analysis and ease of use as described by Braun and Clarke (2006) were key features in its selection as an analytic tool in this research. Although, other methods such as Interpretive Phenomenological Analysis (IPA) and Grounded theory use a thematic approach to analysis they were seen as too 'interpretive' and 'theory driven' respectively for a study exploring the experience of delivering a NNS intervention.

3.7 *Ethical Considerations*

This research aimed to fulfil the requirements set out by the British Psychological Society Code of Ethics and Conduct (BPS, 2006). The four ethical principles contained within the code were addressed as follows:

Ethical Principle 1: Respect

Voluntary and informed consent was obtained from the TAs and parents of the children. The school sent out letters to parents written by the researcher detailing the purpose and nature of the study (see appendix 2). This included information on children participating in assessments, filling out questionnaires, being interviewed and for their comments to be recorded. The anticipated benefits of the approach were also outlined and parents were invited to ask any questions they wished about the process. Participants were given an overview of the nature of the study and notified of their right to withdraw at any time. The right to confidentiality was explained and the limits, such as child protection issues, were also discussed. Great effort was made to ensure that all

parties concerned understood what they were consenting to, to the extent their capabilities allowed. In accordance with the Data Protection Act (1998) any data gathered will be stored securely and destroyed when no longer needed.

Ethical Principle 2: Competence

The researcher possessed the necessary knowledge, skill, training, education and experience to competently conduct the various aspects of this research with children and adults.

Ethical Principle 3: Responsibility

Regulations regarding health and safety were adhered to at all times to ensure the physical well-being of participants, especially the children. Any risks to the psychological well being of participants were eliminated, such as not disclosing to the children that teachers had identified them as 'underachieving'. Due regard was paid to the potential effects of differences in age, ethnicity, gender, language, religion and family status. The researcher remained mindful of the perceived authority and influence over the child participants and others during the course of the research.

Ethical Principle 4: Integrity

The researcher's professional qualifications in terms of knowledge, skill, training, education and experience were accurately and honestly represented. The researcher's current status as trainee educational and child psychologist and previous position as a mathematics teacher were openly declared.

3.8 *Risk Analysis*

As with any real world study there was the potential that things may not to go according to plan. Some eventualities cannot reasonably be predicted and planned for but some considerations were taken into account. Specifically, enough participants were recruited to allow for 'drop out' or long term absence. The selection procedure was conducted early enough to allow substitute participants to be found in the event of participants declining to participate and the commitment expected from participants was made clear so that unavailability or inability to continue with the study part way through was minimized.

CHAPTER 4: RESULTS

4.1 *Introduction*

Quantitative and qualitative data gathered from the three case studies are presented separately below followed by a cross case study analysis (section 4.5). All case study sites were located within the jurisdiction of an Education Authority in a northern English city and part of the researcher's 'patch' as an Educational Psychologist.

4.2 *Case Study One*

School 1 is a large mixed primary school (nearly 500 pupils aged 3-11 on roll) that serves a wide area of mixed social and economic circumstances. The last Office for Standards in Education (Ofsted, 2008) report describes school 1 as a good school and notes that the proportion of pupils with learning difficulties and/or disabilities has recently risen above the national average for the first time and so have the number of pupils from minority ethnic groups. In order to improve further, Ofsted (2008) asked the school to ensure that the increasing number of pupils with learning difficulties and/or disabilities in Key Stage 2 make better progress, particularly in mathematics. They specifically noted that the curriculum is not planned well enough for children with learning difficulties in order to accelerate their progress in numeracy. Work does not often meet their needs and overall progress is not tracked effectively.

The Head teacher of the school was also the special educational needs co-ordinator (SENCo) at the time initial consent was given to participate in this study but this role was later delegated to a deputy head who was just as enthusiastic about the school's participation. The TA involved had been working at the school for 22 years in various roles: 15 years in non-teaching roles and the last 7 working as a TA. She had developed excellent working relationships with pupils and staff and these were evident in her observed interactions. She had previous experience of delivering a different numeracy intervention to another group of children and this provided her with a valuable insight into the process.

Qualitative analysis

Although I had regular contact with the SENCo/deputy head, most of my meetings were with the TA only with some input from the class teacher if she could spare the time. However, there was regular liaison between the TA and the teacher and any important details from discussions were relayed to me by the TA. The TA was very experienced and confident with her own firm views on how things should be done to better the attainment of children. I noted she was well liked and respected amongst the rest of the staff. The children did the intervention for 15-20 minutes every day except when the school was closed due to inclement weather or days when Christmas activities took place. The following table outlines the work done during each of the sessions with the TA. The sessions were generally conducted using a consultative approach (Wagner, 2000). Sessions 2-6 routinely included reflection on the work done between sessions with a solution oriented approach to addressing any challenges that arose. Small successes were celebrated with the TA/children and sessions ended with the drawing up of a joint plan of action for the following session.

Session	Details
1	Introduction to wave 3 NNS materials using the guidance for a professional development session contained within them; Filling in questionnaires and conducting the pre-intervention testing with children using the SENT-R; Interview with TA and observation.
2	Using the tracking charts from the wave 3 NNS materials and incorporating diagnostic information gleaned from the SENT-R and teacher/TA knowledge to identify individual errors/misconceptions. Discussion about addressing the needs identified through modelling the NNS materials.
3	Consultation and observation. Further discussion about addressing the needs identified; behavioural objectives and preferred learning styles; the work of Piaget /Vygotsky and more recent studies into numeracy difficulties.
4	Precision Teaching training to a group of TAs. Discussion about how to create probe sheets to target individual children's needs, monitoring fluency development, extending skills and facilitating retention.
5	Consultation and observation. Discussion and assessment of working memory including support strategies; Precision teaching evaluation; softening the effects of social deprivation and inadequate parenting.
6	Consultation and observation as session 5. Completing questionnaires and arranging a mutually convenient time to conduct final TA interview.

Table 9: Session details for case study one.

A thematic analysis was conducted on the qualitative data gathered during the interviews with the TA and reflections recorded in the research diary during the intervention. The format described by Braun and Clarke (2006) (see section 3.6.3) was followed and figure 4 illustrates the three main themes that were identified.

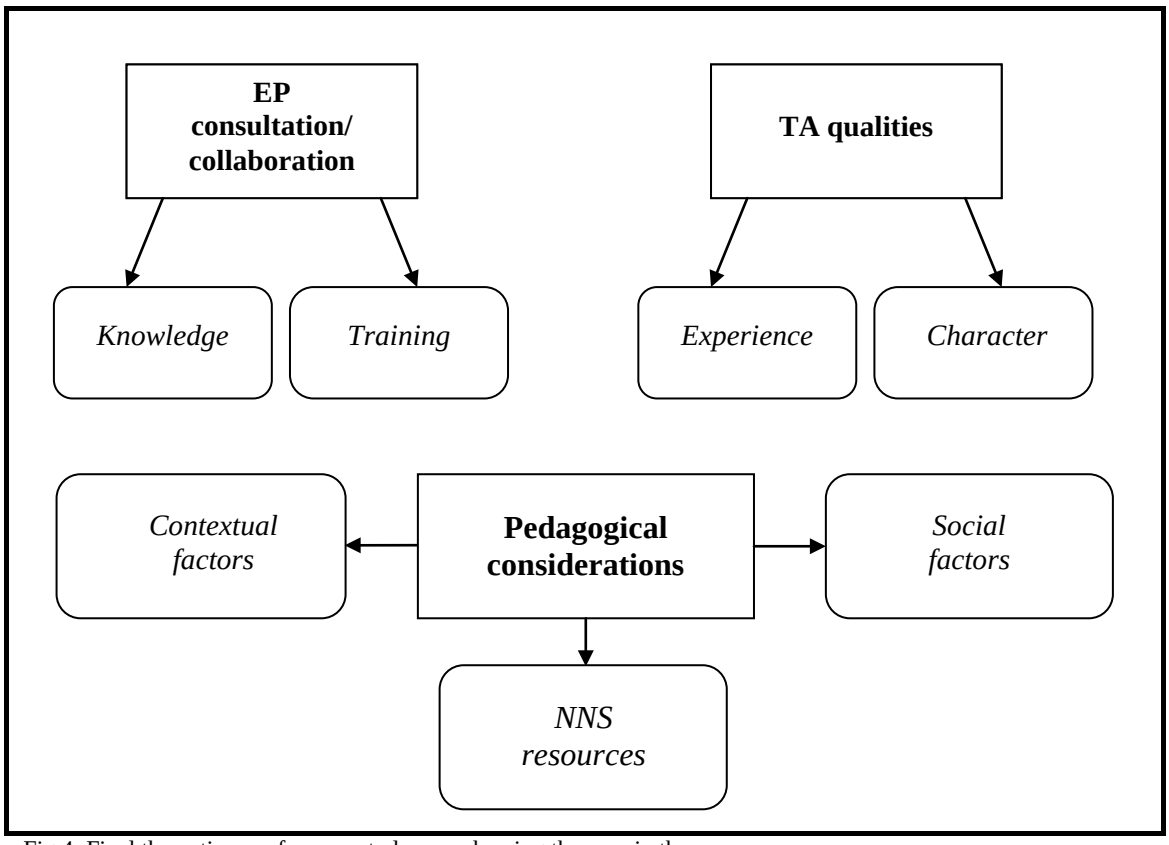

Fig 4: Final thematic map for case study one, showing three main themes

These themes were felt to capture the essence of the data gathered and are discussed in further detail below:

<u>EP consultation/collaboration (knowledge and training)</u>

The TA stressed the importance of being able to meet regularly with the EP throughout the intervention. She regarded the availability of the EP as '*reassuring*' and felt that she was not alone if she stumbled across any barriers that she could not easily overcome on her own. The work done was appreciated and valued: '*I liked the different ideas you (EP) gave me and I shall use them again'; 'I am more knowledgeable now, it's like a little course for us (me) as well*'. Specifically with regard to the consultation format the TA responded: '*you pick up a lot from consultations and the knowledge helps – you*

know where things are in the materials'. These comments indicate that consultations were an effective way to impart knowledge and train TAs in using NNS materials to support children with numeracy difficulties.

Instructional psychology methods were used to address some of the difficulties identified in the target children, specifically, *behavioural objectives* and *precision teaching*. These were modelled for the TA and in the case of precision teaching, training was provided for a group of TAs. Behavioural objectives were used to enable the TA and children to focus upon factors over which they had some control. Namely, observable actions, such as 'write down the numbers 1 to 20 correctly from memory'. Ainscow and Tweddle (1979) argue that acquiring the skills involved in writing behavioural objectives enables teachers to better plan teaching activities for children with an explicit learning goal in mind. This was particularly useful for child B who repeatedly reversed numbers and child A who confused the numbers 12 and 20 both orally and when writing. It gave children an understandable and achievable objective to work towards over the next few days and gave the TA a clear objective to teach to and against which to measure success. An assessment of the children's preferred learning styles also fed into the setting of behavioural objectives and the TA commented that this was '*very useful and changed my thinking*'. All the children had a preference for a visual learning style and this was incorporated into the activities the TA prepared for them.

The precision teaching training was regarded as '*excellent*' by the TA and in fact went down very well with the other TAs involved in the session. The deputy head personally thanked me for my input and said that the TAs were '*literally buzzing*' afterwards when she met them. After a few weeks use, the progress of the children was considered so remarkable that the Head teacher asked if I could train the remaining TAs so that the method could be rolled out across the school to target other children and other areas of need. Specific slots of time were allocated for TAs to conduct precision teaching sessions and so far the results have been very encouraging with TAs reporting that children are '*keen and motivated to learn and come willingly to sessions*'. This lends support to the findings of Chiesa and Robertson (2000) who found that the fundamentals of precision teaching: fluency training and frequent monitoring; were important and effective skill building methods. Daily practice, time probing and

individual tailoring of materials were shown to bring rapid improvement for pupils whose previous numeracy performance gave cause for concern. They also contended that 'some fluency training is better than none' and that special assistance for struggling pupils need not be expensive in terms of either time or resources. For the target children, precision teaching was used effectively by the TA to work towards the objectives identified in the NNS intervention materials such as knowing the number bonds to 20.

Discussion of more recent studies on numeracy difficulties and strategies for supporting working memory were all regarded as '*extra information to help us to help them (the children)*' by the TA and therefore '*useful to know*'.

TA qualities (experience and character)

Needless to say, an intervention is only as good as the person who delivers it and it could be argued that the efficacy of the deliverer is of equal if not greater importance to the nature of the intervention itself. For this reason, it is not surprising that the experiences and personal qualities of the TA were identified as key themes in facilitating positive outcomes for children. The TA's previous experience as a student served to shape her attitude towards mathematics. She reported being unable to ask for help at school even though she '*loved maths*' because the teacher '*embarrassed*' her and consequently she '*didn't learn*'. However this negative experience was useful in helping her to ensure that the children she worked with had better experiences: '*I don't want kids to feel negative about maths. I check that they know and tell them to ask me questions*'. Furthermore, the TA cited intrinsic aspects of her role as professionally rewarding for her: '*Working with children and other TAs is the best part. Seeing children's progress in work and self esteem is really good and needed or else it becomes disheartening…training as a TA was the best thing I ever did*'.

There was also the added benefit of previous experience in adapting numeracy interventions through collaboration with the class teacher: '*I tweaked it to suit the kids. Did more visual and hands on stuff…Mrs J identified the work and I changed it if I needed to. I fed back and filled in record sheets. We're very good me and Mrs J*'. This

final comment reveals that the TA was aware of what constituted good practice and located her own pedagogical style within this 'good practice' framework.

From the outset the TA had a positive outlook on her participation in the intervention that reflected her general identification with the children: '*It's a challenge isn't it? I'm a bit apprehensive but happy to have a go; Looking forward to new ideas and methods. I like to be educated and learn something. I come down to the kids' level me. I'm like one of the children'*.

Participation also had a more practical benefit for the TA: '*It's something else for my CV. It will hopefully help me with my job even if I only take a few things from it; it can't hinder me can it? It's got to be good*'.

This initial optimism was maintained through to the end of the intervention and the TA stressed that empathy was a key component in facilitating children's progress: '*you forget what it's like to be a child. You need to remember how you learned and use that to help*'.

At the end of the intervention, the TA commented that '*if you bring work down to their level, every one can improve at maths to a certain level. Not every one can be Einstein and children have individual limits to the levels they can reach but it's how hard or easy you make it for them*'. This demonstrates that the TA understands that differentiating and presenting tasks effectively can have a profound impact upon the way they are received by the child and a knock on effect on their ability to grasp concepts, make progress and develop confidence in themselves as learners as a result. She also acknowledges her crucial role in making numeracy accessible for these children.

These experiences and personal traits were likely to have a positive impact on the relationships fostered by the TA with the intervention group. The chances of children making progress with their numeracy learning in an atmosphere free from anxiety with a warm considerate adult and where there is enough security for them to take risks are quite high. The TA's 'happy to participate in the intervention' rating went up from 8/10 at the initial interview to 10/10 at the final interview and her 'confident with doing a

numeracy intervention' rating went up from a 4/10 to an 8/10, indicating a positive increase in both respects and a worthwhile use of time and resources.

Pedagogical considerations

The three sub themes associated with the main theme of 'Pedagogical Considerations' (see figure 4) will be considered separately below:

Contextual factors

One of the key challenges identified in the literature (see section 2.8) that inhibits good practice is the lack of time TAs spend liaising with teachers. Although in this case the TA felt there was adequate time for liaison with the class teacher she pointed out that this was done before school, during the time pupils were changing for PE or getting ready to go home, during breaks and when the children were working quietly in class. This is basically the TA's own time or unscheduled time that is utilized when available; which though better than nothing is still far from the ideal.

The TA identified a training need in that she claimed she was never trained to work on numeracy with children who had difficulties and learned as best as she could on the job. She remarked that '*things are done differently now*' and she needed to be trained on up to date methods in order to do her best for the children. The teacher and senior management in this case were particularly supportive and that was regarded as a facilitating factor as the TA was allowed ample time to prepare and deliver the intervention which was viewed as helping the school. The TA remarked that the teacher and deputy head were '*agreeable*' and this '*helped to get things organised and provided good feedback opportunities*'. The interest from school may have been as a result of the Ofsted (2008) recommendation to improve numeracy across the school so that children receive appropriate work, matched to their abilities and their progress is tracked effectively. The teacher had already set up special weekly sessions in which she identified learning weaknesses that the TA could work on with a group of pupils and the current intervention provided an appropriate tool to meet that need for certain pupils.

The children took part in their normal numeracy lessons in addition to the intervention and this was identified as a potential contributor to their numeracy progress. However, this was unavoidable and as the TA put it: '*missing lessons for four months would not have been a good idea*'. What is important is that the TA felt the intervention helped make the improvements. The focus on their weaknesses and the time spent consolidating the basics instead of '*moving on, as happens too often with these children*' was seen as a crucial factor in the progress they made. One criticism was that the intervention was begun a little later into the autumn term and had it commenced in September, the TA felt there would have been a better match between the intervention and the work being covered in class. Although, it was also acknowledged that '*small bits of work*' were better received by these children.

NNS resources

Before the intervention began the TA had already hinted that she thought personalized strategies worked best for children who struggled: '*Everyone can improve using strategies they find comfortable even if they are time consuming. What works for them matters*'. She also added that: '*maths is unusual, it does not make natural sense. If you don't understand it it's lost. You need to make it understandable then it works. This means you have to grab their interest*'. These comments sit well with the guiding principles of the wave 3 NNS resources which call for sharing the purpose of each activity with the children and encouraging reflection on their learning and identification for themselves of possible next steps. These would require work to be 'comfortable' and 'understandable' in order for the child to play the active role expected of them.

With regard to the NNS materials, the TA responded: '*I were worried it was too hard at first but it is easily modified. They liked the games, drawing and going out instead of just sitting at a desk. Incorporating different ideas was good and using things in the real world. I grabbed any opportunity I found around the place (to remind them of the numeracy work)'*. This indicated that the materials were appropriately challenging and the TA skilfully transformed them into a 'lived experience' for the children by reinforcing the concepts in a real life context away from planned numeracy time. This would enable children to see the application of numeracy as more than just work they

do in class and support them in making human sense of the numeracy they learn, which is a guiding principle of the NNS materials.

Moreover, the TA emphasized that: '*You need to know the children. They owned the materials. I needed to use my expertise and differentiate but the materials were quite good at doing most of the work for me*'. This implies that the NNS resources were fit for purpose at least for these children and an experienced TA found them easy to use and modify. The additional notes and recommendations contained within the materials, directing deliverers to differentiated tasks based on children's responses were also appreciated as time saving and effective features.

The diagnostic aspect of the NNS materials and the diagnostic information gathered from the numeracy test (SENT-R) were regarded as essential for good progress. The TA remarked: '*I like the word 'gaps', wave 3 shows you where the gaps are and you need to know this to work on the gaps. Your assessment helped diagnose what to focus on and this is necessary otherwise you waste time doing stuff they know when you could be filling a gap. The gap idea is being taken forward with other groups*'. The final comment reveals how the experience of the intervention has affected practice generally in that constructive ways of working are being transferred to benefit other groups of children.

The TA did not hesitate to recommend the NNS materials, saying: '*they were easy to use, well designed and had good ideas*'. She also stressed that she would: '*continue to use the ideas and integrate it with other work and other groups*'. In particular the materials were viewed as useful for transferring skills to the classroom with their focus on written recording and vocabulary acquisition. The TA felt NNS recommended words like 'inverse' and 'boundary' were too hard initially but was pleased that with repeated use children picked them up and used them in their own contexts. However, in order to explain the meaning of words in language that made operational sense to the children, she initially phrased things differently such as using the phrase '*throwing in the bin*' for 'subtraction' until the children understood and remembered the word 'subtraction' in its own right. Using this approach was seen to appeal to the children's preferred visual style and '*visualising*' was a strategy the TA used to help them retain information and develop transferable strategies for the class room. This was

particularly so when concrete materials were used to explain concepts as the TA mentioned that '*they cannot always have bricks with them can they?*'

The small group size was considered to be beneficial. It allowed for the necessary 1:1 differentiation whilst maintaining a group atmosphere, allowing for friendly competition and peer support to take place as well. The children were quick to help each other out and the TA said they '*enjoyed it, had fun and wanted to do more in their own time*'. These behaviours are likely to assist the children to retain their learning over time and are the hallmarks of a successful intervention. The TA also modified her perception of appropriate challenge for the children involved after realising that materials she felt were '*too hard for them*' at first actually provided sufficient challenge for the children to make further progress with their numeracy development.

Social factors

The children's numeracy knowledge and difficulties with numeracy are socially constructed phenomena. The TA constructed her own understanding of why children have difficulties with numeracy: '*I expect kids to be weak; things are difficult for parents with them working. They can't get involved as much and so the basic start is missing. They don't have those early skills*'. The TA goes on to describe her perceived role in countering this poor start in life: '*We need to start with the basics as if they are our children. Give them a grounding in the basic basics, motor skills, listening, sitting. I'm a great believer in educational toys and games*'. She emphasizes the importance of fostering good relationships conducive to learning: '*Fairness, trust, enjoyment and praise are important. Kids sense when you're not on their wavelength. It needs to be fun and motivating…challenging work and competitive games helps motivation*'. Furthermore, she emphasizes nurture over nature: '*You learn maths rather than being born with it. Doing maths with a child helps them but it doesn't make sense to some as easily so you need to come down to their level*'. This demonstrates an awareness of working within the child's *zone of proximal development* (Vygotsky, 1991) and the TA acknowledged she had '*heard of*' Piaget and Vygotsky during her training.

The TA recognised the impact of the small group work on confidence and progress but noted how it was not as easily transferred to the class room: '*Small group work is good*

but not applied in class. The protective group and friendly competition are lost in class and they know they're weaker than the others and the work is harder in general for them. They always need to know that what they are doing is right in small steps'. However, the intervention served to increase the children's motivation so that they completed further tasks at home without being asked and brought them in to show the TA, indicating the value of this work to their confidence and motivation. The TA perceived this enthusiasm as linked to the attention they received in the intervention: '*They wanted to come out of class. They were enthusiastic, doing things at home and asking when they'd be doing it again*'.

There was a recognition that the engineered social situation was nurturing numeracy development but also that this took skilful management on the part of the TA: '*Ability is definitely improving in the small group with visual work, praise and precision teaching. I let them mark their own charts when I know it will boost their self esteem. But I need to manage their disappointment if they don't win games. They're constantly aware of each other and if they think I don't treat them equally it can affect their self esteem*'. The TA used her own strategies to ensure children did not feel as if they were failing: '*I sometimes give easier examples if I don't think they've got as many right as the others and if anybody notices I say well it's harder for him and it's easier for you*'.

These examples show the TA was aware of the impact of social background on the children's difficulties but also aware of the impact of the social environment she created with the work she did. This was carefully balanced to meet the children's academic and social needs and illustrates how social relationships with and between small groups of children need to be managed to ensure successful learning takes place.

During observation of the TA interacting with the children, I noted that she had developed a mathematical discourse that the children were familiar with and knew how to participate in. The children appeared to understand that during introduction of an activity, an answer did not constitute a mathematical answer unless it was accompanied with an explanation of how they derived it or as the TA put it with a '*check to see if it is right*'. They automatically offered these explanations during the introductory phase of the activity and reverted to supplying only the answer at other times. This practice of explaining reasoning is associated with the development of 'powerful conceptual

structures' in children which assist them in retaining numeracy knowledge and transferring it to novel situations (Cobb, 1988).

It was also noticeable that the children were encouraged to help each other out if one of them struggled rather than expect the answer to be provided by the TA and they readily involved themselves in this peer collaboration while the TA chaired the discussion. The TA made numeracy learning available to all members of the group by encouraging children to share their individual experiences of working on tasks and in doing so created a social context within which mathematical ideas could be developed and mathematical truths discussed. The TA actively encouraged children to voice their ideas and went along with their suggestions as long as they were mathematically correct and in doing so created a space to socially construct shared mathematical meanings and practices (Cobb *et al.*, 1992a). These practices are associated with those of 'highly effective teachers of numeracy' (Askew *et al.,* 1997) and when this was pointed out to the TA who admittedly shaped her pedagogical practice through '*experience of the job*', she remarked: '*It's nice to know though, I'd never know unless someone like you tells me'*.

Points of development discussed in light of the observations included modelling and reinforcing the actual vocabulary recommended by the NNS materials in order to advance children a step closer to engaging in general mathematics discourse outside the small group situation. The TA was reluctant to promote this kind of vocabulary acquisition before this intervention assuming it would be '*hard and confusing*' for the children but experience of the intervention and the ease with which children adopted new vocabulary helped to change her mind. Also, conceptual shifts in the children's thinking were not fully encouraged by explicitly pointing out key mathematical concepts as they arose. This may be related to the reluctance of the TA to use new vocabulary for fear of confusing the children. For example, Child A and C did not notice that 3+11=14 was the same as 11+3=14 and attempted to work out both sums separately. The TA went as far as mentioning that they were the same but did not explain that this was a rule or law of mathematics (law of commutativity, in this case) and emphasise the fact in order to produce a conceptual shift. On another occasion the opportunity to emphasise connections between different areas of mathematics such as addition and subtraction were missed (i.e. stressing the inverse connection between 18-

2=16 and 16+2=18). These kinds of emphases are associated with conceptual mathematical thinking in children that in turn leads to further development of their numeracy skills and understanding (Iannone and Cockburn, 2008). Cobb (1988) asserts that a fundamental goal of mathematics instruction should be to help students build cognitive structures that are more complex and abstract than those that they possess when instruction commences. By failing to adequately stress some of the mathematical concepts that the children encountered, the TA was effectively, though inadvertently, confining them to a discourse of 'low numeracy ability' despite engaging in some otherwise effective pedagogical practices as described above.

Quantitative results

Table 10 shows the results obtained by the three children in the Revised Sandwell Early Numeracy Test (SENT-R) both before and after the intervention. The 'child age' columns refer to the chronological age at the time of testing. Age equivalent figures are based on the median scores expected for children of that age and in this respect provide a 'numeracy age' for each child.

Pre- intervention (form A)				**Post-intervention (form B)**			
Child (age)	*Standard score*	*Percentile*	*Age equivalent*	*Child (age)*	*Standard score*	*Percentile*	*Age equivalent*
A (6:9)	80	9	5:4	**A** (7:1)	81	10	5:10
B (6:7)	73	4	4:10	**B** (6:11)	76	5	5:2
C (6:9)	76	5	5:1	**C** (7:1)	81	10	5:10

Table 10: SENT-R results for case study one.

These results show that all children began well below average age related expectations and made 6 months, 4 months and 9 months numeracy progress respectively within the period of four months that the intervention spanned. Child B was absent due to illness and family circumstances for a considerably long period of time (over one month) and this may explain the slower progress made in comparison to child A and C. She was also younger than the other two children and had a larger gap between her chronological age and her numeracy age from the outset. Despite this, her progress corresponded

exactly to the length of time the intervention was conducted and this implies that the intervention may have played a role in quickening her progress over the shorter period that she actually participated in it.

Table 11 shows the scores (out of a maximum of 30) from the children's attitude to numeracy questionnaire (appendix 3). Question 3 was omitted from the analysis as it was designed to compare literacy attitudes to numeracy attitudes rather than add to an overall measure of children's attitude to numeracy.

Child attitude questionnaire (case study one)	**Child**			**Mean**
	A	**B**	**C**	
Pre intervention score	28	7	19	18
Post intervention score	30	21	26	25.7
Change per child	+2	+14	+7	+7.7

Table 11: Child attitude questionnaire results for case study one.

These results show that all children improved their attitude towards numeracy with a mean increase of 7.7. Interestingly, child B made the largest gain despite her shorter exposure to the intervention, indicating her shifting attitude to numeracy based on her positive experience and probably reflecting her need for the kind of 1:1 support provided through the intervention. When asked at the end of the intervention, she declared '*it were lovely*' taking part and the other children also claimed that they liked the work they did with the TA as part of the intervention. All children made a positive increase in their attitude to numeracy lessons but this was not the case for literacy lessons which remained the same or became lower, indicating a specific shift in attitude to numeracy.

Table 12 shows the results from the TA questionnaire (appendix 4). The table shows the change in response to each individual question for every child and a total change per child and per question. The negative phrasing of question 8 has been taken into account.

TA Questionnaire (case study one)	Child			Change per question
	A	B	C	
1. is happy to do numeracy work	1	-1	1	**+1**
2. is keen to do well and tries hard	2	0	1	**+3**
3. actively participates in numeracy lessons	2	-1	1	**+2**
4. can work out answers in more than one way	1	1	0	**+2**
5. will try even if the work is challenging	1	0	1	**+2**
6. can explain how they arrived at an answer	1	1	1	**+3**
7. can spot their own errors if they talk through the problem	0	1	0	**+1**
8. makes the same errors over and over again	-1	0	0	**-1**
Change per child	**+7**	**+1**	**+5**	**+13**

Table 12: TA questionnaire results for case study one.

Out of a possible maximum of 40, the mean pre-intervention score was 22.3 and the mean post intervention score was 26.7, producing a mean gain of 4.3. Virtually all questions produced a positive change and those that did not were justified by the TA. Child A was making the same mistakes over and over gain because '*he was rushing and needs to stop and think and ask when unsure*' and child B was '*not always here*' and '*lost interest if the work was hard or involved writing*'. Child A and C generally '*tried hard and wanted to do well*'.

4.3 *Case Study Two*

School 2 is a mixed primary school (just over 180 pupils aged 5-11 on roll) with pupils coming from a variety of socio-economic backgrounds. The last Ofsted report concluded that it was a good school with some outstanding features (Ofsted, 2007a). The number of pupils who have learning difficulties and/or disabilities and those eligible for free school meals is average. However, numbers vary dramatically from year-to-year and in some year groups there is a very high percentage of pupils requiring additional learning support. Ofsted (2007a) found that TAs were well deployed and provided good quality support for these pupils and requested the school to focus sharply on the use of assessment data to help teachers share consistently challenging targets with pupils as a means to improve further.

The SENCo at the school was also the deputy head. The TA had worked there for three years and established good working relationships with staff, parents and pupils. She had no previous experience of delivering numeracy interventions but was '*really keen*' to participate as she wanted the children to '*get something out of it*' and felt she might '*achieve something*' with them. The TA worked with the children for 30 minutes, three days a week on the intervention throughout the four months it spanned except when the school was closed due to inclement weather or the children were participating in Christmas activities.

Qualitative analysis

School 2 was the only school that held joint meetings between myself, the SENCo/deputy head, the class teacher and the TA. For me, this demonstrated a genuine commitment to collaborative work with external professionals to raise standards. Ofsted (2007a) noted that TAs were well deployed at this school and asked teachers to focus sharply on assessment data in order to set challenging targets for pupils. The interest in this intervention could have stemmed from their recommendations. The following table outlines the work done during each of the sessions with the TA. The sessions were generally conducted using a consultative approach (Wagner, 2000). Sessions 2-6 routinely included reflection on the work done between sessions with a solution oriented approach to addressing any challenges that arose. Small successes were celebrated with the TA/children and sessions ended with the drawing up of a joint plan of action for the following session.

Session	Details
1	Introduction to wave 3 NNS materials using the guidance for a professional development session contained within them; Filling in questionnaires and conducting the pre-intervention testing with children using the SENT-R; Interview with TA and observation.
2	Using the tracking charts from the wave 3 NNS materials and incorporating diagnostic information gleaned from the SENT-R and teacher/TA knowledge to identify individual errors/misconceptions. Discussion about addressing the needs identified through modelling the NNS materials.
3	Consultation and observation. Further discussion about addressing the needs identified; behavioural objectives and preferred learning styles; the work of Piaget /Vygotsky and more recent studies into numeracy difficulties.
4	Precision Teaching training to a group of TAs. Discussion about how to create probe sheets to target individual children's needs, monitoring fluency development, extending skills and facilitating retention.

5	Consultation and observation. Discussion and assessment of working memory; effect of parental involvement; Precision teaching evaluation.
6	Consultation and observation as session 5. Completing questionnaires and arranging a mutually convenient time to conduct final TA interview.

Table 13: Session details for case study two

A thematic analysis was conducted on the qualitative data gathered during the interviews with the TAs and reflections recorded in the research diary during the intervention. The format described by Braun and Clarke (2006) (see section 3.6.3) was followed and figure 5 illustrates the two main themes that were identified.

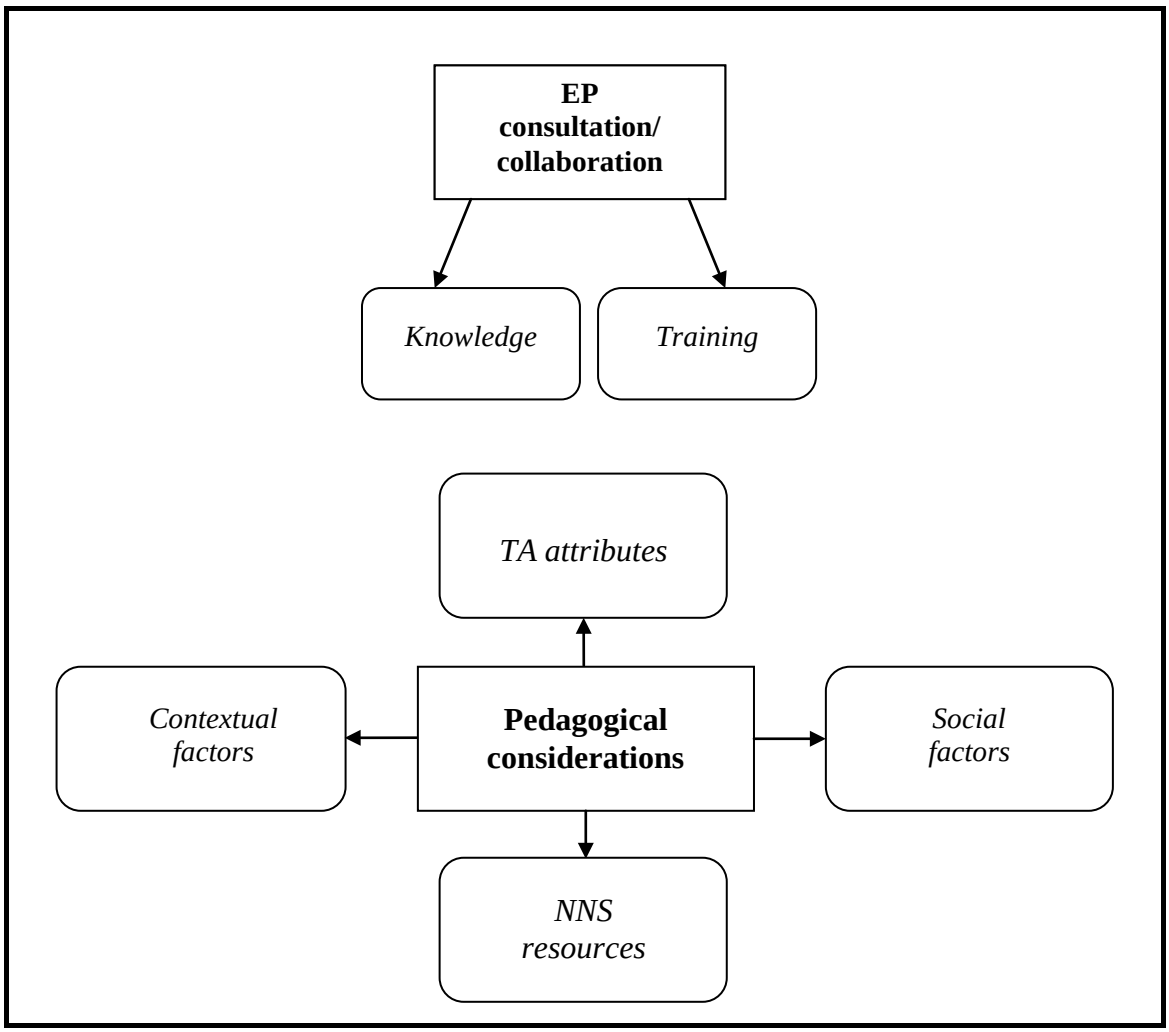

Fig 5: Final thematic map for case study two, showing two main themes

These themes were felt to capture the essence of the data gathered and are discussed in further detail below:

EP consultation/collaboration

The TA particularly found the modelling of NNS materials and training around instructional psychology useful:

'*Watching you and how you did it was helpful. You didn't just read it – you adapted it…I learned to say things differently and that was helpful*'.

'*Precision teaching was very helpful. I've been doing that a lot and plan to continue doing it*'. The children responded very well to precision teaching and the TA mentioned she could see them making progress day by day. She felt this successful experience had '*a knock on effect on their attitude in other subjects too'*. This indicates a perceived transfer of positive self esteem in the children from one curriculum area to another.

The TA reported that the discussions on the work of Piaget and Vygotsky were '*interesting*' and she remembered some of the details from a course she did. It was '*merely interesting*' then but talking about it with '*specific children in mind*' with a psychologist had helped to make it '*more meaningful*'. She could see how working on their conceptual understanding of numeracy within their 'zone of proximal development' (Vygotsky, 1991) could help them to move on from the 'concrete stage' (Piaget, 1991). In particular, for child E, stressing the concept of place value so that he could see the 'tens unit' as a physical block of ten enabled him to reduce persistent confusion of numbers such as 12/20 and 17/71 and appreciate the significance of counting across boundaries such as knowing what comes after 9, 19, 29, 39 etc. The TA was receptive to discussions about emphasising mathematical concepts in order to enhance children's conceptual mathematical thinking and accelerate progress with numeracy (Cobb, 1988; Iannone and Cockburn, 2008) but these methods did not feature in her pedagogical style as often as would be beneficial for the children.

Pedagogical considerations

The four sub themes associated with this main theme are discussed separately below:

TA attributes

As mentioned in section 4.2, the personal traits and experience of the TA are pivotal in determining the success of this or any intervention. The TA considered herself to be good at maths until she went to secondary school where she encountered a teacher who '*would only say things once and it was tough if you didn't get it*' and this made her maths ability '*plummet from good to bad*'. This experience led her to conclude that '*teacher personality*' matters greatly to children and she did her utmost to create an atmosphere where children can learn using praise and encouragement.

The TA had received no training to help children develop their numeracy ability using contemporary methods: '*only what I'm picking up as I go along and helping my daughter with her work. It's different to when I did it*'. She was keen to participate in the intervention and use any newfound knowledge to help other children but apprehensive about getting it right: '*I look forward to learning new things, implementing that and bringing out the best in them. I'll be able to use it with others so I'll be better at my job. Hope I can put it across how it's supposed to be done*'. This anxiety about '*getting things right*' may have been a reflection of her inexperience in the area.

The TA '*loved*' working with the children and '*enjoyed boosting*' them during the intervention. She was '*definitely glad*' she did it and the best part was '*seeing them move on, happy and enthusiastic*'. She felt they had '*learnt a lot*' and their '*progress was obvious and their confidence was definitely boosted*'. She expressed a desire to continue with the work and believed '*it was not over*' and that she would '*take from the experience and continue*'. This implies the intervention experience was successful in increasing the confidence of a relatively inexperienced TA to deliver a numeracy intervention. She rated herself as 10/10 for being 'happy to participate' and 'confident to do another intervention in the future'.

Contextual factors

There were '*no opportunities*' to share information with the class teacher according to the TA. The TA was also trained in giving first aid and this meant that she was often

needed at break times to tend to minor cuts and bruises. The TA sat with the target children and supported them with additional input during the introductory part of the lesson led by the teacher. I observed that that teacher would approach the TA once she had completed this introductory part and provide brief verbal instructions on what to do with the seven children in the lowest ability group. It was left to the TA to explain the task, monitor and evaluate it even though it often differed considerably from the introduction. The teacher was kept very busy working with the other three higher ability groups.

The TA felt she was supported by the school to deliver the intervention as she believed they '*wanted the kids to move on*'. There was interest in what she was doing from senior management and from other TAs, one of whom asked for a copy of the NNS materials for her own child. The numeracy co-coordinator also requested a copy.

Unique to this school was the level of parental interest. The TA and teacher were good at liaising with parents when they came to drop off and pick up children and received positive feed back from all of them concerning their children's numeracy progress and attitudes. This indicates that parents had noticed an appreciable positive change in their children during the intervention. Desforges and Abouchaar (2003) in their review of literature around parental involvement and its relation to children's achievement and attainment conclude that parental involvement in the form of interest in the child and routine parent-child interactions can have a significant positive effect on children's behaviour and achievement even when the influence of background factors such as social class or family size have been factored out. Parental involvement may have been a facilitating factor in boosting these children's numeracy ability into the average range for their chronological age, something which was not achieved by children in case studies 1 and 3 where even though parents met with the TA and teacher regularly there was no specific interest in their numeracy progress.

<u>NNS resources</u>

The TA acknowledged that the children needed '*basic nitty gritty teaching that's the right way specifically for them*'. Her job was '*to discover what the kids need and how they learn'* to make further progress and using '*visual prompts and blocks*' to help them

understand. These views are shared by the NNS resources which aim to identify specific errors or misconceptions and target those in a manner which is accessible to the child using concrete materials if necessary.

With regard to the NNS materials the TA said: '*It's given me ideas of what to do with them. It's been nice following those and it's there for you to use. It's given me new ways of putting things across and using resources and it's nice to have ideas like that especially when you have less experience…helps your confidence*'. This indicates that the NNS materials helped boost the confidence of less experienced TAs. The resource booklet in particular was useful and the emphasis on the children finding and talking about patterns '*changed the way they think; now they spot them so easily in other places too*' according to the TA.

In this case, the differentiated class work for the lower ability group matched the work being done during the intervention quite well and therefore there were more opportunities to reinforce the concepts being learned. At the end of the intervention, the TA believed: '*People are naturally better at some things but everyone can become better at maths, definitely, now that I've done this. They might not be maths teachers but they can become better*'. This indicates that experience of this intervention changed her views of the children's ability to make progress with their numeracy and knowledge, attitudes and beliefs have been found to have a significant impact upon the instructional practice of teachers (Thompson, 1984; Ernest, 1989; Pepin, 1999). The TA felt that the idea of filling gaps in children's mathematical understanding was entirely appropriate for the target children claiming that: '*When the gaps are filled it just clicks for them*'. This leads to increased motivation to do further maths with children looking forward to the sessions and asking: '*can we do the maths miss?*'

Furthermore, she said: '*I prefer to work with the NNS materials as they are already planned and stops you wasting time making materials when it's there for you and you can be confident it will work*'. She stated that she would: '*definitely use the materials again with other groups*' and will '*continue to use them*' with the target children throughout the remainder of the year. This implies the experience of this intervention has added another useful resource to her repertoire which she can adapt to suit the needs of the children she works with.

Social factors

The TA's view was that social set up of the groups facilitated the children's numeracy development: '*They enjoy the attention of the small groups and feel special at being taken out of class. It means they're less distracted and it boosts their confidence*'. This was an appropriate strategy to counteract the 'fear' she had constructed to describe the children's feelings of struggling with numeracy: '*It's scary for them; they know they're not doing as well as the others and it frightens them. Without the basics it's gets harder for them as they get older*'. The TA mentioned that the she could remind the children of their positive group experiences during class work with phrases like '*come on you've done this*' and this helped them to overcome mental blocks to their thinking in class.

This implies that with the experience of the intervention coupled with in-class TA support the children were being encouraged to re-construct their view of their capabilities in class. At the end of the intervention the TA described the children as '*happy, confident and they retain a lot more now. Now they just want to knuckle down and get on with it so I know it's (the intervention) working*'. Having things '*explained at their level'* and being able to ask questions and discuss numeracy in a safe environment has led them to develop '*I can do attitudes in class instead of being put off like they were in the past'*. I observed the children volunteering to go to the front of the class to answer questions during whole class activities demonstrating their newfound confidence.

The TA's inexperience meant that there were often times when it appeared as if she wanted to be told what to do rather than be consulted. Her receptiveness to alternative ideas and eagerness to please were obvious. However, there was a strong sense that she was reluctant to do anything without a qualified teacher's permission. The presence of the SENCo and teacher at most of our meetings may have been construed by the TA as a signal that she could not be left to manage this intervention unsupported or unmonitored. Her confidence towards the end of the intervention was quite marked and this intervention appeared to have produced a genuine improvement in her expertise to intervene with numeracy difficulties.

Quantitative results

Table 14 shows the results obtained by the three children in the Revised Sandwell Early Numeracy Test (SENT-R) both before and after the intervention. The 'child age' columns refer to the chronological age at the time of testing. Age equivalent figures are based on the median scores expected for children of that age and in this respect provide a 'numeracy age' for each child.

Pre- intervention (form A)				**Post-intervention (form B)**			
Child (age)	*Standard score*	*Percentile*	*Age equivalent*	*Child (age)*	*Standard score*	*Percentile*	*Age equivalent*
D (6:2)	84	14	5:2	**D** (6:6)	122	94	7:7
E (6:3)	82	12	5:1	**E** (6:7)	87	20	5:10
F (6:10)	82	12	5:5	**F** (7:2)	88	21	6:5

Table 14: SENT-R results for case study two.

These results show that all children began below average age related expectations and made 29 months, 9 months and 12 months numeracy progress respectively within the period of four months that the intervention spanned. At the end of the intervention they all achieved or exceeded average expectations. Child E and F were now in the average range (standard scores in the range 85-115) but Child D made remarkable progress, and gained a numeracy age that exceeded his chronological age. Child D had recently moved to England from Spain and it may be that he overcame any initial difficulties adapting to a new environment after a period of time. The extra, targeted attention he received as part of this intervention may have given him the boost he needed to '*unlock his potential*' according to his TA. Children, like child B, who are in the process of developing proficiency in a new language typically acquire Basic Interpersonal Communicative Skills (BICS) well before they acquire Cognitive Academic Language Proficiency (CALP). This means they become proficient in social language skills earlier and can appear as fluent as other children but still struggle with significant academic language gaps. Apparent ability to interact at a high cognitive level in the playground does not necessarily imply the same cognitive or communications ability in the classroom (Cummins, 1979). The NNS resources with their focus on language

development and social construction of numeracy may have supported child B to develop the necessary proficiency with mathematical language and concepts.

Table 15 shows the scores (out of a maximum of 30) from the children's attitude to numeracy questionnaire (appendix 3). Question 3 was omitted from the analysis as it was designed to compare literacy attitudes to numeracy attitudes rather than add to an overall measure of children's attitude to numeracy.

Child attitude questionnaire (case study two)	**Child**			**Mean**
	D	**E**	**F**	
Pre intervention score	26	22	22	23.3
Post intervention score	27	27	23	25.7
Change per child	+1	+5	+1	+2.3

Table 15: Child attitude questionnaire results for case study two.

These results show that all children improved their attitude towards numeracy with a mean increase of 2.3. All children claimed they liked doing the work with the TA and she reported that they showed a heightened enthusiasm for the sessions, asking when they were next doing the numeracy work together and when the researcher was coming round to see them again. The children particularly enjoyed the games and Child E said that even though '*it's a little bit hard – I do like it- I like hard things*'. Importantly, all children made positive increases in their attitude to numeracy lessons which were not reflected in their attitude to literacy lessons, which remained the same, indicating a specific shift in attitude to numeracy.

Table 16 shows the results from the TA questionnaire (appendix 4). The table shows the change in response to each individual question for every child and a total change per child and per question.

TA Questionnaire (case study two)	Child			Change per question
	D	E	F	
1. is happy to do numeracy work	2	1	0	**+3**
2. is keen to do well and tries hard	2	1	1	**+4**
3. actively participates in numeracy lessons	2	1	0	**+3**
4. can work out answers in more than one way	1	0	0	**+1**
5. will try even if the work is challenging	2	1	1	**+4**
6. can explain how they arrived at an answer	2	0	0	**+2**
7. can spot their own errors if they talk through the problem	2	0	0	**+2**
8. makes the same errors over and over again	0	0	1	**+1**
Change per child	**+13**	**+4**	**+3**	**+20**

Table 16: TA questionnaire results for case study two.

Out of a possible maximum of 40, the mean pre-intervention score was 25 and the mean post intervention score was 31.6, producing a mean gain of 6.7. All questions produced a positive gain with Child D making the most gain overall. This relatively larger gain in the TA's perceptions is reflected in the much higher attainment for child D in the SENT-R and may also result from his increasing acclimatisation to his new learning environment, as mentioned above.

4.4 *Case Study Three*

School 3 is a mixed primary school (just under 150 pupils aged 5-11 on roll) where all pupils are from English speaking White British backgrounds. Ofsted (2007b) describe this school as satisfactory overall and fewer than average children are entitled to free school meals. The proportion of pupils having learning difficulties and/or disabilities is below average overall, though the proportion with a statement of special educational need is above average. Ofsted (2007b) requested that the school ensure teaching is consistently good so that pupils maintain the good achievement established in the Foundation Stage. They also requested the school to improve communication with parents so they are better informed about events, curriculum and policies.

The SENCo at the school was also the deputy head. The TA had worked at the school for 18 months before which she worked as a respiratory physiologist at a local hospital.

She had no previous experience of delivering a numeracy intervention but was '*looking forward to helping the kids get their ability up*'. The children received the intervention for 20 minutes, three days a week on most weeks. Unfortunately, the TA was off sick for a month in total during which the children did not receive the intervention.

Qualitative analysis

The TA in this case had been at the school for 18 months before which she worked as a respiratory physiologist in a local hospital. She was drawn to the TA role because she wanted a '*new challenge*', '*liked children*' and there was a '*caring element*' to it. The hours also suited her in terms of holidays and doing the '*school run*' with her own children. One of our meetings also involved the SENCo but all others were with the TA only. The class teacher was consulted infrequently when a free moment coincided with my presence in the classroom. I did note a tension between the working practices of the TA and class teacher and was informed by the TA that the relationship was not particularly amicable. This had a knock on effect on the quality and quantity of liaison between the two concerning the work being done with children.

The following table outlines the work done during each of the sessions with the TA. The sessions were generally conducted using a consultative approach (Wagner, 2000). Sessions routinely included reflection on the work done between sessions with a solution oriented approach to addressing any challenges that arose. Small successes were celebrated with the TA/children and sessions ended with the drawing up of a joint plan of action for the following session. Only four sessions were conducted due to TA absence but short telephone consultations were also conducted when the TA rang to cancel sessions.

Session	Details
1	Introduction to wave 3 NNS materials using the guidance for a professional development session contained within them; Filling in questionnaires and conducting the pre-intervention testing with children using the SENT-R; Interview with TA and observation.
2	Using the tracking charts from the wave 3 NNS materials and incorporating diagnostic information gleaned from the SENT-R and teacher/TA knowledge to identify individual errors/misconceptions. Discussion about addressing the needs identified through modelling the NNS materials.

3	Precision Teaching training to all the TAs at the school. Discussion about how to create probe sheets to target individual children's needs, monitoring fluency development, extending skills and facilitating retention. Consultation about writing behavioural objectives, assessing preferred learning styles and working memory; the work of Piaget /Vygotsky and more recent studies into numeracy difficulties.
4	Consultation and observation. Precision teaching evaluation; Completing questionnaires and arranging a mutually convenient time to conduct final TA interview.

Table 17: Session details for case study three.

A thematic analysis was conducted on the qualitative data gathered during the interviews with the TA and reflections recorded in the research diary during the intervention. The format described by Braun and Clarke (2006) (see section 3.6.3) was followed and figure 6 illustrates the two main themes that were identified.

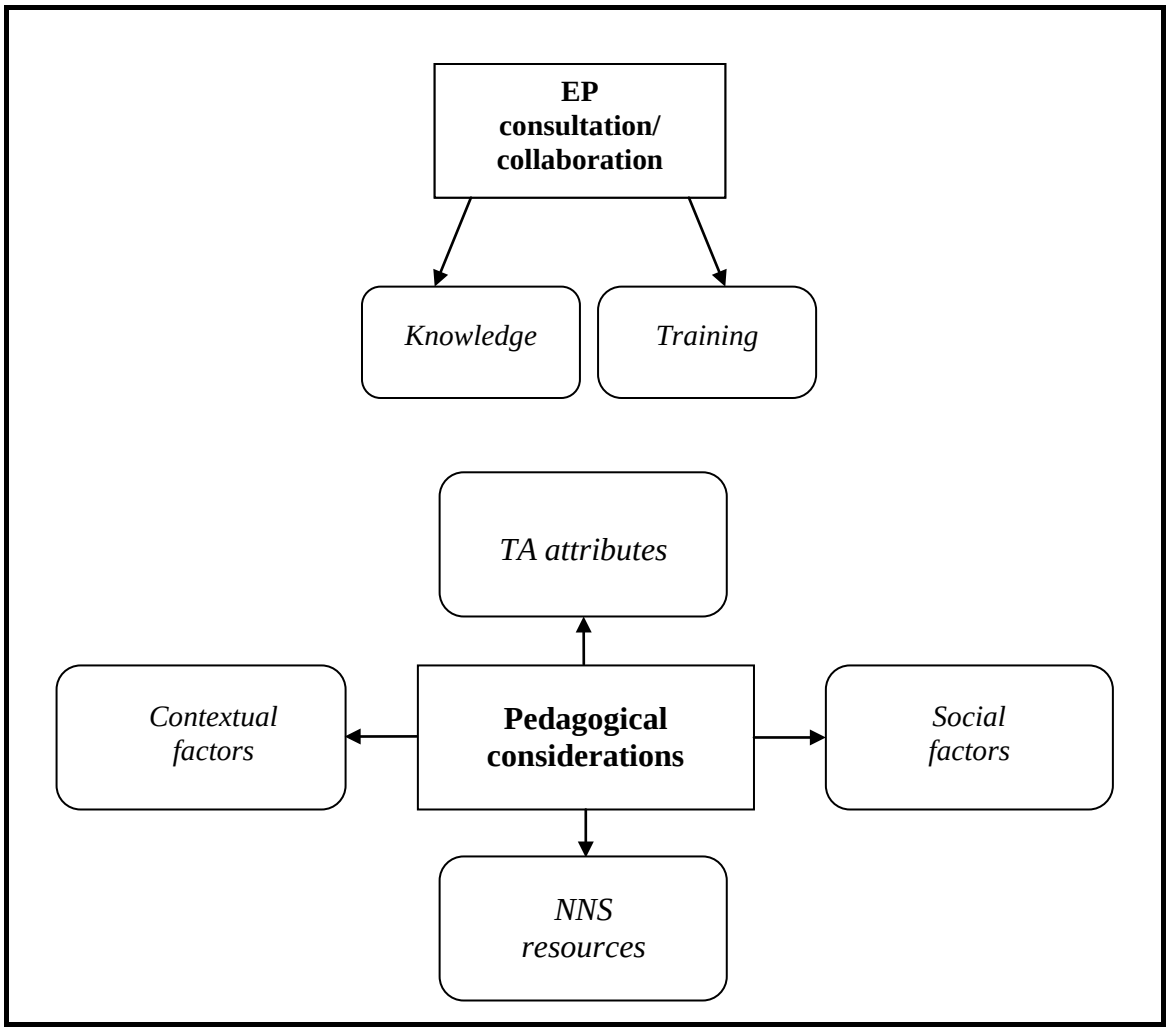

Fig 6: Final thematic map for case study three, showing two main themes

These themes were felt to capture the essence of the data gathered and are discussed in further detail below:

EP consultation/collaboration

The TA felt that working with an EP was helpful especially with regard to feeling confident that '*you are doing the right thing*'. She felt she was more knowledgeable about how to present things to children: 'I *wouldn't have done all the things you (EP) do on my own…I'm glad you came and showed me how things are worded and put to the children*'.

The discussions on the work of Piaget and Vygotsky and more recent research into numeracy difficulties were found to be useful: '*They were useful discussions. It puts things into context. I expected to cover it at college but they didn't do it*'; '*The zone of proximal development was very useful – it made me think about pitching things right'*.

The precision teaching training was '*definitely useful and I've used it loads of times*'. This training was delivered to the SENCo and the nine TAs within the school who had plenty of ideas as to which children they were going to use it with, when and covering what areas. The SENCo commented that she sometimes felt sorry for the TAs as '*teachers get to the point where they can't do any more and hand children over to them*' saying '*do something with them*' with '*no other guidance given and precision teaching could be very helpful here*'. This comment implies that there may be systemic issues around effective deployment of TAs at the school. The importance of TAs to the operation of the school in terms of behaviour management was noticeable during this session where all TAs had been removed from normal duties to participate in the training. The SENCo/deputy head informed me that she had instructed all teachers to plan lessons that did not involve TAs but they were still on '*standby in case anyone kicked off*' and two TAs had to leave briefly to deal with such situations. It appeared that the TAs' behaviour support role was seen as more important than that of raising attainment.

Pedagogical considerations

The four sub themes associated with this main theme are discussed separately below:

TA attributes

The TA had never struggled herself with mathematics and stated that she was '*happy with maths*'. She admitted it was '*frustrating*' working with the target children but '*when they eventually get it and the light bulb goes on it's a lovely feeling*'. The TA eventually hoped to work with older children as she enjoyed the '*challenge, questions and opinions they come up with*'. When asked how her training had prepared her for the role she replied: '*I've learnt more on the job than on the course. I'm loving it'*. The TA acknowledged she had no training on how to deliver numeracy interventions but she wanted to '*know all the different methods of helping them (the target children) improve and develop the skills to do it*'. On a practical level she felt her participation '*should help me with my job and I can use it with other children as well'*. In this sense she had quite high expectations of increasing her knowledge and skills base as well as transferring knowledge to other contexts. At the end of the intervention the TA remarked: '*I wanted to do more. I'm frustrated that I didn't, being ill and everything. I enjoyed it though and I'm gonna carry on*'. This indicates that participation in the intervention was seen as worthwhile and the short term benefits observed so far were worth continuing.

Contextual factors

The TA's prolonged absence due to illness was a factor in this case and she acknowledged progress was slower as a result: '*it's been a lot slower than I would have liked but we're on the road now and I'm certainly gonna continue with it*'. The TA claimed the class teacher was '*not very sympathetic or supportive*' of what she was doing but the SENCo asked for feedback every now and then on how things were going. This seemed to imply the TA was working in a rather awkward atmosphere with little support and limited opportunities for collaboration with the class teacher. Finding the space to deliver the intervention was also difficult as there were so many different interventions going on that most rooms were already in use and so the TA had to settle

for the library which had '*some disturbances but was OK*'. However, she generally did the intervention during assembly time so that rooms were available.

The TA was not surprised that parents had not asked how the numeracy work was going as she felt the '*kids parents don't usually participate in school*'. Parental interest can have a significant impact on children's attainment (Desfourges and Abouchaar, 2003).

I noted during my observations that pupils other than the target children made heavy demands on the TA's time. On one occasion I observed more than half the class line up, snaking around the desks, waiting to show their work to the TA whilst the teacher listened to one pupil read at the other end of the room. I felt this was inappropriate and when I discussed it with the TA, she said: '*Oh it happens all the time. They daren't go to her- she's unapproachable. They want her attention but they're scared she'll bite their heads off*'. This indicated an atmosphere that was not conducive to learning and it later transpired that the school was compiling evidence with which they could construct a case to dismiss the class teacher.

I also noted the inadequate planning and liaison between the teacher and the TA. On more than one occasion the teacher completed the introduction to the lesson which had no relevance to the work the target children were about to do and then handed a worksheet over to the TA and said '*this is what you're doing*'. The TA remarked: '*I'll have about 3 seconds to read it and tune in to it*'. In the short time the TA had been at the school she had experienced much better collaborative work and was aware of better practice. During the previous year she had more planned opportunities to work with another class teacher and wished to continue working like that as '*it were marvellous last year*'. This case demonstrates the significant impact of teacher characteristics and competence on the effectiveness of TAs' work with children and their phenomenological experience of the role.

<u>NNS resources</u>

The TA believed that 1: 1 attention was necessary to provide the '*encouragement and self esteem boost*' needed by the target children to make progress with numeracy along with a '*visual approach using counters and blocks*'. She believed that: '*once their*

confidence is broken, it becomes a mental block and they tell themselves they can't do it'. These views are generally taken into account by the guiding principles of the NNS materials.

One of the main benefits for this TA was being able to work away from the class room with the target children and the independence this provided from the teacher. There was less distraction from other children for both her and the children and working out of class was a '*good experience and something different for them (target children)*'. It also allowed the TA to '*concentrate exactly on weak points*'. She pointed out that '*in big groups you can miss what they aren't getting but in small groups you can give as much targeted specific stuff as they need*' and added: '*I often stopped at times to reinforce ideas based on observations and judging the situation*'.

With regard to the NNS materials she said: '*they're a range of fun ways to teach. The kids love the games and they're learning*'. The group size '*was manageable; you can meet individual needs*'. Even though there was a mismatch with class work the TA felt the materials were helpful as '*short bits of info are better for these kids*'. The TA reported that the she '*loved working with the kids*' and that she '*learnt stuff.*' She felt the children had '*good attention because of the visual materials and short bursts of work*'. She noticed that their '*attitude and confidence was going up*'. She also noticed: '*they got things and when I recapped they remembered so I knew it was working*'. The experience of the small group work was something she could draw on in class to remind them of the work they had done and how it related to the class work tasks. She had no hesitation in recommending the NNS materials and declared she would happily use them again and continue working with the children. In particular she found them to be '*worded well, had a helpful presentation with good ideas and accessible format*'.

<u>Social factors</u>

The TA felt that people were born good at maths: '*if your mind is logical then maths is OK. It's about 90% genetic'*. However, she still felt that: '*everyone can improve – you just need to bring work down to their level- a bit like the zone of proximal development*'. She believed that '*if work is not matched to your way of working then confidence is lost quickly – you just look at stuff and say you can't do it without trying*'. In particular the

idea of '*diagnosing to help fill gaps*' was very important and a helpful feature of the NNS materials.

The TA noticed that the children only seemed confident in her presence: '*I tried to reinforce work in class when possible but the kids need me around, their confidence crashes without me*'. The children appeared to depend upon the TA to reiterate what the teacher had said in a style they understood and to give them regular prompts in the right direction. Without these they appeared unable to carry tasks through to completion independently. The TA felt that maturation and continued exposure to that situation would enable them to develop the skills and confidence to improve, though, the personal characteristics of the class teacher were considered a barrier to that process.

I observed that the target children were rather isolated at the back of the class during whole class activities with their physical isolation adding to the psychological detachment from the rest of the class. They made no attempt to participate and were not encouraged to do so by the teacher. This was no surprise considering the fact that the whole class introduction was pitched at a much higher level than they could access and bore no resemblance to the work they would finally end up doing with the TA. Repeated experiences had made them accustomed to paying no attention to what the teacher said so there was an over reliance on the TA to explain things for them for the first time. In this sense the target children were not included in the mathematical discourse of the rest of the class and effectively restricted to 'low numeracy ability' discourse with the associated negative impact this would have on their identities as learners of numeracy.

As in the other case studies, the TA did not actively foster conceptual mathematical thinking in children aiming instead to transmit, following brief instructions from the teacher, some method of working with numbers that the children had a very limited conceptual understanding of. For example, counting on by drawing 'jumps' on an abstract number line to work out the solution to sums like 8+4=. This was a routine that made little sense to them. The 'jumps' (also referred to as 'hills' by the TA) they drew did not correspond to the actual moves they made and child G and F repeatedly counted the number they started with to get one too few in the answer. When the TA asked why it might be better to begin counting from the bigger number, none of the children gave

an adequate response so she told them: '*then you don't have to draw lots of hills'*. This is an example of how the potential benefits of 'higher numeracy ability' discourse can be denied to these children. The emphasis is on effort, time and the mechanics of tasks rather than conceptual development of mathematical understanding.

The creation of this kind of social learning situation meant that instead of attempting to understand, the children looked for ways of acting that were compatible with the TA's expectations and became skilled at guessing answers, relying on the TA to gradually direct them to the correct answer at which point they received praise for getting it right. They seemed to be no better off conceptually after these experiences than they were to begin with as the content did not address the gaps in their understanding and was dictated by a scheme of work that was inappropriate for them. Often the children would be shown how to carry out mathematical routines in class without understanding and praised for getting it right when tested using similar examples to the ones they had been working on. Cobb (1988) argues that believing that children understand the mathematics based on this kind of observed behaviour and praising them for doing so is misleading.

Even though the children received the intervention for less time than anticipated they made reasonable progress as, contrary to their classroom experience, there was a focus on the gaps in their understanding and they were not expected to move on to new areas until they grasped the concepts being taught. The positive effect of this was reflected in their observed eagerness and enjoyment during the sessions. The TA, who was relatively new to the role, appreciated the pedagogical discussions with the researcher and constructive feedback on how to improve the intervention experience for the children. The TA could not think of anyone else who could have played this welcome supportive role.

Quantitative results

Table 18 shows the results obtained by the three children in the Revised Sandwell Early Numeracy Test (SENT-R) both before and after the intervention. The 'child age' columns refer to the chronological age at the time of testing. Age equivalent figures

are based on the median scores expected for children of that age and in this respect provide a 'numeracy age' for each child.

Pre- intervention (form A)				**Post-intervention (form B)**			
Child (age)	*Standard score*	*Percentile*	*Age equivalent*	*Child (age)*	*Standard score*	*Percentile*	*Age equivalent*
G (6:3)	76	5	4:8	**G** (6:7)	79	8	5:4
H (6:8)	70	2	4:9	**H** (7:0)	71	3	5:2
I (6:10)	84	15	5:7	**I** (7:2)	82	12	5:11

Table 18: SENT-R results for case study three.

These results show that two children (G and H) began well below average age related expectations and one (child I) just below average. They made 8 months, 5 months and 4 months numeracy progress respectively within the period of four months that the intervention spanned, although they only received the intervention for three months due to TA absence. Child I was the only child in the study whose standard score fell from just under average at 84 to a lower 82. This cannot be accounted for by the fact that he moved age bands as all children except child B also moved age bands and managed to improve their performance. It may be due to the fact that he did not receive crucial scaffolding to consolidate his understanding and make the conceptual shifts necessary to accelerate his progress from the level he was at to begin with. Child G and H started from a much lower point and therefore needed to make more basic progress in order to enhance their final score and may have been on the brink of developing these skills from a maturational perspective.

Table 19 shows the scores (out of a maximum of 30) from the children's attitude to numeracy questionnaire (appendix 3). Question 3 was omitted from the analysis as it was designed to compare literacy attitudes to numeracy attitudes rather than add to an overall measure of children's attitude to numeracy.

Child attitude questionnaire (case study three)	**Child**			**Mean**
	G	**H**	**I**	
Pre intervention score	23	24	18	21.7
Post intervention score	29	24	18	23.7
Change per child	+6	0	0	+2

Table 19: Child attitude questionnaire results for case study three.

These results show a mean increase of 2 with only child G producing an overall gain. The ratings provided by the other two children differed between pre and post intervention but the overall changes cancelled each other out. Crucially, all children increased their rating to being 'happy' or 'very happy' about numeracy lessons and to 'good' or 'very good' for how good they felt they were at numeracy. Child G made the largest gains by moving up from a 'sad' and 'not good' rating respectively for these questions. There was no corresponding shift in attitude to literacy which remained the same or became lower, indicating a specific shift in attitude to numeracy. Child G responded particularly well to the adult interaction she received and would hug the researcher and TA during numeracy sessions to express her happiness with the small but important achievements she made and comfort with the social situation she found herself working in.

Table 20 shows the results from the TA questionnaire (appendix 4). The table shows the change in response to each individual question for every child and a total change per child and per question.

TA Questionnaire (case study three)	**Child**			**Change per question**
	G	**H**	**I**	
1. is happy to do numeracy work	0	0	0	**0**
2. is keen to do well and tries hard	1	0	2	**+3**
3. actively participates in numeracy lessons	1	-2	-1	**-2**
4. can work out answers in more than one way	1	0	0	**+1**
5. will try even if the work is challenging	0	1	1	**+2**
6. can explain how they arrived at an answer	1	1	0	**+2**
7. can spot their own errors if they talk through the problem	1	0	0	**+1**
8. makes the same errors over and over again	0	1	1	**+2**
Change per child	**+5**	**+1**	**+3**	**+9**

Table 20: TA questionnaire results for case study three.

Out of a possible maximum of 40, the mean pre-intervention score was 22.7 and the mean post intervention score was 25.7, producing a mean gain of 3. All questions produced a positive gain except for question 3. The TA reported that there was a '*drop in confidence*' in the transfer to the classroom. The children were more secure in the

small group setting and willing to take risks but this disappeared once they returned to the main class as they were '*aware of their lower ability*' and understandably unwilling to set themselves up for public failure. This contrast was particularly noticeable to the TA as she was now able to make a comparison between the children's functioning in two different environments whereas previously she only had the classroom to go on.

4.5 *Cross Case Study analysis*

Table 21 illustrates the mean gain for all nine child participants in the three case studies on the numeracy test (SENT-R), child attitude and TA questionnaires.

Instrument	**Mean gain**
SENT-R	9.6 months
Child attitude questionnaire	4.0
TA questionnaire	4.7

Table 21: Mean gain for all participants

Table 21 shows that the nine child participants made approximately 10 months numeracy progress during the four months that the intervention was conducted which equates to a mean figure that is nearly 2.5 times the expected level, indicating that the numeracy progress of the children involved may have been accelerated by the intervention. This figure conceals the individual differences in progress discussed in the individual case study sections above and so needs to be treated with caution. It is worth noting that although there was a four month interval between pre and post assessments of the children's numeracy ability, the actual intervention was conducted over a shorter period. The Christmas and half-term holidays, participation and rehearsals for Christmas activities and the effects of a particularly bad winter (coldest for 31 years; Gabbatt, 2010) all served to reduce the time available for the intervention. However, these factors reflect normal school practice and therefore are expected features of a real life study such as this.

The underlying belief was that children's numeracy ability is affected by a myriad of factors both within and beyond school based learning activities and is not confined to the times when the intervention is being conducted although arguably there is an intense

focus at these times that is unlikely to be replicated elsewhere in the child's life. Isolating the exact components that lead to improved performance in the post-intervention assessment is therefore difficult and so the intervention was deemed to have covered the full four months to reflect the developmental and maturational time experienced by the children between the formal numeracy assessments. The fact that all children made progress equivalent to four months or more despite the time limitations mentioned above indicates that the intervention is probably likely to have played a part in accelerating their numeracy progress.

The results from the child and TA questionnaires compare favourably to those gathered by the Every Child Counts Team (2009). Although not identical, they used similar questions with nearly 2500 children and found the mean gain for their child questionnaire to be 1.7 and their TA questionnaire to be 3, which equates to a gain of 8.5% and 7.5% respectively.

The results from the child attitude questionnaire (see appendix 3) showed an average 13.3% increase in the positive attitude of the children. A content analysis of the brief comments received in response to question 8 at the end of the questionnaire showed that all children were 'happy' to have participated; they either 'liked' it or claimed it was 'lovely'. The games built into the NNS resources were singled out by most children as particularly enjoyable. All children increased their score for the 'like numeracy' question to 'happy' or 'very happy' if not already there. The TA questionnaire (see appendix 4) showed an average 11.8% positive increase in the TAs' perception of the children's attitude to and participation in numeracy lessons. Comments made by the TAs at the end of the intervention referred to the children having more 'confidence', 'motivation', 'retention' and 'enjoying' numeracy. These results indicate that both questionnaires were sensitive enough to pick up positive changes over the four month period of the intervention in both the children's attitude and the TAs' perception of their attitude and participation in numeracy lessons.

Figure 7, below, illustrates the factors revealed by the thematic analysis of qualitative data from all three case studies that affect TAs' pedagogical style with regard to using the NNS materials to support children with numeracy difficulties.

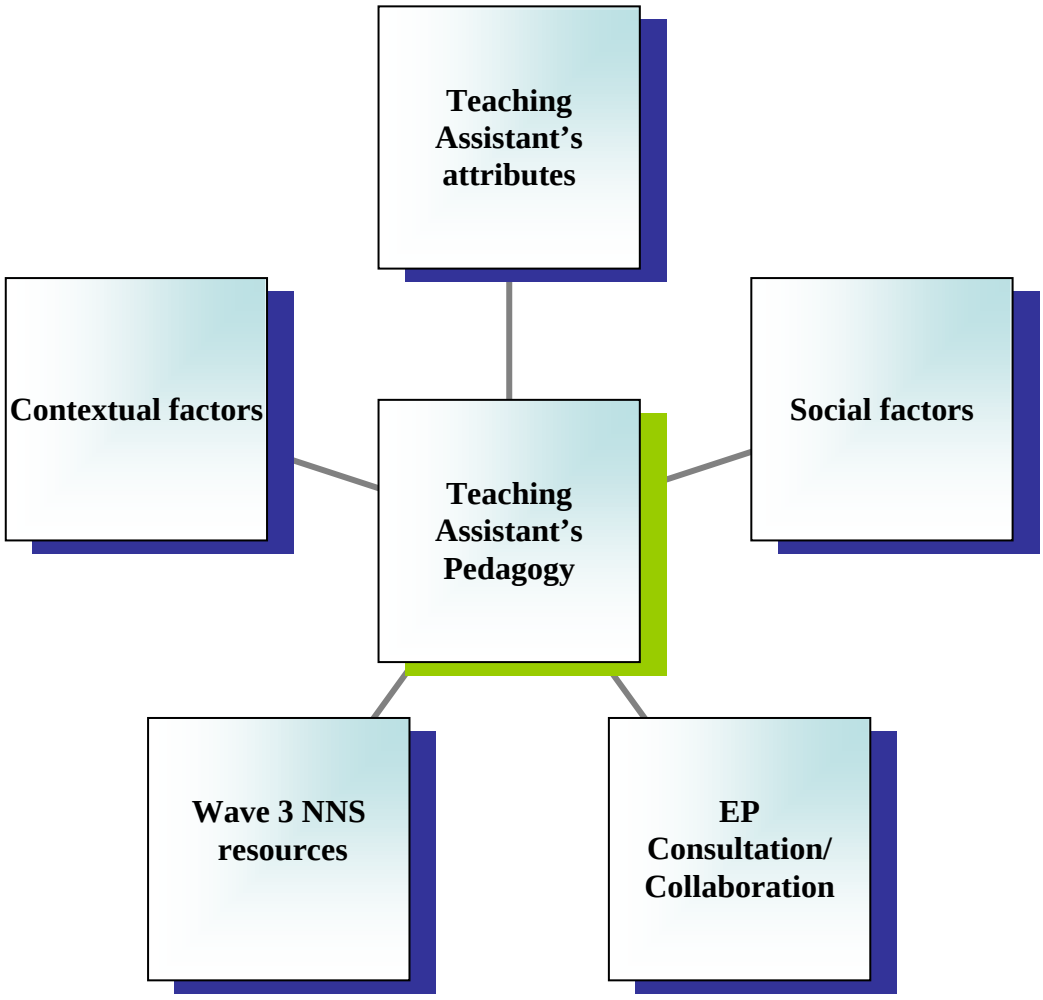

Figure 7: Factors that were found to affect TA pedagogy

The figure shows five factors that were seen to impinge upon the pedagogical style of TAs. These are discussed in greater detail below:

Teaching Assistant's attributes

All three TAs had a positive attitude to their role in developing the numeracy ability of the children they worked with. Even though some felt there was a significant genetic component to numeracy ability this did not affect their belief that children could make progress given the right level of support. They understood their role as one involving diagnosing difficulties and targeting them in a manner specially designed for individual children's needs. There was also an awareness that they were engaged in socially constructing numeracy knowledge and skills with the children and that they were

representatives of the wider mathematics community introducing children to the ways of knowing and working with the subject. Displaying appropriate enthusiasm and confidence were therefore important factors that influenced the perceptions of the children and are closely tied to the TAs' own mathematical self concept (Thompson, 1984; Ernest, 1989; Pepin, 1999). This demonstrates the pivotal role played by TAs in making this intervention a success.

In line with research on the factors that affect teachers' mathematics teaching pedagogy and understanding (Thompson, 1984; Ernest, 1989; Simon, 1995; Brown *et al.*, 1999; Pepin, 1999), this research shows that TAs' pedagogy and understanding is also strongly based on their affective experiences as learners of mathematics themselves. Two TAs stated how these experiences had shaped their instructional practice for the better through the correction of the perceived failures of their own teachers. The TA who had a stronger grounding in mathematics was 'frustrated' by the low ability work she was involved in and hoped to move into a more challenging secondary school environment in the future. Since all three TAs stressed that they learned on the job without any specific training; the effect of their own knowledge, attitude and beliefs would have had a significant impact upon the way they presented mathematics to the children. Personal characteristics coupled with empathy for the children were key factors in presenting an accessible numeracy experience involving warmth, lack of anxiety and the valuing of children's opinions and experience. Development of confidence and enthusiasm in children were seen by all TAs as indicators of success and personal fulfilment.

Social Factors

There is no getting away from the powerful influence of the social context within which TAs work. They recognised their crucial role in fostering an atmosphere that was conducive to learning within their groups and maintaining children's self esteem through their interactions. The small group situation lent itself to alleviating anxiety in children and enabling them to take risks with asking questions and making suggestions in a safe environment. The children's identities as numeracy learners were also influenced through this social process with all TAs claiming that they could use the positive experiences of small group work to help children re-construct their whole class

numeracy identities. Reminders of how they could manage in the small groups and creating links between small group and whole class numeracy content assisted the children in overcoming mental barriers to success in the classroom. Some children, especially those in case study two, were beginning to transfer their confidence into the classroom setting but many over relied on the TA to support them in class in a similar manner to the support and encouragement they received in the small group setting.

Peer collaboration and shared understanding were facilitated through joint discussions reflecting the socially constructed nature of mathematics and the fact that learning is the social construction of meaning (Pepin, 1999). However, there were lost opportunities to advance children's understanding by fostering conceptual mathematical thinking. Although TAs can never really know what is going on inside children's heads they should aim to facilitate cognitive restructuring and conceptual reorganization (Cobb, 1988). This can be achieved through an appreciation of working within their *zone of proximal development* and *scaffolding* them to the point where they are able to *internalize* mathematical meanings, socially constructed with the TA (Vygotsky, 1991).

Contextual factors

All TAs identified a lack of liaison time with the teacher and lack of training in current methods of working with children who have numeracy difficulties as constraints on their ability to perform their role satisfactorily. Supportive teachers and sympathetic senior management teams were noted as facilitating factors in the adequate delivery of this and other interventions. This is acknowledged by the NNS resources which call for a whole school approach involving the leadership team if possible (DfES, 2005c). Although this will inevitably be affected by the objectives identified within the school's development plan.

Both of the least experienced TAs were being expected to manage whole teaching episodes based on a few moments notice and understandably felt this was impeding their ability to meet the children's needs. Parental involvement is associated with enhanced achievement (Desforges and Abouchaar, 2003) and appeared to be a facilitating factor in case study two but was notable by its absence in the other case studies.

A further contextual factor is the exact nature of the children's numeracy difficulties. Research cited in section 2.4 illustrates how complex this area is. Numeracy is a multi-dimensional entity and children can have marked discrepancies in virtually any two components. There is a wide variation in the characteristics of such children, the expression of their deficits and the causes of their difficulties (Augustyniac *et al.*, 2005; Gersten *et al.*, 2005; Dowker, 2004 & 2009). This makes deciphering the exact nature and hence the best course for addressing difficulties problematical for TAs without collaborating with professionals such as EPs with specialized knowledge.

Wave 3 NNS resources

All TAs found the NNS materials to be a valuable addition to their repertoire of resources for working with children with numeracy difficulties. Their easily adaptable nature, suggestions for scaffolding and responses to misconceptions, focus on commonly occurring types of numeracy difficulty, focus on acquiring vocabulary and written recording methods and game style activities were all mentioned as particularly useful features. The time saving aspect of the materials in terms of being a ready resource coupled with the added confidence of knowing that the tried and tested activities contained within them will work were also helpful features according to all TAs. The idea of filling gaps was considered a useful metaphor to describe the intention behind the NNS materials and the goal of TAs in supporting children.

All TAs shared beliefs and attitudes towards pedagogical practice which were compatible with the guiding principles of the wave 3 NNS materials (DfES, 2005c) but benefited from EP support to operationalize them. These included using a variety of engaging materials and activities, making explicit the objectives of each session, inviting and valuing children's contributions, linking mathematics to real life contexts and modelling key vocabulary and recording methods. As would be expected, there was a marked difference in the confidence and adaptation skills of the experienced TA in case study one compared to the other two less experienced TAs who generally followed the suggested activities as they were presented in the materials. Compared to other numeracy interventions, the NNS materials were seen as challenging enough to

promote development in children even though at first they appeared ‘too hard’ for some TAs.

EP consultation/collaboration

All TAs valued the opportunities to collaborate and consult with the EP (researcher). None of them had used the NNS materials before and only the TA in case study one had done a different numeracy intervention in the past so modelling the NNS materials was an essential aspect of this intervention. Gross (2007 and 2009) specifically advocates this role for EPs in order to scaffold later independent use by TAs. The TAs felt reassured that they were doing things correctly and valued the opportunity to share ideas and discuss matters during consultation including discussing learning theories and recent research into numeracy difficulties. They felt this made them more knowledgeable and this may be because it enabled them to piece together the fragmented psychological theory and pedagogical practice they had encountered throughout their lives and construct a more meaningful structure by focussing on specific, real life children’s difficulties in consultation with a psychologist.

Training on instructional psychology methods, especially precision teaching transformed the way TAs worked on building fluency in basic skills with children. Fluency in basic numerical skills has been found to be consistently lacking in children with numeracy difficulties and reinforcement of numerical facts so that they are more easily retrieved is beneficial in terms of promoting conceptual and procedural knowledge of abstract mathematical principles (Geary, *et al.*, 2000; Gersten, *et al.*, 2005). This leads children to develop less time consuming methods, acquire increased confidence and further develop their numeracy at a conceptual level so that they are more likely to retain their learning and apply it in novel situations (Cobb, 1988). Developing conceptual mathematical thinking in children was an aspect of pedagogy for which TAs required EP support. This involved an increased focus on appropriate pacing to enable teaching for understanding, regardless of the time taken, and encouraging TAs to move away from defining progress through amount of content coverage. This drive to cover content filters down from teacher expectations and without EP support would have been difficult for TAs to modify.

The TAs welcomed the opportunity to work with an EP (researcher) and could not think of anyone else who could have provided the support given. The involvement of an external professional meant that there was additional time for liaison that was otherwise virtually non-existent and the benefits of this collaboration were reflected in increased confidence amongst the TAs and children involved. Simple exercises such as thinking about the inappropriate and appropriate responses that they might receive from children to the NNS materials, anticipating potential questions and practising model responses allowed TAs to develop a deeper understanding of the numeracy work to be covered, highlighted connections that could be made with other areas and boosted their content knowledge and hence their confidence. It also enabled useful reflection and development of TAs' knowledge of the children as learners which could be used to better target the intervention.

From an ethical perspective, the NNS materials coupled with EP support served to enhance equality of access to the curriculum by highlighting the need for TAs to move beyond a 'low numeracy ability' discourse for the children involved. The consultative/collaborative approach was also a useful vehicle through which gaps in TAs' curricular or pedagogical knowledge and competence could be challenged or addressed.

CHAPTER 5: DISCUSSION

5.1 *Overview*

The underpinning premise for this study was to test the ideas put forward by various researchers that TAs could deliver interventions satisfactorily given appropriate training and support (Blatchford *et al*., 2009; Alborz *et al*., 2009; Williams, 2008; Dowker, 2004; Ofsted, 2002) and that there may be a role for EPs in facilitating this process with regard to numeracy interventions (Muijs, 2003; Gross, 2007 and 2009; Mackenzie, 2007). The intention was to use the results of this study to potentially inform a more systemic approach to tackling numeracy difficulties which EPs could usefully engage in. Specifically, this research aimed to answer the following questions:

1. What impact do the NNS intervention materials, delivered by TAs with EP support, have on:
   a) the attainment in numeracy
   b) the attitude to numeracy
   of children with numeracy difficulties?

2. What features of the collaboration between EP and TAs may be associated with positive outcomes for the children involved?

Sections 5.2 and 5.3 consider answering the research questions in turn based on the data gathered by the methodology, described in chapter 3, and results reported in chapter 4.

5.2 *Research Question 1*

The impact of children's attainment was measured using the Revised Sandwell Early Numeracy Test (SENT-R). This indicated that all children had made progress equivalent to or greater than the expected four months between pre and post testing. The two children who made only four months progress were both disadvantaged by prolonged absences of one month; either their own or that of their TA. Despite this, their progress was equivalent to the period that the intervention spanned and implies that they made faster progress in a shorter time. Although it is difficult to isolate the

effect of the intervention from other factors that influence numeracy development such as timetabled lessons, maturation and life experience. Those children who participated in the intervention without the confounding effect of absences made a minimum of 6 months progress and most made more than that; the average being 9.6 months. This would indicate that the intervention had a positive effect on the children's attainment. The fact that these results were obtained on a standardized test designed for this age group with the specific purpose of monitoring the impact of teaching interventions on their rate of progress using a finely graded scale (Arnold *et al.*, 2009b) adds a certain validity and reliability to the results. National curriculum test results do not reveal the full profile of children's numeracy ability as strengths and weaknesses are compounded into one result or level and can be affected by poor reading ability, which is a factor for the children in this study and has been shown to affect children's numeracy ability (Jordan *et al.*, 2003; Geary *et al.*, 2000).

Furthermore, all children apart from one (child B) moved age bands between pre and post testing. Since the age equivalent scores indicate the age at which the child's test score is the median score, it would follow that children whose chronological age is at the lower end of the six month age band are at a relative disadvantage. However, all children made progress in age equivalent terms despite this, indicating that considerable progress had been made in order to secure a higher score in the alternative form of the test. It needs to be borne in mind that age equivalent scores have important statistical and conceptual limitations as indicators of ability therefore the associated standard scores and percentile ranks must also to be taken into account when interpreting changes in ability (Elliot, Smith and McCullough, 1996; Cooley, 2004).

The intervention was particularly effective in boosting the attainment of all children in case study two into the average age-related range, though all children in case studies one and three narrowed the gap between their chronological age and their numeracy age, as measured by the SENT-R. Child D, from case study two reached above average age related expectations probably because the intervention played a significant role in helping him to acclimatise to his new learning environment. It is possible that the children in case study two were not as weak to begin with and so were predisposed to make more rapid progress. However, comparison with child I, from case study three, who attained a similar pre-intervention score on the SENT-R but experienced a weaker

intervention, would suggest that the intervention experience had a noticeable effect on the progress made. In this study, the noteworthy factors present in case study two but absent in case study three include effective partnership between school, class teacher and TA; parental interest in the children and no long term TA absence.

A further consideration to bear in mind when deciphering the impact of this intervention is the Hawthorne effect (Olson, Verley, Santos and Salas, 1994). This states that simply being studied produces improvements in a participant's performance and, in this research, increases in children's attainment might be due to the positive effects of receiving attention through the TA/researcher; allowing opportunities for reflection on how to improve their numeracy or because the sessions provided them with performance feedback they would not otherwise have and this extra information allowed improvements. However, there is a strong likelihood, based on accumulated evidence drawn from TAs, children and research diary data, that the intervention itself authentically produced the increased attainment of all children. This is especially so since the advancements made in the test reflect the numeracy work covered in the intervention rather than class work. The content and format of normal lessons was not easily accessible to the children and served to compound their identities as 'weak at numeracy'. TAs pointed out that the children struggled to transfer their emerging confidence from the group sessions into the classroom without intense support but were managing to transfer numeracy knowledge from one setting to another with contextual prompts.

Triangulation of the various data sources indicates that the intervention also had a positive impact on children's attitude to numeracy. The child questionnaire showed an average 13.3% increase overall in positive attitude towards numeracy. This finding is strengthened by the fact that no child revealed an increase in positive attitude towards literacy lessons over the same period. These remained the same or fell by one point, indicating that the questionnaire coupled with the 'semi-structured interview' style of delivery was probably a reliable tool in measuring children's attitudes to numeracy. Individual differences in the children's subjective categorization of their attitudes and their perceptions of the attitudes of significant others were taken into account by analyzing only the change between the child's declared initial position and their final position at the end of the intervention. This nullified the effect of some children's

overly optimistic responses compared to their observed ability, TAs' verbal reports and the responses of more modest peers.

Banister *et al.* (1994) notes how researchers understandably want their study to succeed and can inadvertently communicate this anxiety to the participants and introduce bias into the study, as a result. The administration of the pre and post numeracy testing and the child questionnaire were carefully conducted by the researcher to ensure that any such bias was minimized if not completely eradicated. Another reason for the researcher's involvement with the numeracy testing and child questionnaire was to ensure a consistent approach across all case studies and ensure that all procedural aspects were carried out accurately in a standardized manner. This would have been difficult to guarantee if the task had been delegated to individual TAs at each case study school.

The TA questionnaire (appendix 4) showed an average positive increase of 11.8% in the TAs' perception of the children's attitude to and participation in numeracy lessons. The same TAs filled in the questionnaires at pre and post intervention stages so individual interpretations probably remained constant throughout and had little effect on the change in perceptions demonstrated. However, there is the possibility that interpretation of questions differed between TAs at different schools and this may have affected the changes observed, though the use of clear statements and simple categories may have helped to minimize this variability. All TAs reported observable changes in the children they worked with and these were reflected in the final scores they gave them.

Both the child and TA questionnaires have only been used for this study and have appropriate face and content validity but construct validity and reliability measures remain to be ascertained. It seems unlikely that the TAs were displaying demand characteristics in attempting to confirm a perceived desirable outcome for the study as they had no advantage to gain from doing so and all were scientifically minded enough to state that they would let the researcher know if they felt the intervention was not working. Crucially, there was a general positive correlation between the TAs' scores for the change observed in individual children and the number of months numeracy progress made by the child in the SENT-R. This indicates a positive relationship

between the questionnaire data on TAs' perception of children's attitude and participation and their progress as measured by the standardized numeracy test which adds reliability and validity to the findings.

In summary, the NNS materials delivered by TAs with EP support had a substantial positive impact on both the attainment and attitude of the target children towards numeracy. Most importantly, TAs, Parents and children, appeared to attribute these positive changes to the impact of the intervention. However, isolating the single factor responsible for the perceived effects is virtually impossible and a combination of factors is likely to have produced the outcomes revealed by the data and even these are likely to differ between participants. Therefore, it would be fair to say that the intervention, alone, is not responsible for the beneficial changes noted by this study but a set of, as yet, unidentified factors play a role alongside it. These could involve other aspects of the intervention experienced in parallel to the content, such as the sympathetic attitude, safe social atmosphere, focussed attention, sustained interest and task presentation skills of the TA and EP.

5.3 *Research Question 2*

The collaboration between EP and TA in this research can be associated with positive outcomes for the children involved. The TAs valued the opportunities to liaise with the researcher and claimed that consultation and collaboration with an EP altered the way they thought, felt and behaved in relation to the children's numeracy difficulties. These changes were associated directly with EP collaboration and TAs claimed that they could not think of another professional who could provide this support and certainly had no experience of working in this manner before. Evidence gathered from the various data sources would suggest the following were useful features of the collaboration between EP and TAs:

1. **Modelling the NNS resources.**

Bearing in mind these resources have been available for just over five years, teachers, TAs and numeracy coordinators at all the case study schools were unaware of their existence. This is rather unfortunate considering the amount of effort and evidence

gathering that has gone into producing the materials (see section 2.6). In fact it would be fair to point out that without participating in the current research, these schools would still be unaware of the NNS resources and the potential benefits they could deliver to their numeracy provision. Once available, however, schools were impressed by the structure and relevance to the needs of their weaker children and all expressed a desire to continue using them beyond the intervention period.

Modelling the materials was a key component of this intervention and one advocated by Gross (2007 and 2009) as necessary to scaffold later independent use. TAs acknowledged that without this they may have considered the materials too difficult to use, both in terms of learning to work with a new resource and perceived appropriateness of content to the numeracy needs of the children. The hierarchical nature of the staffing structure within schools also meant that TAs, especially less experienced ones, were unlikely to embark upon new activities without the express backing of the teacher or senior managers. Since the main thrust of teachers' energy seemed to be towards working with more able children in a bid to boost the results by which the school would be judged, this backing was seldom a priority. This manner of working with TAs, reflects the pedagogical approach noted by Hancock and Eyres (2004) where teachers are viewed as 'core' and TAs as 'peripheral' and goes against the grain of inclusive pedagogies that promote collaborative practice. The EP, in this scenario, has the potential to promote collaborative practice with TAs and support them in adopting a more central role in delivering a numeracy intervention by providing them with the necessary scaffolding to overcome barriers to independent use.

A further rationale for modelling the materials was to encourage the development of practice that reflected the intended goals of the NNS materials. The TA-NNS relationship required EP support as it involved a process of unlearning and learning again and making changes like this can cause feelings of discomfort that can be unpleasant and intimidating (Handal and Herrington, 2003). Feelings of self efficacy in teachers (including TAs enacting a teaching role) are highly influential in pedagogical decisions and teaching is deeply connected to the formation of an individual's identity therefore changing teaching requires identity reformation (Smith, 1996; Remillard, 2005). The individual resources and perspectives of TAs go some way to explaining the differences in approach seen while they were working with the same NNS materials.

2. Conducting diagnostic assessments.

Part of the modelling of the NNS resources involved using tracking charts to identify common errors and misconceptions with numeracy learning. These are then addressed using a booklet designed to cover that particular error/misconception out of a series of booklets. The booklets draw on current psychological understandings of how all children learn and on recent investigations of appropriate pedagogies for children with special educational needs (Gross, 2007). In this way the NNS resources form diagnostic tools that enable a targeted approach to address children's specific numeracy needs which have been shown to be the most effective way of improving children's performance and self confidence (Dowker, 2004 and 2009). Both Dowker (2004) and MacKenzie (2007) recommend that EPs carry out a combination of standardized tests and diagnostic interviews, which may be impractical for teachers or TAs to carry out, in order to extract useful information to support children's numeracy development.

In addition to the NNS diagnostic charts, the Revised Sandwell Early Numeracy Test (SENT-R; see section 3.5.1) was also used to provide diagnostic information with regard to children's numeracy strengths and weaknesses. This diagnostic information combined with the hitherto untapped area of TAs' knowledge, beliefs and attitudes with regard to numeracy (untapped by research in general, that is) provided a richer understanding of children's needs and what could potentially be done to address them.

In addition to this, further diagnostic support was provided through conducting tests on memory performance, especially working memory. These tests are generally unavailable to TAs but provided important information on cognitive functioning and formed the basis for consultation over the best strategies to employ to support children's memory needs. See section 2.4 for a discussion on the role of working memory in numeracy difficulties. The diagnostic tests used in this study reflect the identified needs of the participants but this does not preclude the use of any other tests that are available to EPs and in their professional judgement would shed light on a child's numeracy difficulties.

3. Shaping pedagogical practice through facilitating access to psychological theories and contemporary research into numeracy difficulties.

All TAs had some knowledge of the work of Piaget, Vygotsky and other psychologists but this was limited and fragmented in nature. Revisiting the work of these two theorists in particular with specific children in mind enabled them to construct a better understanding of how the theories related to the actual children they worked with. For example, the words 'zone of proximal development' now meant something meaningful in terms of actual steps to take to further children's progress and developed TAs' understanding of their own role within this theoretical concept.

Discussion of more contemporary research into numeracy difficulties was useful in putting into context some of the experiences of TAs. For example, TAs believed that children sometimes gave random answers to questions that reflected their lack of understanding but were interested to learn that this may be due to a retrieval difficulty found amongst children with numeracy difficulties. These children have trouble inhibiting other facts when they try to access specific numeracy facts from long term memory such as 2+3. In addition to the answer 5, they might also have 4 (the number following 2, 3 in the counting sequence) and 6 (the answer to 2x3) pop into their heads at the same time. With so many facts being remembered simultaneously, the children take longer and are prone to make more errors as they consider all the options and pick what they think might be the correct answer (Geary, 2004). Of course this is happening within the social context of the numeracy group and this involves interpreting other cues provided by the TA and the environment which only adds to the difficulty faced by the child. TAs found this knowledge useful and felt that it helped them to empathize with and support children better by developing strategies to aid there recall skills.

TAs were updated on current understandings of practice that enhanced the progress of children with numeracy difficulties. These included understanding the socially constructed nature of mathematics and their role in creating shared mathematical meanings; fostering the development of conceptual mathematical thinking in children (Iannone and Cockburn, 2008; Cobb *et al.*, 1992a; Cobb, 1988) and the development of conceptual connections within and between different areas of mathematics (Askew *et al.*, 1997). This involved developing TAs' understanding of their role as representatives

of the wider mathematical community and ethical duty to enable children to access 'higher numeracy ability' discourse. TAs felt they were more knowledgeable following these discussions and developed a better understanding of why certain methods may be associated with more positive outcomes for children.

4. Instructional Psychology methods.

There is a consistent finding that children with numeracy difficulties have deficits in the retrieval of basic numerical combinations and employ less sophisticated counting strategies. Rapid retrieval of numeracy facts and adopting more mature counting strategies serve to build conceptual and procedural knowledge of abstract mathematical principles (Gersten *et al*., 2005; Geary *et al*., 2000). These in turn, make numeracy less time consuming, boost confidence and conceptual understanding so that knowledge is more likely to be retained and applied in novel situations (Cobb, 1988).

Instructional Psychology (Frederickson *et al*., 2008) and specifically Precision Teaching was useful in developing the necessary fluency in children with basic numerical combinations in order to pave the way for more conceptual development. Training on the method and support with creating probe sheets, monitoring and evaluating progress were well received and incorporated into TA practice immediately. Chiesa and Robertson (2000) showed that the fundamentals of precision teaching (fluency training, frequent monitoring, daily practice, time probing, individualised tasks and 1:1 attention) brought rapid improvements for pupils whose previous numeracy performance was a cause for concern. This was also the case for the children in this study and TAs and schools were appropriately enthused by the results to consider extending the method across the school to cover other groups of children. TAs reported that using precision teaching to address basic numeracy skills led to a transfer of confidence into other curriculum areas. This fits with the findings of Downer (2007) who found that academic self concept and general self esteem were improved through successful precision teaching experiences. EPs can provide schools with access to instructional psychology methods through training and consultation which this research reveals is likely to have a significant and immediate positive impact on the numeracy experience of children with difficulties.

5. Consultation.

Consultative practice based on the approach presented by Wagner (2000) was essential to the successful delivery of all of the above. TAs acknowledged that courses and other types of one-off training sessions were less effective in changing their practice as they did not directly confront the daily challenges of their work. The focused nature of consultation sessions with an EP made them more likely to facilitate change and their frequency made it more likely that change would be maintained. Gross (2009) suggests use of consultation skills could be a unique role for EPs in tackling numeracy difficulties and this study would lend support to that view. The fact that TAs acknowledge that they derive much of their expertise in tackling numeracy difficulties from 'experience on the job' makes this EP role ever more crucial in raising attainment.

A consultation approach sat easily with the social constructionist epistemology adopted by this research. It allowed TAs' knowledge, beliefs and attitudes to be taken into account and psychological and pedagogical discussions were centred on the child recipients of the intervention and what was realistically achievable given the contextual constraints. This enabled the construction of targeted strategies that were likely to be applied with conviction by the TAs involved and more effectively address the concerns raised during consultation. Kennedy, Frederickson and Monsen (2008) suggest that ensuring consultees have the necessary self-efficacy to capably intervene and providing them with appropriate training, if this is lacking, are essential factors for EPs to consider within consultations to ensure commitment to action. They also stress the 'degree of fit' with the classroom ecology is an important consideration that needs to be borne in mind. This research also lends support to the findings of Farrell *et al*. (2000) who note that TAs prefer training to be directly related to their work and value the opportunity to be consulted about the planning and review of pupil's programmes.

A fundamental factor in the success of consultation is time. Alborz *et al*. (2009) and Blatchford *et al*. (2009) along with other researchers have stressed the lack of liaison time between teachers and TAs and described how this has a detrimental effect on their work with children. Even though this lack of liaison time is often reported and lamented, little seems to have changed in the working partnerships between teachers and TAs. This research suggests that EPs could step in to provide a vital service to

schools in raising achievement by effectively increasing the liaison time available to TAs. The consultative approach has shown itself to be a useful vehicle through which gaps in TAs' curricular or pedagogical competence can be identified and addressed in order to promote the numeracy progress of the children they work with. It also fits with the increasing realisation of many EPs that they can more effectively promote and accelerate children's learning by working with adults who are regularly in direct contact with them (Love, 2009).

5.4 *A model for EP and TA collaboration on NNS interventions*

Figure 8 illustrates a model for EP and TA collaboration on delivering NNS interventions including the features that this research has found may be associated with positive outcomes for children.

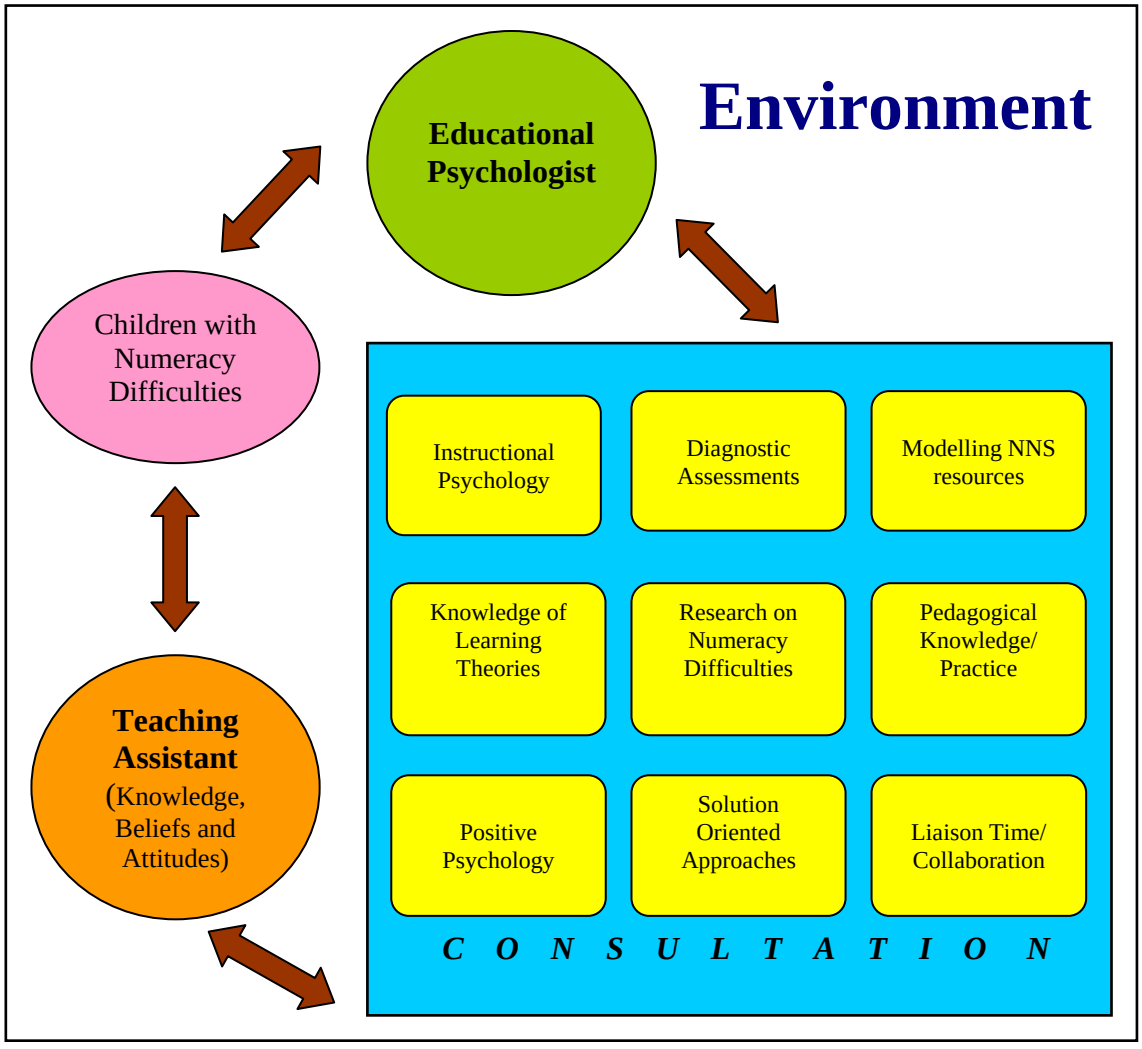

Figure 8: A model for EP and TA collaboration on NNS interventions

The model uses two way arrows to emphasize the reciprocal nature of all interactions: all participants mutually influence each other's behaviour. This is in keeping with the social constructionist epistemology adopted by this research and highlights how all participants are endowed with the same qualities as the researcher. That is, they are all self conscious social actors who can modify their behaviour to take into account both their internal states and external conditions. They can also use language to formulate, communicate and apply complex and various meanings to their experience. These qualities make the identification of specific causal relationships within the system depicted by the model complicated. However, the interview and observational methods adopted by this research served to enhance the ability of the researcher to acquire and understand the participants' multiple social constructions of meaning and knowledge.

The inescapable influence of the environment is highlighted by the outer square within which the various components of the model are enclosed. These include but are not limited to: influence of the community, social background and social attitudes to numeracy; level of facilitating pre-school learning experiences; adequacy of school learning experiences/curriculum; quality of teacher-TA relationship; level of parental interest in the child's numeracy and demands on EP working practices. Needless to say, the quality of the EP-TA relationship is of paramount importance in the success of any collaborative work.

The model also emphasizes the use of consultation skills in the process of collaborative work with TAs (see also section 5.3). Most of the aspects illustrated in the model, apart from Solution Oriented Approaches and Positive Psychology, have been discussed in sections 5.1 and 5.2 and in the interests of brevity will not be repeated here. There are many Solution Oriented Approaches (De Shazer, 1985; Evan, Iveson and Ratner, 2006) but the ones used in this research included Building on Success, Exception Finding, Preferred Future and Rating Scales. These were specifically used to facilitate TA-EP discussions during consultations with a view to utilising the personal resources of TAs to overcome any challenges and to assist in joint evaluation of the progress made between sessions. Aspects of Positive Psychology (Seligman and Csikszentmihalyi, 2000) were used with both TAs and children in order to foster optimism, motivation, self efficacy and general positive emotions. These were mainly centred around

celebrating small successes, focussing on strengths and future potential, reassurance and praise for both children and TAs. Consultations represent an optimal opportunity within schools to achieve some of the goals of Positive Psychology (Terjesen, Jacofsky, Froh, and Digiuseppe, 2004) and specific praise has been shown to improve on task behaviour and enjoyment of numeracy and academic self concept in children (Chalk and Bizo, 2004).

The components encased within the consultation box in the model above reflect the methods and approaches used within this study and are not intended to represent an exhaustive collection. EPs can use whatever methods or tools that are available to them in order to promote the numeracy development of children with difficulties. These will inevitably be influenced, as the model above illustrates, by the environmental factors within which they are expected to make a difference and will require precise targeting to effectively address the specific needs identified.

5.5 *General Discussion*

This research was interested in deciphering whether EPs had a role to play in improving the attainment of children with numeracy difficulties by working collaboratively with the TAs assigned to support them. The quantitative and qualitative data collected suggests that there is a positive and necessary role for EPs in this area. Where other professionals have ventured and appear to have failed, EPs may be able to make a difference. The complexity and diversity of individual children's numeracy difficulties coupled with the impact of the contexts within which they are expected to overcome these are best tackled through a consultative approach which lends itself to a social constructionist paradigm. Conducted over a period of time, this approach facilitates identification, conceptualisation, intervention and subsequent evaluation of the numeracy difficulties exhibited by specific children within their particular learning environments. Consultation skills are an integral part of EPs' toolkits and, considering their links to both psychology and education, places them in an advantageous position to make a difference. Many researchers, such as Augustyniac *et al.* (2005), Gersten *et al.* (2005), Dowker (2004 and 2009) and Geary *et al.* (2000), have recommended that teachers spend time working in collaboration with other professionals, discerning variations in children's performance deficits and exhibited learning impairments, in

order to develop interventions to tackle their needs. The findings of this research suggest that EPs, as professionals with specialized knowledge, can support and train TAs to address individual children's numeracy difficulties by working jointly towards solutions.

There has been no doubt in the minds of previous researchers that TAs had the potential to make a significant difference to the attainment of children with numeracy or other difficulties (Dowker, 2004; Alborz *et al*., 2009; Blatchford *et al*., 2009). The trouble was identifying the exact factors that determine whether TA support is successful or not. It has already been established that TAs are as successful as good teachers in delivering curricular interventions for which they receive training and support (Ofsted, 2002; DfES, 2005a; Williams, 2008; Alborz *et al.*, 2009; Blatchford *et al.*, 2009). What was needed was a deeper understanding of how TAs manage their increasingly instructional role and adapt materials and activities to make them more accessible to struggling learners (Muijs, 2003; Alborz *et al.*, 2009; Blatchford *et al.*, 2009).

The current research lends support to the findings of previous researchers in that modelling strategies and training TAs enabled them to be more effective in supporting numeracy learning. Underachieving children were removed from the classroom and benefited from the more learner centred approaches of the NNS materials with TAs compared to their more able peers who participated in less individualised numeracy lessons with an emphasis on arriving at correct answers at the expense of understanding the process. The intimate groups enabled the development of close TA- child relationships, focussed attention and active, sustained interactions which in turn fostered a secure atmosphere within which children could safely take risks with their learning. In the classroom, they suffered from low expectations and a lack of belief in their ability to improve. Tasks would often be over simplified so that they became no more than number rearrangement exercises and there was no real attempt to develop conceptual mathematical thinking, without the support of the researcher. When children struggled, explanations would often involve little mathematical reasoning and instead were based around convenience and the minimisation of effort and thinking. These approaches seemed geared towards maintaining order and advancing through worksheets rather than fostering numeracy development. This inadvertently reinforced the children's identities as weak at numeracy by immersing them in a 'low numeracy ability' culture and

discourse. Many of these practices can be traced back to the top down approach adopted by teachers, whereby TAs are expected to work with children with significant learning issues with little or no support, guidance and liaison. This leaves TAs to define their own success criteria and drives them to adopt methods that produce short term success, resulting in an illusory sense that the children have made progress with their understanding. Blatchford *et al.* (2009) raised serious concerns about the way TAs are deployed in schools to provide this 'alternative rather than additional support' and could be a possible reason for his research team's conclusion that 'the more support pupils received, the less progress they made'.

This research has uncovered the potential for EPs to involve themselves with efforts to increase children's attainment in numeracy. TAs with no training to deliver numeracy interventions are in need of ongoing support to increase their confidence with curriculum content and pedagogical knowledge. The NNS materials empower TAs to teach rather than administrate a scheme by reducing responsibility for planning and developing mathematics programmes and activities that work. However, TAs need support to mould their skills so that they use the materials in a manner which takes sufficient account of the needs of the children they work with and appropriately increases their expectations of them. A consultative approach, involving modelling and discussion around psychological theories, pedagogical practice and recent research in the area of numeracy difficulties was a useful and welcome medium through which TAs' knowledge, beliefs and attitudes could be shaped. The consultations had the added benefit of being narrowly focussed on TAs' immediate, situated concerns around the target children and therefore had a high relevance factor and potential to incur lasting change. Providing the rationale behind adopting certain approaches and encouraging certain behaviours ensured that TAs were treated as intelligent professionals whose teaching could be enhanced by knowing the reasons behind the approaches they use. This is in stark contrast to methods that adopt a condescending top down approach but in keeping with the notion of promoting collaborative practice.

This research highlights the need to raise awareness amongst schools that EPs can work with TAs to raise children's attainment and attitudes towards numeracy. It also lends support to the findings of Alborz *et al.*(2009) and Blatchford *et al.*(2009) that teachers need to develop the skills to manage and prepare for the growing number of TAs they

work with and TAs need to be prepared for their increasingly pedagogical, instructional role with children. Although EP support has been shown to soften the impact of inadequate liaison time between teachers and TAs with regard to numeracy interventions, it is not intended to be a substitute for effective teacher-TA liaison time. Rather it should be seen as a glimpse of what could be achieved through regular, organized collaborative work so that any positive outcomes achieved serve as an impetus for schools to value such collaboration and incorporate it into general practice.

Furthermore, this research shows that EPs can provide the vital training called for by the DfES (2005a) as essential to the success of NNS interventions. Specifically, that training should enable TAs to: develop their subject knowledge, pedagogical expertise and confidence; deliver the programme with high degrees of fidelity; understand how the programme links to the ongoing work of the class and develop a shared understanding of the programme with the class teacher (DfES, 2005a, p13). This final point required support from the researcher and was limited in nature due to the commitments and responsibilities of class teachers.

Although, all class teachers were consulted initially to help identify the target children, this research did not explicitly demand any further time. There were a number of reasons for this: teacher time is valuable and subject to workforce reforms as set out in the National Agreement for raising standards and tackling workload; the research was less likely to get underway if it made prohibitively high demands upon teacher time; teachers were unlikely to be the ones delivering wave 3 NNS interventions and TAs were the focus of this study and previous research experience has shown the author that teacher evaluations are of limited value if they have not been directly involved with an intervention. Ultimately, the goodwill of schools is essential to the success of research such as the current study and compromises had to be reached in order to ensure that Head teachers felt the value of what they were getting from the research exceeded the sacrifices they had to make to accommodate it. This goodwill is imperative in order to ensure that future trainee educational and child psychologists are also able to get through the school gates to conduct their research.

Despite this apparent lack of teacher involvement, the deputy head teachers (and SENCOs) of all the case study schools were involved throughout the intervention. They

were updated regularly during planned meetings arranged to discuss the intervention specifically or for other matters during the routine work of the EP/researcher. The fact that members of senior management were involved and enthusiastic about the work being done substantially increases the chances of changes being embedded within the schools at a systemic level.

From a methodological perspective, the use of multiple case studies renders this research more robust and the evidence gathered more compelling (Yin, 2003). The unit of analysis was the EP consultation with TAs (and schools) in relation to the target children's numeracy difficulties and use of NNS strategies, which differed based on the individual contexts of each case. Yet similar conclusions were reached based on these varied contexts and this increases substantially the external generalizability of the findings (Yin, 2003). Namely, that consultation is an effective vehicle through which EPs can impart knowledge; model NNS resources, shape TAs' pedagogical practice; collaborate with TAs in joint problem solving, diagnosing numeracy difficulties and planning interventions; provide training on Instructional Psychology; boost TA confidence and raise children's attainment and attitudes to numeracy.

The researcher's background in mathematics teaching played a part in developing an interest in this area of research but there is no reason why EPs without this background could not develop their potential to deliver the kind of work described in this study. EPs are normally expected to deal with children with numeracy difficulties as a general part of their casework if schools bring them to their attention and this is likely to follow a 'plan-do-review' cycle to support the problem holders. This would mean engaging in consultation, research around the needs identified, training if necessary and empowering the problem holders to follow through with conscious decisions to change and achieve desired outcomes. By virtue of their qualifications and experience, EPs are flexible, academically able people who could effectively manage to support TAs with numeracy difficulties in much the same way they would support problem holders with other concerns with which they had little or no previous experience. Furthermore, the model of support proposed by this research (see figure 8) could be applicable to any curriculum area where there is an evidence base of psychological research and proven intervention approaches, that EPs can draw on to provide rigorous and accountable

practice that meets high ethical standards and avoids accusations of 'charlatanism'. In this sense, the proposed model is generalizable across EPs and across curriculum areas.

5.6 *Research Limitations*

One of the main limitations of this research was the use of a small number of participants located within specific contexts which has implications for the extent to which the findings can be applied in other contexts. This was a necessary compromise as time was limited and the case study approach adopted required a relatively high investment of time from both the researcher and TA participants. However, the qualitative data gathered is not reliant on numbers to generate statistical power and the case study schools resemble mainstream schools across the country so there is a degree of generalizability and certainly ecological validity based on the fact that this was real life research in real life settings.

Although Head teachers were not involved directly in the intervention, it is they who decided whether to opt into the research or not and it could be argued that Head teachers of successful schools were more likely to opt in. Schools experiencing difficulties were more difficult to gain consent from. In fact the researcher had verbal agreement from a number of SENCOs and TAs in challenging schools, within his patch of schools as an EP, who wished to participate in this research but the Head teachers were reluctant to consent to their school's participation. Some Head teachers declined due to having 'too much on this year', others delayed replying or gave vague responses to communications delivered by the researcher or by the TAs wishing to participate. This is despite clear assurances that confidentiality and anonymity would be strictly safeguarded. The implications for the findings from this research could be significant. Case studies conducted in more challenging circumstances in terms of both the profile of numeracy deficits presented by the children and the TA provision they receive are likely to produce a different set of emphases on TA-EP collaboration that may be associated with positive outcomes for the children involved. However, there is also likely to be considerable overlap with the schools used in this study and bearing in mind the consultative approach model recommended by this research, there exists the capacity to incorporate additional factors into the model and target support accordingly. One of the key themes emerging from this research is that the interplay between children's varied

and complex numeracy difficulties and the learning environment requires a unique, EP facilitated, response in order to successfully address specific needs.

This study focussed on Year 2 children as previous research identifies this as the preferred National Curriculum Year group within which to address numeracy difficulties (Williams, 2008). This is because literacy interventions tend to be the focus of Year 1 and so Year 2 provides the earliest opportunity to address gaps in numeracy understanding and allay mathematical anxieties before they become entrenched. However, the findings may have differed if other Year groups had been the focus. The NNS wave 3 materials are designed to be used with children up to Year 6 and this would mean the content of the curriculum could become more challenging for some TAs. The content knowledge requirements have been underplayed in this research but TAs implied that it could become a training issue higher up in the primary years. This has implications for the foci of EP-TA consultations.

Isolating the exact factors from complex real life work such as this in order to ascertain the value added by each component is an extremely difficult if not impossible task. Especially, as a number of identified and unidentified factors are likely to impact in a complex manner upon the outcomes achieved by the children and TAs. This research was more concerned with testing whether the EP had a role at all in supporting TAs delivering NNS interventions and as such identified factors from the case studies that appeared to be related to positive outcomes. The exact extent to which these factors contribute towards these positive outcomes was beyond the scope of this research.

A final limitation to point out is the fact that qualitative data were coded by the researcher only, mainly due to time constraints and unavailability of interested or willing persons with the time to carry out cross-checks. However, that is not say that the possibility of bias was not guarded against. Every effort was made to ensure the process was reliable by using clear definitions and names for themes and the author was in the privileged of position of being able to integrate information gathered from personally conducting the interviews with TAs. Nonetheless, the use of independent persons to code the qualitative data for comparative purposes would inevitably have strengthened the data analysis. Obtaining similar codes and themes from people who

were ‘blind’ to the research hypotheses and the author’s previously coded interview data would have added further reliability and validity to the findings.

This study involved a human researcher making observations and interacting with participants in real world situations. This has the advantage of being flexible enough to understand very complex events but Robson (2002) reminds us that there are ‘human deficiencies’ related to the biases humans have as observers and interpreters of events. These biases are linked to memory, perception and social interaction and being aware of these can assist in counteracting them.

Attention, by its very nature is a focus on specific aspects of the environment at the expense of others. This is essential in order to make sense of the overwhelming complexity of our environment but what we attend to is affected by our interests, motives, experience and expectations. These serve to render certain aspects of our environment more salient than others and can lead to overlooking other features of importance that do not fit into our current schema. Enlisting the help of a colleague to observe some of the sessions with TAs and children (actually being present at sessions or watching video recorded sessions) and comparing codes could have increased the validity of the observations and reflections recorded in the research diary. This would also help to guard against ‘expectancy effects’ where researchers, especially those with a vested interest in the outcome, expect to see some positive changes post intervention and make an effort to seek these out at the expense of noticing other features of similar if not greater importance (Robson, 2002).

A further criticism of the methodology could be that comparative elements were not incorporated into the case studies. It may have been more useful to conduct some case studies where professionals other than an EP were also supporting TAs to deliver NNS interventions, such as specialist maths teachers, numeracy coordinators, SENCOs etc. This would have facilitated a more precise identification of the actual value added by the EP by enabling a direct comparison with other professionals supporting TAs and children with numeracy difficulties. In this sense, any factors that are uniquely associated with the support provided by an EP may have been more readily isolated.

5.7 *Implications for EP practice*

Despite the limitations mentioned in section 5.6, this research has clear implications for EPs. Research into numeracy difficulties is an emerging field of knowledge and EPs would do well to keep abreast of developments so that they can be transferred to front line staff as applied practice. Modelling NNS resources in order to scaffold later independent use coupled with successive consultations designed to oversee progress and provide training, as appropriate, appears to be a realistic and functional model of practice in this area (see figure 8 in section 5.4, above, for further details). Interest from an external professional is sometimes needed to prioritize action within eventful schools by busy staff (much like that engendered by an imminent visit from an Ofsted inspector) and EPs can fulfil that role to ensure good practice is consistently implemented.

EPs may be well advised to consider offering such training at a systemic level especially if a number of 'dyscalculic' cases are brought to their attention during planning meetings with SENCOs. Furthermore, as Farrell *et al.* (2006) point out, the success of EPs and the services they provide are to be judged using the five outcomes from the Every Child Matters (DfES, 2004) agenda as benchmarks and recommend that EPs should actively consider how their day to day work is contributing to meeting these five outcomes and this contribution should be recorded and communicated appropriately to other stakeholders, such as parents. Competence with numeracy contributes to all five of these outcomes, either in the short or long term as evidenced in section 2.2, and therefore is a productive area for EP involvement.

In the present climate where confronting the causes of numeracy difficulties is seen by many, here and around the world, as a worthwhile investment of professional time and expertise, EPs would be well advised to demonstrate how their profession is relevant to major national developments and how their work is useful and valuable through actions and results rather than words and theories (Gersch, 2009).

5.8 *Conclusions and Implications for future research*

This research has found that EPs have a potentially distinctive role to play in engaging in a pedagogical alliance with TAs delivering wave 3 NNS interventions. The

qualitative and quantitative data gathered points to a substantial impact upon children's attainment in and attitudes towards numeracy. TAs welcomed the collaborative work with EPs and acknowledged that changes in their knowledge, beliefs and attitudes would have been unlikely without EP involvement. Consultation was shown to be an effective vehicle through which these changes could be facilitated and preferred by TAs in comparison to generalized one-off training sessions. In particular, the research advocates a consultative support role for EPs in supporting children to fill gaps in their mathematical understanding by: modelling NNS resources; conducting diagnostic assessments; shaping TAs' pedagogy through access to theory/research and providing training on instructional psychology methods. It also advocates an important role in boosting TA self efficacy to intervene with children's numeracy difficulties and playing a role in raising children's attitudes to numeracy.

Future studies may wish to explore the current practice of EPs with regard to supporting children with numeracy difficulties to ascertain whether any aspects of existing good practice could add to or modify the findings from this research. There appears to be no research on the knowledge, beliefs and attitudes of TAs with regard to numeracy teaching or any on their knowledge of the nature of numeracy difficulties and what works in tackling them. Future studies may wish to fill these gaps in knowledge and shed further light on the specific needs of TAs in these areas, with a view to identifying a possible EP role in addressing these areas.

As this study focussed on testing whether a distinctive role for EPs existed, future studies may usefully aim to isolate and identify as far as is practicable the exact factors that are associated with positive outcomes for children and evaluate the value added by each of these. From an ethical perspective, EPs and the services they work for may aim to consensually gain access to challenging schools in need of support whose Head teachers are somewhat reluctant to accept support from 'researchers' but may do so from regular EPs. Finally, a systematic study of the quantity and quality of TA support received by children and their subsequent attainment may further illuminate the strongly perceived but difficult to prove link between TA involvement and academic outcomes for children.

CHAPTER 6: REFERENCES

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CHAPTER 7: APPENDICES

APPENDIX 1 – Letter to Head teachers

Invitation to participate in research

Dear M…….

You may be aware that I am your educational psychologist next year. I am in my final year of a three year doctorate course, during which I am required to undertake a piece of research that adds to the knowledge base of education.

I would like to conduct a number of case studies across the LEA area on the effectiveness of supported National Numeracy Strategy (NNS) interventions. Research suggests that modelling the use of these materials increases their effectiveness in schools. I am particularly interested in working with Teaching Assistants (TAs) delivering wave 3 NNS interventions to small groups of children in Year 2.

The aim of the research is to assess what is going well and provide training on psychological or educational aspects that may improve the work being done. The benefit for your school, apart from participating in worthwhile research, is that you will receive additional EP time to support the least mathematically able children. The results of the research may well enable TAs to disseminate their knowledge and skills to others.

All work and interactions will be confidential and the role is wholly supportive - no judgements will be made or communicated to others about how well individual schools are doing. All data will be kept securely and destroyed once the research has been satisfactorily written up. Informed consent will be obtained from all the participants involved in the research and their right to withdraw at any time will be respected.

The intervention will take the form of initial consultations with TAs to explore their experiences of mathematics and delivering NNS interventions. Thereafter, joint planning and discussions will take place on a fortnightly basis over a period of one term, to identify what is working well and what input from an EP may be of use; EP input will be provided as and when appropriate and outcomes from the research will be assessed as follows:

- Children's numeracy progress (assessed using the Sandwell Early Numeracy test).
- Children's attitudes to maths and their views on the intervention.
- TA views on the intervention research.

If you feel that your school will be able to participate please let me know via any of the contact details above. If you would like to arrange a meeting to discuss

this matter further please do not hesitate to ask. I am writing to more schools than are needed for the research and I will contact all schools that have been selected to participate. A report on the main findings will be provided to all participating schools at the end of the research.

I hope you will be able to benefit the least mathematically able children at your school by participating in this research and I look forward to hearing from you in the near future.

Yours sincerely

Trainee Educational and Child Psychologist

APPENDIX 2 – Letter to parents

Dear Parent/Carer

I am working as an educational psychologist for Education LEA. As part of my final year, of a three year doctorate training course, I am required to undertake a piece of research that adds to the knowledge base of education.

I would like to conduct a number of case studies across the LEA area on the effectiveness of supported National Numeracy Strategy (NNS) interventions. Research suggests that modelling the use of these materials increases their effectiveness in schools. I am particularly interested in working with Teaching Assistants (TAs) who are delivering wave 3 NNS interventions to small groups of children and your child has been chosen by the school to take part.

The aim of the research is to assess what is going well and provide training on psychological or educational aspects that may improve the work being done. Your child will continue to be taught in much the same way they would have been ordinarily but I will be talking to the Teaching Assistant working with them to see how things could be changed for the better, if at all.

Your child's numeracy progress will be assessed using the Sandwell Early Numeracy test and their attitude and views on numeracy work will be sought. Your child's input will be completely confidential and they will not be identifiable by anyone else.

If you would like your child to take part in this research which has the potential to benefit their mathematical development then you need do nothing. However, if you would prefer them not to take part then please let me or the school know as soon as possible.

If you have any questions then please do not hesitate to contact me.

Yours sincerely

Trainee Educational and Child Psychologist

APPENDIX 3 – Children's attitude questionnaire

Attitude Survey (children's questions)

Name_____ **School**_____ **Date**_____

1. How do you feel about coming to school?

2. How do you feel about numeracy lessons?

3. How do you feel about literacy lessons?

4. How good are you at numeracy?

5. How good do you think your teacher thinks you are at numeracy?

Very Good Good OK Not good Poor

6. How good do you think your mum/dad thinks you are at numeracy?

Very Good Good OK Not good Poor

7. How good do your friends think you are at numeracy?

Very Good Good OK Not good Poor

8. Would you like to tell me any thing else that I haven't asked about?

Thank you.

APPENDIX 4 – Teaching Assistant's questionnaire

TA questions. **Child's name_____**

Please put a tick in the appropriate box for each statement about the child named above.

Statement	Always	Mostly	Sometimes	Rarely	Never
Is happy to do numeracy work					
Is keen to do well and tries hard					
Actively participates in numeracy lessons					
Can work out answers in more than one way					
Will try even if the work is challenging					
Can explain how they arrived at an answer					
Can spot their own errors if they talk through the problem					
Makes the same errors over and over again					
Do you have any other comments?					

Thank you

APPENDIX 5 - Pro forma for recording key session outcomes

Date_____ Location_____ Session_____

Item	Details	Reflections
Comments from previous session: -What is going well? -Any Concerns? -Issues raised		
Identified needs/focus		
Psychological principles employed/to be employed		
Observations and further comments		

APPENDIX 6 - Semi-structured Interview questions

Initial interview

(Possible prompts in italics)

1. Have you ever done a numeracy intervention before?
   How did it go? What was it? NNS?
   What did you like/not like about it?
   If not done, how do you feel about doing one now?

2. How would you describe your mathematical ability?
   Did you do any further maths after you left school?
   Have you been trained to do any as a TA?
   Did you have help with numeracy in school?

3. What do you think about the (target) children's mathematical ability?
   Have you worked with any of them before?
   What appears to work?
   Are you born good/bad at maths?
   Why do some children struggle?
   Can everyone become better at maths? How? Or why not?

4. On a scale of 1-10, where 10 is 'very happy' and 1 is 'not happy at all', where would you place yourself in terms of how happy you are to participate in this numeracy intervention?
   Repeat with 'confident'

5. What are you looking forward to the most with this work we are going to do together?

6. What concerns you the most about this work we are going to do together?
   How do you feel about working with an EP?
   Excited, nervous, not bothered, special…

7. Do you think this work we do will help you to do your job? In what way?

Final Interview *(Possible prompts in italics)*

1. Can you remind me why you became a TA?

   How long have you been a TA? How long have you worked here?

   What drew you to this job?

   What do you enjoy about it?

   How did you train for this role? Did this prepare you well?

   If you had a choice, what subjects/types of pupils would you prefer?

   Did you volunteer to participate in this intervention?

   How was it sold to you by the Head/deputy head?

2. Now that we have come to the end of the intervention, how was that experience for you?

   What did you enjoy the most?

   Was there anything you did not like about it?

   Were any bits particularly useful to you? What did you learn?

   Is there anything you would do differently/change?

   Was it easy to find the time and space to deliver?

   How did you organise the sessions? time, frequency?

   Did you do anything that involved the whole class/teacher?

   Did you liaise with the school numeracy coordinator? Or other?

   Was there any interest in what you were doing from other staff?

   Any feed back/involvement from parents or others?

3. Did you use the materials as suggested in the pack? (*show materials*)

   Were they self explanatory from the start?

   Did you make any adaptations?

   Why did you feel they were necessary?

   Would you recommend any additions to the materials?

   Did they help/hinder your ability to work with the children?

   How did you reinforce the work during normal lessons?

   Was there a connection between the intervention and class work?

   Ask specific questions based on observations

4. How did you find working with an EP?

   What aspects of working with an EP were useful to you?

   Style, frequency, attitude, coaching/modelling, personality.

   Were you more knowledgeable at the end of the intervention?

   In what way?

   Did the psychology of learning discussions help? How?

   Did the nature of numeracy difficulties discussions help?

   Did the Instructional psychology training help? How?

   Can you think of anything/anyone else that could have helped you?

5. How did you find working with the children?

   Did they enjoy it? Did they learn a lot? or not?

   Timing of sessions, grouping and teacher support?

   Could you see them making any progress? Attitude, confidence, ability?

   Did they receive any other input apart from the NNS intervention?

   What do you think about their numeracy ability now?

   What appears to work for them?

   How did you know that the intervention was having an effect?

   Did you feel there were gaps in the children's understanding of numeracy?

   Did this intervention help in any way to fill these?

   Are you born good/bad at maths?

   Why do some children struggle?

   Can everyone become better at maths? How? Or why not?

6. On a scale of 1-10, where 10 is 'very happy' and 1 is 'not happy at all', where would you place yourself in terms of how happy you are to have participated in this numeracy intervention?

   Repeat for how confident do you feel about doing a numeracy intervention in the future?

7. Would you do this again if the opportunity arose?

   Would you recommend it to others?

   Will you continue to use the NNS materials?

   How is it better than other interventions you have used?

8. Is there any thing else you would like to tell me that I have not asked about?

Appendix 7 – Example of a Thematic Analysis of an Interview Transcript

The post intervention interview with the TA from Case Study 1 is transcribed below. The first column indicates who is speaking, with T = Teaching Assistant (participant) and R = Researcher (Educational Psychologist).

The 'transcript' column constitutes phase 1 of Braun and Clarke's (2006) method of thematic analysis (see table 8) and the 'coded for' column relates to phase 2.

For ease of transcribing and reading, para-verbals used by the researcher to demonstrate active listening have been omitted if it was felt that they did not alter the participant's response or add any further value to the analysis.

T/R	Transcript	Coded for
R	Can you remind me why you became a teaching assistant?	
T	I was asked to do it actually. I was asked to help out with a little boy that needed support in an afternoon and then when he moved on I went back to me other roles and then another little boy came along that needed erm support all day and when they got funding for him they took me on full time and I've stayed ever since.	Spotted for post. Contextual factors.
R	So did it start of as voluntary… or was it a paid job from the start?	
T	Oh no it was a paid. Yeah they asked me to so it. They approached me yeah.	
R	Oh great. So did you have some connection with the school beforehand?	Personal circumstances.
T	Yeah I was a lunch time supervisor.	
R	I see. So they knew your character and so on.	
T	And actually the child that I supported was the one in the class that I was a dinner lady for. Well I actually knew him which made it easier.	Familiarity with setting.
R	That makes it…	
T	Yeah it's better for the child an all.	
R	So how long have you been a TA here then?	
T	Erm seven years now, 2002, might be coming up to eight.	
R	Oh goodness, that is a long time. Have you enjoyed all that time?	
T	I have yes. I've worked at xxxxx for, since 1988, so 22 years altogether.	Experience.
R	What do you enjoy most about the job?	Contentment with role.

T	Working with the children and the teachers yeah	Intrinsic enjoyment.
R	Yeah…and seeing them specifically…progress and…	
T	Yeah. It'd be bit disheartening if you didn't see…you know even if it's not a progression in written work…maybe in self esteem. You know even if it's a progression in that sometimes. Cos maybe their written works OK and their learning but their self esteem is not very good.	Awareness of broader needs. Emotional needs.
R	Yeah, seeing their confidence grow is important too isn't it?	
T	Yeah yeah that's right.	
R	So how did you train for this role?	
T	I did a teaching assistant course through the college through school. When it first came into being and the government was going to plough a load of money in and every school was going to have TAs that were trained. These courses came up and the teacher I was working with asked me if I wanted to go on it and actually erm it were the best thing I did because it gave me a really good insight into the job and it gave me an insight into how the pupils… are… if you know what I mean. They put us in a place of being a pupil and gave us something gobbledegook to work out or to write down you know off a board and just looking up and trying to see... I realised how hard it was for em.	Enjoyment of training and role. Empathy with children's needs.
R	Yeah so it gave you that empathy	
T	Yeah yeah	
R	And you need that sometimes	
T	Yeah you do	
R	Cos you need to know what its like for them …	Empathy.
T	Yeah you can't remember what its like to learn to read and write can you?	
R	Absolutely and you feel that prepared you quite well for the job then?	
T	Yeah I did yeah.	Prepared for role.
R	If you had a choice would you work with specific children or specific subjects or does that not bother you at all?	
T	Erm I like doing a mixture of all sorts. I have worked with speech and language and done you know specialist…I did a training course on speech and language and worked with a couple of children and just took em out so many times a week to work on their language skills. Erm…but no I like the range. I like to do the creative curriculum. I like to do the painting and the arty bit. I like to do the literacy and the numeracy. Yesterday I dressed up as a witch for literacy.	General interest and development of skills on the job.
R	Yes M told me. She said you were quite frightening but I think that was a compliment though.	
T	(laughs) a bit of role play on my part	
R	Yes and that's always great for kids isn't it?	

T	I think you need to bring yourself down to their level sometimes. I like being with children. I do I do get on with the older children but I feel the younger children are more vulnerable. You know…em…sometimes they just need somebody to you know just give em a bit of reassurance sometimes whereas I think the older ones think they know it all.	Finding common ground. Providing reassurance
R	Yeah and younger children respond well to that nurturing approach	
T	Yes Yes	Nurturing attitude
R	Now did you volunteer to participate in this intervention that we've done?	
T	Yeah Mrs J asked me if I would. She didn't say I was. She said we need somebody to do this wave 3 and would I like to do it and then she said it was going to be part of me performance management at the time but the performance management got put back so I finished doing it with you by then so I have taken on now erm another numeracy intervention with some girls because they're wanting to bring the maths up in the girls apparently so now on a Tuesday I do a half hour with the girls that need that little bit more.	Accepted invitation to participate.
R	What are you using with them?	
T	At the moment Mrs J has given me an assessment sheet to do to find out where the gaps are. I like that word 'gaps'. To find out where the gaps are and then if we're doing a lesson like we were doing ten more than and some of the girls couldn't grasp it then during the numeracy lessons after that I've taken those girls out and worked on that with them just as a small group so I'll actually be doing what Mrs J feels they're not getting.	Importance of obtaining diagnostic information.
R	I see. So it's going to be dictated is the wrong word but…	
T	Yeah it'll correspond with whatever Mrs J is doing and whatever she feels they need. She's gonna sort out the gaps and then...	Liaison with teacher.
R	So it was sold to you as an intervention that you might like to take part in and also at the time it was going to be part of your performance management.	
T	Yeah	
R	And you were happy to take part	Content to participate.
T	Yeah	
R	That's great. Now that we've come to the end of the intervention, genuinely, how was the experience for you?	
T	Well at first if you remember I was a bit worried about the work being too hard for them but you can… move it about a bit and tweak it to whatever age group I think...You can make it as hard or as easy as you want. You can make it as fun as you want and erm the children liked it. They liked going into different areas and not doing it all round a table we went outside and did some hopping... erm they enjoyed drawing pictures of what they'd done . They enjoyed drawing me with me glasses and me clipboard you know. Which is som't different - you wouldn't think about drawing a picture about something you'd done but it's given me some ideas to use in other places as well.	Initial apprehension. TAs role in adaptation and delivery. Transferable ideas.

R	What did you enjoy most out of the experience?	
T	Just incorporating erm different ideas and trying to think up different ways you know of doing the programme really. Like with the first, second and third – erm not just using it in the lesson but using it when they're lining up to go somewhere else or if we're outside you know or in the dinner queue. Who's first who's second? You know things like that. It encourages you to use it away from the lesson especially with the children that you're working with because, you really, you've got them in your mind, and you think 'oh they need to know that', here's an opportunity just to have a little, a little go.	Transferring learning to other contexts.
R	So did you feel that you had to use a lot of your own skills to modify the content?	
T	Erm, I think you could have used what were there. I think you need to know the children and you know make it fun for em. It's no good making it boring I mean K had pink bricks because that's her favourite colour erm R had brown and B had black so they all had their individual bricks and actually that made it easier for the learning as well so when we were doing tens and units they could see the colours but they did like having their own you know their own bricks and working with their own bricks.	NNS good enough. Knowing the children. Children owning the materials.
R	It would be fair to say that an intervention is only as good as the person delivering it and I would say that you delivered it well because if you weren't using it as it was intended by modifying it to suit the children you were working with then it would've fallen flat on its face. I think you've made quite a success of it A – which is great. Erm was there anything you didn't like about it, anything at all?	
T	Erm no not really. I mean you didn't ask me to keep all the notes I just thought you know and I'm glad I did as well cos school needs em. Erm not really. It was slow I mean I felt like was I moving quick enough? Cos we didn't get past the addition and subtraction booklets but with the children that I had I don't think there was… you know and in class they haven't gone onto times and you know division yet…	Liked intervention. Pace issues. Work in line with class work.
R	Yeah so it's in line with what they were doing anyway.	
T	Yeah but you do wonder what's the time scale you know. Are you going quick enough or are you not? There's no point moving on if you don't think they've got it.	Teaching for understanding.
R	That's exactly what I think as well cos I think these children have had these little snapshots of interventions all through their lives but we need something to really work for them so if that makes any of it longer then that's fine but you were happy to spend that little bit of extra time were you?	
T	Yeah. I mean even 'inverse', I mean that's a hard word is 'inverse' but because we used it all the time they knew what was expected of them when they come to do it. Now whether they'll remember it when it comes to it later on. It might just twig it might not but it's such an hard word for a six or seven year old 'inverse'.	Mathematical vocabulary initially perceived as challenging but developed with continued use.
R	Yes it's in there isn't it as part of the recommended vocabulary.	
T	Oh yeah yeah and 'boundaries' that's another one as well	

R	That's right I think they are trying to introduce them to the actual language and as you say they do understand it if you've used it often enough and hopefully they'll remember it or something will jog their memory somehow.	
T	Yeah and applying in lessons erm they seem to be alright in a small group but when you get them in and amongst I don't know if it's…erm there's nobody there. I mean there is somebody there but there's more children and so they don't feel that they've got the one to one sort of thing and am I gonna do it right if I do it or you know sort of applying it, I find, applying it when they go back into the classroom.	1:1 still needed to help transfer skills from small group to class room.
R	Hmmm cos it is quite a cosy atmosphere isn't it when you've just got the three of them. They know they're…	
T	Yeah and they've built up quite a competition between one another you know when we're doing the sums and what have you. Who was getting the star and who wasn't? So yeah but maybe that's lost when they go back into classroom when they get on the table with a lot more children	Positive working atmosphere in small group.
R	Yeah do you think it's anything to do with them? When they go into the classroom they know in their heart of hearts that they are the weaker children. When they're with you it's just them and there are no high fliers?	
T	Maybe it could be, yeah. They're on a par with each other, Umm could be yeah.	Comfort with similar ability group.
R	Yeah it could be something like that. They can feel overawed sometimes. What Mrs J is talking about on the board tends to go over their heads most of the time. That's something to think about isn't it?	
T	Yeah it is.	
R	How did you organise the sessions, I know you've described them, you did them every day didn't you?	
T	Yeah 15 minutes.	Organisation issues.
R	Every day in the morning.	
T	Yeah, if we didn't get a chance to do it in the morning we did it maybe two the next day. You'll see on some of me sheets I've put you know two sessions incorporated in one.	
R	As in two sessions all together.	
T	Not two sessions in 15 minutes, two 15 minute sessions.	
R	But together so it's half an hour	
T	Yes but not all crammed in. Not two sessions crammed into one 15 minute session. You now what I mean, two sessions, they got the full time.	Organisation issues.
R	And they seem able to do half an hour anyway. I've noticed that when you do finish they could carry on. It's quite fun for them isn't it?	
T	Well we don't stick to the same thing either when we do two sessions. We recap a bit do the one and then we move onto something else so	Maintaining interest and motivation.

	they're not bored.	
R	You've managed to do this from beginning to end apart from say snow closure days and what have you	
T	And holidays. It's written on.	
R	That's fair enough.	
T	And absence, let's not forget the absence	Absence as barrier to progress.
R	Don't forget the absence, absolutely. I'll keep a record of that. Erm, did you do anything that involved the whole class or the class teacher at all?	
T	Erm not with my little group, no.	
R	That's fine, so you just took them out and did things with them.	
T	When she was doing the mental maths bit or been doing things on the carpet so they didn't miss the actual lesson, the actual numeracy lesson because there's no point to that, you know.	Ensuring entitlement to numeracy hour.
R	OK, just going back for a second, did you find it easy to organise this intervention?	
T	Err, once I got going, yeah, and because Mrs J was, you know, agreeable, she knew, There was no problem. I mean I used to do Max's Marvellous Maths and that were the same, twenty minutes on the mental maths bit for them, you know. And now I'm doing this intervention with the girls if they need the input it's again it's when they're doing the bingo and things so they're not actually missing out on the numeracy lesson as such, it's the beginning bit.	Supportive managers. Previous experience. Access to numeracy entitlement.
R	Hmm, right, thank you for that. Erm, was there any interest from other members of staff apart from Mrs J?	
T	Yeah, Mrs W, yeah, erm Mrs A, the other teaching assistant because obviously we talk about what we're doing and things erm… but I don't think people really notice what you're doing if you know what I mean erm you're just getting on with it.	External interest.
R	Yeah, it's just the normal work that you're doing but there was outside interest in that respect.	
T	Yeah yeah	
R	And did Mrs J want to know how you were getting on?	
T	Oh yeah, feedback yeah	
R	And you did that on a regular basis did you?	
T	Yeah and of course she fed back to me when she you know like she said sometimes they can't apply it when they come back in you know and erm now and again she'd ask them something as she's walking past you know or as they were walking past like you know 'give me a number bond to 10 B'.	TA – teacher Liaison.
R	And?	

T	And yeah he did it.	
R	Oh that's good	
T	And R would do work at home without being asked. We didn't send homework home because they have so much going on erm with key words going home and the literacy homework going home. I didn't feel it necessary to send work home but I did say to them if you want to practice counting back or if you want to, you know, do some inverse for me then you do it and R actually brought some in	Children motivated to do more. Children perceived as 'busy'.
R	Oh great, great. Cos my next question was going to be any feed back or involvement from parents but did you get any feedback from the parents or did you just know what he was doing at home?	
T	He just had a go did R and brought it in, you know but at least he was wanting to do it at home.	Children working without support at home.
R	Yeah that's great. Nothing for B and K?	
T	Well B's things are still in his bag from Christmas you know	Parental involvement perceived as a challenge for some parents.
R	Hmm, I see	
T	And K's mum has got a lot on. There's a lot of them at home to read with and what have you.	
R	That seems to be the case with quite a few parents actually. Now, OK next bit then. Did you use the materials as they were suggested in the pack, I think we've touched on this already because you said you used them as they were but with some modifications.	
T	Yeah I used them…and I used some of my own stuff. I tried to make it as visual as possible. You know and even with like counting on, the hopping, I actually got them hopping, and ordering we went outside and we ordered numbers you know and things. So I mean a lot of your TAs will have resources. If you're starting from scratch you'll probably need to make some but I had a really good file from Mrs J with ponds and fish and allsorts.	Adapting NNS with familiar, additional resources. Using a variety of teaching styles.
R	So you supplemented quite a bit	
T	Yeah and I had number lines and I had me big number line with me apples on already and me number squares.	
R	Yeah, oh great and did you find the materials quite self explanatory.	
T	Yeah	NNS easy to follow.
R	And you mentioned the adaptations you did make but you felt those were necessary did you? You felt they needed bringing in.	
T	Yeah, yeah. I think if it's just paper and writing sometimes they don't always get…you need to be a bit tactile sometimes. You know, even if its only delivering milk bottles to an house, you know if you've got so many houses and so many milk bottles then this house needs three and that house needs two, how many milk bottles have you delivered altogether? Just some things like that rather than it just being numbers. I mean I know they're Year 2 now but I think they still need something to visualise. Even Mrs J, sometimes she'll use counters you know and	Maintaining interest and motivation. Real life, interesting examples.

	things and teddies. I mean they're counting on in twos now with my little group and some others and we're using the teddies you know.	Use of concrete materials.
R	Yeah, that's great. So would you recommend that as an addition to the materials? So if you were asked would you add something to the NNS materials would you recommend that more visual more fun way of working?	
T	Yeah yeah I mean even if your doing your 1, 2, 3, 4, 5 I mean they love the number line with the apples and the worms going through you know.	Use of visually appealing materials.
R	Yeah I've seen that one.	
T	Oh great	
R	Now did you reinforce the work during normal lessons at any point?	
T	Erm sometimes yeah if we were doing take aways or if we were doing additions. I'd say remember if it's a subtraction what are you doing? Because we worked on subtractions as throwing them in the bin, getting rid of them, you know and the additions we worked on…so we simplified addition and subtraction, we threw some in the bin and if we were adding we did the dots underneath and that's something they could do in their book you know or on a whiteboard. If they were on a whiteboard and they were subtracting and they had the numbers they could put the dots underneath and throw some away. If they were adding they knew they had to count them all up and put them on the end. So you need something I think a strategy they can use in the class as well as out. Whereas bricks, they don't always have bricks with them, the cubes, so we did work on using dots as well or sticks or whatever.	Transferring group work to classroom. Defining terms at child's conceptual level. Visual, concrete methods. Developing practical, transferable strategies.
R	Great, Thank you. Now we started this intervention a little later in October didn't we so was it hard to get that connection between what they were doing in the intervention and what they were actually doing in class?	
T	Yeah, I think it needs to run side by side and then maybe what we're doing outside is carried on in the classroom. Maybe that's why they didn't apply it cos what they were doing when they went back into class wasn't what we'd done outside.	Mismatch between NNS and class work.
R	Yes, that was something I was aware of but there wasn't much I could do about it. So had we started first week in September would that have been better in that sense?	
T	Probably, because Mrs J will have her order set out won't she. I mean like Mrs J was doing a number line, she wanted the children to draw a number line in their books, so when we did addition I introduced that to the wave 3 so that was something they didn't miss out because that was something the whole school were having to do now is put a number line in their books so I thought rather than them not know about it I can introduce that in the adding and get them to do a number line.	Inclusion in whole school approaches.
R	Yeah, and does it go up to a specific number?	
T	Well we were doing just up to twenty weren't we.	
R	I thought you might	
T	I mean really a number line you don't want it to go longer than that cos	

	they have to draw it. I mean even a number line, if they're starting off at 36 which is too high for mine they only had to add 10. They could still start at 36 and do a number line to 10 but we just worked on numbers up to 20 and 20 plus.	Use of abstract concepts: number lines.
R	And they're the kinds of bonds that the NNS asks for, up to about 20 usually, isn't it?	
T	Yeah yeah	
R	OK, now how did you find working with an Educational Psychologist?	
T	No problem at all no. I mean I knew where you were if I needed to get in touch with you. You let me know when you were coming. You asked me if I needed anything and if you could help me in anyway. I don't think you can ask for anything more can you?	EP availability/input appreciated.
R	Thank you and what aspects were most useful for you if any?	
T	Well I liked the different ideas you gave me, you know, and I shall use them again. Even with the girls that I'm bringing out, I'll use them.	New ideas internalised.
R	Oh good good. So you feel that you're more knowledgeable at the end of the intervention?	
T	Yes, I am more knowledgeable now.	Increase in knowledge.
R	Erm…	
T	It's like a little course isn't it for us as well.	Perception of 'training'.
R	Yeah, I'm glad you've said that actually. It's not intended… My intention was for this to be meetings, consultations rather than sitting down and yeah we'll do this and this and dictating what goes on.	
T	Yeah and you can pick up a lot in consultations. Now M's got a copy and I've got a copy I can always, if I'm doing something with the girls I could always have a look at that before and see what could I use to make it simpler for the girls.	Consultations effective. Access to and familiarity with NNS materials.
R	Right right	
T	I'm using your precision teaching now for E because she's struggling with ten more than, remembering which is the tens and which is the units. So I took her right back to basics now and started learning her the unit numbers and the tens and unit numbers and eventually I want her to do ten more than but I'm doing the precision teaching five minutes a day with that.	Precision teaching training being implemented.
R	I'm glad you mentioned that, I'll go onto that before the other bits. The Instructional Psychology, as we call it, and Precision Teaching specifically, that's gone down really well hasn't it? So well that M wants me to pass it onto other people in the school. And she's been impressed, she's had the sheets out today showing me all the, even though they were weaker children they were still making progress and that's the key thing I suppose.	
T	I think Mrs L wants us to go back in about three months time to check that they still know it.	Retention issues.

R	Yeah, well that's always an issue isn't it? It's that reinforcement and when I did introduce you to it I said keep the sheets and go back every now and then…	
T	Yeah, we can't keep ploughing can we? Because we've got to stop sometime because usually when they level off, you know…	
R	Erm when I've done it, I've, every month, developed a sort of revision sheet if you like and I've done that one with them and I've gone 'can you remember what we did last time?	
T	Yeah, keep a sort of chart.	Reinforcement ideas.
R	And they tend to remember it even though children at this level do tend to forget things quickly. It's sort of keeping on top of that really. But that particularly was very useful was it as a technique to use?	
T	Yeah it's just, we did say we could actually do with it as a proper slot because it's finding the five minutes.	Time spent on PT valued.
R	Right	
T	Sometimes there isn't the five minutes and then all day you're thinking I need to get this five minutes, I need to get this five minutes. Where if there were a slot for it you know even if they just said to the teachers 'right for ten minutes during registration your TAs aren't doing anything else but it's there for precision teaching' that's what I think. Then you know you've done it, It's done and then you can move on and do the rest of the day.	Organisational issues. Reliance on managers to allocate time.
R	Yeah and it's usually better done fresh in the morning as well.	
T	Yeah you know especially by end of week. If you're getting to Friday and you're trying to fit it in Friday afternoon.	
R	Yeah because timing is very important for learning in that respect isn't it? Well thank you for that A. We also had some discussions about the psychology of learning, Piaget, Vygotsky. Was that any help at all?	
T	Erm I think so. I think they're all different aren't they? You've got your kinaesthetic learners and your other ones and I think it's whatever the child needs really. You know I think you need to know what… I mean I liked the one that you gave me, the questionnaire to find out what sort of children they were. I liked that cos then I thought to meself 'oh he does respond better with this and she does... and like B might not be listening but he might be taking it all in and not to be on his back all time for not listening. Do you know what I mean? But I think a lot of the questions they didn't really understand em.	Learning styles info appreciated.
R	Yes it was quite adult language wasn't it?	
T	I think it was. I think I just got a few answers that you know... they didn't really know.	
R	Yes I should have mentioned reading them with that. Erm also the discussions we had on the numeracy difficulties, do you remember? 12s and 20s being confused …	
T	Yeah, B	

R	And then children giving answers that sound nothing like the answer but then I said they try lots of answers and the ones you respond to are the ones they associate with the right answer because they haven't developed a fuller understanding yet. I mean apart from explaining why that was happening was that any use at all do you think?	
T	Well I did work on the 12s and the 20s with B and we put in rather than just doing it by sight and hearing he actually chose like 12 snakes and 20 tigers and that were his way of when he saw the number he could say to himself, cos I'd say to him 'what's this?' and he'd go '12 snakes, 20 tigers' and then I said to him 'right you don't have to say the tigers and the snakes now. You can just you know. So he actually needed a visual aid there and he decided that himself cos I said to him 'is there anything that's gonna help you remember?' and he said…Like I always think a number 8 is like a snowman, a head and a body, and when I'm doing 8s with K and just trying to draw them I say to start off we'll draw an head and a body that's the shape we want, it's like a snowman, you know.	Children supported to identify self help strategies. Use of visual memory aids.
R	It's that visual thing again isn't it?	
T	Yeah	
R	It tends to work. That's where the Piaget bits came in because they are at that concrete stage where things have to be in front of them to make sense. Anything that's not there it's like what are you talking about? But yes, thank you. Is there anything else that you think would have helped you that should have been done?	
T	Not really no. If I needed anything I would have got in touch with you.	EP support seen as adequate.
R	Can you think of anyone else that could have done this instead. Could you have drawn that support from another professional?	
T	Erm I'm not sure. I've forgotten if anybody else…I think wave 3 is being used in school but I'm not sure who by. I think we're all in our little…we're that enthralled as you know in our work. We're not aware of what's going on around us a lot of the time when we're working.	No immediate alternatives to EP support.
R	Did you liaise with the numeracy co-ordinator at all?	
T	No.	
R	But you do have one?	
T	Yes. I liaise with Mrs J really because I thought we need to yeah.	
R	OK thank you. I think this next question we've covered in general so I'll go through it a little quicker but the general question is how did you find working with the children?	
T	Yeah, they were fine.	
R	That's the best bit isn't it? They enjoyed it?	
T	They enjoyed it. I enjoyed it. You know erm I don't think it'd been the same probably if they were sat there and they were umm but you have to make it fun for em. You get out of it what you put in I think.	Experience enjoyed by TA and children.
R	Yeah, I think you're right and how was the size of the group?	

T	Yes fine.	Group size was manageable.
R	Anymore than that would have been a bit difficult to manage?	
T	And I think there was quite a variation between the two boys and K. I think the two boys were on a par. Erm the work for K really had to be differentiated for her quite a lot.	Differentiation by TA is a key factor.
R	Yeah and that's pretty obvious from my observations as well.	
T	And that might be the bugbear really. How many children can you incorporate? Do you need them at the same level for it to work better although you can see K has come on.	
R	She has yeah	
T	But would K have come on with the same work as them or is it because it was differentiated.	
R	Yes that's true, the other…	
T	Would you advise that? not to plough on with children like K with the B's and R's work and to differentiate for her.	
R	Yes I would. I think the way you've done it is the best way to do it. Keep it to their level because it is supposed to be as individual as possible. I think three is as large a number group as you can manage that with. In that 15 minutes you're technically only giving them five minutes each anyway.	
T	She did notice she was doing different work.	
R	Yeah and…	
T	But we put it down to the she has to learn these first. She can't write numbers the right way round. She can't do sums properly and she was quite alright with that so then she was eager then.	TA awareness of self esteem issues.
R	Yes you don't want to lower her self esteem. Keep it at the right level.	
T	And you need to keep equipment the same as well. Because I gave R and B a number square and I gave K a number square just one that I had and K's was smaller than R's and B's and she wanted a big one.	TA awareness of 'equal' treatment.
R	Yes, for children that is so important isn't it? Because it feels like a judgement. You judge me as less important or something even though you haven't meant that at all. Yeah, well spotted. The timing of the sessions and the support you got from Mrs J that was all fine?	
T	Well yeah. Like I said there was no point taking them out during their main session in numeracy because then what are they gonna do? They've missed four months and everybody else has moved on so I think the timing was the best, the beginning of the lesson.	Contextual issues.
R	Could you see them making any progress whilst you were working with them? Did you think hang on that seems to be coming on in terms of attitude, confidence, ability and other respects?	
T	Yeah yeah. I'm really proud of em really because Mrs A'll be sat doing something and she'd hear one of em say something and she'd say 'did I	TA proud of achievements.

	hear that right? Was that you R? or that were never B?' and I'd say 'I'm gonna faint, I'm gonna faint, Mrs A I'm going to faint'. So tell Mrs A what you've just said you know and spread it about a bit.	Celebrating small steps and boosting confidence.
R	Yeah that's a brilliant way to do it and it boosts their confidence doesn't it?	
T	Yeah	
R	Oh great, great. Did they receive any other input apart from the NNS intervention that you think could have an effect on their numeracy?	
T	No, only the work that they did in class and that was after.	Possible contribution of class work to progress.
R	That was after, OK, so there's nothing specific that…	
T	No we didn't do the Max's marvellous cos that's what I would've done with them. I would have done Max's at the beginning but because we were doing wave 3 we didn't do that.	
R	OK so what do you think about their numeracy ability now? You can be honest.	
T	They're more enthusiastic I think. I don't know if the enthusiasm will stay now they're back in the class room. Erm, I'll try and keep it there. I'm not working with them in the classroom now; I'm working with the girls for me performance management. But Mrs A is supporting them and they do know Mrs A. Erm So hopefully they'll still be enthusiastic.	Increased enthusiasm. Maintaining enthusiasm.
R	Good good	
T	Erm I did think about what you said when does it come naturally. Are you born to know numbers and what have you? And I do think that it's ability now. Cos even though they have progressed I still don't think it's easy for em.	Numeracy remains challenging despite progress.
R	Yeah, I'm glad you said that because that was my next question, You're very good A, it's like we've planned it. I was going to ask what appears to work for them in particular. It is the small group situation is it? And the fact that they've got you for support and the visual stuff, anything else that you can think of?	
T	Erm just the praise and knowing let them… You see I let them on the precision teaching I let them tick the boxes when they got them right. I know if they'd have got them wrong it wouldn't have been a good idea but I wouldn't let them do it if they'd got lot wrong. Just so that they ticked they could see that they'd got it right rather than me ticking and saying 'yes that's right, that's right'. We compared there's to mine and if they got it right they gave it a tick. And stickers and house points. They were eager for them.	Praise. Promoting positive self esteem. Use of rewards.
R	Oh that works for all kinds of children. You go up to Year 11 and they still want them.	
T	I think it shows people. Some aren't bothered about them are they? You usually find the ones that can do it aren't bothered but the ones you know 'I've got two stickers today'.	
R	And everybody likes praise and it's just another form of praise isn't it?	

T	Yeah	
R	So how could you tell that the intervention was working? What was it that made you think 'Ah, it seems to be doing the right thing with these children'	
T	Just the way they were when they came out they enjoyed it and I think if it had been boring and erm not appealing to them they wouldn't have wanted to come. You know and them doing things at home and bringing back and wanting to do well. Wanting to beat each other and see you know. When I gave them a number sheet with erm number sentences on erm put them either side of R and B. You know, I said to them 'don't rush it's not a race it's who gets the most right'. You know and they couldn't wait until the end to see who's got it.	Children were keen to participate. Children did more than expected. Children set personal targets.
R	So you didn't have to drag them from the class room? Because children are very honest, if they don't want to come they'll pull a face or whatever and you'll know.	
T	In fact they were asking when they were going to do it again and I've had to say to them 'not for a while'.	Enjoyable and motivating – no anxiety.
R	You should have told them it's just for a treat.	
T	A treat; if only they knew (laughs).	
R	Erm so you've answered this question that I was going to ask which is are you born good or bad at maths and is there anything we can do to change things? It's the ability like you said earlier. So, philosophically then, can everyone become better at maths?	
T	They can become better. They won't, a lot of people won't become Einsteins. But they can improve on what they're doing I think but I think it depends on what level you're going to take em to. I mean some children I think are just gonna be OK with the basics and other people are going to be able to do pi and this that and the other. You know I think it's the mental ability.	Potential for positive change for all. Limited by individual ability.
R	So we're talking about individual levels aren't we?	
T	Yeah	
R	But would it be fair to say that if you bring work down to a level that the children can understand you can make virtually any child make progress?	
T	Yeah, I think you can. Because addition can be made as hard or as easy as you want. I mean if they go further up the school it's made harder isn't it? Same as subtraction. You use different vocabulary. You use different ways of doing it but I think like these children, they just need the basics. Throwing it in the bin or you know	Task presentation. Importance of TA in delivery.
R	Yeah, understanding the concept of subtraction.	
T	I mean even with the difference, the cubes, they were cutting it off. You know it was something for them to see where the same ended and the difference began. Whereas if you put two numbers in front of them and said 'what's the difference between this number and that number?' Well it's just two numbers but bricks - which one has more and which one has less? You know so what's the difference?	Concrete materials used to support understanding.

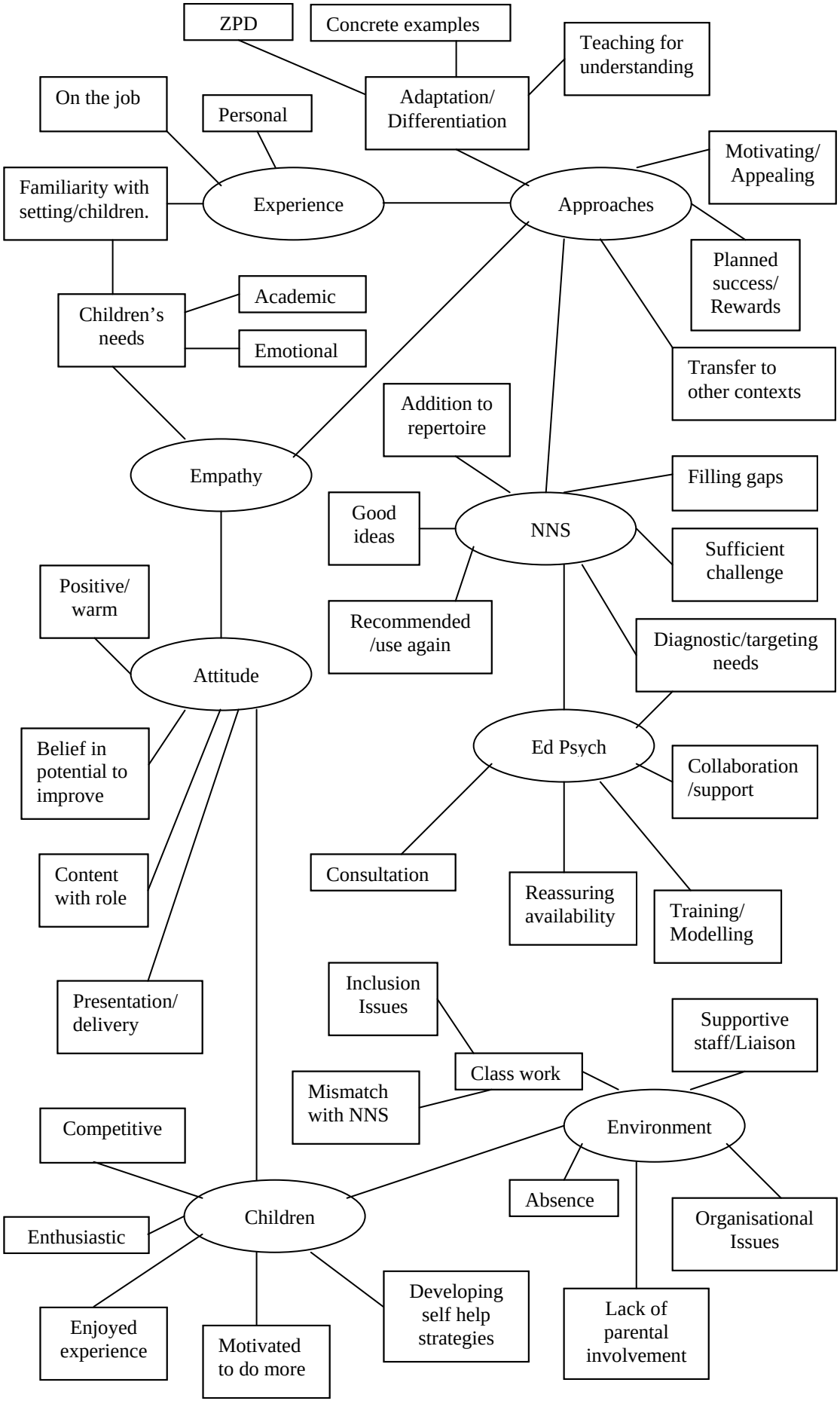
R	Right. Now the intervention is called supporting children with gaps in their understanding and I know you like the word gaps. Do you think that applies to the three children we worked with? Were there actually gaps in their knowledge or? (Interruption by third party). Erm so does the gaps idea apply to these three children or do you think it was more a case of them not having as much experience as they should have had or whatever you think?	
T	I think…that wave 3 shows you where the gaps are. I think really it's, you need to know where the gaps are to be able to work on the gaps. Now I didn't know with those children really where the gaps were. Now like with Mrs J and this intervention group with the girls, she's done an assessment, I mean you did the assessment so you could tell me where the gaps were like with the first, second and third and the vocabulary. But I do think you need to know the gaps.	Diagnosing 'gaps' is important.
R	So that diagnostic stuff needs to take place before you can work on the gaps?	
T	Yeah , to work on , you know, because you could be, recapping is not a bad thing, you know erm, like when I came up and started doing the Max's Marvellous I didn't think that these Year twos were as poor as last years. But they'd had Max's Marvellous in Year 1 so maybe some of the gaps had been filled. And like now with the intervention with the girls, Mrs J is finding the gaps through their work and then I'm working on the gaps. Just the gaps, you know what I mean?	'Filling gaps' idea being used with other groups.
R	Yeah I do. So you're basically saying identifying them is important otherwise you don't know what they are in the first place or what to do with them.	
T	I think you need to know what the gaps are	Diagnosing 'gaps' is important.
R	Yeah, to be able to do anything about them	
T	To fill them. Because you might be going doing something that they already know, which, you'd pick up on that then but that's time wasted really isn't it? You could have been filling a gap with that or trying to.	
R	Great thank you. Right a rating question then, on a scale of 1-10 where 10 is 'very happy' and 1 is 'not happy at all'. Where would you pace yourself in terms of how happy you were to have participated in this intervention?	
T	10…yeah, well I'm not bothered. It hasn't hindered me in fact it's given me some more experience really so I'll do anything (laughs). No I won't I'll have a go.	Boosted rating for 'happy'.
R	And it seems to have worked and it's been a good experience. Good I want to repeat that now with 'confident' where 10 is 'very confident' and 1 is 'not confident at all'. How would you feel about doing a numeracy intervention in the future, a similar one to that?	
T	Mmmm…8.	Confidence boosted by experience.
R	8? So that's pretty confident	
T	Yeah, because I'd research, I'd have to you know, I mean it's like anything else if you're asked to do something I'd have to know what it's all about and what I want. You know like you gave me those things to	

	read and you gave me the set to you know come home and have a look through them. I think you've got to erm make it easy for you. You know I don't think you should go in blind in anything not anything you know.	TA needs to be clear about expectations.
R	I agree	
T	Even if I'm doing independent reading and I'm not sure about something I'll ask, you know what do you mean by that? I'd rather know than just to bluff it or whatever so I'd be confident about doing it if I got to see it first and have a look at it and decide. If I weren't sure then I could say but for having a go, yeah.	TA needs to be clear about expectations.
R	Oh good and inevitably you're going to do some things differently based on that experience aren't you?	
T	Yeah, Like I'm looking forward to working with the girls see if we can improve them on their gaps.	TA keen to use NNS again.
R	Would you recommend this intervention to others?	
T	Yeah yeah.	TA would recommend to others.
R	Will you continue to use the materials?	
T	Yes and the ideas.	
R	It's become part of your toolkit has it now?	
T	Yes it has, if I'm doing Max's Marvellous I'll probably integrate the two because Max's Marvellous can be too easy. You know a lot of it's visual where with wave 3 you have got some writing and you know and some er…	NNS added to TA's repertoire.
R	So do you think this is more orientated towards class work? as in being able to be in a classroom and to write mathematical sentences and actually getting thinking down on paper so it gears you towards that written maths?	
T	Yeah and using it, you should be able to use some of the things you've done with wave 3 in your numeracy work in class whereas Max's Marvellous you can use some of the ideas but can't actually use the ponds and the fish if you know what I mean.	NNS more challenging and useful for transfer to class room.
R	Yeah so helps your understanding, Max's Marvellous Maths, but sometimes it may not transfer as well into the classroom.	
T	Yeah	
R	Right OK and I think you might have touched on this anyway but how is it better, if it is better, than other interventions you've done or do you think it's on a similar level?	
T	No I think it's erm, at first I thought it were gonna be too hard. So you have got the higher range. If you want to use it on a lower range, you can, because you can adapt it. So you can follow the wave 3 on a lower range for your children but it is a bit more of a higher range than Max's Marvellous maths. Max's Marvellous is only supposed to be for Year 1.	NNS seen as sufficiently challenging and adaptable.
R	I see	

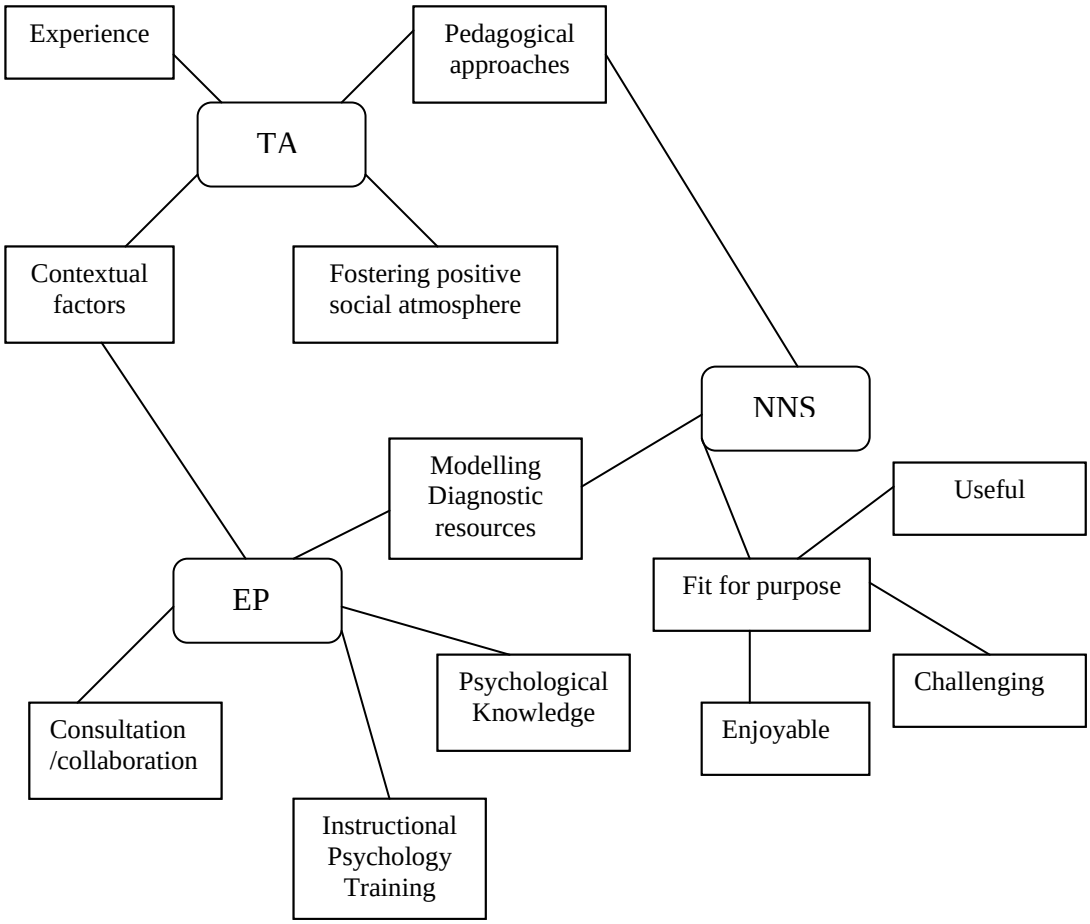
T	But because ours are poor it's like we'll do Max's Marvellous again but I probably would make it a little bit harder	TA acknowledges need for greater challenge.
R	Yeah	
T	You know Cos like I say I thought these were quite a bit better than Max's Marvellous maths so then I myself would now have probably incorporated some wave 3 but before I would have probably just asked Mrs J that you know this is a bit too easy for em what do you suggest?	TA developing self sufficiency with NNS.
R	OK right	
T	But now I'll use some of that.	NNS added to TA's repertoire.
R	OK last question then. Is there anything else that you'd like to tell me that I haven't asked about?	
T	They could get right disappointed if they didn't get the right praise.	
R	Right is that something you think you managed well?	
T	Yeah because if like R got more than B you know B would say ugh but I'd say it don't matter because look. You know they've got to go away feeling that they've done their best. You know and they're not daft even if it's not a competition they're looking to see who's got it right and who's got it wrong.	Careful management of social situation.
R	Right that's a good point A, thank you for that. Because that can really affect children's self esteem because children look at all kinds of things it's not just, they're not just there for the numeracy. It's a social situation and if they're feeling that they've failed then that goes with them.	
T	And if they leave that's it. So you know every body gets house points even if they weren't the best that day - that one may get a sticker but every body gets a house point and every body gets told they've done well and you always end on a high note.	Maintaining self esteem.
R	Oh good. So did you ever engineer it so that somebody who maybe hadn't done as well as they could have but you thought I can't let them leave here feeling down. Have you ever deliberately put some praise in there or something …?	
T	And I gave em an easy one at their level.	Strategies for planned success.
R	Yeah but that would be appropriate.	
T	And somebody would say like 'he's had an easy one' and I'd say 'no that's not an easy one for him that's the level he's working at that's a hard one for him you know easy for you but that's a hard one for him because you know it'	
R	Yes yes and when I saw you in action A, I must admit I was very impressed. I though there's not really much I can add to what you were doing because you were doing so well.	
T	I'm just trying me best.	
R	So well done you.	

T R	I feel like I'm what is it but I'm not it's just how I do it. Yes I think it comes naturally to you, I really do and I think it's been a success because of your personality so thank you for that and thank you for taking part A.	TA personality/ attitude facilitates successful group work.

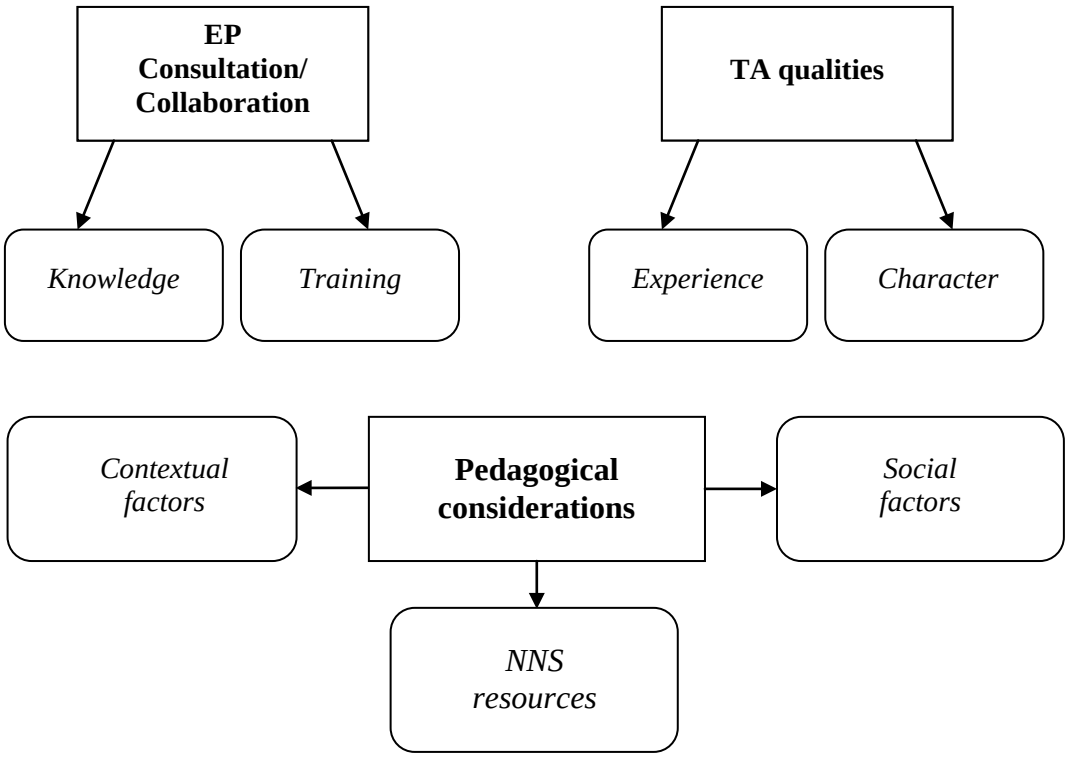
Following phase 3 of Braun and Clarke's (2006) method of thematic analysis (see table 8), an initial thematic map was created as illustrated below:


ZPD
Concrete examples
Teaching for understanding
Adaptation/ Differentiation
On the job
Personal
Motivating/ Appealing
Familiarity with setting/children.
Experience
Approaches
Planned success/ Rewards
Children's needs
Academic
Emotional
Transfer to other contexts
Addition to repertoire
Empathy
Filling gaps
Good ideas
NNS
Sufficient challenge
Positive/ warm
Recommended /use again
Diagnostic/targeting needs
Attitude
Ed Psych
Belief in potential to improve
Collaboration /support
Content with role
Consultation
Reassuring availability
Training/ Modelling
Presentation/ delivery
Inclusion Issues
Supportive staff/Liaison
Class work
Mismatch with NNS
Competitive
Environment
Absence
Children
Organisational Issues
Enthusiastic
Developing self help strategies
Lack of parental involvement
Enjoyed experience
Motivated to do more

Following phase 4 of Braun and Clarke's (2006) method of thematic analysis (see table 8), a developed thematic map was constructed from the above initial thematic map as follows:



Following phase 5 of Braun and Clarke's (2006) method of thematic analysis a final thematic map was constructed as illustrated below:



Final thematic map for case study one showing three main themes.

APPENDIX 8 – Example of a completed Children's attitude questionnaire

Attitude Survey (children's questions)

Name__XXXXXXXX__ **School**_____**X**_____ **Date**_March 2010_

☑ = the face ticked by the child in response to the question.

9. How do you feel about coming to school?

Very Happy Happy ☑ OK Sad Very Sad

10. How do you feel about numeracy lessons?

Very Happy ☑ Happy OK Sad Very Sad

11. How do you feel about literacy lessons?

Very Happy Happy OK ☑ Sad Very Sad

12. How good are you at numeracy?

Very Good ☑ Good OK Not good Poor

13. How good do you think your teacher thinks you are at numeracy?

Very Good Good OK ☑ Not good Poor

14. How good do you think your mum/dad thinks you are at numeracy?

Very Good Good OK ☑ Not good Poor

15. How good do your friends think you are at numeracy?

Very Good Good OK ☑ Not good Poor

16. Would you like to tell me any thing else that I haven't asked about?

I liked it.

I liked playing the games the most.

(*The verbal comments above were made by the child and recorded by the researcher)*

Section 3.5.2 describes the content analysis method used.

The unit word categorised in this example was 'liked'. Most children used this word whilst others used 'loved'- it was felt the same sentiment was being expressed by both. All children made these positive comments only reflecting that they were 'happy' to have participated.

Thank you.

APPENDIX 9 – Example of a completed Teaching Assistant's questionnaire

TA questions. **Child's name**___XXXXXXX__XXXXXX__

Please put a tick in the appropriate box for each statement about the child named above.

Statement	Always	Mostly	Sometimes	Rarely	Never
Is happy to do numeracy work	☑				
Is keen to do well and tries hard	☑				
Actively participates in numeracy lessons		☑			
Can work out answers in more than one way			☑		
Will try even if the work is challenging	☑				
Can explain how they arrived at an answer		☑			
Can spot their own errors if they talk through the problem			☑		
Makes the same errors over and over again			☑		
Do you have any other comments?	Definitely has more confidence. Much better retention now.				

Section 3.5.2 describes the content analysis method used.

The unit words categorised in this example were 'confidence' and 'retention' – both reflecting positive change. Other examples used 'enjoying' numeracy and having more 'motivation'. TAs did not comment on every child but all comments made were positive.

Thank you

APPENDIX 10 – Sample from a research diary.

Date___XXXXXXXXXX____ Location____X____ Session____X_____

Item	Details	Reflections
Comments from previous session: -What is going well? -Any Concerns? -Issues raised	Precision Teaching has gone down very well. Head wants it rolled out across the school. Trained TAs 'buzzing' with their newfound skills and other TAs keen to get involved after hearing about it. Children are enjoying taking part. ***Coded for: pedagogical approach and contextual factors***	Great to see effort put into preparing training was worthwhile. Feel quite chuffed about this. Should help to develop the essential fluency with basic numeracy needed in order to make further progress. Possible systemic input emerging. Need to measure the value added by this.
Identified needs/focus	TA wants to make sure the way she is going abut Precision Teaching is correct/acceptable. NNS stuff going OK. TA likes it and will carry on. Concerned about slow pace. ***Coded for: EP consultation and EP modelling.***	Reassurance needed from EP. TA wants to be told what to do (power issues?)but this could be due to PT being new to her. Continue to monitor and advise. Children like this have had a number of interventions and need to be given time to learn with understanding before moving on. Reassure TA that pace is fine and consolidating learning is more important.
Psychological principles employed/to be employed	Vygotsky's zone of proximal development. ***Coded for: Psychological knowledge*** Instructional Psychology. ***Coded for: EP consultation and EP modelling.*** Positive Psychology ***Coded for: fostering positive social and learning atmosphere.***	TA using without realising. Says it makes more sense when discussed in relation to specific children. TA enthusiastic about Precision Teaching. Keen to get further probe sheets made and track progress. Seems to want to take a lead amongst TAs - possibly because she is seen as the one liaising with the EP. Plenty of praise, good humour and confidence building being used. TA relates very well to the children and fosters a safe, secure learning atmosphere. This is a crucial but undeclared part of the intervention. Role of deliverer in presenting numeracy is obviously pivotal.
Observations and further comments	TA and children doing number bonds initially to 10 and then to 20. Mostly verbal but involving some written recording too.	Good recap of previous work using concrete materials to support understanding and key vocabulary to broaden

	Children are asked to split blocks of ten cubes and write a number sentence using signs. Bonds to 20 still causing confusion. ***Coded for: NNS resources***	children's access to the 'wider mathematical community'. Children obviously enjoying the success being experienced with the bonds to 10 task.
	Moved onto number partners for numbers up to 20. TA: 'use thinking head not fingers or cubes'. Using hops on a number line to assist with calculations. TA: 'put one number in your head and count on'.	Attempt to shift away from reliance on concrete materials. Use of abstract number line.
Coded for: pedagogical approach and NNS resources.	TA focusing on one child at a time and encouraging others to observe and help out if necessary. All children actively participating for the full session.	Use of peer support and encouraging social construction of shared mathematical meaning – effective teaching skills.
	Children did not recognise 11+4 and 4+11 as the same and attempted to work both out separately. TA said 'don't worry' but did not stress the reversibility of these mathematical sentences.	Development of conceptual mathematical thinking limited by lack of emphasis on law of commutativity. Need to discuss with TA how to incorporate methods to encourage conceptual shifts in thinking.
	Session ended with a competitive game from the materials – well received by all children.	NNS ideas engaging and appealing to this ability range. ***Coded for: NNS resources useful and enjoyable.***
	Back in class, children sat at the back continuing to work on their own tasks. More noise in class but children seemed to be used to it and focused on work with TA.	Only physical inclusion. Children working the same as before but now whispering.
Coded for: contextual factors	Teacher passed worksheet to TA and briefly explained what needed to be done. Small group work with the TA helped prepare children to take on the class work on number lines at a basic level. Though less support in larger group of 7 was difficult for them to cope with.	Better if TA could have introduced this to children before they returned to class. Children struggling to manage without the 1:1 attention they had in the small group. Need reassurance that every little step is OK before moving on to achieve the next little step.

Codes from research diaries were combined with codes from TA interviews for each case study to construct the final thematic map.