Target 1

To Monitor and Evaluate the Effectiveness of Catch-Up Numeracy with the Aim of Raising Achievement and Confidence in Pupils with Mathematical Difficulties.

Introduction

The aim of this research was to investigate how the support given to low attaining pupils in mathematics could be improved to help them overcome their learning barriers and narrow the attainment gap. The study took place in a single form entry primary school on the outskirts of a large city. The school is broadly in line with the national average, (RAISE online 2012) with 23% of pupils on the SEN register including 4 pupils with a Statement of Special Educational Need. Most pupils on the SEN register are at the School Action level for Moderate Learning Difficulties (MLD) or Speech, Language and Communication Needs (SLCN). (DfE, Code of Practice, 2001*a*).

Following the SENCO audit, it was recognised that a more robust system for monitoring the progress of pupils on the SEN register was required. A tracking graph was implemented which provided a clear visual representation of termly progress in Reading, Writing or Maths (Appendix 1). From this tracking it was evident which children were not making adequate progress in these core curriculum areas. (DfE, 2010 & The National Strategies, 2008). Work had already been done on implementing interventions to support pupils with literacy difficulties, based on the research report by Brooks (2007). However, as a school it was recognised that more needed to be done to support pupils with mathematical difficulties.

Firstly, it was important to investigate whether there were common areas of weakness amongst the pupils who had low mathematics attainment or progress and research factors that may be influencing this, particularly Dyscalculia. Secondly, a range of possible interventions needed to be investigated to ensure they matched the pupils' needs. Next, the selected intervention needed to be trialled and evaluated to ensure it was effective in meeting the intended outcomes. Finally, the outcomes needed to be fed back to staff and development targets set where appropriate.

What are Mathematical Learning Difficulties and Dyscalculia?

Developmental dyscalculia (DD) is a specific learning disability that the pupil is born with and is therefore not as a result of poor teaching or low intelligence, although they may appear to have similar characteristics. It is estimated that it affects around 5-7% of the population (Westwood, 2011). It is still a relatively new area of study and research is continuing into its cause, screening techniques and treatment. (Bird 2007, Williams 2008, Butterworth 2011, Chinn 2012).

The DfES (2001*b,* p.2) defined Dyscalculia as: '*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.'*

Evidence suggests there is a link between specific brain areas and number processing. In the DFE training materials (Unit 16, 2012) Lamb cites Hulme and

Snowling (2009) who found: '*the horizontal intraparietal sulcus may be implicated in deficient 'number sense', and less activation in the parietal areas* (a part of the brain just above the ears) *occurs in dyscalculiacs during calculation'.*

Butterworth, a neuroscientist and leading professional in the area of Dyscalculia, also believes that numerical abilities rely on specialised brain networks. He claims: '*we are beginning to understand how the brains of dyscalculic learners are different from typical learners, but we still do not know why they are different.*' (Butterworth, 2010, p.v11). One possible reason may be that brain development is genetically altered, as dyscalculia (like dyslexia) often runs in families; however, there are still many cases that are not genetically linked, suggesting there may be other causes. (Callaway, 2013; Butterworth, Varma & Laurillard 2011).

Dyscalculia is defined as a specific learning difficulty (SpLD). However, labelling in this way would require expert diagnosis and suggests there is a 'treatment' to minimise the impairment (medical model of disability, Sakellariadis 2010, p. 27 & Gifford 47). Weedon (2012, p.55) states: *'affixing a label implies some kind of certainty about just what causes the difficulty, what it stems from. Yet the most rigorously derived label for a specific learning difficulty may still be no more than a description dignified as a diagnosis.'* It also implies that the child cannot be taught. However, Studies have shown that children who appear to have dyscalculic tendencies can be taught, using targeted wave three interventions (Gifford, 2005, p.46). Therefore, 'mathematic difficulties' is a better description as it suggests the pupil has barriers to learning which can be identified and addressed. It is common for pupils with mathematical difficulties to have difficulties in other areas such as difficulties with their working memory, language skills or dyslexic tendencies. This co-morbidity, is one of the reasons that categorising specific learning disabilities causes confusion. (Weedon, 2012, p.54).

It is also important to highlight that a much higher percentage of pupils (than the 5-7% identified as having dyscalculia) are low achievers in mathematics and may make limited progress. In fact it is estimated that at least 15% to 20% of the population have difficulties with certain aspects of mathematics which can impact on their educational performance and long-term ability (Bynner and Parsons, 1997 and 2005; Every Child a Chance Trust, 2008). These pupils often display a poor attitude towards the subject and have little confidence in their own ability (Westwood, 2011 p.165).

Literature Review:

Research suggests there can be a difference of three years in the early number knowledge of children starting school in Reception. Low attaining pupils have been found to remain at a low level throughout their education, with the gap between them and their higher achieving peers widening as they move through the school. (Wright, Martland and Stafford, 2000).

Williams (2008, p. 43) found that there is still a group of pupils who fail to achieve level 3 in mathematics by the time they leave primary school at age 11 and approximately 6% of pupils do not achieve higher than level 2. He states that: *'there is no consensus about any single, dominant cause of this under-attainment. This is an important conclusion in itself, as it strongly suggests that there is therefore likely to be no single solution to the problem'.* (Williams 2008, p. 43-44). It is possible that this 6% relates to those pupils with the most severe specific difficulties and who would benefit from individually targeted wave 3 interventions (Dowker, 2009, p.16).

The House of Commons Public Accounts Committee (2009, p.3) also reported on mathematics performance in primary schools and found that despite a large investment and national strategy to improve maths in primary schools, improvements have levelled off. *'In 2008, 79% of pupils met the Government's expected standard at Key Stage 2 (age 11) in national tests.. well short of the Department's ambitions of 85% by 2006. This means that 21% of pupils—over one in five—are starting secondary school without a secure foundation in mathematics.'*

The major factors associated with learning difficulties in mathematics include:

- An inability to subitise: Subitising is recognising the quantity of an array of objects at a glance without the need to count them. (Emerson & Babtie, 2010, p.4). Subitising contributes to early forms of grouping and seeing parts in the whole. This makes it possible for children to think about a number as being made up of other numbers – an important factor in developing pupils' number knowledge. (Wright, Martland, Stafford & Stranger 2010)
- An inability to estimate whether a numerical answer is reasonable (Bird 2007)
- Long-term memory difficulties: This leads to difficulties remembering basic mathematical facts, particularly if they are given verbally. (Emerson & Babtie, 2010, p.5.) *'Just how much the inability to learn all the expected basic facts contributes to a learning difficulty depends on the specific demands of the maths curriculum and the way it is taught.'* (Chinn 2012, p.172). In order for children to remember information McGrath (2010, p.33) claims there are two principles: imagination and association. In order for a fact to be remembered

the pupil must be able to build a story associated with the fact so that it can be recalled at a later stage. This is the principle behind mnemonics which have proved helpful to some children.

- Short-term memory problems: This leads to children forgetting the question or difficulty remembering a sequence of instructions. (Spooner 2006, p.43 & Emerson & Babtie, 2010, p.5.)
- Working memory difficulties: This can cause difficulties in many areas of mathematics but particularly mental arithmetic. (Chinn 2012, p.173).
- Difficulty counting, particularly backwards or in chunks of two, threes or more, which affects basic 'number sense': Counting helps children to make sense of the spoken number system. The DfES (2001*b*, p.3) states pupils need: '*clear instructions on how to count in an organised, meaningful way. They should count objects frequently, move objects as they count, count rhythmically to synchronise counting words with counting objects, and pause to 'take in' the quantity counted.'* Haylock & Cockburn (2012) also highlight the importance of learning and teaching mathematics with understanding which involves the use of concrete materials, symbols, language and pictures.

Chinn (2012, p.171), Gray (1997) and Emerson & Babtie (2010, p.5) stress the importance of developing number sense and make the link between counting, addition and subtraction and the later link with multiplication. As counting is also linked to place value, an over-reliance on counting with fingers and poor understanding of number structures (i.e. that numbers contain other numbers, so 4 can mean 4 but it can also be seen as 2+2 or 3+1) can dramatically impact pupils' mathematical ability.

Professor Eddie Gray (1997) has researched work on counting and developed the idea of the ‘counting trap’. Pupils who experience difficulties in maths and have poor working memories and sequencing difficulties will often rely on counting on their fingers in ones. This is an arduous and long winded process that puts unnecessary strain on their working memory, as the pupil must keep track of the running total as well as a count of how much they are adding or subtracting. The answer, which is arrived at only after a great deal of effort, anxiety and time, becomes disassociated from the question, so the pupil never learns new facts, which can be stored in their long-term memory.

- A weakness in visual and spatial orientation and directional confusion: This can affect the pupil’s ability to make sense of visually presented material, shape, co-ordinates and symmetry. It may also affect their ability to skim and scan texts or numbers and they may lose their place on a page easily. It can impact on their ability to sequence, order and understand place value, particularly in larger numbers. They may also have difficulties handling data, including graphs, charts and diagrams. (Emerson & Babtie 2010, Spooner 2006 & Reid 2011).

- Slow processing speed: This means the pupil may require more time to process the different aspects of information when solving mathematical problems, compared with someone who does not have this barrier to their learning. This can have a particular impact on their mental calculations, particularly when time-limited. It is necessary therefore to ensure that additional time is provided for pupils with processing difficulties. (Reid 2011 & Bird 2007).

- A tendency not to notice patterns (Bird 1997).

- A problem with all aspects of money (Bird 1997 & Reid 2011).

- A noticeable delay in learning to tell the time and an inability to manage time in their daily lives. (Bird 2007)

- Language: using mathematical language can be a barrier to pupils' learning and they will need to be taught specific vocabulary. They may also need support with reading maths questions, naming symbols and the double-meanings of words such as right and write. Finally, there are some inconsistencies with mathematical language which may also cause difficulties, e.g. eleven and twelve do not follow the pattern of the other two digit numbers which have the unit before the ten, e.g. sixteen (six-ten). (Chinn 2012, Lee 2006 & Spooner 2006).

It is important to note that no two children are the same and only some of these factors may be present in a pupil with mathematical difficulties. Conversely, pupils may appear to have similar needs but in fact their underlying barriers may be very different. Equally, a pupil may have other barriers which may impact on or mask their mathematical difficulties such as poor organisational skills or speech and language difficulties. (Weedon, 2012)

Other factors believed to impact on primary mathematical achievement are:

1. Social and economic factors, including deprivation: Parents may have low expectations of their children; given that many adults do not have basic numeracy skills, many parents are unable to support their children with their homework and learning. Also, poverty may lead to a lack of resources and added stress in the home. (The House of Commons Public Accounts Committee, 2009; DfE, 2010 *b;* Westwood, 2011).
2. Overall quality of classroom teaching: Quality-first teaching is essential for all pupils to make progress and learners are more enthusiastic if they are taught well, particularly if it is meaningful and fun. (Williams 2008)
3. Barriers to learning of a clinical or psychological nature. (Williams 2008): In addition to dyscalculic tendencies mentioned previously, anxiety may also be a contributory factor as it often has a debilitation effect on performance and have a negative effect on working memory (Chinn, 2012 & Ashcraft, Kirk & Hopko 1998). Pupils who succeed in maths will have the confidence to take risks to solve a new problem. Conversely, a learner with a limited success rate will only tackle problems within their known success range and will be reluctant to take risks, resulting in little or no progress in learning.

In order to plan for intervention it is important to find out the specific strengths and weaknesses of the learner; and to investigate particular misconceptions and incorrect strategies that they may have. Emerson & Babtie (2010, p.2) state: *'It is essential to find the point at which they have failed to acquire some fact or concept that is crucial to numeracy development. Teaching should start at this point using a* *structured multi-sensory approach which uses real objects to explore maths ideas with the child discussing what they are doing.'* It is also important that the intervention focuses, not only on addressing their numerical weaknesses, but also helps to reduce the immense anxiety often associated with dyscalculia. (Dowker, 2009, p.3 & DfE 2012).

Methodology and Study:

In recent years there has been an increase in neuroscience and cognitive developmental research to gain a greater understanding of mathematical difficulties (Dowker & Sigley, 2010: p.65) however, this medical understanding does not help support teachers or pupils in the classroom. In this case, action research was used to help identify barriers to pupils learning and how these could be overcome using a specific Wave 3 intervention, Catch Up. The DfE (2012: p. 38) highlight the importance of early identification and appropriate support to help all pupils to progress well.

The aim of this small scale study was to acquire '*specific knowledge for a specific problem in a specific situation*' (Cohen & Manion 1994: p.194) with the purpose of using this knowledge to improve practice (Koshy 2005: p.9). Action Research, a term first used by Kurt Lewin, involves a series of enquires with critical reflection and questions arising at each stage of the process (Baumfield, Hall & Hall, 2012, p.3).

Following the detailed analysis of the pupil tracking grids, pupils who had failed to make expected progress in mathematics (despite additional classroom support and wave 2 interventions) were identified. This raised important questions about why they had not progressed and what could be done to support them better.

The Mathematics Subject Leader had already spent time carrying out book scrutinies and pupil interviews for research into Pupils' Misconceptions. This, together with evidence from Assessing Pupil Progress (APP) data and lesson observations, suggested the main area that pupils were struggling was MA1: Using and Applying Mathematics and MA2: Number (QCA, 2008) with counting strategies being a particular issue. INSET training was given at this point to help raise staff-awareness and introduce new strategies for developing MA1 and MA2 in all pupils, through quality first teaching.

Time was also spent investigating Wave 3 interventions and advice was sought from the LA SEN Inspector. It was decided that, due to the limited resources available, age of the pupils identified and their specific needs, Catch-Up Numeracy would be trialled as it was the most appropriate intervention for supporting children with 'moderate mathematical weaknesses' Dowker (2009).

The school invested in training for the SENCo as manager and an experienced teacher, who would be allocated time to work 1:1 with the pupils. The training allowed those involved to gain a sufficient grasp of the Catch Up Numeracy approach and ensure the intervention was implemented appropriately (Evans, 2008: p.5) The target pupils for the intervention are pupils in Years 2 to 6 (Dowker, 2009). Initially, 4 pupils from Year 3 and one pupil from Year 4 were selected for the intervention as their tracking graph showed a large attainment gap; they had difficulties in number; they relied heavily on ineffective counting strategies and displayed high levels of anxiety (Catch Up, 2011: p.7).

The pupils' number age was tested, using the Basic Number Screening Test (Gillham & Hesse: 2001) in order to allow some form of quantative evaluation in addition to on-going qualative evaluation. (DFES, 2003: p.5-6). Pupil questionnaires were conducted (appendix 2) and formative assessment learner profiles were carried out, in accordance with the programme, to identify misconceptions and gaps in mathematical knowledge (appendix 3). Emerson & Babtie (2010: p.2) state: *'It is essential to find the point at which they have failed to acquire some fact or concept that is crucial to numeracy development.*

Sessions were planned according to the specific needs of the pupils and taught twice per week for 15 minutes, with outcomes recorded on the individual session record sheet (appendix 4). The pupil's sessions log, progress booklet and record sheets were used for ongoing monitoring and their number age was tested termly to monitor impact. Their number age was used as part of the exit criteria for the programme, with children being taken off the intervention once their number age matched or exceeded their chronological age (Williams, 2008: p.43). Pupil's confidence levels were also considered and a maximum time scale of 12 months was allocated to each pupil. (Catchup 2011: p.135)

Questionnaires were given to class teachers and parents to gain their views of the impact. (appendix 5 and 6). The initial questionnaire was also repeated with pupils at the end of the process, to identify any changes in attitude towards mathematics (appendix 7). Time limited interventions that are closely monitored and adapted according to the needs of the pupil have been recognised as good practice by OFSTED (2010: p.11).

The Ethical Guidelines for Education Research (BERA, 2011) were adhered to throughout. Participants were informed of the study and consent was obtained from parents. Pupils are referred to anonymously and were treated with respect throughout. Questionnaires were completed independently and anonymously by staff and parents. Pupil questionnaires were completed with the children at the start and end of the intervention, in accordance with the programme's guidelines.

Findings and Analysis:

The research carried out by Dowker (2009: p.30) showed that pupils on the Catch-Up Numeracy programme had a mean ratio gain of 2.2 (standard deviation 1.9). Ratio gain is a measure '*of the amount of progress in mathematics, in months, divided by the time in months during which the gains were made'* (Dowker: 2009, p. 13). This is above the recommended ratio gain of 2.0, which is considered to be 'good impact'. (Brooks, 2007: p.30, Cheminais: 2010 p.44).

In this study, an Excel graph was used to help track the pupils' progress (appendix 8). Pupils number age was calculated in months to allow the ratio gain to be measured. It is evident from this data that all pupils on the intervention made progress and in most cases the ratio gain was greater than the recommended 2.0. Pupils who were on the first wave of the intervention (from March 2012) generally made greater progress between July and December 2012. This may be due to the extended period that the formative assessments take to complete impacting on the teaching time available. Dowker & Sigley (2010: p.76) claim the assessments take 2-3 hours in total per child, administered in small blocks of time. They are however, a crucial part of the process as they feed into the Learner Profile, thus providing a clear picture of the pupil's strengths and needs.   This also provides the starting point for the intervention and allows appropriate targets to be set. (CatchUp 2009). Dowker (2009: p.17) highlights the importance of assessment in effective interventions to: *'(a) indicate the strengths, weaknesses and educational needs of an individual or group; and (b) to evaluate the effectiveness of the intervention in improving performance.'*

Additionally this improved ratio gain (from July to December) which ranged from 2.4 to 5.4, may also be as a result of improved confidence by the teacher running the intervention and the pupils receiving it. Williams (2008: p.52) highlights the importance of qualified teachers with secure mathematics running wave 3 interventions and for adequate training prior to starting. However, initial training and the use of a qualified teacher to support pupils 1:1 this does have significant cost implications and may mean that a limited number of pupils can be targeted, as was the case in this study (Ekins 2012: p.140). Fortunately, the amount of time given for this intervention to be effective is only half an hour per week for each child, once the initial assessments have been completed.

Interestingly, the pupil who made the greatest ratio gain of 11.0, was a pupil with receptive and expressive language difficulties. A great deal of work had been done in the school on developing speech and language, including whole school training on Every Child a Talker (ECAT). This pupil also received regular 1:1 speech and language support as recommended by the Speech and Language Support Assistant. The Department of Education (2012) published materials on Speech, Language and Communication Difficulties which stated that pupils with receptive language difficulties have problems understanding '*abstract concepts (impacting on learning areas especially Mathematics and Numeracy'* (p.410). It is therefore possible intervention and support to improve the pupil's receptive language skills has also helped to improve her mathematical understanding.

In addition to the improvement in number age, most parents and teachers reported an improvement in pupils' confidence as a result of the intervention. This reflects findings by Dowker (2009: p.14) and the ECC Development group on maths interventions which states: '*Emerging evidence indicated that children gain confidence and play a more active part in their daily mathematics and other lessons, following the intervention work* (Williams 2009: p.47). Pupils' responses were often similar when compared to their initial interview but CatchUp was identified as a positive aspect, particularly with reference to playing games and receiving certificates and housepoints.

However, there appeared to be less transference of skills into the classroom in older children and one pupil, who with emotional and behavioural difficulties, did not want to be withdrawn as he did not want to be viewed as 'different'. Williams (2009: p.49) highlights the need to intervene before the child's long-term confidence is eroded. CatchUp is designed for pupils in Years 2 to 6; however, there is a great deal of evidence to suggest that early intervention is more effective and this is certainly the view of the DFE as outlined in their paper: 'Support and Aspiration: Progress and Next Steps (2012). In order for any intervention to be effective the pupil must engage with the process. Westwood (2011: p.5) highlights the importance of early identification of learning difficulties as without effective teaching to narrow the attainment gap, pupils are at risk of developing serious social and emotional problems associated with constant failure at school. Considering the risks associated with late identification of needs and the 'perpetuating low attainment from key stage to key stage' (DFE 2012: p.77) the programme may be more appropriate for use in Year 2 or 3. Moving forward it would also be beneficial to investigate other interventions such as Every Child Counts which are specifically designed for targeting pupils in Key Stage 1.

Liaison time between the intervention support teacher and class teacher had not been formally arranged as part of this study. Williams 2009: p.47 stresses the importance of this liaison '*in ensuring that the child's learning is coordinated and intervention is effective and can be sustained beyond the period of support.'* This is an area for development for the school. Further analysis also needs to be carried out to ensure that the skills developed through the intervention continue to move the pupils forward in their learning and transfer to improved national curriculum levels.

The study was only carried out on a small scale; however, there were some common areas of mathematics that were problematic for the majority of the pupils. As a key part of the role of the SENCo is '*providing professional direction to the work of others*' (TDA 2009) Sharing the outcomes of the research project with support staff and identifying common areas of difficulty was important to promote improvements in teaching and learning. (Appendix 9). This information will also be fed back to teaching staff during the next academic year. Burton and Bartlett (2005: p.70) also highlight the importance of '*working with peers and disseminating findings'* as part of action research.