What is the secondary mathematics classroom like for pupils with Asperger Syndrome*?

(*as defined in the DSM-IV, pre-2013)

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Contents

List of Tables……………………………………………………..…..………. page 5
List of Figures.…………………………………………………………...…… page 5
List of Acronyms………………………………………………………….. page 6
List of Appendices ……………………………………………..……...….....page 7
Acknowledgements……………………………………….……….....…… page 8
Declaration……………………………………………………………........ page 8

The Abstract page 9

1. The Introduction

1.0 Introduction page 10

1.1 Background to the Study page 11

1.2 The Analytical Framework page 13

2. Literature Review

2.0 Introduction page 22

2.1 Asperger Syndrome or High Functioning Autism as a Label page 24

2.2 Recognising Asperger Syndrome in the Mathematics Classroom page 29

2.3 The National Curriculum for Mathematics for Pupils with Asperger Syndrome page 36

2.4 Secondary Education for Pupils with Asperger Syndrome page 46

2.5 The Mathematics Learning Environment for Pupils with Asperger Syndrome page 51

2.6 Summary page 57

2.7 Gaps in the Literature page 60

2.8 Research Questions page 63

3. Methodology

3.0 Introduction page 66

3.1 Methodological Principles page 69

3.2 Research Strategy page 74

3.2.1 Sampling page 76

3.2.2 An Introduction to the Schools and Pupils in the Sample page 79

3.3 Research Questions page 93

3.4 Data Collection Methodology page 95

3.4.1 Stages 1 & 2: The Pre-pilot and Pilot Phases page 98

3.4.2 Stage 3: Interviews with Professionals page 112

3.4.3 Stage 4: Identifying the Schools page 114

3.4.3.1: In-school Interviews: Staff page 115

3.4.3.2: In-school Interviews: Pupils page 118

3.4.4 Stage 5: Observation page 119

3.5 Ethical Considerations page 130

3.5.1 Validity and Reliability page 133

3.5.1.1 Validity page 134

3.5.1.2 Reliability page 138

3.6 Summary page 140

4. Analysis

4.0 Introduction page 142

4.1 The Observations page 144

4.2 Categorisation of the Raw Data page 160

4.3 Themes page 168

4.3.1: The Pupil page 169

4.3.2: The Environment page 182

4.4 Summary page 199

5. Discussion

5.0 Introduction page 203

5.1 The Relationship between my Findings and Existing Research page 206

5.1.1: The Pupil page 206

5.1.2: The Environment page 223

5.2 Summary of Teaching and Learning Strategies in the Mathematics Classroom page 239

5.3 Limitations page 242

5.4 Recommendations for Further Research page 248

6. Conclusions

6.0 Introduction page 251

6.1 Current Policy and Practice page 251

6.2 What is the Secondary Mathematics Classroom Like for Pupils with Asperger Syndrome? page 252

6.3 Implications for Practice page 255

6.3.1 The Pupil and the Curriculum page 255

6.3.2 The Environment page 257

6.4 Summary page 258

References page 260

Appendices page 274

List of Tables

1. How Researchers and Clinicians Categorise Sample Characteristics (Taken from the 1994 DSM-IV) page 28
2. Results of the Elephant Task page 46
3. Overview of Lesson Detail and Observation Strategies page 89
4. Questionnaire for Teachers and TAs page 101
5. Observation Schedule 1 page 103
6. Revised Observation Schedule page 105
7. Comment on Pupil Participation According to School Type page 107
8. Pilot Phase Pupil Questionnaire page 109
9. In-school Interviewees: Staff page 118
10. Summary of Data Collection Methodologies page 143
11. Completed Table: Comment on Pupil Participation According to School Type page 161
12. Completed Observation Schedule page 163
13. Summarised Table of Class Observations page 165
14. Selection of the Narratives and Personal Diary Notes page 166

List of Figures

1. The Embedded Figure Test page 41
2. Advanced Embedded Test page 41
3. A House for Thin People page 45

List of Acronyms

1. AfL: Assessment for Learning
2. AS: Asperger Syndrome
3. ASD: Autism Spectrum Disorder
4. AWL: Assessment without Levels
5. HFA: High Functioning Autism
6. IQ: Intelligence Quotient
7. MLD: Moderate Learning Difficulty
8. NAS: National Autistic Society
9. SENCO: Special Educational Needs Co-ordinator
10. TEACCH: Treatment and Education of Autistic and Related Communication Handicapped Children
11. ZPD: Zone of Proximal Development

List of Appendices

Appendix 1: DSM-V Autistic Spectrum Disorder page 274

Appendix 2: DSM-IV Criteria AS page 277

Appendix 3: Waves, 1, 2 and 3 page 278

Appendix 4: Student Andy: Puzzle Picture page 279

Appendix 5: Student Charles: Classwork page 280

Appendix 6: Completed Questionnaires:

6.1 Teacher of mathematics at Arlidge Arts Academy page 280

6.2 TA at Arlidge Arts Academy page 282

6.3 Teacher of mathematics at Bowman Hill page 283

Appendix 7a: Letter of Introduction page 284

7b: Revised Letter of Introduction page 286

Appendix 8: Examples of Mathematics Work Shown to Pupils page 288

Appendix 9: Interview with Professor Raymond page 294

Appendix 10: Interview with Dr Linden page 295

Appendix 11: Example of Interview Question Subset page 296

Appendix 12: Diary Entries page 297

Appendix 13: Ethics Approval Form page 298

Appendix 14: Completed Questionnaires

14.1: Pupil Andy from Arlidge Arts Academy page 300

14.2: Pupil Ben from Bowman Hill page 302

Appendix 15: Partial Transcript of Conversation with George from Glebe Street Academy page 304

Appendix 16: Psychologist King’s Assessment of Student Mark page 306

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DECLARATION BY CANDIDATE

I hereby declare that this thesis is my own work and effort and that it has not previously been submitted anywhere for any award. Where other sources of information have been used, they have been acknowledged.

The Abstract

This research enquiry was conducted to investigate contemporary teaching and learning methodologies in the mathematics classroom for pupils with Asperger Syndrome and to explore ways in which the pupils are supported in the mathematics learning environment. Asperger Syndrome is a pervasive developmental disorder that can affect the motor system, memory, organisation and intrinsic motivation. Accordingly, the condition has the potential to adversely affect the learning of mathematics both theoretical and practical. Therefore, in addition to an exploration of external factors which could influence the mathematics learning experience for pupils with Asperger Syndrome, also considered was the potential part played by intrinsic and self-regulated processes.

The investigation was divided into distinct phases. The first of these was an examination of how compatible intrinsic characteristics are perceived to be with contemporary mathematics teaching and learning. The second was a review of mathematics teaching pedagogical frameworks and settings. A case study approach involving ten students with Asperger Syndrome between the ages of 11 and 19 in a variety of educational establishments and interviews with internal and external professionals provided the data for analysis. The pupils were observed working on various mathematics tasks delivered via differing teaching and learning methodologies using a range of resources.

There were several outcomes of the study. It was ascertained that the greatest factor governing a pupil's perseverance with a task is a mathematics specialist Teaching Assistant who utilises a ZPD (Zone of Proximal Development) scaffolding style of support as proposed by Vygotsky (1978). Secondly, activities presented via a genuine real-world cross-curricular perspective had the greatest influence on interest in mathematics learning irrespective of subject matter. Thirdly, it was found that there was no significant difference between one-size-fits-all computer-based tasks and traditional methodologies in the support of mathematics learning. Finally, despite ongoing debates about the importance of educational setting, it appeared that school type alone (specialist or mainstream) had no discernible effect on the mathematics classroom experience for pupils with Asperger Syndrome.

Chapter 1: The Introduction

1.0 Introduction

The focus of this study was on the various factors which might influence practice in the mathematics classroom for pupils with Asperger Syndrome. To aid my understanding of the disorder, I initially relied solely on the accounts of the syndrome given by Hans Asperger (1944). This was partly a consequence of the range of definitions of Asperger Syndrome (AS) proposed by more contemporary researchers and clinicians. Although some suggested that there were a number of differences between AS and what became know as High Functioning Autism (HFA) such as linguistic and cognitive capabilities (Wing et al., 2011), other researchers, clinicians and some educators used the terms AS and HFA interchangeably.

Because of certain traits that people with AS share with other autistic groups such as difficulties with social interaction and communication alongside restrictive interests, differentiating between the two disorders for clinical diagnostic personnel led to the eventual removal of Asperger Syndrome as a separate entry in the Diagnostic and Statistical Manual of Mental Disorders (Barahona-Correa & Filipe, 2016). However, although there is no longer a separation of cases but rather an autistic spectrum continuum, the pupils in my study had all been given a diagnosis of Asperger Syndrome before the enquiry began and, consistent with Wing et al.'s findings (2011), all were said to be cognitively able. So, despite its brief existence, entering the Diagnostic and Statistical Manual of Mental Disorders (DSM) as a separate entity in 1994 (Appendix 2: DSM-IV) and leaving it in 2013 (Appendix 1: DSM-V), I continue to use the term Asperger Syndrome (AS) rather than 'on the autistic spectrum' or HFA to define the disorder.

This chapter provides an overview of:

- the reasons for the study
- how and why the literature review was conducted
- how the study was expected to fill gaps in existing literature
- the research questions
- the choice of methodology
- the ways in which the data were analysed
- the basis upon which the findings are discussed and concluded

1.1 Background to the Study

Personal awareness of differences in the teaching and learning of mathematics at all levels along with the interrelated pedagogical processes, particularly with respect to pupils who have this special educational need was the partial incentive for this research project. Specifically, observations of how pupils with Asperger Syndrome interacted with teaching and learning of mathematics in traditional and contemporary classrooms inspired the work. These initial observations of certain pupils who had been diagnosed with the condition suggested that they could find mathematics lessons more challenging than did their neurotypical counterparts. This was despite some evidence that there is a link between Asperger Syndrome and talent in mathematical subjects (Baron-Cohen et al., 2001). Findings from Baron-Cohen et al.'s (ibid.) single case studies of very high achieving mathematicians, physicists, and computer scientists with Asperger Syndrome suggested that the condition need not be any obstacle to achieving the highest levels in these fields.

However, although pupils with this condition may not appear to experience multiple setbacks in the conventional sense, they do have an intrinsic set of needs which are more pronounced in certain contexts. Asperger Syndrome is a complex neurological disorder (DSM-V, 2013) for which at this present time there is no cure (NAS, 2015) and aspects of the syndrome can have a major, sometimes detrimental, effect on mathematics learning. A university student with Asperger Syndrome (Peter), who was someone I had known for several years, left primary school with a set of reasonable grades and a Maths Challenge Award but, despite showing early signs of giftedness in mathematics, went on to leave his secondary school at the age of 16 with a mediocre Grade C in mathematics and subsequently dropped the subject altogether. His story was the primary inspiration for the study into life in the mathematics classroom for pupils with Asperger Syndrome.

The research enquiry began in earnest several years ago following a couple of observational incidents in mathematics classrooms at two schools visited pre-pilot. I was at each school to give a talk on teacher training and, whilst there, I was asked to observe and provide feedback on two educators who were retraining as mathematics teachers. During each lesson, I became aware of a pupil who was strikingly different to the rest of the class and who bore certain similarities of character to Peter. At that point, I was not aware of whether either had a diagnosis of Asperger Syndrome but through my own understanding of the condition, their behaviours, and their similarities to Peter and each other strengthened my view that they could have had the disorder. Although their peers seemed to progress sufficiently well, there was no involvement with the mathematics tasks in evidence in either of the focus students. Both left their classrooms having done no work, and seemingly having learned very little. As a result of these findings, I wondered if this could be the norm in the majority of mathematics classrooms for pupils with Asperger Syndrome. Based upon later discussions with the teachers involved, I surmised that these particular educators had been reluctant to make personal decisions about the needs of their pupils. In one case, the teacher had always relied heavily on the Teaching Assistant, who was absent on the day and so the boy was ignored. In the other, the teacher taught her special needs pupils rigidly according to the information provided by the Special Educational Needs Coordinator (SENCO) who had supplied an IEP (Individual Education Plan) for one boy in the class but not this one. Whether or not other mathematics educators in similar situations would behave similarly with Asperger Syndrome pupils was not clear at that stage but determining this became one of the central features of the study.

These observations provided some initial data for research study and established some of the underlying principles informing the investigation. There follows a rationale for the framework of the study from outset to completion.

1.2 The Analytical Framework

Subsequent to my initial observations, in order to fully investigate the current situation in the mathematics classroom for pupils with Asperger Syndrome, I determined that the enquiry would follow a logical pathway and begin with a literature review. This section provides an overview of the structure of the thesis which exemplifies the process.

This Chapter provides an introduction to the study. Chapter 2 reviews the literature that was necessary to inform the study and Chapter 3 describes the methodological principles. The fourth chapter explains the data classification process and presents the analysis. A discussion of the findings in relation to the literature follows and, finally, the conclusion to the work incorporates suggestions for practice and implications for the future. In greater detail, the entire thesis comprises the following chapters:

1. This introduction which provides the context for the study and introduces the subquestions
2. A literature review which includes an examination of the typical characteristics of Asperger Syndrome, an assessment of how the pupil with Asperger Syndrome experiences mathematics teaching and learning, and an evaluation of how the National Curriculum for Mathematics acts as a guide to the contemporary learning environment
3. A review of current methodological principles along with the reasons for selection of the methodology I considered to be the most appropriate for this study. With the two supporting research questions, which were determined after the literature review driving the rest of the enquiry, the practical element including observations of how characteristic traits, teaching and the environment are connected with the mathematics learning experience for the pupil with AS in the secondary classroom is described in this chapter
4. A thorough analysis of the data collected from observation, questionnaire and interview makes up the fourth chapter
5. A discussion which critically compares and contrasts the findings from the practical research element with the literature review is included in the fifth chapter along with limitations and recommendations for further supplementary research
6. The final chapter comprises a conclusion which is based upon all of the findings and proposes recommendations for practice along with implications for the future.

Before conducting the literature review, I had already decided upon the overarching theme of the research, and this determined the main research question, i.e. 'What is the secondary mathematics classroom like for pupils with Asperger Syndrome?'

But, although they are included here for completeness, I had not selected the subquestions at that stage. They were determined after the review in response to the finding that there were gaps in the literature relating in part to the requirements of the Mathematics National Curriculum. Through the review, I established that, while a considerable amount of literature had been published on how best to assist pupils with classic autism in the mathematics classroom, there were relatively few contemporary studies on how pupils with Asperger Syndrome are supported with mathematics learning in order to fulfil the requirements of the modern classroom setting. I found that there had been a number of studies focusing on mathematics learning for people with Asperger Syndrome, these dating from the research of Hans Asperger in the 1930s and 40s through to those conducted by Baron-Cohen et al. since the 1990s. Yet, I did not find any which fully investigated the relationship between the various elements of the mathematics classroom for secondary pupils, to include the influence of the Mathematics National Curriculum, and how they are jointly connected with mathematics learning for pupils with Asperger Syndrome. Hence, unlike previous writings, this study focused exclusively on the requirements of the National Curriculum for Mathematics combined with the expectations of the contemporary learning environment for pupils with Asperger Syndrome.

The subquestions were chosen to ensure that the focus of the enquiry would be on aspects found within the secondary mathematics learning environment that I believed would produce the most appropriate data to answer the main question. My intention was that the practical data collection stage of the enquiry would provide relevant evidence to confirm or disprove findings from the review and to fill any obvious research gaps that I had not been able to establish from the literature.

The subquestions:

a) How compatible are some of the common traits attributed to pupils with Asperger Syndrome with contemporary mathematics teaching and learning strategies?

b) What aspects of the secondary classroom environment could be perceived as supportive of mathematics learning for pupils with Asperger Syndrome?

In order to explore the situation for a pupil with Asperger Syndrome and to investigate the common characteristics and capabilities in terms of learning mathematics, there were three modes of data collection. The first necessitated a review of a range of traditional and contemporary research literature. The second was a series of interviews with professionals. Thirdly, there was a succession of observational studies of interactions between students, mathematics educators and Teaching Assistants in a wide range of settings in the USA and the UK. Interleaved with these, to support the findings from observation, was a series of in-school interviews with my study group. These were all conducted to determine how the pupil with Asperger Syndrome experiences the various features in the mathematics learning environment and utilises the associated resources.

A point to note on the potential differences between the education systems in the UK and the USA in relation to mathematics learning follows. In both countries only the characteristics of pupils with Asperger Syndrome, the classroom environment, teaching methodologies and types of resource were analysed. Therefore, while the alternative types of institution were of interest, any differences in educational systems were not expected to impact adversely on the findings.

The literature review began with an examination of some of the perceived differences, according to specialists, between Asperger Syndrome and HFA and included factors relating to mathematical capability. Throughout the Literature Review chapter qualitative variations between AS and normal development as suggested by the experts are explained, in part through inclusion of accounts relating to current developments in thinking on how pupils with Asperger Syndrome might develop mathematics learning skills and how difficulties in the mathematics classroom for them can arise. Various practical teaching methodologies were also explored with a view to understanding how pupils with Asperger Syndrome can be assisted to learn mathematics and the findings from these writings are fully documented within the next chapter. Finally, there is a further section covering issues relating to the learning environment and how they are perceived to support mathematics learning for the AS pupil.

The practical data collection period focused mainly on mathematics teaching and learning in secondary schools. For triangulation purposes, there were also some narratives drawn from questionnaires and interviews with pupils, professionals and a student with Asperger Syndrome who was studying at a tertiary level. The data were analysed using each research subquestion as a lens through which to reveal what mathematics learning is like for secondary students with Asperger Syndrome. The investigation into the teaching and learning processes for the focus pupils in the mathematics classroom was expected to provide documentary evidence of how pupils with AS interact with mathematics problem solving tasks, educators, teaching methodologies and resources. At the start of the research, whether or not the pupils observed would be sufficiently challenged or given adequate assistance needed to maintain the level of concentration required to succeed in mathematics classes was unclear. So an investigation into these aspects of teaching and learning was incorporated into the enquiry with an expectation that examples of useful practice in various settings might be found and subsequently shared.

Although occasional reference is made to others on the autistic spectrum, for the purpose of appropriate analysis, access to pupils with more similarities than differences in terms of where they lay on the continuum was considered to be paramount. Accordingly, to ensure parity, selection of a specific pupil type through identification of similarity in characteristics was necessary. In the initial stages, suitable candidates with consent for inclusion in the study remained unknown, so before visiting any schools, to fit with the enquiry's purpose, I asked educators to identify pupils with the general characteristics of Asperger Syndrome only. I pre-supposed that the pupils selected would be relatively similar but had no intention of arguing against a diagnosis if a pupil's traits differed from the others in the study. However, I had already decided that data relating to observations of pupils who may not have had Asperger Syndrome might have had to be removed from the analysis (see Limitations) to avoid invalid skewing of the results. Finally, while there has been occasional reference to varying characteristics throughout, as the investigation revolved around the experiences of the group with AS only in the mathematics classroom, I concluded that there would be no requirement to provide an in-depth comparison with any other sample sets such as neurotypical control groups.

Following the initial approaches to schools, observations of a sample of ten pupils, most of whom were suggested by Headteachers, from a range of secondary educational establishments, (inner-city, village and specialist training schools in this country and the USA), were selected with the expectation that data collected from pupils in these diverse settings would produce sufficient information for an in-depth analysis. While each school was unique in certain respects, I expected that the pupils would be similar enough to make direct comparisons between educational settings. However, ‘the boundary line between [each pupil and his context was, to some degree,] blurred’ (Yin, 2009:18). Although the cases selected were individual pupils, each was potentially interdependent on his personal educational surroundings. Therefore, it was not guaranteed that any pupil would act or react identically in an alternative setting. And, in respect of specific mathematical topics taught, although they were not analysed in detail as separate entities, they could not always be separated from their respective teaching and learning methodologies so some are commented on at various stages throughout this enquiry.

Throughout this study, there was no intention to develop any experimental activity to produce scientific measurements. Rather, only certain perceived effects of neurological dysfunction were to be considered and discussed. Additionally, socioeconomic, cultural and academic backgrounds were not examined. Nonetheless, had it transpired that distinct differences in learning styles or responses to specific teaching methodologies were to be identified based on any of these or an additional classification, I planned to subdivide the resultant data into groups and report on these in terms of potential similarities and differences between cases. If evidence of qualitative variance in mathematical learning capabilities were to emerge, then attention would be paid to strengths and weaknesses relating to individual pupils. However, If the pupils’ levels of participation in any type of mathematics classroom were found to be similar enough regardless of external factors, then maybe this group could be considered to be representative of such pupils nationwide and internationally.

With the enquiry centred on exploration and insight, the interpretivist paradigm suited my study best. The data were collected naturalistically through interview, questionnaire and observation. Due to the sensitivities of the pupils in question (Frith, 1991), it was not considered appropriate to openly observe, or to record parts of lessons or interviews using digital technologies (Cohen et al., 2011). The analysis and interpretation were dependent upon the findings from each specific setting at any one particular moment in time, these reliant to some degree upon personal beliefs and on my understanding of the literature. The final report is based upon personal analysis of the findings gleaned from the practical research data gathered for this project, i.e. from observation in the classroom and narratives. Significant findings have been addressed in the Analysis and Discussion sections with final recommendations produced which relate only to the pupil type under consideration. Although issues of reliability and validity were not addressed until the group samples had been selected and finalised, no part of the enquiry should appear to be biased as a result of any of my initial theories on pupils with Asperger Syndrome and it is absolutely the case that all reasonable findings have been reported, (some in the Limitations section), regardless of whether or not they agreed with my initial assumptions or inferences taken from the literature review.

The conclusions and implications of the study are to be found in the final sections of this report. It is expected that they might allow the educator to acquire an understanding of life in the mathematics classroom for the pupil with Asperger Syndrome. Subsequently, individual needs could be potentially appropriately assessed, and thereby, via School Action (DfE, 2015) appropriate support with which to assist the pupil with AS to reach his or her full potential could be provided. Any useful finding from this enquiry which ultimately results in some kind of educational reform for pupils with Asperger Syndrome should benefit not only those with the condition but also their parents or carers, educators and maybe even society.

To summarise, Chapter 2 puts the study into context through a thorough review of existing literature, Chapter 3 explains the research procedures in full and includes reasons for choice of methodology, Chapter 4 analyses the findings using the research subquestions as the theoretical lenses, Chapter 5 provides a discussion of the findings and reflects on the extent to which these deductions support the arguments put forward in the Literature Review from Chapter 2, and Chapter 6 concludes the piece.

Chapter 2: Literature Review

2.0 Introduction

There are two main research themes relevant to this thesis. The first relates to how common characteristics of pupils with Asperger Syndrome correspond with mathematics learning, and the second to the specific teaching and learning approaches proposed as ‘essential to everyday life, critical to science, technology and engineering, and necessary for financial literacy and most forms of employment’ (The National Curriculum for Mathematics, 2013). Therefore, it was imperative before the practical research could begin that I had a perspective of how the pupil with Asperger Syndrome fits in to the modern mathematics teaching environment. Part of this early process included a review of the ways in which the various components of the most recent National Curriculum for Mathematics help to inform contemporary teaching and learning provision for pupils with Asperger Syndrome. Hence, this chapter introduces existing literature on the separate elements that were considered fundamental to facilitate a secure understanding of the current situation from which to determine the research subquestions, and subsequently against which to inform the practical element of the study. The review was not intended simply as homage to the works of others however; rather it was approached with criticality in order to determine a relevant set of illuminating subquestions through which to advance the enquiry.

In outline, the investigation comprised an examination of the mathematics classroom for the pupils with Asperger Syndrome in this study. Could internal processes be perceived as the sole determinant of the way in which the pupils experience mathematics learning, or would external environmental support be more influential? Maybe a combination of various features of these two components would be central to outcomes. Therefore, issues surrounding both the pupil and the learning environment directed the review and the later subquestions.

The various elements in the framework of interactions that inform the mathematics classroom for pupils with Asperger Syndrome are considered below. Specifically, in the ensuing subsections, I explore how some of the capabilities of pupils with Asperger Syndrome match with contemporary teaching and learning methodologies and what influence the environment has on mathematics learning in this group of pupils.

Part 1 reviews the similarities and differences between High Functioning Autism and Asperger Syndrome and explains my reasons for choice of the label Asperger Syndrome over High Functioning Autism or Autism in this study.

Part 2 examines some of the typical traits of both autism and Asperger Syndrome and explores the associations between certain definitive attributes and mathematics learning in general.

Part 3 links the common characteristics of AS with mathematical capability and corresponding teaching and learning issues associated with modern methodologies. This section includes how the pupil with AS responds to the process requirements of the mathematics curriculum.

Part 4 provides an overview of secondary school provision for pupils with Asperger Syndrome.

Part 5 considers the relationship between the environment and mathematics learning in pupils with Asperger Syndrome. Here, the provision of Teaching Assistants alongside various and varying modern teaching strategies are jointly examined.

Part 6 presents a summary of the findings from Parts 1 to 5.

Part 7 outlines the research gaps.

And, finally, Part 8 introduces the subquestions.

Throughout, I put forward my perspectives concerning the relevance of prior research and how certain elements of the review shaped my own enquiry.

2.1 Asperger Syndrome or High Functioning Autism as a Label

In prior studies much has been written about the range of expressions of Asperger Syndrome. Therefore, in order to be able to reliably identify the typical characteristics of someone with the condition, and to determine how these characteristics are perceived to affect mathematics learning, it was important to seek out some kind of commonality in such writings. Hans Asperger, famous for working extensively with pupils with what, in the 1990s, became known as Asperger Syndrome said that:

> One can spot such children instantly. They are recognisable from the small details, […], the way they enter the room at their first visit, their behaviour in the first few moments and the first words they utter.
>
> (Asperger, 1944:2)

Although, as a consequence of prior experiences, I had reasonable confidence in my ability to distinguish pupils with the condition, I needed to ascertain if there were any additional indicators, subtle or otherwise, of which I might not be aware to help with rapid identification of pupils. Hence, the first part of the review investigated the various distinctive traits that I might notice in the mathematics classroom, and the second part explored the ways in which having Asperger Syndrome shapes mathematics learning.

Asperger (1944) classified the syndrome as a neurobiological developmental disorder with more than one symptom and characterised by impairments in social interaction, restrictions in choice of special activities and interests, and no clinically significant delay in cognitive development or onset of language (Wing et al., 2011): 'They tend to speak fluently by the time they are five […] even if their language is noticeably odd in its use for communication' (Frith, 1991:3). While '[those] with Asperger Syndrome bear no physical resemblance to each other, [they] often appear gauche in the way they move and almost always sound odd in the way they speak' (ibid.:4).

I chose to use the term 'Asperger Syndrome' to describe the study group's condition rather than '(High Functioning) Autism' partly because all of the pupils studied had Asperger Syndrome as a diagnosis (Mintz, 2008). Further, Asperger (1944) stated that he was, when he referred to autistic psychopathy, alluding to a quite different condition than that investigated by Kanner (Gillberg & Ehlers, 1998). Significantly, Schopler et al. (1998) reasoned that, in order to recognise Asperger Syndrome in a pupil, the typical symptoms are poor motor skills, evidence of impaired executive function, higher than average IQ and pedantic speech, and if these four traits are found together then that is enough for identification.

But, are they 'different labels or different disabilities' (Schopler, 1996:109)? While there are many similarities (see Table 1 below) to 'suggest a common factor underlying the disorders described by Kanner and by Asperger [,] the differences suggest that the disorders are not exactly the same' (Roth, 2009:10). For instance, in searching for links between motor skills and coordination, Szatmari et al. (1990) found that their High Functioning Autistic group scored more highly on tests of motor speed and coordination than did the AS group (Romanczyk et al., 1994). In addition to 'nonverbal weaknesses [and] increased spatial or motor problems relative to individuals with HFA' (Volkmar et al., 2005:103), according to Tantam (1991), there is also increased cognitive ability in AS relative to HFA. Ozonoff et al. (1991) too determined that verbal IQ was better in the AS group and performance IQ was higher for the HFA group. The team at Austin Psychological Assessment Centre (2009) confirmed these findings stating that social and communication difficulties are often found to be greater in people with High Functioning Autism.

Williams (1996), herself diagnosed with HFA, believed that there were both low and high functioning autistic groups and, quite separately, those with low and high functioning AS. She argued that there are significant differences between HFA and AS individuals, for instance in their preferences. According to her, people with HFA like sensory repetitive activities such as flapping things whereas those with AS much prefer to talk and think non-stop about their obsessions and projects (Williams, 1996).

According to Baron-Cohen (2009:2), the DSM appears to be a moveable feast, which is organised solely according to the whims of one small group of doctors who 'can move the boundaries and add or remove "mental disorders" arranged into groups in many ways, and there is no single right way to cluster them'. If autism means 'mental condition, usually present from childhood, characterised by complete self-absorption and a reduced ability to respond to or communicate with the outside world' (Oxford English Dictionary, 2010), then it could be difficult to state with certainty that this is how someone with AS typically behaves. But, if we redefine autism as meaning socially restricted (Wing, 1988), then maybe HFA and AS do belong to the same group. Yet, 'while the symptoms of AS overlap with other conditions, it is often the unique combination of behaviours in social interaction and restricted areas of interest that baffles professionals and parents alike and commonly leads to misdiagnosis' (Safran, 2001:1). Furthermore, according to Attwood (2007), as they get older the distinction between the mathematical capabilities of High Functioning Autistic and Asperger Syndrome pupils becomes more difficult to determine. As ‘individuals with Asperger Syndrome can exhibit a variety of characteristics and the disorder can range from mild to severe’, (Kirby, 2001), then such symptom variety is said to prevent accurate diagnosis (Attwood, 2007).

However, ‘Gillberg’s family genetic studies [found] that Asperger Syndrome and autism frequently occur in the same family,’ (Frith, 1991:15). This indicates that the two conditions may indeed be different expressions of the same basic defect. Attwood (2007), in his work as a clinician, states that a diagnosis of autism is more likely to provide the child with vital services that are not available to those with a diagnosis of AS. Alternatively, some parents prefer the diagnosis of AS as it has connotations with greater intelligence and minimal disability, (ibid.). This too suggests that HFA and AS could be the same condition given different labels according to preference or need. Despite the distinct differences mentioned between the HFA and AS groups, many researchers and clinicians believe that there are a substantial number of similarities (See Table 1 below). Accordingly, although the alternative capabilities of pupils in the lower-functioning autistic, Asperger’s and neurotypical communities are separated for the purposes of this study, HFA and AS are both classed as the same syndrome and are referred to simply as AS throughout.

Table 1: How Researchers and Clinicians Categorise Sample Characteristics (Taken from the 1994 DSM-IV: Appendix 2). *Column 1 shows various diagnostic symptoms taken from DSM-IV (1994) and Columns 2, 3 and 4 shows to which category clinicians or researchers believe each symptom relates: AS, HFA or both.*

	AS	*HFA*	*BOTH*
Marked impairment in the use of multiple nonverbal behaviours such as eye-to-eye gaze, facial expression, body postures and gesture to regulate social interaction	*Asperger (1944, 1979)* *DSM-IV (1994)* *Gillberg & Gillberg (1989)* *Szatmari et al. (1989)* *Tantam (1988)* *Wing (1981)*	*Pomeroy (1998)*	*DSM-V (2013)* Freisleben-Cook (2004) *Mesibov et al. (2008)* *Wolff (1998)*
Failure to develop peer relationships appropriate to developmental level	*Asperger (1944, 1979)* *Gillberg & Gillberg (1989)* *Tantam (1988)* *Wing (1981)*	*Klin et al. (1995)* *Pomeroy (1998)*	*DSM-V (2013)* *Wolff (1998)*
A lack of spontaneous seeking to share enjoyment, interests or achievements with other people		*Lyons & Fitzgerald (2005)*	*DSM-V (2013)* *Mesibov et al. (2008)*
Lack of social or emotional reciprocity	*DSM-IV (1994)* *Gillberg & Gillberg (1989)* *Tantam (1988)* *Wing (1981)*		*DSM-V (2013)* *Pomeroy (1998)* *Szatmari et al. (1989)* *Van Krevelen (1971)* *Wolff (1998)*
Delay in, or total lack of, the development of spoken language (and not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime).		*Klin et al (1995)* *Pomeroy (1998)* *Szatmari et al. (1989)*	
In individuals with adequate speech, marked impairments in the ability to initiate or sustain a conversation with others		*Volkmar & Klin (1998)*	*DSM-V (2013)* *Frith (2004)* *Szatmari et al. (1989)* *Wolff (1998)*
Stereotyped and repetitive use of language or idiosyncratic use of language.	*Asperger (1944, 1979)* *Pomeroy (1998)* *Szatmari et al. (1989)* *Wing (1981)*	*McDougle (1998)* *Volkmar & Klin (1998)*	*DSM-V (2013)* *Ozonoff (1998)* *Schopler (1998)* *Wolff (1998)*
Lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level.	*Wing (1981)*	*Klin et al. (1995)* *Pomeroy (1998)*	*Baron-Cohen(2000)* *DSM-V (2013)* *Wolff (1998)*
Encompassing preoccupation with one or more stereotyped	*Asperger (1944, 1979)* *Szatmari et al. (1989)* *Tantam (1988)*	*Pomeroy (1998)*	*DSM-IV (1994)* *DSM-V (2013)* *Gillberg & Gillberg*

and restricted pattern of interest that is abnormal either in intensity or focus.	*Wing (1981)*		*(1989)* *ICD-10 (1994)* *Lyons & Fitzgerald (2005)* *Ozonoff (1998)* *Schopler (1998)* *Volkmar & Klin (1998)* *Wolff (1998)*
Apparently inflexible adherence to specific, non-functional routines or rituals.		*Lyons & Fitzgerald (2005)* *McDougle (1998)* *Pomeroy (1998)*	*Baron-Cohen(2008)* *DSM-IV (1994)* *DSM-V (2013)* *Ozonoff (1998)* *Schopler (1998)* *Wolff (1998)*
Stereotyped and repetitive motor mannerisms (e.g. hand or finger flapping or twisting, or complex whole-body movements).		*McDougle (1998)* *Ozonoff (1998)* *Pomeroy (1998)* *Schopler (1998)*	*DSM-IV (1994)* *DSM-V (2013)*
Persistent preoccupation with parts of objects.		*Ozonoff (1998)* *Schopler (1998)* *Volkmar et al. (2005)*	
Motor Clumsiness	*Asperger (1944, 1979)* *DSM-IV (1994)* *Gillberg & Gillberg (1989)* *Pomeroy (1998)* *Tantam (1988)* *Volkmar & Klin (1998)* *Wing (1981)*		*Ghaziuddin et al. (1994)* *Lyons & Fitzgerald (2005)*
Exclusion of Autism	*Asperger (1979)* *DSM-IV (1994)* *ICD-10 (1994)* *Szatmari et al. (2007)* *Wing (1981)*		

2.2 Recognising Asperger Syndrome in the Mathematics Classroom

Asperger (1944) tells of Fritz and his work on a given construction test. The boy glanced briefly at the layout of some sticks, which were then removed. He was subsequently asked to replicate the design from memory. While he constructed the original design correctly, Asperger (1944) makes the point that it was done in haphazard fashion, the sticks literally thrown into place and no amount of coercion could persuade Fritz to do it neatly. Asperger (1944) says that his behaviour was typical and that intransigence is a symptom of Asperger Syndrome. Yet, because his 'motor milestones were rather delayed, [he] was extremely clumsy and unable to do things for himself' (ibid.:39). Clumsiness, as a specific marker of Asperger Syndrome, was proposed by Klin et al. (2000) as central to separating people with Asperger Syndrome from those with any other ASD (Autism Spectrum Disorder). This, in conjunction with no language deficit is said by Asperger (1944) to be a major outward indicator that an individual might have Asperger Syndrome rather than any other type of ASD.

Motor deficit is a way of describing difficulties with coordination and is often indicated by unusual gait, (which might be caused by lack of awareness of body position), poor handwriting or problems related to visual perception and conceptual learning. These are claimed to be intrinsic to the set of challenges common to the AS individual:

> Gross motor movements are clumsy and ill-coordinated. Posture and gait appear odd. Most people with this syndrome (90%) are poor at games involving motor skills, and sometimes the executive problems affect the ability to write or to draw.
>
> (Wing, 1980:115)

Asperger was aware of the prevalence of motor skill deficit in his group of pupils (Asperger, 1944). Because of his dyspraxia, as evidenced by his response to the construction task, Fritz was said by Long (2007) to have had great difficulty with practical activities. Szatmari, Brenner and Nagy (1989) determined that the AS group score poorly on tests of motor speed and coordination and the National Autistic Society (NAS) in the UK, like Gillberg (1991), added motor skills deficits to their definition of the disorder:

> The view that Asperger Syndrome can only occur when there are additional difficulties with motor skills has become more prominent; 91% of Asperger Syndrome subjects [are] judged to be clumsy.
>
> (Tantam, 1991:163)

'Although Dyspraxia may occur in isolation, it frequently coexists with other conditions such as Asperger Syndrome' (Dyspraxia Foundation, 2013:1). The NAS states that dyspraxia, the cause of 'poor co-ordination and difficulties with fine motor control' (2015:1), affects concentration, organisation and information processing. This disorder means that the pupil with Asperger Syndrome can exhibit poor organisational skills, experience high levels of distraction, and process information relatively slowly (ibid.). Studies involving people with Asperger Syndrome seem to suggest that the combined effects of these factors can adversely influence mathematics learning skills such as those associated with practical work, problem solving and reasoning (Frith, 1991).

However, despite weaknesses in motor skills and reduced levels of concentration relative to the neurotypical, according to Tantam (1991), there is evidence that autistic pupils with the greatest levels of motor skill difficulty have the fewest neurological setbacks along with a superior cognitive ability. Correspondingly, Asperger describes his pupils as noticeably unique in several respects:

> [While] the [AS] personality is highly distinctive despite wide individual differences, [some are distinguishable by their] intellectual ability, [along with] their personality and their special interests, which are often outstandingly varied and original.
>
> (Asperger, 1944:67)

According to Asperger, while pupils with Asperger Syndrome will need constant support, as intrinsic motivation is not always available to them, they:

> …are able to analyse and retain what they catch in […] glimpses, […] they are good at logical thinking, and the ability to abstract is particularly good. […] Naturally, [pupils like this can astound] examiners in mathematics.
>
> (Asperger, 1944:49)

On the other hand, the ability to abstract is not something that is universally agreed upon. Lakoff & Nunez say that 'abstract human ideas make use of precisely formulatable cognitive mechanisms such as conceptual metaphors that import modes of reasoning from sensory-motor experience' (2000:8). But, it is said that metaphors are not always understood by pupils with Asperger Syndrome (Dennis, Lazenby, & Lockyer, 2001) or at least not made use of. Hence, for them, managing abstract concepts is not necessarily a simple task. If 'the mathematical world is a product of the way the human mind encounters the physical world' (Devlin, 2000:142), for pupils with Asperger Syndrome who see the world differently (Attwood, 2007) visualising an image of the physical that is said to facilitate mental dexterity (Devlin, 2000) could prove difficult. This means that abstract concepts might not easily be accommodated and this could be disadvantageous for problem solving activities.

At times Asperger (1944) mentions the savant tendencies he observed in some of his pupils but, according to Griswold et al. (2002), a diagnosis of Asperger Syndrome does not necessarily mean that the pupil is gifted in mathematics, a savant or highly talented in one or more of the sciences. While the pupil with AS is said to be able to develop several advanced specialist skills, these often linked to analytical areas of expertise, certain unique mathematical talents are suggested by Griswold et al.

(2002) as common only to lower-functioning autistic savants. To concur, Snyder and Mitchell (1999) report on the difficulty in determining whether well-developed mental calculation agility co-exists with Asperger Syndrome or classic autism. One autistic pupil was able to 'double 8 388 628 up to 24 times to obtain 140 737 488355328 in several seconds' (Hill, 1978:279), and 'Joseph, the inspiration for the film Rain Man, could spontaneously answer "what number times what number gives 1234567890" by stating "nine times 137174210"' (Sullivan, 1992:243). Sacks (1985) found autistic twins 'who could "see" the number of many objects at a glance. When a box of 111 matches fell to the floor, the twins cried out 111 and 37, 37, 37' (p.209). And in 1801, 'a child named Dase, who was singularly devoid of mathematical insight and of low general intelligence' (Treffert, 1989:9) was found to have similar skills. As Griswold et al. (2002) state though, these abilities do only exist in classically autistic people rather than in those with Asperger Syndrome and may be simply a case of rote learning. Based on these reports, for identification purposes, noticing this type of skill could make it relatively easy to distinguish between these particular subgroups.

Frith (1991) goes on to describe people with Asperger Syndrome as:

> …socially inept but often socially interested, who are articulate yet strangely ineloquent, who are gauche and impractical, [and] who are specialists in unusual fields [to include mathematics].
>
> (Frith, 1991:12)

In the case of Ernst (Asperger, 1944) everyone thought that he would become an exceptional student. His pre-school learning capability was outstanding. He had independently learned to count and to read letters; and he spoke eruditely with imagination on many subjects. However, once at school, he struggled to move up from the first year group, was considered to be unteachable, and was eventually transferred to a special school. So, while some with Asperger Syndrome can do well, as suggested here, if they do have a natural flair for mathematics, then it might not always be teased out by the educator, the school curriculum or the learning environment. Because most pupils with the condition are educated in the mainstream, maybe without specialist help (Simpson et al., 2001), Chiang and Lin (2007), concerned by the low scores achieved by pupils with Asperger Syndrome in mathematics felt that it was imperative that the mathematical capabilities of pupils with this disorder be fully recognised. While the significance level was negligible for the majority of mathematical weaknesses relative to intellectual capabilities (ibid.), Griswold et al.'s 2002 study of students with Asperger Syndrome found that, despite mean standard scores for mathematics within the normal range, typically their numerical operations subtest scores were very low relative to the general population. This implies that expertise in other areas of mathematics was higher than average:

> Although most students with Asperger Syndrome […] have average mathematical ability and, [because of some poor subtest scores], test slightly worse in mathematics than in general intelligence, some are gifted in mathematics and Asperger Syndrome has not prevented them from major accomplishments such as winning the Nobel Prize.
>
> (Morris, 2008:1)

So it could be that certain individuals with Asperger Syndrome have an innate aptitude for certain areas of mathematics. The preliminary review of existing research suggests, however, that while they might want to be high achievers in mathematics, for any of a number of reasons, they are not all able to do so. Learning styles can be compromised by frontal lobe damage, weak central coherence and malfunctioning executive function. All of these are fundamental to many of the cognitive processes required for connecting with mathematics learning activities, and have all been detected in people with Asperger Syndrome (Butterworth, 2002).

So, in summary, according to the experts, typical outward symptoms of Asperger Syndrome that can help with identification include these characteristics:

- Late onset of symptoms but the opportunity for a positive outcome in later life
- Intense interest in one or two topics
- Unusual use of language
- Motor clumsiness and lack of coordination
- Problems with certain areas of mathematics
- Difficulty with numerical calculations but higher than average ability to reason
- Trouble maintaining concentration
- Problems with organisation
- Verbal IQ (scores on verbal sections of standardised intelligence tests) usually higher than performance IQ (how well the pupil performs in school)
- Complications connected with mathematics task completion
- What looks like limited motivation for mathematics learning

Although much of the material for this part of the review was written by some of the greatest influences in the field, a substantial amount of their research was conducted some time ago. As a consequence, I was aware that I would have to use personal initiative when observing pupils to determine whether the descriptions of the condition so far were indeed a reasonable match to the fundamental characteristics of Asperger Syndrome. And, with the DSM definition of AS now subsumed into the general classification of autism, it might have been that some of these elements were no longer thought to be characteristic of AS alone.

To further investigate specific idiosyncrasies in pupils with Asperger Syndrome and how modern views on certain types of teaching methodology influence mathematics learning, the next section critically appraises the current situation using a range of more contemporary literature. While certain aspects of Asperger Syndrome and corresponding development of potentially singular mathematics learning techniques may not have changed over the years, the varying views of the effects of particular features of AS on learning in the mathematics classroom might.

2.3 The National Curriculum for Mathematics for Pupils with AS

For this part of the review, as a guide to current initiatives, the process requirements of the National Curriculum for Mathematics were investigated. This element of the study explored how some features of Asperger Syndrome match with the types of skill advocated by and embedded in the curriculum which are said to support mathematics learning. Common characteristics in pupils with Asperger Syndrome were appraised and matched with the attributes suggested by the National Curriculum for Mathematics for effective learning.

At Key Stages 3 and 4, the National Curriculum for Mathematics (2013) proposes that:

> Mathematics is an interconnected subject in which pupils need to be able to move fluently between representations of mathematical ideas. The [programmes of study for both key stages are] organised into apparently distinct domains, but pupils should build on [the previous] key stage and connections across mathematical ideas to develop fluency, mathematical reasoning and competence in solving increasingly sophisticated problems.

And, from this, educators are asked to ensure that all pupils:

- become fluent in the fundamentals of mathematics, including through varied and frequent practice with increasingly complex problems over time, so that pupils develop conceptual understanding and the ability to recall and apply knowledge rapidly and accurately

- reason mathematically by following a line of enquiry, conjecturing relationships and generalisations, and developing an argument, justification or proof using mathematical language

- can solve problems by applying their mathematics to a variety of routine and non-routine problems with increasing sophistication, including breaking down problems into a series of simpler steps and persevering in seeking solutions.

  (National Curriculum for Mathematics, 2013)

In summary, processes over content are described in the National Curriculum for Mathematics as fundamental to mathematics learning. From my experience of pupils with AS, these four processes:

Complex Problem Solving

Reasoning

Rapid Processing

And Perseverance

can sometimes problematic areas in mathematics learning for them so, to determine what had already been written about these characteristics in pupils with AS, they are the focus of this part of the review.

These are some of the skills across the two secondary Key Stages (3 and 4) put forward as essential for:

> the increasingly complex, dynamic, and powerful systems of information required by a knowledge-based economy [which calls] for a work force that can interpret complex systems involving important mathematical processes — constructing, explaining, justifying, predicting, conjecturing and representing, quantifying, coordinating, and organising data.
>
> (O'Brien, 2006:1)

Billington, Baron-Cohen and Bor (2008) state that the desire to find rules and thereby exert control, forces the person with Asperger Syndrome to work well in technical, natural, abstract, social, and spatial fields. However, apart from the technical, described as an area of special interest in many pupils with Asperger Syndrome (Jackson, 2002), not all clinicians or researchers agree that pupils with Asperger Syndrome can become skilful in these areas without expert guidance and support. Abstract thought, spatial awareness and social skills are all said to be weak (Wing, 1981) and, by studying groups with Asperger Syndrome, Butterworth (2002) stated that individuals with dyspraxia are typically underachievers in mathematics:

> We have anecdotal evidence that these people are worse at maths than average, it might have to do with their manual dexterity or lack of it, or it might have to do with something else, […] the kinds of difficulties they have are the sorts you would expect them to have if they had problems counting on their fingers when they were little.
>
> (Butterworth cited in Joyce, 2001:1)

Jackson (2002) explains, ‘I have a friend [who] is dyspraxic like me. […] it seems a lot of people with Asperger Syndrome have this to some degree or another’ (p.46) and, if many do have dyspraxia, which also affects writing speed, demands for reasoning skills in tests or examinations that naturally require lengthy answers could further prevent a large proportion of AS students from achieving their full potential (Frith, 1991). A slower response time for this style of questioning in mathematics papers implies that the examination results of someone with Asperger Syndrome may do little to reflect his or her true ability, this despite evidence of ability to process mathematical information effectively, albeit at their own pace (ibid.). Davidson (2010) states that, with success or failure based purely on an examination system where a D grade is classed as a poor result, and a successful C grade achievable with just one mark more, some pupils’ innate drawbacks put them at a hugely unfair disadvantage. He says that results should be put into context and that pupils should be given merit for what they can do rather than penalised for what they cannot.

In addition to the difficulties associated with dyspraxia, a large proportion of people with Asperger Syndrome are said to be affected by some of the hidden characteristics of dyslexia too (Hale, 2008). This includes failure to retain information in memory for short lengths of time, inability to organise thoughts, and poor concentration, the last of these a consequence of the propensity to self-distract (ibid.). But, in order to develop an aptitude for lessons involving complex mathematical activities, a pupil needs many different skills, not least the ability to concentrate and organise (ibid.). Inability to do so can interfere with problem solving activities that require organisation, concentration and structure. So, dyslexia and dyspraxia are then potential barriers to full participation in classroom mathematics tasks where attainment levels are often gauged by responses to lengthy, probing questions such as those presented for AfL (Assessment for Learning) and AWL (Assessment without Levels) purposes.

Further, although it is suggested that reading skills in AS individuals are comparatively well developed, their comprehension of lengthy mathematical texts may not be so advanced (Attwood, 2007). While verbal and full-scale IQs might be higher in students with Asperger Syndrome than recorded in other groups, typically performance IQ is said to be lower (Ozonoff et al., 1991; Attwood, 2007). Tantam (1991) cites a study of 'Richard', whose psychometric tests showed a far higher level of achievement for verbal reasoning than for performance and very poor results linked to logic, arithmetic, picture arrangement and digit tests. These included 2 and 3-dimensional image manipulation activities, digit/ symbol coding and problem solving techniques. As a consequence, Tantam (1991) suggests that the grades of people with AS are brought down only by results of performance tasks. Further, difficulties with problem solving, spatial awareness and geometrical reasoning can be compounded by weak central coherence, which affects the ability to focus on the whole picture (Baron-Cohen, 2013). A study in 2001 showed that people with Asperger Syndrome cannot easily identify an object from its composite parts. While they have no difficulty with defining an object given just one fragment of it, it appears that impaired ability to integrate information means that they are unable to identify an object when presented with all the fragments randomly rearranged in a different form. This seems to support the view that certain aspects of learning mathematics, particularly in relation to geometrical arrangements, could be a challenge for pupils with Asperger Syndrome (Baron-Cohen & Jolliffe, 2001).

More recently, Baron-Cohen (2013) identified information overload and over-sensitivity to minute detail as synonymous with Asperger Syndrome. These characteristics interfere with ability to see the bigger picture and could be a further reason for Asperger's Fritz failing to complete the construction test conscientiously: 'He had only half-glanced at this figure […] but he could not be persuaded to arrange them properly' (Asperger, 1944:44). Behrmann (2006) too states that, in the mathematics classroom, tasks that require grouping skills such as this are problematic for those with Asperger Syndrome. She discovered that, while her study group could see many tiny letter '*h*'s perfectly clearly, they failed to identify the composite letter S which was made up of the tiny '*h*'s. Their difficulty, she says, is in seeing how the pieces fit together to produce the whole. The Embedded Figure Test, (s*ee Figures 1 & 2 below*), a measure of both cognitive method and analytical ability, involving detecting simple objects built into larger, more elaborate figures, is an example of a mathematics problem solving exercise which, because of weak central coherence, could be challenging for the pupil with AS. Further, the complexity of a task appears to have the potential to affect problem solving ability. While a pupil might be able to calculate the area, for example, of one single structure, failure to realise that the whole is made up of several of these might affect progress in mathematics tests involving compound shapes (Attwood, 2007).

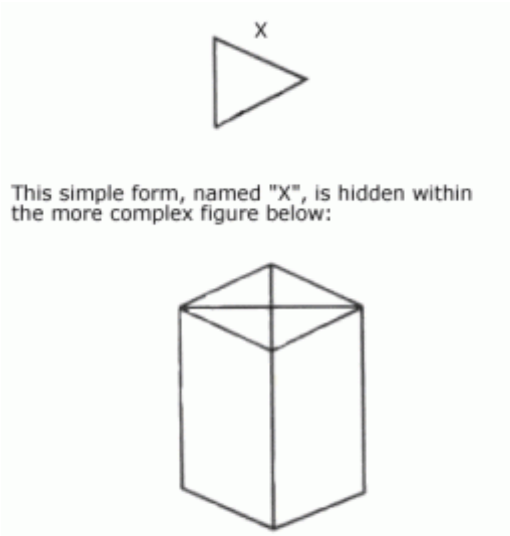


Figure 1: Embedded Test, Schutte (2010)

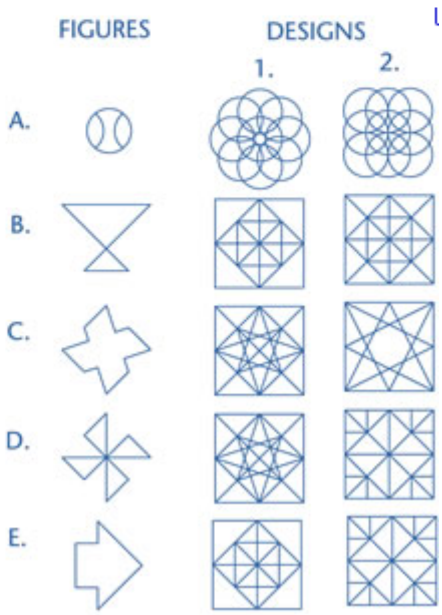


Figure 2: Advanced Embedded Test, Bragdon & Gamon (2010)

Researching calculations skills, Ward et al. (2009) found that, in the normally developing student, although the strategies used in one area of complex multiplication depend purely on personal preferences, ‘simple multiplication tends to rely on verbal rote retrieval, and subtraction relies upon online calculation using a spatial mental number line, with addition dependent on a mixture of both’ (Dehaene and Cohen, 1995, in Ward et al., 2009:3). However, some of the strategies used by pupils with AS are explained to be quite different to those common to the neurotypical. Many with this disorder are said to be visual rather than conceptual learners (Butterworth, 2002). Asperger (1944) gives an example of how a pupil with AS might work through mathematical calculations. One of his pupils, (Harro, aged 6), when asked to add 27 and 12, said the following:

> 2 times 12 equals 24, 3 times 12 equals 36. I remember the 3 [he means 27 is 3 more than 2 times 12], and carry on.’ [To subtract 12 from 34, he reasoned that:] ‘34 plus 2 equals 36, minus 12 equals 24, minus 2 equals 22, this way I worked it out more quickly than any other.
>
> (Asperger, 1944:55)

This type of methodology is far lengthier than the simple methods commonly used by the neurotypical (Ward et al., 2009) and could be a further reason for low processing speeds:

> Well-adapted Asperger Syndrome individuals […] may have learnt to solve […] problems, yet may not have a normally functioning theory of mind […] behaviour as resembling the normal pattern but arising from quite abnormally functioning processes.
>
> (Frith, 1991:21)

Problem solving and reasoning for the neurotypical are linked to planning and decision making capabilities. A slower processing speed when planning and decision making (Roth et al., 2009) means that, for those with Asperger Syndrome, it can take considerably longer to solve complex problems than for the neurotypical. In addition, unusually low processing speeds can affect novel problem solving activities, tasks which require selection of appropriate data for calculations, and lengthy mathematical questions (Bissonette, 2009). Weak motor function, dyslexia, dyspraxia, and the inability to shift attention or focus, along with the self-distractibility trait, can compound the challenge. Before reaching the end of a problem solving activity, they may either have become distracted and lost focus or become fixated on one small section of a question, thereby forgetting the purpose of the task (Attwood, 2007).

Inference, according to O'Brien (2006), is the logical derivation of new information based on existing knowledge and is the basis of mathematical thinking. Without the ability to fit prior knowledge and understanding to novel situations, and to visualise mathematical concepts vital to contemporary mathematics learning (Attwood, 2007), problem solving, anticipating and adapting to novel settings alongside conceptual and abstract thought can be adversely affected (Butterworth, 2002). Some of the standards required at GCSE level (QCDA, 2010) demand skills in abstract visualisation and adapting prior problem solving techniques to novel situations, so deficits in this area can also affect levels of attainment in mathematics. With a large proportion of the current mathematics curriculum reliant on a pupil's understanding and ability to adapt prior learning to accommodate (Inhelder and Piaget, 1958), process and solve mathematical problems set in novel contexts, it might be that the pupil with Asperger Syndrome is further disadvantaged when required to work independently on atypical problem solving tasks. In standard mathematics examinations, where questions will be unavoidably unfamiliar, students with deficits in this area are very likely to experience feelings of failure and, correspondingly, low self-esteem (Attwood, 2007). Moreover, examinations that demand reasoning and exhaustive responses are said to compound the problem (ibid.). These areas alone can result in lower than average attainment scores amongst pupils with Asperger Syndrome. An obvious consequence of relatively poor GCSE scores and low confidence for the student with Asperger Syndrome is the potential lack of motivation for higher level mathematics study (Walsh, 2015).

However, while certain aspects of the curriculum might be challenging, there is evidence of increased cognitive ability in the pupils with AS relative to others on the spectrum (Volkmar et al., 2005). Asperger (1944) believed that problem solving was not necessarily a difficult process for pupils with Asperger Syndrome. He found that they may be able to analyse and retain information more quickly than average:

> One could not help feeling that he was not listening at all, only making mischief [but] he seemed to see a lot using only 'peripheral vision', or to take things 'from the edge of attention.
>
> (Asperger, 1944:49)

The Austin Psychological Assessment Centre group (2009) found that as well as strong verbal ability, individuals with Asperger Syndrome have mental creative competence, and that both of these qualities can help with the understanding of mathematics questions when they are written in a novel way. While this is in contrast to the finding in the DSM-IV (1994) that mental creativity does not exist in pupils with Asperger Syndrome, there is said to be a distinction between imaginative creativity and reality-based creativity (Baron-Cohen & Craig, 1999). For instance, pupils with

Asperger Syndrome are far more likely to say 'this pencil resembles a lamppost' (Figure 3 below), than 'this pencil resembles a house for thin people', because a lamppost exists whereas a house for thin people does not.

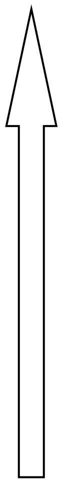


Figure 3: A House for Thin People

Responses to being asked how to make a toy elephant more exciting, with potential suggestions falling into one of four categories:

(i) Additions or alterations: e.g. 'Give him a hat', or 'made his ears bigger'.

(ii) Manipulation: e.g. 'Cuddle him', or 'Take him to the park'.

(iii) Movement: e.g. 'Flap his ears'.

(iv) Imaginative: e.g. 'He could fly', or 'He could read you bed-time stories'

resulted in those with Asperger Syndrome more likely to choose realistic 'alteration' over the other choices (Baron-Cohen & Craig, 1999).

Table 2: Results of the Elephant Task (MLD: Moderate Learning Difficulty)

Groups	Additions or Alterations	Manipulations	Movement	Imaginative
Normal	29.7%	4.2%	17.7%	48.4%
Autism	17%	45.4%	15%	22.6%
Asperger	70.1%	22.7%	2%	5.2%
MLD	20.8%	1.1%	12.3%	65.8%

This part of the review has shown that there are some distinct differences in the way the pupil with Asperger Syndrome learns mathematics compared to the lower-functioning autistic pupil or the neurotypical. This is likely to have implications not just on the teaching and learning of mathematics to fit with some of the requirements of the National Curriculum for Mathematics, but also in relation to the provision of appropriate resources to support this group of pupils to develop skills for mathematics learning. Thus, matters relating to the teaching environment, teaching methodologies in the mathematics classroom and resource provision are examined in the next two subsections.

2.4 Secondary Education for Pupils with Asperger Syndrome

The Education Act, 1944, established that children's education should be based on age, aptitude and ability. But with Piaget (1954) arguing that all students aged 11 and over have reached the formal operational phase, the stage at which they are able to manipulate ideas mentally and draw conclusions using prior knowledge and mental reasoning without the need for concrete examples, the secondary National

Curriculum for Mathematics appears to be designed to fit with some of his ideas from the time. However, such generalisations do not quite recognise the individual nature of each student within a modern fully comprehensive school. In a study of 96 schools in Cambridgeshire (Baron-Cohen et al., 2009), it was revealed that, on top of those on the SEN register with an ASD, another 60% of pupils went undiagnosed, almost all of whom were later assessed as having Asperger Syndrome. Previous studies found prevalence estimates for Asperger Syndrome approximated 0.5% of the general population but these findings suggest a new figure approaching 1%. Despite the knowledge that 'the child with Asperger Syndrome lives in our world but in their own way' (Van Krevelen, cited in Williams, 1995:82-86), a ratio of 3:2 detected to undetected raises concerns over the number of pupils in schools, (diagnosed and undiagnosed), who might become the low achievers of the future in mathematics if resource provision and teaching methodologies do not match learning style (Sherman, 1979). Although this group is relatively small, there is nevertheless an obligation to educate all pupils in an appropriate way (Asperger, 1944):

> The significant divergence of neuropsychological profiles suggests that intervention strategies for Asperger Syndrome should be of a different nature to all others, directly addressing specific neuropsychological deficits [but also] building on neuropsychological assets, an approach that has been described as very useful with individuals with Nonverbal Learning Disabilities.
>
> (Klin et al., 1995:1128)

With various and varying potential co-morbidities to take into consideration, it might not be an easy skill for the mathematics teacher or SEN coordinator to develop. However, for those who have Asperger Syndrome, each presents certain distinctive traits which are seen over and over again in others with the same condition (Frith, 1991). This indicates that one exclusive set of strategies in the mathematics classroom might prove to be all-encompassing, subsequently enriching the experience of mathematics learning for those with common characteristics:

> According to [experts, for someone with Asperger Syndrome], early intervention involving educational and social training, performed while a child's brain is still developing, is highly recommended.
>
> (Walter, 2012:1)

The Department for Children, Schools and Families' framework (DCSF, 2008) regards high quality teaching and learning, including interactions between teachers and pupils, as essential for developing personalised learning, stipulating that individual action plans and idiosyncratic educational strategies should be put into place in the mathematics classroom so that all can access high quality teaching and learning. Likewise, Chiang & Lin (2007) believe that a label of Asperger Syndrome does not determine true individual capability or need, and that each student should be individually assessed in order to provide a truly personalised curriculum which matches each unique talent. However, Mesibov & Shea (1996) report that students with Asperger Syndrome typically demonstrate 'irregular patterns of cognitive and educational strengths and deficits, including splinter skills and isolated discontinuous abilities' (Simpson et al., 2001:1), and this diversity could be a challenge to secondary school educators, even those who have strong modification programmes in place. Nevertheless, Attwood (2007) suggests that educators who have complete understanding of their pupils' fundamental mathematical strengths and weaknesses, are able to develop effective strategies to support the development of skills appropriate to mathematics learning.

The general philosophy in 1944 was that the child should fit the school rather than the school fit the child (Silas, 2010). In the 1978 reforms, Baroness Warnock proposed that training should be provided for teachers in recognition of Asperger Syndrome in children, with the intention that over the years their needs could be catered for in mainstream schools:

> What the committee actually recommended was that large numbers of children with moderate learning difficulties already in mainstream schools should be identified, and their needs provided for where they were.
>
> (Warnock, 2010:1)

The committee's intentions were misinterpreted and soon many more children than necessary were being labelled as having a moderate special need, this Warnock believed in order for the school to be able to obtain more money and to remove the child from the very public examination results list. '[We also] never [said] that all children should be taught under the same roof or that special schools should be abolished' (ibid.). Rather the money was supposed to be spent on those whose needs would best be served in the mainstream setting, 'for specialist teachers or for classroom assistants [and] units or withdrawal classrooms on the campus for use by [pupils with Asperger Syndrome]' (ibid.:2). She reports that the consequence of this now is that many of those who have the potential to damage the education of those with anxiety disorders, through severe bullying for instance, remain in the mainstream setting. Most schools in the UK are now inclusive whilst in America, services across states and interstates are variable (Morrison, 2010). Some schools in the USA still adopt inclusion but most are standalone establishments for pupils with autism and other special needs.

In the UK's mainstream secondary environment, concerns have been raised for the educational welfare of the quietly disaffected, such as pupils with Asperger Syndrome. Because, typically, they do not always present outward symptoms (Frith & Happé, 1994) they can go unnoticed and detection can be problematic:

> There are children with autism-spectrum conditions, notably children with Asperger Syndrome, who remain undetected in primary schools. These children may use strategies to mask their social and communication difficulties such as going to the computer room at playtime. They may be quiet and cooperative at school and not difficult to manage and therefore teachers might not be aware that they have problems with certain elements related to mathematics learning. It may not be until these children move to secondary school that their true differences are revealed.
>
> (Baron-Cohen et al., 2009:8)

Consequences of communication difficulties include misunderstandings relating to the standard classroom environment, the content of a mathematics lesson and the requirements of a mathematical assignment (ibid.). Typical school structures require students not only to learn but also to follow the rules such as sitting quietly and listening while the teacher instructs the class even if the subject matter is familiar (Jacobsen, 2009). Generally, students with Asperger Syndrome are said to find it difficult to adjust to such expectations (ibid.). Roberts & Prior (2006), working on a report from South Australia, confirm that secondary pupils with AS are adversely affected by anxiety in the classroom and that it can become more extreme the older they get.

2.5 The Mathematics Learning Environment for Pupils with Asperger Syndrome

Over stimulating environments and frequent changes are particularly stressful for a person with Asperger Syndrome (FPLD, 2002). Kim et al. (2000) indicate that a higher proportion of people with Asperger Syndrome suffer from greater levels of stress than others in the general population. Anxiety is said to impede the ability to learn and master a new skill, even in a calm and safe environment (Nauert, 2008). People with Asperger Syndrome are often oversensitive to noise, light, taste and touch (Freisleben-Cook, 2004). For the pupil with AS, extreme issues relating to these elements can determine their perceptions of learning in the mathematics classroom (Cumine, Dunlop & Stevenson, 2010). Such hypersensitivity means that environmental issues, which could include aspects of educators' personalities, might be the trigger for severe distress. Poor instructional settings are thought to contribute to difficulties with challenging mathematics tasks (Risley, 2009), whereas '…favourable environments all play a positive role' (Frith, 1991:24). Heightened awareness can lead to anxiety which subsequently leads to underperformance in cognitive functioning and memory (Sousa, 2008).

Furthermore, although AS students can usually think creatively in the real-world sense and are very good at structured mathematical problems (DFES, 2009), they are said to 'experience severe difficulties in transferring mathematical knowledge to real-world problems' (DFES, 2009), the 'correlation [increasing] with the complexity of mathematical tasks' (Sherman, 1979:243). But, real-world learning is advocated in the National Curriculum for Mathematics as essential to the development of effective mathematics learning so this alone suggests that pupils with AS might not be able to become proficient mathematicians.

In addition to the difficulties with abstract thought and transference to real-world scenarios, Klin et al. (2000) suggested that dysfunctional coordination can affect the ability to solve certain types of problem requiring mental manipulation and visualisation of rotation skills. These are, they say, particularly challenging for people with Asperger Syndrome. According to Schopler et al. (1998), motor skill deficit not only affects mental mathematical manipulation but also the physical. This was a discovery mirrored in tests by the team at Austin Psychological Assessment Centre (2009) who stated that spatial ability emerged as one of the least developed areas of expertise in the AS group. These findings are significant because if motor skill is indeed one area in which the majority face challenges, then certain features of the mathematics curriculum such as those associated with practical activities and manipulation will not be accessible to the pupil with AS. However, the TDA (SEN manual, 2010) states that learning styles should not be seen as just 'visual, auditory and kinaesthetic' and that it could be possible to improve spatial skills through the use of ICT. There are a number of online games such as 'Learnanytime' (2010) that are said to be able to determine and improve how well the pupil with Asperger Syndrome functions with spatial awareness tasks. Many of these are graded so that no matter where the pupil is developmentally, he or she can participate in the activities as required while receiving personal training in spatial awareness at his or her own pace. Through mathematical computer programs such as this, pupils who struggle with problems that require spatial understanding gain substantially with minimal supervision, particularly if the topic incorporates an area of special interest (Jackson, 2002). Furthermore, it is suggested that 'technology tools provide external cognition support for overcoming weaknesses in internal working memory…' (Berninger and Richards, 2009:1).

According to Jackson (2002), for a pupil with AS, experience is an important factor in contribution to learning and can enable them to acquire greater skills in a particular area. He says that if something interests them enough outside the classroom, drawing it into the lesson could produce outstanding results. 'For example, if computers are a person's favourite topic of interest then they may find it easier to learn through the use of a computer rather than writing or reading…' (ibid.:45). Mintz (in Miesenberger, 2014) further suggests that the pupils have a special affinity with their own mobile phones and that bespoke applications (incorporating personalised video and audio skins) utilise this emotional attachment to provide an aid to learning. He also points to the benefits of mobile technology for independent learning purposes (2013, cited in Silton, 2014). He found that feedback was better received via its use than was teacher intervention for all of the ASD pupils in his study.

But, according to Bölte et al. (2010), electronic applications, which they say: can provide predictable responses, are 'fair (all users are treated equally), and do not demand swift *in vivo* social behavio[u]r that can overtax learners with ASD' (p.158) should be used to encourage small group work. In O'Brien's (2006) discussion of the benefits of technology with AS pupils, he agrees that pupils should not be working alone on computer-based learning but that the communication opportunities they afford when working with a study partner help pupils with Asperger Syndrome to progress. He observes, however, that there is no gain to be had from producing a set of answers to mechanical tasks that depend upon rote learning, with such answers marked by a teacher or computer and awarded a grade of some sort. Rather, he says, there is more mileage in giving pupils real hands-on tasks that utilise real thinking skills, logical or otherwise. Problems such as these can be provided via personal devices, such as smart phones (Mintz, in Miesenberger, 2014), in the classroom or elsewhere and the responses discussed and peer assessed (Bölte et al., 2010). Any rational observations should be given credence and answers in this scenario should not be right or wrong (O'Brien, 2006). Responses to the tasks that make sense and can supported by evidence are judged by the rest of the group and can be upheld or modified as required until a general consensus is reached (ibid.). This type of task, he says, can facilitate development of group work skills in pupils with Asperger Syndrome.

Despite Asperger's finding that pupils with Asperger Syndrome would 'never join in with the gang and would panic when forced to participate in a group' (Frith, 1991:10), he maintains that they usually want to join in with peer group activities. According to him, they desire social acceptance so that they can be appreciated (Asperger, 1944) but lack of motor skill in for instance football or handwriting often precludes them from joining social groups. They are proud of their achievements and profoundly embarrassed if they do not meet the expectations of the group (Bogdashina, 2005). Burton (2009) says that we are social beings, and that this fact is a central aspect of learning. Her socio-cultural argument suggests that learning is achieved through active participation in meaningful engagements with others and the environment. Wenger (1998) coined the term 'communities of practice' to explain how students working in groups in the mathematics classroom benefit from the experience of shared activities, collaboration and communication. Vygotsky (1986) too saw social interaction as a necessary condition for learning. His key principle was that that learning is closely linked to social interaction and he believed that the only way to promote learning is through creating 'opportunities for meaningful interaction between a learner and another individual who takes the role of teacher during learning experiences' (Jarvis, 1987:166). The Mathematics Matters report suggests that improvements in learning are notable when pupils 'use rich, collaborative tasks' (Symington, 2008:5) and in lessons that 'promote discussion' (ibid.):

> … students are more engaged when working with each other than when working alone. [...] The lowest achieving students have shown the most dramatic gains when using co-operative learning but the most able are said also to benefit from the in-built reflection and coaching opportunities provided by the structures.
>
> (Kagan, 1994:1)

But, pupils with Asperger Syndrome often feel unable to join in with the peer group conversation which may appear immature to them in some respects, and incomprehensible in others (Asperger, 1944; Nordqvist, 2015). However, despite this, even if they do not participate in the discussion, according to Frith (1991), they are said to be able to gain as much through reading written responses produced by their peer group. Unlike verbal group discussion, a written transcript can benefit the pupil with AS as it affords greater processing time (ibid.). Ultimately, it could be that mandatory small group work, whether with collaborative hands-on or computer-based tasks, is the catalyst for positive mathematics learning.

While pupils with Asperger Syndrome are generally believed to possess the intellectual capacity to solve mathematical problems (ibid.), intrinsic motivation is not necessarily a skill that they possess (Asperger, 1944). For this reason, a learning peer or a TA is suggested as potentially able to provide the guidance necessary for full participation in group work (ibid.). Working with peer groups could help pupils with Asperger Syndrome to bypass certain difficulties, not least in relation to the social aspect of learning. However, because the pupils tend to prefer working alone (Barber, 1996), this could be difficult to engineer (Frith, 1991). As an alternative, it might be that the Teaching Assistant, as a source of support, could successfully take the role of a peer (Asperger, 1944). Yet the London Institute of Education's comprehensive report on the effectiveness of such support in the classroom across a range of settings relating to pupils and staff in more than 70 schools (Blatchford et al., 2009) found that at Waves 1 and 2 *(*See Appendix 3) there was a negative relationship between 'the amount of support a pupil received and the progress they made in […] mathematics across all year groups, bar Year 9; the more support pupils received, the less progress they made' (ibid.:2). However, in Year 9, the more support received, the more mathematically capable and sociable the pupil. Wave 3 *(*see Appendix 3) where the greatest levels of targeted support are required, is said to be an area where 'specialist expertise' is likely to be required but, 'at this level, 60% of support staff reported that they did not need specific qualifications in order to be appointed to their post', and only 45% had previous experience (Blatchford et al., 2009:4). Additionally, at this stage, Teaching Assistants are said to be frequently assigned to pupils with behavioural difficulties or low-attainers (ibid.). This, in direct conflict with Baroness Warnock's original intention (2010), means that the proportion of students with less obvious learning needs, such as those with Asperger Syndrome, may not get the support required to help them in the mathematics classroom. Although Handover, working for the Government as State School Advisor, reported that while TAs are shown to be valuable to teachers in reducing their stress (Kirkup and Irvine, 2009), they do nothing to improve the progress of the pupils they support, Blatchford et al. (2009) contradict this finding. Indeed, they state that, minimally, TAs are able to act as scribes for those with Asperger Syndrome and this can take significant stress and physical strain away from the student too. Blatchford et al. (2009) do suggest, though, that the ways in which schools deploy TAs could be better. Alborz et al.'s research (2009) indicates that TAs who are trained specifically in mathematics with a focus on intervention strategies can strengthen pupils' progress. They also found that TAs who work with groups of pupils, and so allow for full involvement in class activities, have a better chance of improving pupil outcomes than those who work in a one-to-one setting. And the better educated the TA, the more successful; therefore, they advocate subject specific training for these staff early on with ongoing developmental opportunities made available to ensure that contemporary issues continue to be focused upon and adopted as appropriate (ibid.).

2.6 Summary

For the pupil with AS, it appears that an intense interest in the subject or a feature of it is very likely to enhance the learning of mathematics. According to Asperger (1944) and Jackson (2002), to inspire a fascination in mathematics and to encourage perseverance, linking lessons to a 'special interest should enable pupils with Asperger Syndrome to achieve quite extraordinary levels of performance in a certain area' (Asperger, 1944:45). However, it has been shown that, in conjunction, there are other causal factors to consider. Low levels of perseverance can be a consequence of any or all of the deficits mentioned in this chapter; therefore, it seems that a pupil cannot persevere if there is any type of barrier that disrupts progression whether this is intrinsic or extrinsic. It may not be that pupils with AS choose to give up on a mathematics learning task, but rather that there is no alternative. Ultimately, therefore, it seems that these 'exceptional human beings must be given exceptional educational treatment' (Asperger, 1944:37). Collectively, the findings above provide evidence of many of the major factors governing skills for the learning of mathematics for pupils with Asperger Syndrome and a summary of the key issues emerging from the review follows:

- Some pupils with Asperger Syndrome might have problems related to specific teaching methodologies, complex problem solving, reasoning, rapid processing, group work, real-life learning, practical work and perseverance, each of which is a requirement of the National Curriculum for Mathematics (2013);
- For pupils with Asperger Syndrome, relevant mathematics can be more puzzling than pure mathematics, this because of social and linguistic detail (Sherman, 1979);
- Motor skills deficit would be very obvious in pupils with the condition. Many of the authors in this review concur, e.g. Schopler et al. (1998) and Jackson (2002);
- In relation to spatial awareness, some pupils with Asperger Syndrome can find manipulation and rotation of objects both mentally and physically a challenge (Klin et al., 2000);
- Asperger (1944) reports that, although mathematics, for most part interests them, ordinary everyday calculations have the opposite effect on pupils with Asperger Syndrome. Writing endless lists of numbers in an automatic fashion is something that is likely to induce distraction, whereas finding something of great significance to them could keep the pupils focused on the task (Asperger, 1944);
- Some of the pupils can be mathematically able, some not (Asperger, 1944; Frith, 1991). Despite the widespread belief that individuals with Asperger

Syndrome are peculiarly mathematically able, in part due to films such as *Rain Man* (Sullivan, 1992) and the novel *The Curious Case of the Dog in the Night-time*, (Haddon, 2004) and that some students with Asperger Syndrome can excel in mathematics (Baron-Cohen et al., 2001), many do not:

> Their knowledge seems to remain curiously fragmented. They fail to put their experience and knowledge together to derive useful meaning from these often unconnected bits of information [and], despite sometimes high academic abilities, lack common sense.
>
> (Frith, 1991:4);

- Many appear to be loners and dislike collaborative work but group work might be necessary to facilitate appropriate mathematics learning skills through sharing of ideas (Vygotsky, 1986; O'Brien, 2006);
- Anxiety could create meltdown in the classroom environment (Kim et al., 2000);
- Digital technologies are suggested by some to be the panacea in helping to teach pupils with Asperger Syndrome and the pupils might be better able to work independently or in small groups with the use of a computer (Jackson, 2002; Berninger and Richards, 2009);
- Pupils with Asperger Syndrome have lower than average levels of intrinsic motivation and so need targeted support (Asperger, 1944);
- 'An increase in the number of support staff is linked to a drop in results for English, mathematics and science' (Kirkup and Irvine, 2009). However, the DCSF (2008) emphasises that the research also acknowledges that, with the correct training, Teaching Assistants do have a positive effect on pupil progress (Alborz et al., 2009; Blatchford et al., 2009);

- Because of the diversity of pupils with Asperger Syndrome, educators are not always be able to provide adequate support but TAs could have a greater insight to the problems faced by these students to assist teachers in the development of realistic IEPs (Asperger, 1944);
- And Warnock's idea of inclusivity has meant that most pupils with Asperger Syndrome are taught in mainstream schools with separate specialist units but that other pupils who *should* be in specialist schools have been included too and some of these pupils can create problems in the classroom for pupils with high levels of anxiety (Warnock, 2010).

Based upon the detail from this review, I expected to find that the pupils would have a wide range of traits but that certain common physical characteristics such as poor motor control would probably be immediately obvious to me. However, despite the increasing attention paid to pupils with Asperger Syndrome, the definition of the syndrome by some authors has not been made entirely clear. According to the literature, there are some typical characteristics in pupils with AS but there is also substantial symptom variety. As there are not clear boundaries between autistic spectrum pupil types, it appeared that Asperger Syndrome as an easy to define condition might not prove to be as simple as I first envisioned. Accordingly, I expected that this lack of clarity could influence my decisions regarding the type of pupil to study during the practical data collection phase.

2.7 Gaps in the Literature

Despite the wealth of literature documenting the educational needs of pupils with classic autism, based upon findings here, there appears to be comparatively little on teaching and learning of mathematics for pupils with Asperger Syndrome. Many of those with this largely hidden condition 'prefer subjects rooted in logic and systems, such as mathematics' (NAS, 2015). Therefore, it seems to me essential that educators firstly understand how pupils with Asperger Syndrome can develop the necessary skills for the learning of mathematics in the classroom. Secondly, recognition of the contribution made by specific resources in the development of unique mathematical skills in pupils with Asperger Syndrome is vital.

In 2009, the DFES produced a guide for teachers of pupils with ASD, but the document itself was narrow in range and did not specifically advise on how to become a supportive teacher of mathematics for the AS student. Their examples referred only to the classically autistic and so were largely unconstructive. Although certain characteristics of Asperger Syndrome might be found in pupils elsewhere on the continuum, in general their needs are quite different to those at the other end of the spectrum. The NAS in the UK advises that for both autism and Asperger Syndrome, treatments, therapies and educational approaches should be broadly similar (NAS, 2015), but this does not allow for individuality. It is in opposition to the recommendations of the evidence-based practice advisory committee (Tweed et al., 2009), which deems that personalisation based on the individual should be at the forefront of all educational practices. If we assume for a moment that pupils with either autism or Asperger Syndrome require the same types of intervention in the mathematics classroom, then current practice needs no adaptation. However, if their needs are in variance, then a one-size-fits-all policy, while it may be cost effective, could prevent one type of pupil from achieving their potential.

Furthermore, there is no definitive study into which type of learning environment for the teaching of mathematics suits pupils with Asperger Syndrome best. Is it mainstream, specialist or one with a special needs unit? Is it one with a TA, use of computer software as a teaching and learning tool or one with a traditional textbook style of mathematics teaching and delivery? Should pupils be taught the same way as everyone else? Should they be made to participate in group work? Do the specifications of the National Curriculum for Mathematics promote mathematics learning skills in these pupils or are their learning styles compromised by potential restrictions like demands for rapid processing? There is little on how well the National Curriculum for Mathematics specifically suits the capabilities of pupils with Asperger Syndrome.

There are varying views about the usefulness of TAs in the classroom. Some researchers suggest that they are only marginally effective in certain circumstances. Others state they have no effect and some say that they often have a negative impact (Kirkup and Irvine, 2009). While there have been several studies that consider the effect of the work of Teaching Assistants (TAs) on pupils in the general classroom, there seems to be little that focuses on assistance with mathematics learning from any source provided for pupils with Asperger Syndrome. With no in-depth study into the value of TAs in the mathematics classroom to pupils with Asperger Syndrome, it is hoped that conclusions from this work, which draws upon teaching methodologies from various types of educational establishment, can make a significant contribution to current literature and perhaps assist those involved in the development of support programmes for Teaching Assistants and the pupils.

Hence, the practical research stage was developed to explore various elements of the mathematics classroom with a view to:

- evaluating the various points uncovered in this section to determine whether they still held in the contemporary mathematics classroom;
- addressing the inconsistencies;

- supplementing existing research literature and eliminating some of the omissions.

2.8 Research Questions

Prior to the literature review, although the subquestions had not been formulated, the main question being asked for this study had already been decided upon:

'What is the secondary mathematics classroom like for pupils with Asperger Syndrome?'

To facilitate an effective study into how pupils with Asperger Syndrome fit into their personal learning environments, and in order to support the main research question, following careful examination of existing sources of literature, I established that two subquestions would be necessary to the enquiry. To summarise, the literature review contributed a range of information relating to what life is like in the mathematics classroom for pupils with Asperger Syndrome and covered the following:

- a definition of the profile of someone with Asperger Syndrome to include how the condition can shape the classroom experience, particularly in respect of mathematics learning;
- the requirements of the National Curriculum for Mathematics and how compatible they are with the individual learning styles of pupils with Asperger Syndrome;
- and the alternative types of learning environment alongside teaching methodologies and resources provided, to include teachers and Teaching Assistants, so that the pupil with Asperger Syndrome can work towards the specifications of the National Curriculum for Mathematics.

Subsequent to the review of the National Curriculum for Mathematics, it was clear that this was where I would find the detail to inform the subquestions. In response to the findings from the literature, the first subquestion asks what, if any, are the common traits in respect of mathematics learning for someone with Asperger Syndrome and reflects upon how well these characteristics match with the requirements of the National Curriculum for Mathematics. Corresponding to the latter part of the review, the second subquestion asks how elements of the mathematics learning environment might support learning for pupils with Asperger Syndrome.

Following the review, I surmised that the mathematics classroom comprises a web of interactions between the following elements:

- national mathematics education policies
- the ways in which mathematics is taught
- the educators
- the environment
- the resources
- and the learners

If they are inextricably linked, one component might have had a major influence on another which could not be ignored, so all factors had to be investigated. The mathematics learning environment features various teaching and learning practices such as collaborative working along with types of resource such as teachers, TAs and computer software. Thus, to address the ways in which the pupils are supported to realise certain target skills and to ensure that the full set of elements informing the teaching and learning of mathematics for pupils with AS could be considered, the subquestions chosen to drive the enquiry were:

Research Subquestion a):

How compatible are some of the common traits attributed to pupils with Asperger Syndrome with contemporary mathematics teaching and learning strategies?

Research Subquestion b):

What aspects of the secondary classroom environment could be perceived as supportive of mathematics learning for pupils with Asperger Syndrome?

I expected that these questions would be broad enough to allow me to develop a view of how various features of the mathematics classroom setting can shape the experience of mathematics learning in pupils with Asperger Syndrome. In addition, they allowed for an in-depth study of the principal elements from the outset. Pertinent issues surrounding personal attributes along with the various elements of the teaching environment as proposed by the National Curriculum for Mathematics as essential for successful mathematics learning were predicted to be extensively addressed by these questions.

The findings emerging as a consequence of the practical research element are reported in the Analysis chapter, and compared and contrasted with the detail from this Literature Review at the Discussion stage. The choice of Methodology relating to the practical data collection element of the study is justified in the next chapter.

Chapter 3: Methodology

3.0 Introduction

Following on from the literature review and subsequent to the preparation of the research subquestions, I arranged visits to various educational establishments. Through these, I expected to uncover practices relating to the mathematics learning environment: to examine what mathematics learning is like for pupils with Asperger Syndrome and to explore how the students are supported to realise the targets of the National Curriculum for Mathematics. In view of Baroness Warnock's concerns regarding inclusion (2010) and noting that the USA had moved away from inclusivity, I determined that both types of school (inclusive and specialist) should be visited in the interest of identifying any differences between mathematics classroom environments for pupils with Asperger Syndrome. Significantly, although historically the curriculum for mathematics in the USA varied state to state, a core curriculum similar to the one in the UK has recently been introduced, so for the purposes of this research, all reference to National Curriculum for Mathematics or national education policies for mathematics learning pertains to and has significance in both countries.

In part, the literature review aimed to analyse contemporary issues, to facilitate understanding of how Asperger Syndrome might be recognised in a pupil and to establish whether there are indisputable common characteristics in the condition. This clarity was vital to the enquiry. I had to be certain that the pupils I would be observing in the mathematics classroom were going to be similar enough that various teaching methodologies and alternative strategies for such pupils could be compared and contrasted appropriately. This understanding was necessary to allow me to notice (Mason, 2001) and focus on pupils with certain learning needs in the classroom rather than to simply hope to identify them when and if the opportunity arose. As a starting point, for instance, one suggestion in the review was that motor dysfunction has the potential to affect the legibility of written work (Frith, 1991). Therefore, noticing disordered classwork, (see Appendices 4 & 5), could be a preliminary indicator of pupils with the condition, or confirmation that the pupils selected by the schools for observation purposes did indeed have Asperger Syndrome.

To ensure that validity and reliability were addressed, the processes of data collection and subsequent analysis demanded thorough planning, comprehensive collection procedures and systematic scrutiny of the findings. Specific research practices are governed to some extent by certain methodological conventions, these largely dictated by the type of study being conducted, and the methodology description had to include enough detail to enable others to replicate a study in such a way as to be able to produce similar results (Cohen et al., 2011). So that I could develop a detailed phenomenological understanding of each individual in his setting, I adopted a case study approach. Yet, while this was considered to be the best method on which to base an analysis of data concerned with the individual in a specific setting, there were, nonetheless, potential drawbacks with this type of methodology. For instance, if the data pertaining to each case had been found to be wholly disparate, then summaries and comparisons could have been relatively complex. However, in this instance, the primary inclusion criterion for the subjects of the enquiry was similarity of character and this meant that the study was anticipated to find a representative amount of commonality in the summary data. Regarding variation in respect of the schools, the rationale for conducting observations in a range of settings is defined in section 3.1 below, (Methodological Principles).

This chapter of the thesis is split into six parts:

1. The initial section, 'The Methodological Principles', explores various types of educational research methodology and outlines the approach that is appropriate to this particular study, explaining the reasons behind the final choice of methodology and how it was expected to inform the results of the enquiry;
2. The second section, 'The Research Strategy', opens with a discussion surrounding the basis for the choice of strategy and this is followed by a brief examination of the nature of case study research, a subsection on the sampling methodology in this instance, and a description of what constitutes the case in this enquiry along with the cases selected. Here, an overview of the pupils and their settings is provided to give an insight to the supplementary descriptive information that I managed to gather over the data collection period. Further detail can be found in the Analysis chapter;
3. Part three introduces and briefly discusses the purpose of the two subquestions selected to help with the enquiry alongside an overview of how the data were collected for each;
4. In the fourth section, the pre-pilot, the pilot and the main parts of the study are described in some detail. The data collection methods selected for their appropriateness relative to each research subquestion and individual situation are presented. Additionally, the reason for the pilot study is discussed along with some of the vital information that came out of this stage to subsequently inform the practical component of the main research programme. This includes establishing the typical characteristics of the pupil with AS, determining which schools to approach for their suitability, and ascertaining whether to engage in participant or non-participant observations. Lastly, the

various elements of the practical data collection aspect, including the need for narratives, are explained and points for consideration in the development of each part of the programme examined;

5. The penultimate section defines the ethical issues that had to be taken into account in the study of these vulnerable young people in their educational settings and includes a discussion of the validity and reliability in respect of this piece of research;
6. Finally, the summary ties together the significant methodological considerations.

3.1 Methodological Principles

In typical educational enquiries, there are two major approaches to research and these are commonly referred to as positivist and interpretivist methodologies. As research design depends upon the topic and the location being investigated (Cohen et al., 2011), for the purposes of this study, certain contributory factors were taken into consideration to determine which of these methodologies would be most appropriate. Polanyi (1959) suggests that all reading, research and analysis demand some kind of interpretation, either from a personal or theoretical viewpoint. While positivism and interpretivism both allow for the psycho-social study of the human being in relation to individual or personal settings, the approach of this research was, in some respects, about seeking meaning in observed behaviours and actions. The main aim of this research was to explain certain behaviours emerging from idiosyncratic characteristics, teaching and learning methodologies and environmental settings. Thus, it was decided that, to uncover the appropriate detail from which informative findings could emerge, an interpretive study was most likely to expose and explain any observations of differing types of behaviour in alternative settings.

Hammersley (2007) states that supportive teaching and associated success in learning relies solely on an evidence base of good practice, measurable quantitatively with a reliance on a library of discrete skills and knowledge. He suggests that all educational research should depend upon 'the systematic collection of data' (2007:72) alongside full analysis and rigorous trialling before publication of definitive results. He maintains that recommendations must offer a sense of predictability which only an objective approach to research can satisfy. However, on quantitative research methods, Guba and Lincoln (1981) perceive those that rely upon such generalisations as able to produce context free results only and, as a consequence, they suggest that these methods cannot measure or report on behaviour. Furthermore, Schofield (1990) equates results from quantitative research to a 'snapshot', applicable only to one moment in time and space. She regards qualitative research as the only reasonable option for studies such as this, stating that its effectiveness lies in its ability to evolve over time in order to improve practice. She avers that the qualitative approach is the only sensible method, maintaining that this methodology almost always produces the best results. Although qualitative research is believed by some to offer no more than subjective impressions, qualitative researchers endorse subjectivity arguing that it is an effective way to improve practice in that it allows for alternative perspectives to be interleaved with their personal understanding and beliefs. Based on this, while limiting elements of bias in investigative studies, the researcher can achieve a better understanding of the world (Hammersley, 2007). Although the quantitative researcher, with a controlled, systematic and scientific style of enquiry, continues to be considered by some as capable of providing the only route to valid and reliable findings, 'the world has changed since Newton, Einstein and Bohr gave their versions of how it is'

(Eisner, 1992:14) and so too has the field of education (National Curriculum for Mathematics, 2013). ‘Even the work of natural scientists, despite their use of sophisticated measurement technology, relies on judgment’ (Eisner, 1992:123) to some extent. So perhaps even quantitative research is shaped by the researcher’s own subjective preferences and this naturally introduces bias to an enquiry. Both qualitative and quantitative researchers derive evidence from a variety of sources, including personal opinions and all researchers need to draw on many different viewpoints in order to produce a balanced argument (ibid.).

While the one argument states that if reliable generalisations are expected to come out of a research programme then only the objective nature of a series of logical scientific experiments can produce the type of data necessary to an enquiry, the other demands that, as no two establishments or people are identical, such idiosyncrasy necessitates subjective enquiries. Therefore, for the data collection and subsequent analysis pertaining to this study, quantitative research methods were discounted as unlikely to unearth the types of information necessary to the enquiry. Further, the use of analysis techniques to produce scientific laws would not have been relevant to understanding and explaining the individual behaviours and learning styles of people with Asperger Syndrome. According to the findings from the literature review, pupils with AS are not identical in every respect; therefore, flexibility was paramount.

The settings in which this enquiry took place were intentionally relatively diverse, this to ensure that the findings from the study would not be peculiar to just one individual in his exclusive setting. Moreover, although certain elements of each individual's character were predicted to match some of the definitions of traits of Asperger Syndrome described in the Literature Review chapter such as motor skill deficit and problems with manipulation, other than in the pupils at the two pilot schools, the behaviours of the pupils were not necessarily anticipated to conform to some distinctive standard model. As human beings are deemed capable of changing their behaviours according to setting, my view was that it could not necessarily be said that because a pupil is observed behaving in one way in a particular lesson, then she or he would always behave in the same way regardless of setting or teacher. I determined that the findings arising could not be shoehorned to fit with predetermined theories (Cohen et al., 2011). Rather, each of the discoveries would be discussed for its own merits. The intention here was to compare and contrast the perceived realities of each individual in one space and time with the realities of others in alternative settings. Therefore, taking a qualitative approach which looks at individuals and how they react according to setting was selected as an appropriate methodology.

Any theories that might have arisen from this enquiry were anticipated to be justified through ongoing analysis of the data collected over the period of this research (ibid.). As it was expected that a large proportion of theories might emerge from the data, and because they were not predetermined, it was not possible to formulate a proposition with any certainty before conducting a thorough analysis of the data. However, I had some preliminary ideas based on personal experience and readings prior to the literature review, such as:

- pupils with Asperger Syndrome learn best in a calm environment
- certain types of teacher can be more encouraging than others
- some pupils with AS find the learning of mathematics difficult but, if they are interested in certain elements of the subject, they can learn quickly
- dyspraxia can inhibit pupils with AS in the mathematics classroom particularly in relation to practical work and manipulation of mathematical tools

- mathematics should be taught from a real-world perspective
- and learning mathematics with the use of computer software might be a preferred medium for pupils with AS

There was no expectation ahead of the process of how the enquiry might develop until full analysis of the data was complete. Therefore, it was not possible to determine whether or not my initial thoughts could be expanded on, or indeed in which direction the findings from the enquiry might go. These are stated simply so that the reader can make a decision about whether or not these personal assumptions adversely influenced the later analysis and conclusions. Further, as these were not hypotheses to be tested, I decided that an open-ended study would probably be the most productive.

In the early stages of this particular enquiry, in acknowledgement that there might be more similarities than differences in the preferred learning styles of pupils with Asperger Syndrome, I determined that multisite studies would produce the most appropriate results in order to classify one way or the other (Schofield, 1990). By examining the characteristics of one or more pupils in one type of educational establishment and making comparisons with those found in another pupil or pupils at a differing type of school, I thought that it might be possible to find similarities in the traits of this group of pupils. If there were more similarities than differences then, maybe, setting could be considered to make a minimal difference to how pupils with Asperger Syndrome experience the teaching and learning of mathematics, with the external factors irrelevant to some degree. Alternatively, if certain characteristics belonging to one distinctive group in one type of setting were never or rarely found in another, the variation might be considered good enough to be able to generalise the results relating to each distinct group and to categorically define the members of each set through their differences according to setting.

Even though studying potentially disparate groups of pupils in dissimilar settings does not necessarily offer the homogeneity that might be regarded as crucial to this type of enquiry, it can provide an indication of how the environment influences outcomes. In order to increase the generalisability of qualitative research, Schofield advocates a 'best-fit' policy that studies 'the typical' (1990:189) and makes it possible to narrow the search for constructive teaching and learning strategies. Guba and Lincoln (1981) agree concluding that, instead of generalisation, a degree of 'fittingness' should be adopted. If differences are relatively superficial, then the research could be judged able to provide a best-fit scenario. One way or another, it was expected that, if such fittingness could be established, then this would be the most useful outcome from the enquiry but until the analysis stages, it was not possible to state this with certainty.

3.2 Research Strategy

The pupils studied throughout this enquiry, although similar in certain respects, were located in a variety of schools and purpose built institutions in the UK and North America, each employing distinctive strategies for the education of pupils with Asperger Syndrome. The education system for pupils with AS, or indeed any additional need, in the US differs from that in the UK where full inclusion is actively promoted. In the UK, in most instances, the pupils are educated in mainstream schools. Occasionally, they might be home-schooled, attend a specialist school or have some lessons in a special unit but, in general, mainstream education is the norm. In the USA, twenty-five years ago their education system too supported full inclusion. However, at the time of this study, for reasons they said were in the best interests of their pupils, it had reverted to educating those with Asperger Syndrome in 'special schools' dedicated to working with pupils on the autistic spectrum. As each of the various institutions in the UK and America, whilst catering for similar types of pupil, used some contrasting teaching methodologies, the results of this study were anticipated to be predicated on the advantages and disadvantages of each individually and, where reasonable, in relation to each other.

The methodological framework was based upon how best to ascertain the answers to the research questions. So, as stated, this investigation demanded an overall procedure which was qualitative in nature; and within that, a multiple case design approach was expected to be the most appropriate means of informing the enquiry. The use of qualitative case studies is an established approach to ‘catch the complexity and situatedness of behaviour’ (Cohen et al., 2011:129). Yin (2003) states that case studies are desirable when there is no intention to manipulate the behaviour of the observed and when contextual settings with fuzzy boundaries between setting and phenomenon are difficult to disentangle.

There are various types of case study. One such is explanatory which is appropriate when it is likely that there will be no clearly defined set of outcomes. For instance, explanatory case studies can be used to help with determining relationships between students and educators. Another is the descriptive case study that might be appropriate to help explain links between certain phenomena and the settings in which they occur. Here, in the initial stages, I determined that, in accordance with my preliminary views, an explanatory study would be useful to explain any links between the in-school educational programs and staff, and their perceived effects on the pupils. Additionally, a descriptive study was to be utilised to describe the observed events alongside the real-life context in which they occurred. The case study design was central to this investigation and any apparent effects of contextual conditions were considered to be relevant in determining how pupils with Asperger Syndrome would interact with each individual educational setting. Therefore, explanatory and descriptive holistic studies in a multiple case design with units of analysis, as defined by Yin (2003), and relating to a variety of pupils in various settings were identified as most appropriate to this enquiry. In this instance, the cases selected were determined by the research questions (Yin, 2009) and these were the pupils with Asperger Syndrome within the institutions where they were educated as a whole. Further, it was a multiple case study in that the research was dependent on many differing sources to provide evidence of how the learning mathematics might differ according to educational setting or the learner.

Sources of data included students' work, questionnaires, interviews, (with professionals, educators and students), transcripts, personal diary entries, and notes from direct semi-structured and unstructured observation. In particular, it was anticipated that the observations of pupils in classroom settings and various discussions with educators would provide a substantial set of data from which reliable relativistic analyses could be produced, with some or all resultant findings applicable to a subset or to all pupils with Asperger Syndrome. If end results were to contribute to improvement in knowledge and understanding, they had to be derived from purely observable facts and appropriate data, and it was expected that the conclusions drawn from all of the data collected might then be transferable to other occasions, locations and individuals (Cohen et al., 2011).

3.2.1 Sampling

The population for this study was the entire group of pupils with Asperger Syndrome aged 11 to 19 in the UK, and 11 to 22 in specialist schools in the USA. As it would have been near impossible and time consuming for me as a lone researcher to visit every secondary school across the UK and the USA with the intention of finding all the pupils in this category, it was important to determine an effective sampling procedure.

The principal sampling considerations follow:

a) As Ehlers and Gillberg reported in 1993 that there are only 36 cases of Asperger Syndrome per 10 000, finding a large sample was expected to be unlikely;

b) Initially, letters were sent out to the Headteachers of all the Secondary schools (see Appendix 7) in two regions of the UK with a view to finding pupils with Asperger Syndrome at the local schools. There were several schools whose Headteachers failed to respond to the initial approach but, of those who did, (15), most said that they could not help with the research as there were no pupils at their schools with such a diagnosis;

c) To gain a unique understanding of the pupils in question, an ideographic approach to the investigation was probably more appropriate than a nomothetic one (Cohen et al., 2011). By concentrating on the individual rather than a large group, a greater understanding of idiosyncratic behaviours was expected to emerge;

d) Cost was a huge concern, with time, money and resources top of the list (ibid, 2011). The visit to the USA alone proved very expensive in terms of travel and accommodation costs, let alone time constraints;

e) Finally, the preliminary assumption that there were likely to be strong similarities in a substantial number of the traits exhibited by these pupils suggested that a larger sample would have provided no new information and was therefore deemed unnecessary.

A random sample taken from a large population is considered by some as the most effective way to produce reliable unbiased results (Job and Morley, 2003); yet, for the purposes of this enquiry, sampling a large group would neither have been practical nor cost effective. According to Swann et al. (2003), a focused study conducted on a much smaller subgroup can produce an equally comprehensive and reliable set of findings. Hence, the decision to restrict the sample to a narrow group was considered preferable insomuch as collection of sufficient data for qualitative analysis is achievable if the right research questions are asked (Cohen et al., 2011). The decision was made early on to limit the sample group. I expected that, as the enquiry was attempting to find some kind of commonality in the behaviours of one specific set of pupils in the mathematics classroom, a sample of no more than ten taken from diverse educational settings would be sufficient. Based upon the potential for contrasting types of evidence according to contextual setting, this would allow for a thorough in depth analysis and discussion of the varying teaching and learning practices observed. While such a test group might at first appear too small to allow for credible statistical analysis, a limited sample like this allows for a fully-focused enquiry from which relevant conclusions can be drawn.

In consideration of the points detailed above, the approach I decided upon was one of non-probability intense purposive sampling (Cohen et al., 2011), with the study cases being selectively chosen to ensure that the group consisted of clear examples of pupils with particular sets of characteristics. This type of purposive sampling facilitated intentionally selective choice of educational establishment with the sample for this study taken from secondary schools, both specialist and mainstream in the

UK and the USA, each with a potentially unique teaching approach for pupils with Asperger Syndrome. Furthermore, as it was not the intention to generalise findings to the whole population, with the target group containing only those with Asperger Syndrome, non-random sampling was considered appropriate to the investigation. It is important to note that random probability sampling would not have been useful in this study because, as there are so few cases of pupils with Asperger Syndrome (Ehlers and Gillberg, 1993), the probability of finding anybody in a random sample with the syndrome would almost certainly be very low indeed, the time consuming nature of such a procedure notwithstanding.

Diversity in the types of school from which the sample groups were taken was an important feature of this enquiry as this kind of focus was expected to help with distinguishing between varying systems of teaching and learning for pupils with Asperger Syndrome. Although selection of specific pupils was not planned in advance, in that they remained anonymous to me until each individual school visit took place, it was imperative that, for the aims of this research project, purposeful decisions were made about the sample groups. Once in school, to limit the risk of personal bias, the pupils included in the sample were those who were convenient in terms of availability, (as determined by the Headteachers). Much of the data for this study were only gathered once I had confirmed a study subject as suitable and this was, by necessity, usually in situ (Yin, 2003). So, although the schools were chosen purposively, the group of pupils themselves formed a convenience sample.

3.2.2 An Introduction to the Schools and Pupils in the Sample

In this section, I provide an overview of the schools and pupils in this study. The introductory information provided here on each school and pupil simply recounts the detail I was provided with prior to the observations and is not intended as a fully informative description of the cases. Further in-depth detail and comparisons which were uncovered through personal observation are to be found in the Analysis chapter.

Pseudonyms are used throughout and any identifying information has been modified sufficiently to represent a similar order of magnitude to the original.

The ten observations were carried out between July 2009 and September 2011. The schools chosen included, in the UK, two mainstream state secondaries with specialist units, two mainstream state secondaries without specialist units, one mixed selective independent secondary, one mixed non-selective independent secondary and one single-sex independent specialist boarding school, and in the USA, two mixed independent specialist secondaries and one independent specialist boarding school for post compulsory education.

In the UK:
Mainstream Secondary schooling: ages 11 – 18
Specialist Secondary Schooling: ages 11 - 19

In the USA:
Mainstream Secondary schooling: ages 11 – 18
Specialist Secondary Schooling: ages 11 – 22

All schools visited in both countries catered for pupils aged 11 and over and all were mixed except for Epsom Boarding school which catered only for boys. All schools bar Hamilton Road, Inglewood Farm and Jodrell Community School were in the UK, with these three located in the USA. In addition to the schools in the UK, the sample from the USA was included because, as previously mentioned, the authorities there had veered away from inclusion, citing the ineffectiveness of mainstream teaching and learning for pupils on the autistic spectrum as the reason (Morrison, 2010). In the early planning stages, I expected that, dependent on the type of learning environment, there would be substantial differences in teaching and learning, and this was the rationale for choosing pupils in various diverse settings. With this in mind, I approached a colleague who had links with the Education Department in one of the universities in Ohio. This particular state was renowned for its research into educational strategies for pupils with all types of autism. Therefore, to gain a contemporary and focused insight to their perspectives, I believed that it would be conducive to the study to become immersed, albeit for a relatively short time, in their system within schools, at Initial Teacher Training providers and Boards of Education across the state.

Whilst over there, I was introduced by the Professor in charge of the US side of the programme, Professor Morrison, to the mother of Harry who had recently been diagnosed with Asperger Syndrome. Harry's mother arranged a day's visit to his school with the Headteacher, who allowed me to shadow the pupil as he participated in various learning activities including one elongated mathematics session. Professor Morrison contacted the Headteachers of the other two schools in the USA to arrange those visits.

In addition to the two pilot schools and the eight others used in this enquiry, there were two schools pre-pilot, the findings from which initiated the enquiry. Therefore, their details are included below for completeness.

<u>Pre-pilot Case Studies: Linwood High and Margaret Barclay Schools</u>

Linwood High School was a Church of England state school (11 – 16) with approximately 500 pupils. It had just emerged from special measures and struggled to attract pupils. The school has since closed and the pupils moved to another local but much larger academy. The pupil observed, Laramie, in one mathematics lesson was about 14 years old, seemingly with no friends in the class and introverted.

Margaret Barclay School was a Roman Catholic school (11 – 16) in the same region as Linwood High. The school was popular although results were average, (52% A to Cs all subjects), and the buildings a little run down. There were approximately 700 pupils at the school. It has since been demolished and a new school in academy style built on site. The boy observed, Michael, again in one mathematics lesson, was 12 years old and had two friends in the class who walked with him to school on most days. In this particular lesson, he was directed by the teacher to sit with another 'group of pupils for a change'.

Case Study 1: Andy

Arlidge Arts Academy was the first pilot school and was a mainstream mixed state secondary with nearly 1000 pupils (11 – 16). Results at the school were below average but there was some evidence that it was improving, particularly in mathematics, which was the weakest subject area at the time. The school day was split into six 50-minute lessons plus a 1-hour lunch break and two 15-minute breaks. Lessons followed a standard timetable with a different combination of lessons each day. There were 28 pupils in the sample student's group, 1 teacher and 1 TA, both female. Andy, the observed pupil, was an 11 year old with Asperger Syndrome, the elder of two siblings, the younger of whom was female and due to start in Year 7 at the school the following year. Andy's special talent was memorising long words and he had a reading age of 16+ although his teacher said that understanding was poor.

Case Study 2: Ben

Bowman Hill was a mixed independent secondary school (11 – 18) with above average results at GCSE which catered for approximately 120 pupils altogether. The school day was split into six 50-minute lessons plus a 1-hour lunch break and two 15-minute breaks. Lessons followed a traditional timetable, with a different combination of lessons each day. There were 10 pupils in the group, one of whom, Ben, had Asperger Syndrome. There was one female teacher and no TA. Like Andy, at Arlidge, Ben was aged 11, the elder of two and lived with both parents and his sister. His special talents included reading, mental mathematics and basic computer programming. There was no outward indication that he fully understood the work provided; it was suggested that he merely responded in a rote fashion to familiar questions. Each day he was brought to school in the school's minibus which collected him from home.

Case Study 3: Charles

Chelsea Mill Science and Technology College was a mixed non-selective independent school (11 – 18) with 1 out of the 9 pupils in the group, Charles, having Asperger Syndrome. The day was split into seven 50-minute lessons. The teacher was female and there was no TA. Charles was 11, and the eldest of 3 siblings, the other two being girls. He lived with his mother and sisters. He enjoyed reading science fiction and mathematics and was reported to be obsessed with computer games. He lived 5 minutes away from the school so walking in should have been relatively straightforward but his mother accompanied him on most days.

Case Study 4: Dan

Drake Academy was a mixed mainstream secondary (11- 18) with a specialist unit. There was one pupil with AS in the group of 28. The day was split into five 60-minute sessions. When in the specialist unit, these were loosely based around TEACHH principles. This was a personalised structured programme which was said to help the boy at the school, Dan, to manage mathematics tasks more successfully than he might otherwise (NAS UK, 2015). There was one female teacher and a female TA. Each day pupils followed the same pattern, moving from session to session at the command of the teacher. Special interests were catered for randomly throughout the day and not necessarily as a reward for completing a task successfully. Dan, 12, was reported as having an aptitude for jigsaws and mathematics, although this was not supported by findings from observation. He was the younger of two boys and lived with his brother and parents. He was brought to school daily by taxi.

Case Study 5: Eli

Epsom was an independent specialist boarding school for statemented boys (11 – 18) with very good results at GCSE level. The school had just started teaching A level to pupils of the ages 16 – 18. Although most classes comprised 4 pupils, one of the observed lessons on A Level mathematics was for just one boy, Eli, who was excelling in mathematics. There was 1 teacher, and 1 TA, both female, allotted to him in all lessons plus a male corridor monitor. Each day was split into six 50-minute sessions, normal timetable and pupils followed the schedule, moving from session to session at the sound of a short alarm. Special interests were catered for to some extent. The computer games room and snooker room were used for mathematics lessons. Eli was 13, the elder of two. When at home, he lived with his sibling, gender unknown, and both parents. He was reported as being exceptionally good at art and mathematics for which there was some evidence.

Case Study 6: Freddy

Flynn Road School was a mainstream mixed state secondary (11 – 18) with excellent exam results and oversubscribed (1000+ pupils), running a normal timetable of six 50-minute lessons. Lessons followed a standard timetable with a different combination each day. There was 1 pupil with AS in a group of 31 pupils, 1 male teacher and a TA who was not assigned to the pupil in question. The boy, Freddy, was 13, the elder of two, the other being a girl. He lived with his sister and mother, and maybe the father but this was unknown. He was skilled in mathematics and at reading. He also had a great interest in drawing but, as a result of dyspraxia, was not especially adept. Freddy came to school each day in a taxi as he lived outside the catchment area and, also, would not have been able to find his own way to school.

Case Study 7: George

At Glebe Street Academy, an average mainstream mixed secondary (11 – 16) with a special unit for pupil with autism, the exam results were below average but the school was subscribed to its limit (800 pupils) and was said by the Head to be improving. The school ran a normal 60-minute 5 session day. There were 30 pupils in the group observed, three of whom were on the autistic spectrum. One was low-functioning and one had other specific needs. Collecting data on these two might have impacted on the overall findings so they were discounted in favour of George with whom I spent the most time and who most closely matched the others in the study. Data pertaining to George only were analysed in this enquiry. He was 15, the younger of two siblings, the other also male. He lived with both parents and his brother. He said that he enjoyed computing and mathematics but, while it was explained that he was reasonably good at mathematics, there was no confirmation given with regard to computing. The Head of SEN confirmed that ICT and mathematics were his favourite subjects and that all TAs in the mathematics classrooms were trained as mathematics specialists. According to the Head, this was for two reasons: one so that they became fully conversant with the subject and secondly so that the pupils gained their independence, i.e. ‘not stuck with the same

TA for all lessons'. There was one male teacher and a female Teaching Assistant (shared with the other autistic students) in George's mathematics lessons. Pupils generally arrived at Glebe Street at the start of Year 7. This was reported as instrumental in enabling them, in most cases, to find friendship groups. As in most other cases, George was brought to school in a taxi. He lived a relatively long way outside the catchment area and was unable to get on a bus alone.

Case Study 8: Harry

Hamilton Road School was a mixed specialist independent school (11 – 16) for 30 pupils in total, with 5 pupils to a group, all with autism. There was one teacher along with two TAs, all female. The day was split into ten 30-minute sessions loosely based on TEACHH principles and pupils did not take examinations. Each day pupils followed the same pattern, moving from session to session at the sound of a short quiet alarm. Special interests were not catered for, although there was a room with boxes of special interest toys and books. These were used when absolutely necessary and only as a reward for completing a task successfully. Harry was the only pupil at Hamilton Road said to have Asperger Syndrome, (the rest were elsewhere on the spectrum,) and was the youngest of four, aged 13 at the time, living with both parents plus the three siblings, all girls. He was said to have a special talent in memorising car journey routes but lacked ability elsewhere. His mother drove him to the school daily and occasionally stayed with him.

Case Study 9: Ian

Inglewood Farm School was an independent specialist educational establishment for statemented young people (male and female) aged 16 to 19. All work was modular with no examinations. The day was split into five 60-minute sessions, all activity based with no theory. Along with 3 students with low-functioning autism and 1 with

Asperger Syndrome in the observed group, there was one male teacher and one female TA. The student with Asperger Syndrome, Ian, was 18 and said that politics was his area of expertise although there was no clear evidence of this and he easily distracted himself from tasks. Family background was unknown and he lived in at the school.

Case Study 10: James

Finally, Jodrell Community School was a mixed independent (11 – 16) specialist school for statemented pupils. The day was split into five 60-minute sessions. Pupils followed a normal timetable but with some TEACHH principles included. Exam results were said to be average. At this school, there were six pupils in the year group to which I was assigned who had been diagnosed with an ASD, but one, a female, was described by the Headteacher as a 'definite case of misdiagnosis'. The girl was said to be a school bully who had been expelled from several schools and the parents, out of desperation to get her into any school, had 'somehow managed' to get her diagnosed with Asperger Syndrome so she was discounted as a study case immediately. The other five were very similar in many respects but James was the most like the others in my study, so he was chosen for observation. He was the younger of two, (gender of sibling unknown), and aged 16. He apparently had talent in computing and mathematics but, as at Inglewood, this was not evident.

In summary:

- The two pupils from the pre-pilot stage were educated in the UK, as were seven of the remainder of the pupils, (including the two from the Pilot Phase), while the other three were from the USA;
- All pupils were statemented, (each had a professionally determined diagnosis of Asperger Syndrome) and all of the pupils observed were boys;

- Three were 11 years old, and the others older, one 12, three 13 year olds, one 15, one 16 and one 18;
- Six out of ten lived with both parents and siblings, while three out of the other four lived with their siblings and mothers (with one unknown). None of the nine lived with just the father or without siblings;
- In six out of ten establishments, there was just one pupil with Asperger Syndrome per group. In one school, there were two out of the thirty in the classroom; (attended to by one TA), and, in four out of the ten schools, there were more than twenty-seven pupils to a group, each with one pupil with AS;
- Four schools were purely mainstream with no particular specialism in teaching pupils with Asperger Syndrome, two had specialist units attached to the main school and the other four were purpose built;
- The more specialist the school, (independent), the smaller the group of pupils in a class;
- Initial observations suggested that the most relaxed environment was at the boarding school in the UK where all pupils had Asperger Syndrome, and the most regimented was at one of the two mainstream schools with a specialist unit. At the former, there were the greatest levels of autonomy in the mathematics sessions.

Table 3 on the next page presents a summary account of the session detail and observation strategy in each setting.

Table 3: Overview of Lesson Detail and Specific Observation Strategies in Each Establishment.

School	Mathematics session(s) observed	Detail of session	Observation Strategy
PILOT	STAGE		
Arlidge Arts Academy	Numeracy session	Although there was a wide ability range in the class, the teacher seemed to be concentrating on number bonds. No differentiation. The pupil observed could not progress past the colouring-in stage.	This was a structured **non-participant** observation, one of the first, which was used as a practice session to gain some ideas for approaches to observation methodology. As the findings from the copious field notes were expected to prove useful to the study, the data from this session was kept for later analysis.
Bowman Hill	Assessment with a practical element	Textbook mathematics, Assessment (Aged 12 – 13) part of which involved calculating the number of smaller cubes making up a larger one; and a practical session based around running a shop with real items for sale where these items had to be added mentally and correct change given in a number of different scenarios. Pupils grouped according to ability. Pupil in question worked alone with the most difficultly priced goods.	As part of this session involved a practical activity, there was an element of **participant observation** in that there was a requirement that everyone in the room should visit the 'shop' to 'buy' some goods. Therefore, much of what was later transcribed may not be entirely precise although it is believed to be 95% accurate. Before the practical activity, the text-book assessment was completed in silence so there was plenty of opportunity to write about what I noticed at this point in the session; however, although there did not appear to be any critical incident of worth during this section of the lesson other than that Ben sped through the questions on cube calculation, the opportunity to write up may have been gained at the detriment of noticing some other potentially interesting points during the assessment period that could have provided some useful data for analysis.

Chelsea Mill	A test practice session	At this school, there was an emphasis on testing, with Friday regularly given over to tests all day. So this was what was observed. The pupils did not seem to be overly worried by it. It was clearly a process with which they were all very familiar.	This time, much of the observation was conducted from the front of the class. Maybe the teacher's intention was to make the pupils think that there was a visiting invigilator in the room. Apart from a few asking who I was at the start, they rarely looked up and, as far as could be discerned, never looked directly at me. Charles did not appear to notice my existence in the class. This was a semi-structured observation and because of the type of lesson, making extra open-comment field notes was straightforward.
Drake Academy	Classroom textbook exercise followed by various sessions in the unit. There were also opportunities to see other pupils with Asperger Syndrome and classic autism in their mathematics lessons, both in the mainstream classes and in the specialist Unit.	Mathematics sessions included various different mathematical topics with which some of the assigned Teaching Assistants were unfamiliar, so that alone was enlightening.	In the classroom, the strategy depended upon which pupil I was observing. The boy might have been aware that I was observing him but he appeared to have no problem with it. Nevertheless, I sat at the back of the classroom. In the cases of the others, the staff asked me to act as TA, (ostensibly to give them a break), which I was happy to do, so these observations were much more hands on, participatory but the findings from them are not included in this study. For Dan, some notes were written up after the day in school. Occasionally, information came from the educators, some of which they wrote up for me so note-taking when speaking in semi-structured interview format to them was minimised as a result, (see also Interviews).

Epsom Boarding School	Snooker game; GCSE practice; A level work	Two boys playing snooker as part of their practical mathematics session under the direction of a specialist (male) TA; one to one GCSE tuition in a special small classroom followed by A Level work. As a consequence of ability, Eli was entered for both examinations.	After the first classroom observation, Eli was asked by the Assistant Headteacher to show me around the school but to go to his lessons when required and to introduce me to his teachers. He was not made aware of the reason for my visit and he did not ask. I went to lunch with him (along with all other pupils and teachers at the school) and he spoke to me at length throughout the day about various aspects of his education and hobbies. I interviewed the in-house psychologist for 50 minutes while he attended his French lesson. As a result of being in the company of Eli during the majority of the sessions, I could not write up the field notes in situ but compiled a log of events later in the day in a room provided for me at the school.
Flynn Road	Practising for in-house SATS examinations	The teacher circulated and helped each pupil individually with any problems associated with the practice exam paper	Non-participant writing field notes.
Glebe Street	Observed in the classroom: Working from the board and a worksheet with occasional input from the TA	The pupils all attended mainstream classes and this was no different. For each lesson they were assigned a different specialist TA (one who accompanied them to sessions in one particular subject only).	Non-participant taking field notes and completing a semi-structured observation sheet. Later, there was an opportunity in the specialist unit to talk to one pupil about his interests and future plans, which were written up later, as detailed in 'Interviews'.

Hamilton Road	Counting and grouping with plastic creatures; Manipulation with interactive whiteboards.	This was an extreme version of a specialist school where the ratio of staff to pupils was higher than elsewhere. The pupil was taken into a small side room where the desks were laid out in a square formation and was given tuition in numeracy strategies. Later, the pupil had a chance to play with objects on the interactive whiteboard, which he appeared to enjoy more that the first session with real manipulatives. However, the interactive whiteboard was new so the enjoyment might have more to do with novelty that lasting interest.	Non-participant but sitting opposite the pupil and teacher and talking to the teacher later when the pupil worked with the interactive whiteboard. Some of the field experiences were logged in-situ and others compiled later that evening.
Inglewood Farm	Observed in the woodworking shed: Working on measuring lengths of wood for the band saw with full teacher involvement	The instructor talked through his requirements with the group and each was given a small task to work through collaboratively. Most students had classic autism; only one appeared to have Asperger Syndrome. The sessions were probably slightly under-pitched for his ability.	I was introduced to the students and the teacher and my notes later were based upon unstructured observation and some of the information that had been gleaned from talking to the AS student during the session.

Jodrell Community	Observed in the classroom, working on the computer with no input from the teacher	All pupils in the class had individual tasks to complete but few seemed to understand what they were supposed to be doing. The teacher rarely circulated but was available should a pupil ask for help. Only one did this however.	Although the work here concentrated on one pupil in one group, (only one class of pupils comprised those with AS - all other classes consisted of groups of pupils with classic autism), there were extra opportunities to visit other classes too. All of the classrooms were explored, and conversations with a large proportion of pupils and teachers took place whilst circulating. Additionally, the computer programs that the pupils were working with were scrutinised for the purposes of gauging their appropriateness. These were semi-structured observations with some extra notes written up later that evening.

As one of my preliminary assumptions was that people with this syndrome have distinct idiosyncrasies that transcend social status, culture and location, there was no intention to analyse the financial status, class or geographic location of the pupils in the sample. Therefore, the overarching field of study related only to the nature of the pupil, the type of educational establishment and the style of mathematics education received.

This subsection has provided the rationale for the case study approach, reviewed the sampling methodology and provided an overview of the cases. The next part of this chapter justifies the choice of subquestions used to extract suitable evidence through which to satisfy the main research question.

3.3 Research Questions

The main purpose of this enquiry was to uncover the ways in which pupils with Asperger Syndrome experience mathematics in the, largely social, learning environment. In order to ensure that the web of elements connected to the learning of mathematics for them were addressed, and to sort the data manageably so that the findings could be presented logically, I chose to subdivide the data into two individual but linked topics; thus, two explicit subquestions were formulated:

Research Subquestion a): How compatible are some of the common traits attributed to pupils with Asperger Syndrome with contemporary mathematics teaching and learning strategies?

Research Subquestion b): What aspects of the secondary classroom environment could be perceived as supportive of mathematics learning for pupils with Asperger Syndrome?

The first subquestion was intended as a means of establishing how pupils with Asperger Syndrome might behave during problems solving activities in the mathematics learning environment. Evidence collected was expected to determine the ways in which pupils with Asperger Syndrome participate in various tasks. The evidence for this part of the research was expected to come out of the records obtained during personal observation and interview. The respective data collection sheets, questionnaires and interview schedules were largely informed by conclusions drawn from the literature review and the pilot study. In order to fully answer this subquestion, discussions with pupils, teachers and other educational professionals alongside observation of the pupils working on varying types of mathematical task were necessary. Analysis of the observation data was to be supported by selected narratives taken from questionnaires and interviews with members of staff and professionals. On account of the small number of cases in the sample, some caution had to be exercised when interpreting findings, with any generalisations expressed given as applicable only to those with Asperger Syndrome, and not the wider population. Subsequently, I hoped to determine whether or not pupils with Asperger Syndrome had common problems with certain types of mathematical processing and, if so, leading into the second subquestion, what teaching strategies might be useful to counteract such barriers to learning.

Much of the data for the second subquestion was expected to come from an evaluation of the differences between teaching strategies at the various educational establishments, to include numbers and types of staff, (teachers and TAs), and the equipment utilised, (textbook, worksheet, practical tools or computer). Here, it was considered vital that the pupils were observed in the classroom to enable a complete record of how behaviours might be influenced by individual teaching methodologies and mathematics tasks in the social learning environment. If, for instance, the pupils' responses could be shown to be dependent upon teaching styles or other resource provision such as computer software, then findings from these in-situ observations would facilitate a detailed analysis of likely outcomes per setting. Such evidence, if found, would be significant, as one theory gleaned from the literature review was that it might be that these pupils achieve more when they are taught in a particular way and by a particular type of teacher (Asperger, 1944).

3.4 Data Collection Methodology

This section provides details of the practical data collection period and explains how each collection method was decided upon. Included here are the specific features of the differing observation and questioning techniques. Each was chosen to correspond with setting or respondent to ensure that suitable data were gathered to answer the main research question effectively. The evidence was collected using a variety of methods in order to gain access to the rich data necessary to present the cases in detail. Six methods of practical data collection were employed:

- structured questionnaires for teachers and a Teaching Assistant (see Appendices 6.1, 6.2 and 6.3);

- semi-structured questionnaires for pupils;
- structured observations during the pilot stage;
- semi-structured interviews with teachers, Teaching Assistants, members of the management teams, and other professionals most closely involved with identified pupils;
- impromptu and unstructured interview with students;
- and finally, semi-structured in-class observations.

and there were five components to this part of the enquiry:

- Stage 1 was the pre-pilot phase – the findings from which formed the impetus for the principle enquiry;
- Stage 2 was the in-school pilot phase where various theories were examined, the data from which were used to inform the main study;
- To supplement the findings from the initial phases, Stage 3 extended the pre-pilot and pilot phases and consisted of arranging and performing a series of interviews with professionals from outside agencies;
- Stage 4 comprised a mixture of a set of interviews with teachers, Teaching Assistants and pupils;
- Finally, Stage 5 necessitated observation in the mathematics classroom, the findings from which were expected to produce substantial evidence to answer the two research subquestions and ultimately the main overarching question: 'What is the secondary mathematics classroom like for pupils with Asperger Syndrome?'

Stage 1: Pre-pilot in 2 schools and 1 university in the UK

Observations- unstructured of 2 pupils, opportunistically selected

Questionnaire and interview - with one known AS student (Peter from Garford University)

Stage 2: Pilot Phase in 2 schools in the UK

Questionnaires - structured with the teacher of mathematics at Arlidge Arts Academy, the TA at Arlidge Arts Academy and the teacher of mathematics at Bowman Hill School

Questionnaires – semi- structured to two pupils, Andy from Arlidge Arts Academy and Ben from Bowman Hill School (both aged 11) on their views of mathematics teaching strategies

Observations - structured in two schools, Arlidge Arts Academy and Bowman Hill School (the analysis of which is combined with the analysis of the observations from Stage 5)

Stage 3: *Interviews* - semi-structured with professionals from outside agencies

Stage 4: *Interviews in school* - semi-structured with teachers, TAs and unstructured with pupils

Stage 5: *Observations* - semi-structured of pupils in 8 further educational establishments, 5 in the UK and 3 the US (although Arlidge Arts Academy and Bowman Hill School from the Pilot Phase are included in the later analysis making 10 schools altogether, 7 from the UK and 3 from the US)

During the initial stages, the study concentrated on collecting data through observation and interview or questionnaire in order that subsequent selection of pupils included those with characteristics similar enough to each other to ensure that the final report would be reliably informed. Based upon the findings from the literature review, the 'selected' individuals would be unlikely to be gregarious outgoing students. Rather, they would be more likely than the average pupil to be introverted, to exhibit anxiety and stress, to demonstrate inability to cope under pressure and to be intellectually capable yet socially naïve (Asperger, 1944; Frith, 1991). I believed that the potential for disaffection in these pupils might be greater than in more extrovert characters. In order to identify characteristic traits of pupils central to this enquiry, a substantial proportion of the data collection stage within this enquiry was spent immersed in the general classroom environment in schools observing practices and talking to representatives from various agencies.

3.4.1 Stages 1 and 2: The Pre-pilot and the Pilot Phases

Although the in-school pre-pilot phase was unplanned and impromptu, together with the pilot, the purpose of these stages was three-fold:

1) to better understand the mathematical capabilities of pupils with Asperger Syndrome;
2) to begin to formulate the main research question;
3) and to develop interview and observation schedules for use in the main body of the research.

The findings at Linwood and Margaret Barclay Schools during the pre-pilot phase were the inspiration for the entire piece of research. These incidents helped to inform the enquiry that aimed to determine, in part, how mathematics educators and TAs plan for and engage with pupils who have a diagnosis of Asperger Syndrome. Observing the boys with Asperger Syndrome in the classes was purely by chance. Following these two observations, I conducted an unstructured interview with a university student who has Asperger Syndrome to provide me with an understanding of learning mathematics from his perspective. The student, Peter, was someone with whom I was familiar, and I believed that his descriptions would be rich (Geertz, 1973 cited in Cohen et al., 2011:442), honest and reliable (Asperger, 1944).

I subsequently made an initial approach to the secondary schools in two districts in England explaining my intentions for the project, (see Appendix 7: Letter of Introduction). The Headteachers at two schools in one of the districts, Arlidge Arts

Academy and Bowman Hill School, responded immediately reporting that they each had one pupil whom they believed to be on the spectrum and whose characteristics they determined were synonymous with specific traits required for a diagnosis of Asperger Syndrome. The second stage comprised the pilot study for which the pupils were selectively chosen and through which the details for the main questionnaires were determined. I was invited to meet the pupils and their respective educators, and subsequently chose these two pupils within their schools, (jointly, the cases,) to form the Pilot Study group. Before going into these schools, I produced a questionnaire for the staff (see Table 4) that I hoped would identify any similarities in the pair. Identification of the right sort of pupil was paramount, (see Chapter 2: Literature Review). If misdiagnosis had occurred or the Headteachers had selected a different type of pupil, any data collected in response to the research questions could potentially have impaired the later analysis and invalidated the conclusions. To enable me to become more familiar with outward indicators of Asperger Syndrome, I compiled a second questionnaire, this time for the pupils at the two schools (see Table 8). Although the questionnaires presented to the pupils during the Pilot Stage were different to those given to the teachers and TA at their schools, they were designed to expose how the pupils connected with differing elements of mathematics teaching and learning.

Following preliminary planning, visits were arranged - a full day at each of the two schools, this so that a feel for the workings of the schools could be obtained and to allow time for interviews with the educators to gauge their perspectives of the condition. In addition to the planned observations and discussions with teachers, Teaching Assistants and others as appropriate, the first questionnaire I compiled, (see Table 4), adapted from the 1994 DSM-IV AS, (Appendix 2), was presented to the Teaching Assistant and mathematics teacher at Arlidge Arts Academy and, as no TA had been assigned to Ben at Bowman Hill School, just the mathematics teacher there. As this part of the research came before the DSM-V (2013) was introduced, the questionnaire was based upon the diagnostic criteria for Asperger Syndrome (Appendix 2: DSM-IV). This step required a method of systematic data collection (Merriam, 1998). The selectively chosen respondents were asked to provide simple data sets that required no written responses and no qualitative judgments. Choices were restricted in order to allow me to categorise and so this questionnaire was a simple tick sheet designed to gauge the educators' awareness of their pupils and to gather their views on each pupil's skills in the mathematics classroom. I also provided a copy of the Diagnostic Criteria for Asperger Syndrome, (Appendix 2: DSM-IV), to assist with their understanding of the condition. For me to ensure that the appropriate types of pupil had been identified for my enquiry, the focus here was purely on how closely they were able to match their pupils' general psychological profiles to the diagnostic criteria for a pupil with Asperger Syndrome. For any number of reasons, time constraint being one, it was possible that I might not have been able to make a spontaneous decision myself.

Table 4: Questionnaire for the Teacher of Mathematics and TA at Arlidge Arts Academy, and the Teacher of Mathematics at Bowman Hill (pilot phase)
(expanded detail taken from the DSM-IV (1994) definition of AS characteristics - See Appendix 2 and below)

Characteristic	**TICK**
Part of a friendship group	
Few friends	
No friends	
Talkative	
Silent	
Independent	
Independent worker	
Contented	
Shows signs of depression	
Skilful with language	
Skilful with written work	
Determined	
Actively seeks assistance	
Knowledgeable	
Shouts out in class	
Appreciates help	
Is polite	
Avoids eye contact	
Good communicator	
Likes routine	
Shows impaired coordination skills	
Displays weakness in fine motor ability	
Displays weakness in gross motor ability	
Pedantic monotonic speech	
Any sensitivity (smell, taste, touch, sound, visual)	
Finds it difficult to understand what is required	
Has advanced spatial capabilities (e.g. geometry)	
Is deficient in spatial skills	
Signs of introversion	
Extroverted	
Likes own company	
Chatty	
Capable	
Flamboyant	
Aware of condition	
Understands condition	
Lacks vital understanding of some terminology	

Although much of the later data was taken from semi-structured interviews and semi-structured observations, this part of the pilot study required a certain amount of structure, this because the respondents were pre-selected and how their responses were to be recorded was predetermined (Kawulich, 2005). Once the accumulated data sets had been compared for patterns of commonality, analysed and evaluated, I predicted that any distinctive trait clusters that were to emerge should provide evidence of how closely the educators' perceptions matched the generally accepted understanding of characteristics of Asperger Syndrome.

An Observation Schedule, (see Table 5), was also trialled during this stage. As mentioned previously, the DSM-V (2013) had not been created in 2010, so the questions for this too were derived from the DSM-IV's (1994) indicators of Asperger Syndrome. At that stage, I aimed to gather as much information as possible to ensure that I did not consciously ignore anything that might prove to be pertinent. Naturally though, I expected that, according to ease of use and appropriateness during this phase, adaptations to the observation schedule would be inevitable.

Table 5: Observation Schedule 1

SCHOOL QUESTION	A	B	C	D	E	F	G	H	I	J	Relevance to research subquestion
Which of the DSM-IV characteristics does the pupil exhibit:											a
Marked impairments in the use of multiple nonverbal behaviours such as: eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction											
Failure to develop peer relationships appropriate to developmental level											
Lack of spontaneous seeking to share enjoyment, interests, or achievements with other people?											
Lack of social or emotional reciprocity											
Encompassing preoccupation with one or more stereotyped and restricted patterns of interest											
Inflexible adherence to specific, non-functional routines or rituals											
Stereotyped and repetitive motor mannerisms											
Persistent preoccupation with parts of objects											
2. How does the pupil enter the class?											a & b
3. Any issues on entrance?											a & b
4. Where does the pupil sit?											a & b
5. Who does the pupil sit with?											a & b
6. What types of mathematics are											a

taught in the session?											
7. What types of teaching style are there?											b
8. Does the pupil remain on task?											a & b
9. Is the pupil given any specific help of guidance to complete the task?											a & b
10. Is homework set?											b
11. Is homework handed in from the previous session (if applicable)?											a & b
12. Anything else?											a & b

During the first stages of the enquiry, I found that some of the questions in this observation sheet did not provide appropriate or sufficient data for the analysis. The underpinning constructs within both subquestions were not fully addressed. As a consequence, certain questions such as Q10 were removed for their irrelevance to this enquiry and others added for use during the full data collection period. Questions relating to the DSM were removed as the areas I was interested in were adequately covered by the other questions. For instance, ‘Failure to develop peer relationships appropriate to developmental level’ was adequately addressed by ‘Who does the pupil sit with?’ and ‘Does the pupil work successfully in a group in mathematics lessons?’ (see Table 6 on the next page).

(*The completed tables are provided later in the Analysis section*)

Table 6: Revised Classroom Observation Schedule

SCHOOL / QUESTION	A	B	C	D	E	F	G	H	I	J	Relevance to research subquestion
1. Does the pupil engage in problem solving activities?											a
2. Is there any evidence of rapid processing of data?											a
3. Does the pupil remain on task (persevere)?											a
4. Does the pupil achieve the outcomes expected of all pupils?											a & b
5. Is the pupil given any specific help or guidance to complete the task?											b
6. Does the Pupil have a TA?											b
7. Does the pupil work well with the TA?											a & b
8. Is there interaction between the pupil and the classroom teacher?											a & b
9. Where does the pupil sit?											a & b
10. Who does the pupil sit with?											a & b
11. What types of teaching style are there?											b
12. Does the pupil work successfully alone in mathematics lessons?											a & b
13. Does the pupil work successfully in a group in mathematics lessons?											a & b
14. What types of mathematics are taught in the session?											a & b
15. Open Comment Field Notes											a & b

Personal Coding System

9. Where pupil sits

Front = F; Back = B; Elsewhere = E; Teacher/ TA selected = T

10. Who pupil sits with

Friend = F; Alone = A; Teacher/ TA selected = T

11. Teaching Styles

Didactic = D; One-to-one = O; Group Work = G; Technology-based = T; Creative = C

14: Types of mathematics

Textbook = T; Worksheet = W; Real-life = R; Game-based or practical = G

Although I could not be sure that school type would be the greatest factor governing the experience of learning of mathematics, I initially thought that it could prove to be significant. Hence, I created another data collection sheet for use once all the observations had been conducted (Table 7). I determined that, following all observations, I would personally assess the levels of participation in each school to see if any evidence of this could be found. Entries in this table were to be benchmarked against each other rather than to a national or international standard.

Table 7: Comment on Pupil Participation in Activities According to School Type (**Relative to Each Other** *i.e. Involvement levels here are set against each other rather than national benchmark).*

SCHOOL TYPE SCHOOL	Fully Integrated	Partially Integrated (with a Specialist Unit)	Specialist School
Arlidge			
Bowman			
Chelsea			
Drake			
Epsom			
Flynn Road			
Glebe Street			
Hamilton Road			
Inglewood Farm			
Jodrell Community			

In addition, to ensure that pupil voice was given some weight, the questionnaires presented to Andy and Ben from Arlidge Arts Academy and Bowman Hill respectively were devised to allow me to explore their perceptions of and preferences in the mathematics classroom, (see Table 8). A questionnaire format for gathering data here was selected rather than interview because both pupils were of nervous disposition and I, as any unfamiliar interviewer would be, was unknown to them. Accordingly, I suspected that face-to-face interviews would have been unsettling and as a result, their responses might have proven to be uncharacteristic. Therefore, I decided that the less personal data collection method of questionnaire would probably be more productive. This was relatively short and designed so that the pupils would not be deterred from the outset by lengthy personal questions. Nevertheless, as pupils with Asperger Syndrome are said to be more reliable and honest in many respects than most (Asperger, 1944; NAC, 2009), I expected that they would be inclined to answer all questions and to respond truthfully. The first few questions required Likert scale 1 to 5 responses. Unlike the questionnaire presented to the educators at Arlidge Arts Academy and Bowman Hill School, this one had a central category. With relatively few choices to make in this section, I hoped, but could not be sure, that they would not go through ticking the middle box. The second part of the questionnaire was more involved and included open-ended questions, this because 'where rich and personal data are sought, then a word-based qualitative approach' (Cohen et al., 2011:382) is necessary. As the pilot sample of two pupils was small, analysis of the resultant open data was not expected to be too onerous. Andy from Arlidge Arts Academy completed his in the 'Unit' with his TA while Ben remained in the classroom alone after the lesson to complete his electronically. Each took less than half an hour to finish his questionnaire and neither needed prompting so the process was relatively straightforward.

Table 8: Pilot Phase Pupil Questionnaire

Please tick the appropriate box(es)

Year Group	7	8	9	10	11	12	13

1 = Not at all
5 = Very much

	1	2	3	4	5	Relevance to research question
Do you enjoy mathematics lessons?						a & b
How difficult is mathematics for you?						a
Do you like working in groups?						a & b
Do you like to work in a pair?						a & b
Do you enjoy working on your own?						a & b
Do you like to work in silence?						a & b
Do you enjoy textbook maths?						a & b
Do pictures in textbooks help you to understand questions?						a & b
Do you like real-life worksheets such as this one?						a & b
Do you like mathematical games involving Tarsia?						a & b
Do you like computer maths?						a & b
Do you like computer games which incorporate maths?						a & b
Do you like board games such as this one?						a & b
(*See Appendix 8 for examples shown to students*)						
Which would you choose as your favourite?						b
Why do you like the one you chose as your favourite?						a & b
What is it that you don't like about your 'least favourite' choice?						b
What is it that makes mathematics lessons interesting for you?						a & b

What is it that makes lessons boring for you?	a & b
Which would you choose as your least favourite?	b
What is it that makes mathematics lessons difficult for you?	a & b
What is it that makes mathematics easy for you?	a & b
What is it about working alone/ in a pair/ in a group/ in silence that you like?	a & b
What is it about working alone/ in a pair/ a group/ in silence that you dislike?	a & b

The provision of open-comment questions was intended as a means of gaining a reasonable understanding (Bernard, 2006) of the areas of interest or concern in mathematics lessons for pupils with Asperger Syndrome. There was sufficient space below each question to allow them to write as much as they liked, although neither wrote much. This questionnaire was intended to provide me with a preliminary representative understanding of how pupils with the syndrome find various aspects of mathematics teaching and learning. However, so that disruption or upset to the pupils was minimised, it was not used in the other schools visited. Yet, as it was not assured at this stage that much in the way of productive data would come from these questionnaires, if it had transpired that no relationship between the two sets of responses to the questions were to be found, I planned that I would have had to go into the research proper with the view that any findings from the data collected might be quite disparate. It could even have been found that, in the extreme, there were at least two distinct types of learner with Asperger Syndrome. If the findings from the first two schools had not been definitive, and so could not inform the compilation of a focused observational strategy, I decided that theoretical information from the literature review could assist with the development of appropriate semi-structured observation schedules. Additionally, the review could be used as a guide to the production of a set of relevant interview questions for the teachers and TAs in the schools used later in the study.

The observation at Arlidge Arts Academy was non-participant while the observation in Bowman Hill included an element of participation during a practical session on running a shop. I chose the two contrasting observational methodologies during the pilot phase to determine which type of strategy would supply richer, more appropriate data, interaction with the pupils or observation at a distance. As a non-participant it was easier to attend to the schedule than it was in Bowman Hill, where becoming involved was distracting and reduced the time available in class to keep an accurate record of proceedings. Observing at a distance allowed me to complete a more detailed transcript, while interacting meant that some detail had to be memorised and transcribed later. This inevitably had the potential to lead to omissions and misremembered detail. Although Andy and Ben both knew that I was conducting some research, it was predicted that the rest of the case study pupils might be more inclined to behave as they normally would if they were unaware of the purpose of the visits (Shaughnessy et al., 2003, cited in Cohen et al., 2011:473). Accordingly, following the Pilot Stage, I concluded that there was no more to be gained, (and often less), through participation than non-participation, so for the remainder of the study, all observations were non-participant.

3.4.2 Stage 3: Interviews with Professionals

Building on the Pilot Stage with the selected experimental group, the formation of an appropriate preliminary question set for the external professionals, teachers and TAs was expected to subsequently generate a supporting set of data for analysis. With the primary focus on the needs of the pupils with AS in terms of mathematics teaching and learning, wide-ranging evidence data gathered over a substantial period detailing the experiences of appropriately representative cases were to be accumulated from questionnaires, and personal accounts transcribed during classroom observations and interviews. The exploration of various data sources, not just observation, was expected to offer a greater understanding of the experiences of pupils with AS and to provide me with an appreciation of the syndrome from alternative viewpoints (Eisner, 1992). To supplement findings from the observations and to maximise the potential bank of data for later analysis, interviews with pupils, the in-school team of educators and the external professionals were essential. The in-school educators were mainly nominated by the Heads of Schools, while the names of the team of professionals were suggested by people I interviewed throughout the study. All were chosen to provide a range of accounts relating to their particular fields of expertise in order to complement existing findings.

The three interviews with the external specialists set up for this stage were all in the UK:

1) Professor Raymond, an educational psychologist from District X SEN Service, UK;

2) Dr Linden who worked for the diagnostic service, District Y, UK;

3) Dr King, a psychologist from District Z's Psychological Service, UK who worked with pupils who had already been diagnosed.

There were two types of interview with the professionals: two face-to-face and one via telephone. The reasons for these choices were purely practical. The telephone interviewee requested this style of questioning as he stated that 'it would make it easier for [him] in view of [his] full diary for the foreseeable future'. The other professionals stated that they preferred the face-to-face format as they felt ‘more comfortable talking like this’. There follows an outline of the interview proceedings with these three experts. The response data can be found in the Analysis chapter. The first telephone interview, (see Appendix 9), with Professor Raymond, who was introduced by the Headteacher at Arlidge Arts Academy as someone with whom the school worked closely, was semi-structured. The purpose of the interview was to determine the extent to which he, as someone who was heavily involved with the home-schooling of disaffected pupils with autism, considered his students to be mathematically able. The contact details of the Headteacher at Glebe Street Academy were provided by Professor Raymond who suggested that he might allow me to observe one of his (Professor Raymond’s) ex-pupils for this enquiry. The second was a face-to-face interview, (see Appendix 10), with a local psychologist who specialised in diagnosing Asperger Syndrome for whom I prepared three prompt questions:

a) *How easy is it to make a diagnosis?*

b) *How do the people with Asperger Syndrome get referred to you?*

c) *What questions do you ask in order to determine whether to diagnose Asperger Syndrome?*

Subsequently, the interview comprised a detailed discussion surrounding diagnosis and the questions that she as a psychologist typically asked of her patients to establish the correct diagnosis. This interview and the questions asked enabled me to augment my bank of knowledge accumulated from personal experience of the syndrome and the literature review, thus enhancing my ability to identify pupils with Asperger Syndrome for inclusion in the enquiry. And finally, the third interview with the psychologist, Dr King, whose job it was to determine specific areas of weakness in pupils who had been diagnosed with Asperger Syndrome to enable them to 'get the right sort of classroom assistance' was informal and semi-structured. He provided detailed information about the needs of one of his recent cases (see Appendix 16). The student, Mark, although bright, had always struggled with levels of understanding in the mathematics classroom and so had been referred to Dr King by a school-linked educational psychologist.

3.4.3 Stage 4: Identifying the Schools

Following the preliminary data collection phase in the two schools from the pilot, (Arlidge Arts Academy and Bowman Hill School), and the interviews with outside professionals, the next stage began with an initial approach to the schools selected for their particular relevance to the enquiry. Now the focus was on settings specifically targeted for their particular associations with the education of pupils with Asperger Syndrome. Dr King proposed Chelsea Science and Technology College, Drake Academy, Epsom Boarding School and Flynn Road School. Professor Raymond named Glebe Street Academy. The mother of Harry, a pupil at the school, suggested Hamilton Road (USA). Inglewood Farm and Jodrell Community School in the USA were identified by Professor Morrison, (my university link). All were selected for their specialism and uniqueness in educating pupils with Asperger Syndrome. As previously stated, distinctiveness was an important element in the research. In searching for differing examples of teaching and learning in mathematics education, these diverse learning establishments were predicted to each have the potential for unique examples of such. Findings from these individual institutions, whether similar or contrasting, were expected to generate a comprehensive record of mathematics teaching methodologies for pupils with AS.

Since the pilot phase contact letter to Arlidge Arts Academy and Bowman Hill explained my study adequately, few changes were required and a similar one was sent out to the other five schools in the UK, (Chelsea Science and Technology College, Drake Academy, Epsom Boarding School, Flynn Road School and Glebe Street Academy). The only adaptations comprised personalisation and an addition of a sentence naming the contact who had provided the name of the school. One day was subsequently booked at each of Chelsea Science and Technology College and Flynn Road School. At Epsom Boarding and Glebe Street two days were planned and at Drake Academy the Headteacher offered five days over which to observe various interactions and to become fully immersed in the life of each school. I spent a substantial amount of time at Drake Academy acting as a TA to Dan and various other pupils with low-functioning and classic autism. As their characteristics were so dissimilar to the other pupils in the study, none other than Dan from this school was included in the analysis.

3.4.3.1 In-school Interviews: Staff

In addition to the observation of at least one mathematics session, the programme for the visits included meetings with the Head of each school, the Head of the SEN Department, at least one TA and at least one teacher where possible. All of the programmes were fully prepared and extensive to ensure that the process of data collection would be manageable and systematic. To gain alternative perspectives of mathematics education of pupils with Asperger Syndrome, a series of semi-structured interviews were planned with teachers, Teaching Assistants and members of the management teams who were most closely involved with identified pupils.

Although the interviews alone were not expected to produce a complete set of reliable data, they were included in the study as I believed that the interviewees' accounts of their longer-term perceptions of each study case pupil would provide a contributory supplement to the personally collected observational data. The information gathered was amalgamated with the data derived from interviews with professionals to balance the inevitably subjective and therefore potentially biased field notes produced by me as researcher.

All were asked an appropriate selection of approximately ten to fifteen questions from one pre-prepared question bank, (see Appendix 11: Example of Interview Question Subset), which had been composed following the pilot phase. In respect of potential time constraints, this was considered to be a sufficient list of questions to pose. Utilising the 'interview guide approach' (Patton, 1980 cited in Cohen et al., 2011:412) where the 'interviewer decides upon the working of questions during the interview' (ibid.:413), it was rare for all questions to be asked of any one respondent; they were not always appropriate and, besides, there was rarely enough time available to do so. The questions selected depended upon who was being interviewed, this because certain questions such as:

'*Do you make use of ICT?'*

might be appropriate for the class teacher at one school, but not necessarily for the Educational Psychologist. It was anticipated however that there might be a number of comparative responses from the different sources to each question which would allow for generalisations be made.

The first three interview questions were not expected to contribute much to the enquiry but were selected to:

a) start the interview off in such a way as to put the respondents at ease before launching in with the more searching questions;

b) allow me to gain a general understanding of each school's intake procedure;

c) test the respondent's knowledge of the characteristics and potential effects of the syndrome. If limited, their answers to some of the later questions might have been invalid and would have had to be discounted.

At each school, at least 2 members of staff were selected by the Headteacher as suitable for interview, that is, all except at Hamilton Road School, where the Headteacher also had the roles of Head of SEN and class teacher so there was only one interviewee. This was a very small school where the ratio of pupils to staff was approximately 2 to 1. Similarly, at Inglewood Farm School, the Head Teacher was also the Head of SEN although at this school there were other members of staff available for interview. There were 22 interviewees in this part of the enquiry, all of whom were willing to discuss their position, daily tasks and pupils. Many of the interviews were conducted on the move or between lessons in a range of classrooms, (see Appendix 12: Diary Entries Extract), which meant that use of recording equipment would not have been practical. At times, note taking had to be left until after the interview. This element of the research was anticipated to be particularly enlightening. These personal accounts, rare as they were, were expected to provide the opportunity to compare and contrast in order to discover whether the number of differences was greater than the number of similarities between specific cases in their experiences of mathematics learning. It was hoped that the resultant thick descriptions based on these accounts (Geertz, 1973 cited in Cohen et al., 2011:442) would bring a section of each interviewee's microcosmic world to life. Additionally, to complement the narratives from the other data sources, interviews with pupils, when the opportunity arose, were deemed likely to produce rich personal accounts and provide substantial perceptions of teaching and learning preferences as experienced by them.

Table 9: In-school Interviewees: Staff

School	Head teacher	Assistant Head	Head of SEN	Teacher	Teaching Assistant	Psychologist
Arlidge Arts Academy				√	√	
Bowman Hill School				√		
Chelsea Science and Technology College		√		√		
Drake Academy			√		√	
Epsom Boarding	√	√		√	√	√
Flynn Road	√			√		
Glebe Street		√			√	
Hamilton Road	√		√	√		
Inglewood Farm	√		√	√	√	
Jodrell Community	√			√		

(Shaded entries indicate that one educator fulfilled several roles.)

3.4.3.2 In-school Interviews: Pupils

It would have been desirable to use similar interview strategies for all respondents, but it was not always appropriate. In consideration of the well-being of the pupils, interviews with them could not be of the same format as those conducted with professionals. The pupil-researcher relationship is quite different; hence, an alternative strategy was required. A rapidly developed rapport needed to be in place in order to ensure that each interviewee felt comfortable and would, as a result, speak candidly with me. As discussions with the pupils throughout were not actively sought but rather instigated by the respective pupils, it was clear that only unstructured interviews would be practicable. This type of interview was considered to be the most suitable as the questions would not have formed in my mind ahead of the discussions. Besides, the impromptu nature of the interviews at this stage demanded unstructured formats where appropriately relevant responses and interjections were made possible.

Finally, although the sections in this chapter have been kept separate for clarity, interleaved with the interviews, the mathematics lesson observations were also taking place, and the detail surrounding the data collection methodology relating to these observations is covered in the next section.

3.4.4 Stage 5: Observation

All of the interview data collected were ultimately expected to develop into a detailed account of the views of specialists, staff and the pupils. However, although data yielded from interview is beneficial, reliance on second hand accounts alone would not have been appropriate for this type of enquiry. This is, firstly, because one cannot always be certain that what a respondent says in interview is synonymous with what he or she actually does or thinks (Cohen et al., 2011) and, secondly, because interviewees' personal perspectives can be overly subjective. With the probability that their perceptions would differ from the other respondents in some respects, their accounts were only to be used in support of findings from observation of the pupils in their settings.

As this project was an investigation into what mathematics learning is like for pupils with Asperger Syndrome in the classroom, for me, an essential part of the process incorporated a critical examination of the workings of the secondary mathematics learning environment. To ascertain the extent to which pupils with Asperger Syndrome are supported with certain mathematics activities in terms of teaching and learning, classroom observation was seen as a crucial data collection methodology. Observation was expected to provide the best opportunity for in-depth examinations of the students' in-class interactions with their educators, their Teaching Assistants, and their peers. Moreover, the observations of non-verbal behaviours were expected to contribute a substantial amount of data for analysis.

The enquiry was based around the experiences in the mathematics classroom of a comparatively small section of society. The members of this group were anticipated to exhibit a fairly common set of distinct characteristics, so, including those from the pilot study, the practical data collection phase concentrated on a cluster of ten cases. I determined that this sample would be sufficient for a detailed, in-depth analysis. According to Patton (2002), there are no rules governing sample size in a qualitative enquiry, with the sample chosen dependent on ‘what you want to know, the purpose of the inquiry, what’s at stake, what will be useful, what will have credibility and what can be done with available time and resources’ (p.243). As Ehlers and Gillberg (1993) reported that there were only 36 cases of Asperger Syndrome per 10000, and this was the whole population including adults, finding a larger sample could have proven logistically prohibitive in terms of time and cost. Further to this, on account of the quantity of potential data for analysis relating to each case study, widening the net might have rendered the research findings to some extent shallow, superficial and incapable of providing enough focused detail to generate an informative final report. Finally, by limiting the number of study cases, both personal classroom observation and the subsequent analysis were predicted to be reasonably manageable within the time constraints of this enquiry.

With its inherent capability to limit disruption, observation from a distance was selected as appropriate for the practical data collection period. This was, in part, due to the sensitivities of members of the chosen group in this study and partly to facilitate production of representative data through observation of the pupils in their usual naturalistic environments performing their normal social and educational activities. According to Yu (2010):

> If you want to know what motivates a guy to take up skateboarding, you could bring him into a sterile laboratory and interrogate him … or you could spend a week in a skate park observing him interacting with his friends, practicing [sic] new skills and having fun. [Through] observing people's behaviour in their own environments, […] you can get a holistic understanding of their world – one that you can intuit on a deeply personal level.
>
> (Yu, 2010:5).

As observation within a naturalistic setting is regarded as capable of generating substantial realistic and honest evidence, and can 'portray […] what it is like to be involved in the situation' (Lincoln and Guba, 1985 cited in Cohen et al., 2011:241), I expected the findings from the practical observations to produce most of the data needed to satisfy the main objective of the enquiry. Individual case reports pertaining to each separate establishment were anticipated to contribute to a collection of sufficiently rich data on which to conduct an extensive qualitative analysis. This would subsequently allow me to compare and contrast findings with a view to developing comprehensive cross-case conclusions.

When pupils are personally chosen in advance of an observation, this could be suggestive of a positivist approach, i.e. one in which the observer selects 'who is observed, when and where they are observed, what is observed, and how the observation is recorded' (Kawulich, 2005:15). However, in this study, while the schools and pupils were selected in advance, they were not personally chosen. My approach was dependent to a degree on the availability of the pupils and schools. Other than stating that observations of the pupils needed to be conducted within mathematics lessons, I did not decide who, when, where or what to observe (ibid.). Nevertheless, I did anticipate that the series of whole class observations arranged would be enough to allow me to assure myself about each pupil's suitability for inclusion in the study. I did not expect the pupils to be so-called 'high fliers'. Rather I envisaged that they would be more likely to exhibit difficulties relating to, in part, anxiety and poor motor function, and that they might not always find mathematics easy. Indeed, it was always a possibility that there would be nobody suitable in any of the schools, in which case the investigation net would have had to be widened. I had already made the decision, subsequent to the initial stages, that students finally selected for inclusion would be those whose mannerisms most closely resembled the two from the pilot study. Nevertheless, in most cases, other than where I had the opportunity to select from a group, it was not necessary for me to make any qualified judgments as the pupils chosen by the in-school teams matched, closely enough, Andy and Ben from the pilot phase.

Once the final group of pupils had been decided upon for their representativeness, I intended that all observations would be personally conducted so that reliable evidence could be gathered about how the pupils interacted and behaved, both verbally and non-verbally. For accuracy and consistency, I felt that data gathered by me as a sole researcher, observing all pupils, rather than inclusion of observational records from other researchers was imperative. Lincoln and Guba (1985), cited in Cohen et al. (2011:242) advise that an individual researcher's personal accounts of observations are central to the authenticity of a final report; thus, they say, any biases will be consistent across cases. Furthermore, the solitary researcher, utilising individual observational strategies, is in a good position, personal bias aside, to notice similarities and differences between cases. There was just one concern about the personally gathered field notes produced during the observation period. As they were not confirmed by any other observer, I was aware that personal preconceptions or interpretations may inadvertently have skewed the findings from this part of the enquiry despite attempts to eliminate all elements of partiality. Nevertheless, through reference to existing literature and alternative viewpoints from the interview and questionnaire responses, along with subsequent peer checking of the work, all biases were, I believe, sufficiently minimised.

In acknowledgement of the likelihood that the very nature of the observational studies involved in this type of research could have affected how the observed behaved and reacted, disruption to the normal workings of the mathematics classroom was kept to a minimum. To avoid the pitfalls associated with direct observation techniques, indirect methodology using recording equipment is, for some researchers, the preferred medium (Edwards and Westgate, 1994) and, for this study, it was an initial consideration. But, although it is believed by some that the use of 'inanimate' recording apparatus is less intrusive than an unfamiliar person in the classroom, there is some evidence that pupils find such equipment threatening (Cohen et al., 2011). In addition, Shaughnessy et al. (2003 cited in Cohen et al., 2011:473) report that, in the face of a recording device, pupils are less likely to behave as they normally would. In this study, even supposing that the individual pupils with Asperger Syndrome would not have reacted to the equipment in the room, as they do not like to draw attention to themselves (NAC, 2009), the conduct of others in the vicinity would undoubtedly have affected the behaviour of the pupils of interest (Labov, 1969 cited in Cohen et al., 2011:205). Secondly, it is argued that parents, carers and Headteachers are less likely to agree to engagement in a research project if there could be a permanent record of it (Ochs, 1979). Thirdly, in this study, the pupils in question might have found audio or video recordings invasive and upsetting. Finally, as the investigation concentrated on the experiences of just one pupil together with his resources and educators in each classroom, although possible, it was not expected to be likely that as many issues of importance would be missed as might be if an entire group were under scrutiny. Awareness of these issues caused me to question the merits of recording equipment. Hence, the effectiveness of indirect observational methods for this piece of research was, in my opinion, uncertain. In view of the greater challenges attributed to indirect observations over direct methods, not least the potential for distress in the pupil as detailed above, despite sacrificing the opportunity to review footage of the observations in this study, audio and video recordings of the sessions were discounted as impractical.

For the direct observer, any one of a structured, semi-structured or unstructured observation technique can be used, this dependent upon opportunity and individual requirements. Structured observations often make use of schedules and questionnaire-style forms, with such questionnaires or tick sheets completed by the observer in situ. In this style of observation, the hypothesis has usually already been decided upon and any data gathered will either 'confirm or refute' (Cohen et al., 2011:457) the theory. It is possible to observe the workings of the classroom using a pre-planned tick sheet if one simply wants to reveal the frequency of one particular type of incident. But, when the individuals being observed have the potential for unpredictability, pre-planned observation schedules can be quite restrictive. As a data collection method, if the document includes a large amount of detail, and there is limited time in the classroom to scan for the correct boxes in which to enter specific pieces of information, its use can be prohibitive in terms of efficiency. Vital incidents could go unnoticed as a result. Nevertheless, because all the categories have already been defined, the analysis stage is usually straightforward. A thoroughly thought through and meticulously formulated schedule requires less work than does a series of semi- or unstructured observations, apart from potentially time-consuming data entry into a software package.

Cohen et al. (2011) advise that, when applying direct observational strategies, where there is a plethora of potential points of interest, it is preferable to make use of unstructured or semi-structured techniques to gather data. Semi-structured observations are more flexible as, although certain questions require definite responses, there is some provision for unexpected events to be recorded. Finally, an unstructured observation is the least rigid in that there is no predetermined agenda and the researcher is free to record any point of interest or critical event, even those which may initially seem to be irrelevant to any preconceived idea of how the enquiry might unfold. Semi-structured observations can produce a wealth of material upon which to base an analysis. Specific detail can be determined more easily through the use of a semi-structured process than via a simple tick sheet. Biases notwithstanding, one way to determine any similarities or differences between cases is through use of a semi-structured observation schedule where freestyle records can be documented. From these, if it were to be found, for instance, that there were no similarities between cases except for in one unique aspect, then this would be just as valuable as it would be if it transpired that the majority of cases in this study had a great deal in common. Both semi-structured and unstructured strategies allow the hypothesis and justification to come out of the data. Both are a flexible means of obtaining data where any particular incident can take precedence over another according to its significance at that time. Specifically, in relation to pupils themselves, they give the researcher the opportunity to look for causal relationships among variables. They are flexible enough to allow for conjecture and decisions based on solid foundations whilst allowing for unpredictability. In this study, boundaries were not clearly evident from the outset, and no control or manipulation was to be exercised so I decided that the observations in situ should be semi-structured (Benbasat et al., 1987). Structured observation schedules were rejected as they were considered to be unlikely to provide for the collection of necessary data to feed appropriately into this enquiry. Unstructured schedules were also rejected because I needed a pre-planned focus on specific teaching and learning strategies so that relevant comparisons between cases could be made and the subquestions answered effectively.

I was aware that the use of semi-structured over structured schedules could have allowed selectivity to occur, where only incidents that confirmed my prior beliefs would be recorded, and others which appeared to contradict these views would be ignored. However, the main aim of the research was to determine the typical AS student’s experience of mathematics learning in relation to individual teaching styles and environments so it was important that I recorded every event regardless of perceived relevance. As each of the interactions of interest generally involved just one pupil and two members of staff in each establishment, I believed that semi-structured observation schedules would be an effective practical method of data collection through which to capture the relevant detail. Finally, as the data collection sheets for the observations in this study had less structure than those required for a typical quantitative study, they were easier to prepare. On the other hand, as a consequence of the potential for a large range of resultant field notes within these partially structured observations, the time needed for the analysis of data gathered was expected to be longer.

So that the information for this particular enquiry could be collected as unobtrusively as possible, my intended role in the classroom had to be thoroughly planned for. An observer-as-participant's role is defined by Cohen et al. (2011) as one where the observer 'may participate a little or peripherally in the group's activities [but is] as unobtrusive as possible' (p.457), and where the group is unaware of who or what is being observed. Conversely, participant-as-observer is one where the observer explains his or her role and collaborates with the pupils for their benefit (Armstrong, 1980). The role of observer-as-participant rather than participant-as-observer was imperative for this study as a low profile had to be maintained. During the pilot stage, the observation strategy at Arlidge Arts Academy necessitated my stance as non-participant observer working to an unstructured schedule. At Bowman Hill there was also no pre-determined schedule, but this time there was some participant observation, (see Table 3*:* Detail of Specific Observation Strategies in each Establishment). Subsequent to these preliminary observations, I determined that there was nothing more, and probably less, to be gained through participant observation than could be obtained through similar but non-participant observations. I found that my involvement might have affected my ability to manage the data collection sufficiently well. Firstly, I might have missed important non-verbal actions, and secondly, writing up the field notes later, even though this was not long after, potentially reduced my ability to remember all incidents. Therefore, all subsequent observations were conducted from the position of non-participant observer. For me, as the researcher, taking the stance of non-participant observer in a situation where there was no intention to manipulate or intervene (Benbasat et al., 1987) was likely to be the key to identification of outcomes associated with different practices. Hence, except for at Bowman Hill School, the time in the classrooms involved only passive observation within which, whilst allowing for some kind of empathy in terms of quality time spent in the mathematics classroom, there was a sense of detachment that action research, for example, would not allow for. There was no intention to become involved with the classwork or to attempt to show understanding of how the objects of study, in this case the pupils with Asperger Syndrome, might feel (Cohen et al., 2011). This ensured that the findings were as realistic as possible. I felt that research which comprised isolated, experimental activity would not have produced accurate and credible data for analysis (Yu, 2010). However, there were only relatively short periods of time spent with each pupil; therefore, there was never full immersion in the ethnographic sense. Any kind of activity, even if intended to improve their prospects, had to be carefully considered. As these pupils had the intelligence to understand the world around them, they would not have welcomed interference (Asperger, 1979) or intervention (Wing, 1980). Thus, the final analysis of AS pupils' experiences of learning mathematics was to be based upon findings from settings which were as naturalistic as possible. To summarise, the study was to be qualitative in nature with data recorded personally within naturalistic settings and gathered through semi-structured, non-participatory, direct observation.

In respect of the cases chosen for this study, the majority of the observation data came from the individual pupils in mathematics lessons. Each session was selected by the Headteachers for convenience according to when the mathematics lessons on the observation days in question were held. Just one day was booked at the majority of the schools because the respective Headteachers were unable or disinclined, it was not clear which, to offer more. At Epsom Boarding and Glebe Street two days were allotted, and at Drake Academy I spent a week observing Dan in various lessons including several mathematics sessions in the mainstream classrooms and in the Specialist Unit. At Glebe Street there were two pupils with Asperger Syndrome in the class but I only wrote observational notes on one, George, as he was more similar to the others I had studied up to that point. Therefore, I believed that observations of him would provide more relevant data for comparison. The other pupil had additional, and somewhat severe, problems that could have impacted on and weakened the quality of the findings from the analysis, as a consequence. Additionally, I was reluctant to observe both as this would have reduced the time available to observe George. Fortuitously, to supplement the findings, George later approached me to talk about his interests and ambitions, and subsequently invited me along to observe him in his computing lesson. Occasionally, an observation took place in a lesson in an alternative subject area such as an art class at Epsom Boarding School and the computing lesson at Glebe Street Academy. As these were not mathematics lessons, and were often related to areas of special interest in which the pupils were naturally motivated, the teaching strategies and learning experiences were not entirely relevant to the enquiry and so much of the data drawn from these sessions went unanalysed.

3.5 Ethical Considerations

In respect of requesting informed consent from the participants or their parents and carers for the use of data emerging from this enquiry, there were several issues for consideration. For instance:

- LeCompte and Preissle (1993) cited in Cohen et al. (2011:226) state that in naturalistic settings, natural behaviour is essential and, ‘the more participants know about the research, the less naturally they may behave’. Therefore, it would not have been sensible to request consent of the pupils ahead of the enquiry as there would have been a chance that they might modify their behaviours which could then have adversely affected the findings;
- Had I made the request for consent from the pupils, they were certainly too young to give it. The permission would have had to come from their parents or carers who may not have understood the rationale behind the enquiry. Further, discussing proposals and findings with parents and granting them access to the enquiry might have allowed them to read about other students or issues surrounding views of the schools and their respective teaching strategies;
- There would have been a time delay in gaining consent from all parents;
- None of the students in this enquiry was familiar with me and, unless they approached me first, being questioned by a stranger could potentially cause distress or discomfort and thus damage my chances of acquiring pertinent data for the enquiry.

In the cases of Andy and Ben, the Headteachers granted the permissions and, in these instances only, each pupil was told of the reason for my visit. According to staff, both agreed willingly to participate but I could not be sure that their behaviours had not changed as a result of knowing why I was there.

In all of the remaining cases, the specific pupils of interest were not made aware that the observations were focused largely on them. This was firstly so that the classroom norms were preserved and secondly to limit the risk of distress for the pupils in question. While it may initially appear that covert data collection methods such as these were unethical, in this instance it was important to me that the pupils were unaware of the nature of the study. Bernard (1994 cited in Cohen et al., 2011:472) explains that, in certain cases, it is imperative that data is collected covertly. Although there were no disclosures to the pupils, the educators who arranged the observations were made fully aware of the need for discretion. During observations, I knew that evidence of certain abilities such as rapid recall, for instance, might not necessarily have been easy to observe unless the pupils were verbally tested or I had hovered over them. Most observations were conducted at a distance. There were just a few instances of the classroom observations being undertaken from vantage points close to the pupils being studied and, when they did occur, they were purely out of necessity. So, to find out whether or not the pupils possessed certain skills, I expected to have to ask the relevant educators in this study, and this was another pragmatic reason to request permissions from them rather than from the pupils. As the schools were acting in loco-parentis, it seemed that requesting consent from these interviewees and Headteachers was a better option than asking the pupils directly. This is explained by Cohen et al. (2011) as perfect reasonable. So permission was neither sought nor required from the pupils themselves, other than Andy and Ben, this because it was provided by their schools. The teachers, Teaching Assistants and others involved in the pupils' care were fully consulted about the objective of the proposed enquiry. They were advised that they could opt out of the questioning at any time if they desired and that they could request that some of their responses be kept out of the final report. They could also, at any time, request that the research cease or change course.

Importantly, the 'deception' would not have put anyone in danger, nor was it for reasons of personal safety. No harm was to come to the pupils; they would not be ‘physically, psychologically, emotionally, professionally or personally’ (ibid.:85) damaged by straightforward covert observation. Rather, they might have experienced greater negative effects through knowing the purpose of my research. It could have put them under pressure that could have subsequently proven detrimental to them and to their educators. Those who had spent a considerable amount of time building a rapport with their pupils would not want to have it destroyed by a single action. Further, in most cases, there was not enough time for me to build a rapport with the pupils before the lessons in question to be able to request and gain their consent. Although there were a few cases where it might have been possible, that alone presented me with another ethical dilemma. I would then be informing some and not others. I therefore thought it best, for parity, to maintain a somewhat justifiable silence.

In order to maintain a low profile, records of interviews based on the actual conversations with pupils, were written up after each event. I had decided, prior to the observation stage, not to record sessions but I knew that there might be impromptu opportunities to talk to pupils becoming unexpectedly immersed in a fully unstructured interview situation. This possibility had to be considered and planned for before going into any school. Firstly, as it was considered unlikely that any pupil would talk candidly with a microphone pointed at him or her (Cohen et al., 2011) and it would not have been appropriate to take notes while they were speaking, it might not have be possible subsequently to remember everything said. With no recording device to hand, there would be no means of checking later that any mentally recalled transcripts were entirely accurate. Secondly, in maintaining the subterfuge already decided upon, the unstructured nature of interviews with pupils meant that not only were initial interactions, (verbal and non-verbal), to be later recalled but also the questions posed along with the responses to them. This had to be done while maintaining a seemingly casual manner in order to prevent distress. As a result, some potentially important disclosures would unquestionably have been forgotten after the event. However, the unexpected opportunity to talk at length to any of the boys had the potential to provide the greatest insight into their experiences of mathematics learning that would otherwise have remained unknown. Although I did not seek individual permissions from the pupils who chose to talk to me, I took their willingness to discuss certain aspects of their school life, along with the schools' approvals as tacit consent for me to make use of some of their comments.

Finally, all names, places and identifying information have been changed to protect their anonymity. And, along with oral consent from the educators and Headteachers of the schools, ethical approval was also sought from and provided by Warwick University's Institute of Education's Ethics Department (see Appendix 13: Ethics Approval Form).

3.5.1 Validity and Reliability

To be confident that the validity and reliability of my work could be rigorously defended, I had to ensure that the research tools measured what I expected them to measure (Roberts et al., 2006) and that my interpretations of events closely matched the data collected. Thorough ongoing scrutiny of both my research methodology and inferences drawn from the raw data was anticipated to determine that the findings were sound and justifiable. I have made no claims that are unsupported by data and, to counter potential effects of personal prior beliefs and the inevitable subjective perceptions of a lone researcher, I have explained the rationale for all elements of the study in detail from inception to completion (Cohen et al., 2011).

3.5.1.1 Validity

There are various types of validity, four of which were of particular importance to my study: internal validity, external validity, population validity and construct validity. According to Hammersley (1987), a report is only valid if it is an accurate representation of the findings from a research study and so it was vital that I addressed each of these types of validity at various stages throughout the enquiry.

In respect of internal validity, to evaluate how valid the findings were in relation to just the members of the sample group, I had to check that I was gathering and appraising credible data (Hammersley, 1992). This was addressed in part through 'peer examination of the [records of findings]' (Cohen et al., 2011:188) and partly through robust personal monitoring systems to ensure that I was not manipulating the cases or changing my views and judgments over time.

External validity in this study concerned my ability to generalise the research findings from the sample group to encompass the wider population (LeCompte and Preissle, 1993 cited in Cohen et al., 2011:184). Although random selection of cases from a larger group would have provided greater external validity, this was not possible to do because of the limited availability of pupils with AS (Ehlers and Gillberg, 1993). However, through 'triangulation of sources' (Lincoln and Guba, 1985 cited in Cohen et al., 2011:185), I expected that rich data relating the one select group of pupils with AS (ibid.) could provide robust evidence of particular characteristics and classroom behaviours. Secondly, in respect of being able to categorise, I was aware that findings from case studies of specific learners might not be universally generalisable. So, while I collected data on each case using similar methodologies and my question sets for interview and questionnaire were taken from one question bank for parity, it was entirely possible that the final records might have indicated few, if any, links between individuals in the study group.

This qualitative research case study depended in part upon unobtrusive data collection, the provision of enough detail to allow others to reconstruct events to test the credibility of the argument and, for greater accuracy, the use of several methods of data collection such as observation, interview and questionnaire (Kemmis, 1988). In each type of methodology, to prevent distortion of the facts, I recognised the need to avoid personal bias and reactivity if possible. During the practical data collection phase, the latter was minimised through clandestine observation procedures. In most cases, although I explained the reasons for observation to the classroom teacher, the pupils were left to make their own inferences about my role in the classroom. As the research explored normal everyday life in the mathematics learning environment for pupils with Asperger Syndrome, it was vital that observations were conducted as unobtrusively as possible, this to ensure that findings from the data analysis closely reflected reality (Woods, 2005). Further, ensuring that the sample was not too large (Cohen et al., 2011) and conducting a pilot study to help with benchmarking of questions along with procedural equivalency helped to confirm that the observations were standardised.

In deference to potential concerns about being interviewed or questioned that the respondents may have had, the particular question set, the way in which the questions were posed, and my responses to their answers, were all important factors for consideration during the development stage (Cohen et al., 2011). In interview, both the types of question and my reactions to interviewees' responses had the potential to cause non-natural answers (Onwuegbuzie and Leech, 2006 cited in Cohen et al., 2011:185) so care needed to be taken in the early stages to ensure that these concerns were recognised and addressed. I considered it essential that I remain neutral and avoid personal reactions or responses to comments made by the interviewees. Here, 'as with observation, one endeavour[ed] to be unobtrusive in order to witness events as they [were], untainted by one's presence and actions [...] uncoloured and unaffected by [me as] interviewer' (Woods, 1986 in Cohen et al., 2011:154). Any obvious personal judgments or opinions hinted at by me might have made the respondents question their own views and so provide answers that were not entirely consistent with their own beliefs (Cohen et al., 2011). The respondents' own views were important and it was essential that they answered the questions honestly from a personal perspective. Had I chosen to intervene with 'probes and prompts, [there would have been a] greater […] chance of bias entering the interview' (Fowler, 2009 cited in Cohen et al., 2011:421). Furthermore, in both questionnaire and interview, invasive questioning might have made the interviewee wary of answering truthfully. All questions that could have elicited noncommittal or restrained responses were removed and none of the remaining questions was worded in such a way as to be considered leading.

I attempted to avoid ambiguity and I judged that the questionnaire and interview lengths were neither too long nor too short (Cohen et al., 2011). This was to ensure that 'accurate, representative, relevant and comprehensive data' (King et al., 1985 in Cohen et al., 2011:198) were captured. To affirm the appropriateness of my strategies, a colleague reviewed various aspects of my data collection methodology to check that my questions and summaries of personal, interview and questionnaire accounts were valid (Elliott and Adelman, 1975).

To support the validity of this study, space-triangulation, which 'attempts to overcome the parochialism of studies conducted in the same country or within the same subculture' (Cohen et al., 2011:196), was implemented. The differing educational establishments in the UK and in the USA were expected to be diverse enough to be able to show whether or not the behaviours of the pupil type in question changed according to setting or culture. Even though triangulation methodologies might be seen as positivistic and unnecessary in qualitative research (Silverman, 1985 cited in Cohen et al., 2011:197), they were essential to this enquiry, firstly because they helped me to maintain focus and, secondly, to determine if individual outward traits could be largely a consequence of setting.

Population validity was high as this particular sample group were presumed to be very similar to the wider AS group in the mathematics classroom. Although comorbidities were expected to differ between individuals, the cases were all boys with Asperger Syndrome and records of their experiences all came from the mathematics learning environment.

Construct validity was attended to through consistently checking that my understanding of the demonstration of a quality was ‘similar to that which is generally accepted’ (Cohen et al., 2011:188). This was an important element of the study. My own views and observations could potentially have been more subjective than objective because prior beliefs can make it difficult to separate findings based on personal perceptions from accounts based on reality; therefore, it was imperative that I thoroughly reviewed all recorded judgments to ensure that I was correctly reporting the facts. Construct validity was primarily established through a return to the definitions of behaviours associated with Asperger Syndrome as suggested by prominent researchers and clinicians along with findings from the pilot study and peer evaluation. Triangulation of evidence helped to ensure that my understanding of how particular qualities translate into outward indicators matched those generally accepted by the wider community including the pupils themselves (Cohen et al., 2011). Had my interpretations been solely self-constructed, I might have inadvertently made unfounded inferences from some of the observed events. Thus, this piece of research was not simply based around my own perceptions of experiential issues and the interrelated behaviours of pupils with Asperger Syndrome in the mathematics classroom. To further ensure that my beliefs did indeed conform to generally accepted views of the behaviours of pupils with Asperger Syndrome in relation to experiencing differing types of activity in the mathematics classroom, the ways in which I interpreted outward symptoms as correlating to various underlying factors were analysed thoroughly and later peer reviewed.

Because of the nature of this type of research enquiry, a certain element of bias was unavoidable but my appreciation of the ways in which it could have impacted on findings, as reported here, was expected to have acted to minimise its effects. In summary, the validity of my qualitative research findings can be verified and tested through following the methodological procedures for replication purposes and using the same methods of triangulation described here, these all intended to ensure that this research enquiry can be considered credible.

3.5.1.2 Reliability

The interview responses to this enquiry were considered largely, if not completely, to be subjective narratives which needed to be analysed thoroughly for examples of bias. However, I believed that a replication of this study with different interviewers and interviewees in alternative settings would almost certainly produce similarly subjective accounts (Kleven, 1995 cited in Cohen et al., 2011:203).

To limit personal bias and interviewees' misinterpretations (Cohen et al., 2011), individual interview questions were kept short and pertinent with all responses recorded and later fully analysed.

I considered the responses provided to the questionnaires by the two pilot study pupils to be reliable, this because the pupils were not put under pressure and because people with Asperger Syndrome are generally honest (Asperger, 1979). I assumed that the data drawn for analysis, including the written sections of the questionnaires, provided dependable supporting evidence relating to each pupil's personal views. For instance, both Andy from Arlidge Arts Academy and Ben from Bowman Hill School ticked the box indicating that they did not like to work in groups and in each case this was qualified by a written statement to explain why.

Reliability of observational data could have been affected by personal bias and important events might have been missed in the classrooms when I noticed or focused on alternative incidents. But triangulation in the form of findings from various data sources, (narratives and field notes), were expected to limit these effects.

Disruption to classroom activities and the day-to-day lives of pupils and educators was kept to a minimum as I conducted each observation as naturalistically as possible with no indirect recording methodology or open discussions with pupils in the classrooms.

Cohen et al. (2011) suggest that reliability can be further compromised during the analysis by a number of other factors, some of which were of consideration in my study:

- Classification of narratives may be inconsistent due to coding variability;
- Coding and categorising may result in the loss of richness of specific words and connotations;
- In condensing data, incomplete portions of text are less reliable than sentences and phrases that have the highest reliability.

(Cohen et al., 2011:573)

In categorising and condensing the detail from the narratives in this work, some of the identifying features may have been lost but as far as possible, I tried to ensure that the original meanings remained clear. For affirmation, I asked a colleague to check that, in abridging some of the accounts, I had not removed any vivid data and also to confirm that the themes I saw emerging were indeed justifiable. This support ensured that personal beliefs were not colouring my perception of events. My own views could have unintentionally altered the intended meanings in write-up so it was vital that the final version was checked and re-checked for anomalies. The data, findings and analysis were personally and externally examined several times for inaccuracies, and checks to ensure that the main research questions were adequately addressed were rigorous.

Finally, while some of the narrative accounts from one particular external professional have been reported, not all of the data gathered from him were analysed as, according to him, despite a diagnosis of AS, his pupils had low functioning autism and not Asperger Syndrome (see also Chapter 2: Literature Review and Chapter 5: Limitations).

3.6 Summary

Although case study methodologies are sometimes considered as able to generate only subjectively functional conclusions (Hammersley, 2007), in order to facilitate consistency, I minimised bias by reducing the influence of personal belief systems.

As a researcher, I was fully aware throughout of how I might have been constructing my enquiry's micro-world through studying it. I have explained my own perspectives and personal decisions made about the advantages and limitations involved in observer participation (Hammersley, 2007). These clarifications were intended to limit adverse reaction and criticism regarding the potential for subjectivity in this piece of research. By specifying, in this chapter, facts about selection and sampling techniques as well as detailing factors influencing personal interpretation, I have justified my reasons for decisions and judgments made along with the principles applied to the study. At both the data collection and the analysis stages, subjectivity was, I believe, to a large extent eliminated; all background information has been provided and the data coding has been made explicit and straightforward for ease of replication as necessary. Adhering to my own methodological procedures closely, despite ongoing concerns regarding subjectivity and recall when notes were transcribed after the event, I managed to amass a considerable amount of data for analysis. The findings are conveyed in the next chapter and analysed ahead of the Discussion chapter which refers back to the Literature Review in support of some of the findings. Later, although there were no hypotheses to accept or reject, personal beliefs concerning pupils with Asperger Syndrome that changed following the analysis are reported accordingly.

Chapter 4: Analysis

4.0 Introduction

The Analysis chapter presents the findings from this research enquiry which was conducted to examine the situation in the contemporary mathematics classroom for pupils with Asperger Syndrome. Significant features of the new National Curriculum for Mathematics that developed into the research subquestions formed the lenses through which the narratives and field-notes were analysed. Including a section to compare common characteristics and learning styles, the eight themes which informed the subquestions and subsequently became the lenses are:

INTRINSIC	EXTRINSIC
Common Characteristics	Assisted Learning
Complex Problem Solving and Reasoning	Group Work
Rapid Processing	Practical Mathematics (including computer use)
Perseverance	Real-World Learning

The data for analysis in this study were taken from:

- Narratives from questionnaires and interviews
- Records of observations
- Diary entries
- Pupils' work (see examples in Appendices 4 & 5)

For triangulation purposes, the narrative data drawn from five questionnaire responses, (see Appendices 6 and 14 and Table 14), and interviews with three professionals, twenty-two staff, (see Table 9), one university student and six pupils (see Table 10 below) provided a variety of alternative views for analysis (Walker, 2007).

Table 10: Summary of Data Collection Methodologies

Data Collection Methodology	Number
Observations Unstructured (Pre-pilot)	2
Observations Structured (Pilot)	2
Observations Semi-structured	8
Questionnaire Structured	3
Questionnaire Semi-structured	2
Interviews Unstructured	6
Interviews Semi-structured	26

The external viewpoints enabled me to maintain both validity and an objective focus on pupils with the condition. The data arising from the interviews and questionnaires supported the records of classroom observations, (see Tables 12 and 13), and discussions with in-school educators. While the questionnaire and interview questions varied somewhat dependent on setting and respondent, (see Appendices 6, 9, 10, 11 & 14), a number of common features emerged from the narratives.

The structure of this chapter is representative of the way in which I organised and amalgamated the data. Following these introductory paragraphs, I present, in Section 4.1, individual accounts of the classroom observations. In Section 4.2, a brief description of the classification process is provided to contextualise the analysis. An example of the coding system applied to the data ahead of the analysis is exemplified using a selected range of data drawn from the various observations, questionnaires and interviews. Next, in subsection 4.3, the various evaluated and generalised findings are linked to the themes. General practice that addresses the learning needs of pupils with Asperger Syndrome is presented in this section. Accounts of the findings from the various types of observation, interview and questionnaire can be found interleaved throughout for illustrative purposes. A further selection of supporting transcripts and field-notes, some unabridged, is to be found in the Appendices. For brevity, I have not included every sheet used in classification. Those provided are simply for clarification purposes. Categorised findings from all summary sheets are referred to throughout Section 4.3. Finally, the chapter closes with a comprehensive summation of the significant findings to come out of the analysis.

4.1 The Observations

In this section, I provide an overview of the observations. A limited selection of the verbal accounts from this period are included here, with the majority found in subsection 4.3 which matches the narratives with these observational events.

<u>Arlidge Arts Academy (mainstream)</u>

At introduction, the first impression of Andy was of a quiet, fragile and reasonably studious boy. I had been introduced to Andy early in the day so he knew who I was and the purpose of my visit. He had also agreed to complete my questionnaire (Appendix 14.1) electronically and had chosen to do so after the lesson in the Special Needs Unit. Later, before his lesson began, I saw that he had slipped into the classroom unobtrusively and was sitting alone at the back of the room. I was already at the back a few desks away from where he chose to sit. I noted that he did not once acknowledge that I was there. His stance was overly rigid however and his demeanour appeared to be somewhat guarded. I thought it probable that it was a sign of anxiety. This might have been due to my presence or it may have been simply a common response to the social element of his mathematics learning environment.

He was 11 years old at the time. There were 28 pupils in the group, a female teacher and a female TA who was assigned to the class as a whole. His teacher had informed me that he had a reading age ‘off the scale’ but that his understanding of text could be poor.

I had been told that I would be observing a numeracy session based around number bonds. Somewhat surprisingly though, Andy, along with the rest of the class, was initially directed by the teacher to colour in a set of large numbers from 1 to 10 with jumbo felt pens. If he could finish the work satisfactorily, she said that he would be allowed to progress to the numbers 11 to 20 but his evident problems with holding the pen and staying within the lines meant that he did not manage to get to that stage.

This was a very simplistic task that had little to do with mathematics and certainly no links with number bonds. There was no differentiation in place and the TA hovered around the class helping others but ignoring Andy. This might have been teacher directed so that I could see how he worked alone but I was not sure. Evident from his continual shifting in his seat and increasingly hunched shoulders, Andy was clearly distressed at not being able to colour in sufficiently well. Throughout the first part of the lesson, he was repeatedly provided with a new 'number 1'. This was, according to the teacher, because he kept ‘going outside the lines’. There was no discourse between them; she simply removed what she perceived to be inferior work and thrust each new piece of paper at him at random intervals. As there was, in her opinion, no real improvement after 10 minutes, she simply left him to ‘get on with it’. The purpose of the activity was not entirely clear but when I asked, she mumbled something about portfolio dividers. I surmised that the reality was that she had decided upon this particular teaching strategy to prove to me how 'difficult he could be' to teach. There was clearly no new mathematics learning and certainly no engagement with the task. I noticed that most pupils in the class had moved on past the number 15 after 30 minutes and the majority had progressed by the end of the lesson to working through number bond problems from a textbook. But not Andy; he had barely finished his number 10. This was a very disappointing outcome for him. He had spent much of the lesson lining up the pens with the edge of his desk rather than concentrating on the task. Although it was difficult to disentangle his behaviours from the activity, the simplicity of the task did allow me to gather substantial evidence in relation to how the teacher interacted with him and his non-verbal responses. The activity also provided me with an insight into the impact of his motor difficulties for him and demonstrated how he managed with an overly simplistic task which bore no relationship to mathematics learning.

When the bell went, the TA accompanied him to the Special Needs Unit to complete the questionnaire as agreed. At this point, the teacher produced a piece of work (see Appendix 4) which she said was to provide extra evidence of his limited fine motor skills and lack of perseverance with a task. He had been unable to complete this piece of work too she said, this time because he had become stuck on one question and would not move on. As before, when she had explained the activities that she had devised for the class, I did not get the impression that she was interested in supporting Andy to improve his skills. Rather, she was looking for some kind of validation that her impression of him was correct, namely that he was 'unteachable'.

Bowman Hill (independent)

Ben's lesson started at 11.30am. He entered the classroom swiftly and ahead of the other pupils, taking a seat at the back of the room near me although, like Andy, he did not acknowledge me. Ben knew the reason for my visit and had agreed to complete the questionnaire provided (see Appendix 14.2). As it was lunchtime after the lesson, he said that he would remain alone in the classroom to complete it electronically.

Half of independent Bowman Hill School's session was textbook-based mathematics and the other half somewhat unrelated practical mathematics for reinforcement purposes. There was no TA available, so all support was provided by the teacher. For the first 30 minutes the pupils were working through pseudo-real-world textbook problems (Assessment for Ages 12 - 13). These included intermittent visual geometric challenges such as 'Calculate how many small cubes make up this larger one'. Throughout this part of the lesson, Ben kept his head down very close to the book and sped through the pages but did not appear to be writing much. He seemed to be reading the questions and may have worked out the answers in his head but he did not commit any working to paper. Later, the teacher said that he often had the right answers but would not usually show any working unless prompted. She explained that she did not spend much time with him in lessons such as this because mental mathematics was one of his special talents. However, she did not know whether or not he was using any reasoning skills. She thought that he was merely responding in rote fashion to familiar questions.

The remainder of the lesson consisted of a practical element based around running a shop with real items for sale in a number of different scenarios. The cost of items had to be added mentally and the correct change given. The pupils were grouped according to ability. Ben, however, chose to work alone with the most complexly priced goods and demonstrated clear ability to correctly calculate totals and change extremely quickly. Like the others in the class, Ben seemed to like the practical element and spent a lot of time neatly sorting the money in to piles according to the value of the coin. But, he would only 'sell' items to the adults, the teacher and me, with confidence. Throughout, he acted as though he considered himself to be a real shopkeeper, carefully checking and rechecking his takings. He certainly appeared to enjoy the level of responsibility. This was the only time that the teacher interacted with Ben and there was no conversation between the two. Only when members of his peer group approached was it evident that the social element of the activity was stressful for him. In these instances, he became flustered, coloured up and stuttered.

By the end of the session, he appeared to have reinforced his already evident mathematical skills but I could not be sure that he had learned anything new. As the work was mental rather than theoretical, it was not possible to determine what type of methodology Ben used to calculate his answers but rapid processing was certainly evidenced by his speedy handling of relatively complex number bonds. There was full participation in the tasks although slightly less so in the textbook exercise, despite inclusion of a type of real-world element to some of the questions. At the end of the lesson, he gathered up all the items and money and, as instructed, returned them to the containers at the front of the classroom. He then waited until all other pupils had left the classroom to start on his questionnaire.

Chelsea Mill Science and Technology College (non-selective independent)

At Chelsea Mill Science and Technology College, where there was one female teacher and no TA, Charles (11) came into the classroom quietly and sat near the back alone. At the time, I was sitting near the front talking to the teacher and it was from this position that my observation of the lesson was conducted. It was a very compact classroom so in reality he was not sitting too far away from me and there were only 9 pupils in the class. He did not seem to notice me although I felt that, in reality, he must have been aware of me as all of the other pupils were; some asked who I was which I suspected he must have heard.

The lesson was based around preparing for examinations. Therefore, the entire session involved exam practice. Charles appeared to be engaged at the start but, at about 20 minutes in, he stopped turning the pages and sat staring at the paper. He seemed to be stuck on a question on finding the angles in a complex shape and did not move on to see whether or not he could do the later questions. The teacher who had noticed too did not approach him to help. She had previously told me that, as history and English were her main areas of expertise, and not mathematics, she did not feel especially confident enough to help. In fact, she believed that he was 'more mathematically able' than she was. Although there appeared to be some reinforcement of learning in evidence up to a point, Charles clearly found the geometry problem difficult to solve and, possibly compounded by lack of teacher input, he was unable to progress. As time went on, he seemed to become more and more distracted. Ostensibly staring at the paper, he was clearly thinking about other things. His eyes were glazed and his fists clenched. At first I thought he was daydreaming but on seeing the clenched fists, I further noticed that, like Andy, his posture was rigid. I considered that it could have been that he was suffering from anxiety, possibly because of my presence, possibly because of the mathematics problem or maybe he was always like that in the mathematics classroom environment. However, as I had not noticed this behaviour at the start of the lesson, I believed it was most likely to be task related.

When the bell rang 30 minutes later to signal that the lesson was over, Charles sat in his seat until the rest of the class had gone and waited until the teacher told him that he could go. He carefully gathered up his classroom equipment, put the items into his pencil case, placed the case into his bag and slowly walked out of the room, leaving his work on the desk. This gave me the opportunity to look at what he had done in the lesson. As suspected, he had written nothing for the question he was stuck on and there was no working out for any of the questions he had completed. The majority of his answers were correct but about a quarter were wrong. The teacher provided me with another example of his work from her file to exemplify his difficulties with working at pace (see Appendix 5). She explained that his handwriting was poor because of his fine motor deficits and pointed out that, as always, he had initially written down the answers only. I noticed that he had needed a written prompt to push him to redo them, this time with working out. According to the teacher, he had only managed to complete half as much work as the rest of the class as a consequence of the extra time needed to start again from the beginning. She did say, however, that had he been allowed to do the work in his own way, he would have been able to complete more than the others in the group.

Drake Academy (mainstream with specialist unit)

At Drake Academy, Dan (12) came into the class with his TA and, as directed, sat with her at the front. I was at the back of the class, one row away. Dan appeared not to notice me there. The TA provided him with a pencil case full of mathematics equipment which he slowly removed and lined up in front of him. His female teacher taught the class from the front and did not once approach or acknowledge Dan, who was aided only by the TA.

The session constituted purely theoretical tasks with no real-world or practical elements. As directed by his TA, he spent the first part of the lesson in the classroom working on surds from the textbook. I noticed that he wrote in pencil and that his work was unusually neat. This could have been because he was copying the layout of his working from his TA. But previous experience of pupils with AS in terms of chaotic organisation, inability to write neatly and lack of working out initially made me think that maybe he had some other disorder and not AS.

After approximately 20 minutes, when his TA could not understand the mathematics and had helped him to give the wrong answer, she very suddenly gathered up the equipment, got up and took Dan with her having spent less than half the lesson in the classroom with the teacher. I naturally followed. Again, although he was aware of my presence as the TA was talking to me, Dan ignored me. When they got back to the Specialist Unit, they, including Dan, decided that they had had enough of mathematics for the day and took an elongated lunch break. The TA jovially proceeded to discuss her problems with the topic in front of Dan and suggested that difficulties with mathematics learning were generally acceptable. I felt that this kind of reinforcement, namely that it is excusable to 'leave the room if you do not understand', which I overheard the TA say to Dan, had the potential to encourage loss of interest in learning mathematics. This was particularly true when the lesson was replaced by computer games or completing jigsaws which were Dan's favourite pastimes.

I was told that as well as working with jigsaws, Dan was adept mathematically but I cannot say that I saw any evidence of this. He appeared to accept that the TA's methodologies were correct and continued to apply them in a rote fashion even when they produced wrong answers.

In respect of appropriate TA support, during another lesson, the TA decided that the way the teacher was explaining fractions was too difficult for the group of ASD pupils to understand, so she taught them a different method. However, when they went to the computer room, the TA disappeared and, it quickly became evident that, in order to progress, the pupils had to understand the teacher's original technique. This, they managed perfectly well, working through the problems using the correct methodology. The TA had merely taught her way of doing it with no consideration of the pupils' capabilities and no discussion with the teacher. This lack of awareness though was partly the fault of the teacher's non-communication. Subsequent low levels of engagement were largely a consequence of the limited expertise of the TA but partly accredited to the class teacher's lack of involvement.

Epsom Boarding School (independent specialist boarding for boys)

At Epsom Boarding School, in each lesson there was one teacher and 1 mathematics specialist Teaching Assistant. There was also a corridor monitor (TA) who had had some training in mathematics teaching. In all lessons, Eli (13), who could choose where to sit and with whom, sometimes sat alone and sometimes with a friend. All teaching and learning sessions were flexible and largely based around the pupils' own skills and interests. Although all Key Stage 3 and 4 disciplines were catered for, some subject sessions were attended less frequently than others, this dependent on pupil preference. Eli's interests and skills were in mathematics and Art and he chose to spend a substantial portion of each day in mathematics sessions. These lessons were usually split into a series of revision tasks, learning a new skill and practical reinforcement work. During my observation period at his school, he introduced me to his teachers, TAs and friends and showed me the school pets but did not once ask what my role was. He seemed happy to be in my company and to show me what he could do. I was aware, however, that the Headteacher might have produced him as an exemplar because of his atypical social skills; he did appear to be an anomaly at the school.

In mathematics lessons, I observed him playing a game of snooker with a TA to estimate angles, on accelerated GCSE exam practice (algebra) and starting a new Advanced Level topic (calculus). In all instances, he worked well with his teachers and TAs and appeared to be fully engaged, but this could have been because mathematics was an area of special interest to him. Although some of each day was spent on revision, most of the teaching was based around new topics which were introduced and taught using whichever method was most appropriate for Eli. As all of the TAs were mathematics specialists and knew Eli well, they said that they knew when to step in and how to adapt the teaching to keep him motivated. Unlike the others in this study, he was quite an intense boy. He was quietly spoken but, like Dan and Ian, relatively confident. He appeared to be unconcerned when the TAs discussed him in front of him, but this I suspected was because he was proud of his achievements and his familiarity with the TAs. Upon questioning, he easily articulated his appreciation of mathematics learning and the assistance provided.

Flynn Road School (mainstream)

At Flynn Road School, there was 1 part-time TA who was not assigned to Freddy alone. In the lesson observed, the pupils were practising for the imminent mathematics SATs examinations. Freddy was already in the classroom when I arrived. He did not look at me at all and kept his head pointed downwards. Like several other pupils, (including the two from the pilot study), Freddy (13) was quite a fragile looking boy. He had arrived without equipment but the teacher did not make a fuss, and provided him with a pencil case from the drawer. This appeared to be routine. Freddy was sitting at the front next to the teacher's desk and I sat nearby. Although he seemed to ignore the brief teacher exposition at the start, I noticed that, although he had not followed the instruction to write his name on the front page, he had turned to the correct starting page. This indicated that, although he acted like his entire focus was on the pencil case and deciding which equipment to take out, he must have been paying attention to at least some of the teacher's instructions.

He had directed teacher support throughout the lesson and he managed to complete approximately half of his paper. His writing was spidery and there was not much in the way of working out but he did include some when directed. As he had finally decided that all he needed was a pen on the desk, all shapes and lines were drawn in ink and without a ruler. There were occasional crossings out and scribbles but the answers were largely correct, mainly, I suspected, because of the assistance provided. I could not be sure but I thought that he might have struggled otherwise. There were times when he stopped completely and only resumed the work when prompted to by the teacher. He was certainly slower than the rest of his peer group, most of whom were at least two-thirds of the way through by the end of the lesson. However, there was great teacher-pupil rapport and the teacher said that, although he rarely spoke in class, Freddy would happily sit at the front next to his desk. He stated that Freddy enjoyed mental mathematics and that he appeared to enjoy some practical activities but that he (the teacher) had learned not to put Freddy's work on display because the other pupils laughed at his poor geometric drawing skills.

When the bell went, Freddy waited patiently at his desk until his paper was collected and he was told that he should go to his next lesson. He looked quite upset at this and walked out of the room with an unusual and awkward gait. I had the impression that he wanted to stay behind to talk to his teacher about something and that this was something that he did regularly. The teacher had mentioned that Freddy rarely spoke in class but reserved everything he wanted to say or ask until all pupils were out of earshot. In this instance though, he had another lesson to go to so there was no time for conversation.

Glebe Street Academy (mainstream with specialist unit)

At Glebe Street Academy, there was one male teacher and one female TA. George (15) was in the top set of the lower band at the school and was expected to get a Grade C for his mathematics GCSE. He, like several others in the study, appeared to be quite a delicate and nervous boy. In the observed lesson, which was the first lesson of the day, he came into the classroom last with his TA and another pupil who was also said to have AS. The two boys were directed by the TA to sit together at the front. I was already at the back on the other side of the classroom.

The pupils were observed working from the board and a worksheet on problems involving algebra. Because of my vantage point, it was not possible to see exactly what George was doing but I did notice that he never once looked up at the teacher. Yet, occasional glances in the teacher's direction and at the board indicated that he was listening at important moments. With the assistance of the specialist TA and the prompts from the teacher, he appeared to work well and the TA confirmed that he always worked to the best of his ability. I noticed that he seemed to have a reasonably high degree of perseverance with the tasks. There was no time when he looked as though he was off-task but the TA stated that she always kept her eye on him and was aware of the right times to approach or prompt him. She said that she rarely communicated with him verbally. Normally, just pointing at where he had gone wrong or where to look in the text was enough to set him back on track.

In my view, George's progress could have been ascribed to the charisma of the teacher and the skilled work of the TA. The tasks themselves, (working from the board and worksheet), although manageable, did not appear to excite George. He merely worked according to teacher and TA direction, to some extent by rote. At the end of the lesson, the TA directed the two boys that it was time to leave. During the entire session, there had been no communication between George and the other boy. Later, in the Unit, George approached me and, although he professed to not having noticed me during the lesson, he was quite happy to talk about his experiences at the school, (see Appendix 15) and his dislike of his working partner.

Hamilton Road School (independent specialist)

At Hamilton Road School, each lesson was only 30 minutes long although most lessons were in the one classroom. One teacher and two TAs (all female) were provided per group. In one observed lesson, all of the work was practical, based around counting and grouping plastic creatures as well as manipulation of objects using the interactive whiteboard. The desks were arranged in a square formation with pupils sitting around them according to teacher direction.

The student Harry (13) was already working at a desk, so I sat in one of the spare seats opposite him. He was fully engaged with the work as the tasks incorporated one of his special interests but the educational level of the work was quite low. There was no real challenge or engagement with prior learning in evidence. Throughout, he ignored me and spoke very little to his teacher or assistant. Most of the time he played with an interactive whiteboard with which he seemed to be fascinated. He received no instruction at this point so presumably had no idea in mind of what he should be doing. I was equally unsure of the expected outcomes of the task but his body language suggested that it would not be a good idea for me to question him.

Like some of the others in the study, he turned away from me when he could and sat with a rigid posture. One teacher referred to him as a ‘rabbit in the headlights’.

The educators left him to his own devices and appeared to a large extent happy that he was doing something rather than nothing. His mother had told me that he had an excellent memory but only in areas of interest. Otherwise, he would quickly tune out and switch off. The teacher had intimated earlier that Harry could be quite disruptive at times if he did not like an activity. When the bell went, one TA had to wrestle the board pen from him, after which he quickly got his bag and stormed out of the classroom. As the next lesson was in the same classroom, the TA had to leave the room to find him. She later said that he had been found in a nearby room in tears, this he said because he did not know where he was supposed to be.

<u>Inglewood Farm (independent specialist)</u>

Although all sessions at Inglewood Farm incorporated mathematics learning from practical and real-world perspectives, they were highly structured and there was no free choice. 1 male teacher and 1 TA (female) were provided as often as possible.

The lesson observed took place in the woodworking shed with the pupils standing around the teacher. Ian stood furthest away and to the side. For safety reasons, the teacher did most of the work. But this lack of pupil involvement gave Ian (18) the opportunity to distract himself, and to think and talk about his special interests. He started to tell me about his recent life achievements and then quickly distracted himself, changing the topic to animals. This was followed by a description of where he lived, how long he had been there and how long he intended to stay. Despite attempts by his TA to refocus him throughout, he continued like this for the entire lesson. He could not stay quiet for more than a few minutes at a time. I suspected that he was not concentrating on the teacher at all, but rather thinking about what to say next. Ian was a relatively confident young man demonstrated partly by the fact that he approached me to talk about his interests. The staff explained that from the moment pupils arrived at Inglewood, they were all coached in how to interact so that when they left they would have a better chance of securing employment. However, one TA said that it sometimes meant that the pupils could not differentiate between appropriate and inappropriate times to enter into a discussion with a stranger.

Like the activity at Arlidge Academy, the task, (this time measuring lengths of wood for the teacher to cut), appeared a little simplistic. Ian did not appear to learn anything new in the session and the activity was little more than rote learnt. He dropped the tape-measure on numerous occasions and rarely held it correctly when the TA or teacher asked him to measure a length of wood. He often simply guessed where to draw a pencil mark. After a very short time, he gave up altogether, preferring to talk to me about unrelated topics. The teacher had taken an inordinately long time to explain the task to the pupils, which in my view could have been a further reason for Ian's rapid disengagement. Ian stated that he had 'no interest whatsoever in becoming a carpenter or anything to do with wood', which might have been a further reason for his lack of attentiveness to the task.

Jodrell Community School (independent specialist)

At Jodrell Community School, where the teacher was the least connected with the pupils, they worked exclusively from the computer and later, for some, the textbook. There was no TA in the classroom and the teacher was the sole means of assistance. However, he remained at the front of the class and did not once approach the pupils. I was not sure if this was the norm or that he wanted me to see what the pupils could do without his input. So, James (16) was left to work independently with various mathematics-based computer programs which were differentiated according to ability. The computers were situated around the edge of the classroom and all of the pupils sat at the far corner furthest away from the teacher. Because they were already there when I arrived, I could not be sure of whether or not the seating arrangement had been decided upon by the teacher. However, I suspected that it must have been teacher-chosen as the one girl in the class who had been identified by the Headteacher as incorrectly diagnosed and a school bully was sitting in amongst the boys. As the Headteacher had stated that they were frightened of her, I surmised it unlikely that they would have chosen to sit around her. Unlike at the other schools in the study, there was some, albeit limited, interaction between some of the boys. However, this was only in relation to discussing the special interest that they shared, namely playing computer games, and not mathematics and they did not include the girl in their discussions.

While the levels of learning appeared to be minimal, James was initially clearly excited because the lesson incorporated mathematics problems using computer-based teaching methodologies. However, this might simply have been a consequence of the computing element. Although the tasks interested him because of their interactive quality, no real progress was observed. Without teacher assistance, he got stuck each time he was presented with a novel problem and so could not access higher levels of learning truly independently. He did not ask for help or acknowledge the teacher’s presence. When I asked what he was doing, he replied 'playing games'. Further prompting persuaded him to state that it was a 'maths lesson', but he could not articulate the mathematical significance of the 'game'. Left to his own devices, he lost interest, and subsequently became completely disengaged from the task. He spent the remainder of the lesson alternating between fiddling with items in his pencil case and talking to me about his family and how he came to be at the school. Once he asked if I could help with a problem, but, when solved, he got stuck on the next one despite its similarity. I suspected that he had not assimilated and accommodated the advice I had offered but rather that his understanding was relatively superficial – just enough to answer the question in order to progress to the next problem. It was apparent that he was thinking of the work more as a computer game than a learning experience and he merely wanted to beat his previous high score.

4.2 Categorisation of the Raw Data

Systematic organisation enabled me to categorise and identify patterns in the observational and narrative data efficiently. However, as the classification procedure proved lengthy, with a considerable quantity of data from many different sources to link to the themes, for clarity I include here detail of the significant aspects of this process.

The practical research phase took place in a range of educational settings: mainstream secondary schools, mainstream with specialist units, and specialist independent schools here in the UK and in the US. All schools in the US were independent as inclusion did not feature in their education system. Comparisons of teaching and learning styles and statements made regarding pupil participation levels according to school were not set against any benchmark unless specifically stated (see Table 11). Rather, they were determined according to a personally constructed interpretation from the observation period concerning how the pupils at each school compared with each other. Supported by detail from the narratives, these judgments were not established until the end of the practical data collection stage.

It was clear from the start that pupil experience varied according to school rather than to school type (see Table 11). It also quickly became evident that were no significant differences between types of pupil or teaching and learning strategies connected with location or national policy. Therefore, all data arising from observations, interviews and questionnaires were amalgamated into one group for analysis. No further comparisons relating to school type, locality or national policies have been made during this analysis.

Table 11: Comment on Pupil Participation in Activities According to School Type (Relative to Each Other *i.e. Involvement levels here are set against each other rather than national benchmark).*

SCHOOL TYPE / SCHOOL	Fully Integrated Mainstream	Partially Integrated (with a Specialist Unit)	Specialist School
Arlidge	Low		
Bowman	High		
Chelsea	Mediocre		
Drake		Mediocre	
Epsom			High
Flynn Road	High		
Glebe Street		High	
Hamilton Road			High
Inglewood Farm			Low
Jodrell Community			Mediocre

The analysis was conducted using records taken from the data collection proformas and personal diary entries, along with accounts from professionals and the staff in the schools. Some of the data collection sheets are presented below to illustrate how the records were summarised and grouped for the analysis. The data from each observation schedule that I used in the schools (see Table 12 below) were amalgamated (see Table 13) to facilitate straightforward matching to the themes. In Tables 12 and 13, all highlighted entries are those that I considered significant and which provided some of the evidence to inform the data analysis. Using these tables, broadly similar groups of data were linked with the most applicable themes. In Section 4.3, each theme is reported on in a standalone section using the aggregated findings from the data collection period. Included in each section is a selection of pertinent transcripts.

Table 14 is an example of how I made use of a simple matching system to sort the data into themes. Most of the headings for this table were taken from the National Curriculum for Mathematics but, for full categorisation of the data collected in relation to subquestion a), also included is: 'What are the common characteristics in pupils with Asperger Syndrome?'

For Table 14, I simply took partial detail from the narratives, (verbal or from questionnaire), or a fragment from the field notes and matched it with the most appropriate category. For example, the observation that Andy had: '*No interest in other people in class but does have friends outside the group'*, most closely linked with the initial part of research subquestion a), so it was added to the first column labelled: 'What are the common characteristics in pupils with Asperger Syndrome?' (highlighted). Categorisation was not always easy because, for instance, findings related to motor skill could fit with: 'Common characteristics in pupils with Asperger Syndrome' or 'Practical Mathematics'. In write-up, there were not always clear demarcations; therefore, this section should be read as a whole.

Table 12: Completed Observation Schedule

SCHOOL / QUESTION	A	B	C	D	E	F	G	H	I	J	Relevance to main research question
1. Does the pupil engage in problem solving activities?	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	a
2. Is there any evidence of rapid processing of data?	No	**Yes**	No	No	**Yes**	**Yes**	**Yes**	No	No	No	a
3. Does the pupil remain on task?	No	**Yes**	**Yes** partially	No	**Yes**	**Yes**	**Yes**	**Yes**	No	No	a
4. Does the pupil achieve the outcomes expected of all pupils?	No	**Yes**	No	No	**Yes**	No	No	No	No	No	b
5. Is the pupil given any specific help or guidance to complete the task?	No	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**	No	No	b
6. Does the Pupil have a TA?	**Yes** Not personal though	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	No	b
7. Does the pupil work well with the TA?	N/A	N/A	N/A	No	**Yes**	N/A	**Yes**	**Yes**	No	N/A	a & b

8. Is there interaction between the pupil and the classroom teacher?	No	No except for when ‘buying goods’	No	No	**Yes**	**Yes**	**Yes**	No	No	No	a & b
9. Where does the pupil sit?	**B**	**B**	**B**	F T	N/A	F	F T	E T	**B**	E T	b
10. Who does the pupil sit with?	A	A	A	A	A **F**	A	T	A	A	A	b
11. What types of teaching style are there?	D	D **C**	D	D	**O** **C**	D	D	**O** **C**	**GTC**	**T**	b
12. Does the pupil work successfully alone in mathematics lessons?	No	**Yes**	No	No	No	No	No	No	No	No	a & b
13. Does the pupil work successfully in a group in mathematics lessons?	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	a & b
14. What types of mathematics are taught in the session?	T W	T **R**	W	T	T W **R** **G**	W	W	**R** **G**	**R**	**G**	a & b
15. Open Comment Field Notes	See Section 4.1 and Table 14										a & b

9. Where pupil sits: *Front = F; Back = B; Elsewhere = E; Teacher/ TA selected = T*

10. Who pupil sits with: *Friend = F; Alone = A; Teacher/ TA selected = T*

11. Teaching Styles: *Didactic = D; One-to-one = O; Group Work = G; Technology-based = T; Creative = C*

14. Types of mathematics: *Textbook = T; Worksheet = W; Real-life = R; Game-based or Practical = G*

Table 13: Summarised Table of Class Observations

Significant figures are highlighted

	YES	NO
1. Does the pupil engage in problem solving activities?	**8**	2
2. Is there any evidence of rapid processing of data?	4	**6**
3. Does the pupil remain on task?	**6**	4
4. Does the pupil achieve the outcomes expected of all pupils?	2	**8**
5. Is the pupil given any specific help or guidance to complete the task?	4	**6**
6. Does the Pupil have a TA?	**6** Not always personal	4
7. Does the pupil work well with the TA?	**3**	2
8. Is there interaction between the pupil and the classroom teacher?	3	**7**
12. Does the pupil work successfully alone in mathematics lessons?	1	**9**
13. Does the pupil work successfully in a group in mathematics lessons?	0	**10**

9. Where does the pupil sit?	Front	Back	Elsewhere	N/A
	3 Teacher/ TA selected	**4**	2 Teacher/ TA selected	1 One-to-one

10. Who does the pupil sit with?	Friend	Alone	Teacher/ TA selected
	0	**9**	1

11. What types of teaching style are there?	Didactic	One-to-one	Group work	Technology-based	Creative
	6	2	1	2	4

14. What types of mathematics are taught in the session?	Textbook	Worksheet	Real-life	Game-based or Practical
	3	**5**	**4**	3

Table 14: Selection of the Narratives Drawn from the Questionnaire Responses of Andy & Ben and Personal Diary Notes on all Cases in the Enquiry

	What are the common characteristics in pupils with Asperger Syndrome?	Complex Problem Solving and Reasoning	Rapid Processing	Perseverance
Andy	No interest in other people in class but does have friends outside the group	Quite enjoys maths and believes he learns a lot. Does not find mathematics difficult. Likes a challenge. Does not like competition. Does like higher level maths.	Competition – I don't like that sort of thing	Can remain on task if the mathematics is challenging
Ben	Ben like computers and dislikes group work. He also finds friendship groups difficult to engage with: 'I don't like other people in my group and they don't like me'	Does not find mathematics difficult.	Evidence of rapid recall throughout the observation period – evidently better than the rest of his neurotypical peer group at mental calculations	States that a good teacher is what makes mathematics easy and interesting
Personal Diary Notes on all Case Study Pupils	All entered the classroom unobtrusively	Capability in the classroom appears to rest on the rapport with the teacher or Teaching Assistant alongside provision of stimulating mathematical tasks	In terms of practical mathematics opportunities, rapid recall is in evidence, e.g. Ben in the shop task but as most got stuck at some point, I don't think there was rapid recall generally in problem solving activities	Usually remain on task except for when confused by the work and with no assistance available. They enjoy the challenge – provision of stimulating mathematical tasks appears to encourage them
Research question	a	a	a	a

Assisted Learning	Group Work	Practical Mathematics	Real-World Learning
Likes working alone	Does not mind working in a pair with a friend	Sometimes enjoys textbook maths (although this is least favourite as he believes that it is more appropriate for low achievers. He finds rote mathematics boring but likes Tarsia and loves computer maths	Is ambivalent about work sheets with real-life questions but is interested by real-world 3D programming and how matrices are used in this field
Likes working alone in silence	Does not like groups or pairs but would work in a pair if he had to: 'You have to play games with other people and I don't like other people usually'	Does not like board games. Sometimes likes Tarsia. Finds writing difficult but can type easily so prefers computer maths	Does not enjoy textbook maths but does like worksheets with real-life problems
All pupils were working alone but not necessarily successfully Most are not given help in task completion. They need someone to help them overcome hurdles	No one engaged in group work except when made to sit with another pupil with AS (George). They are all disinclined to contribute and unhappy when sitting with people who are not members of the friendship groups. However, the assistance of a TA was vital for group work tasks	They do not mind which kind of teaching strategy is used but prefer hands on maths	It was not clear whether or not real-world learning affected their abilities to achieve the same or more than the neurotypical group but the pupils did enjoy lessons which incorporated real-life skills more than other lessons
b	b	b	b

To confirm that I had grouped the data appropriately, a colleague examined a sample of my coding system. She verified that my decisions conformed to generally accepted classification procedures so no adaptations were required.

The complete data file has not been included here, but samples from it have been referred to throughout. A further selection of narratives and field notes can be found in the Appendices. Occasionally, consideration has been given to an individual observation or narrative as there were some views on particular issues that needed emphasising. For instance, one educator said that pupils with Asperger Syndrome were always slower than their peers while two pupils believed the opposite. Significant single-case perspectives have been reported as they are assumed to be indicative of how others in the study might have responded had they been asked the same questions.

Although general types of school environment have occasionally been mentioned throughout this thesis, questions about it were not specifically raised in interview or via questionnaire. Therefore the type of school does not appear as a separate category in this section. The rationale for omitting the question was that any views that respondents might have had would have undoubtedly been largely subjective. Responses to questions on the learning environment in general, such as how many TAs they believed should be in each classroom, could have been based purely on personal experiences of their environs, with 'their judgments affected by their close involvement' (Cohen et al., 2011). Prejudiced views such as this could have adversely affected the internal validity of the enquiry (Wood, 2005). Thus, I made the decision that I, as a sole researcher, would be better positioned to evaluate how school types (mainstream and specialist) compared to one another (see Table 11).

4.3 Themes

There follows an analysis of the data from the personal research phase with the focus on how particular mathematics teaching and learning strategies drawn initially from the National Curriculum for Mathematics (2013) influenced the classroom experience for the pupils in the study. Although there are potentially multiple interpretations of qualitative data (Cohen et al., 2011), the analysis here is based upon a personal but peer-checked view of each narrative and observation. In the Discussion chapter, these views are compared critically with those of other researchers in the field to determine their validity.

Linking the fragments of narrative and observation data to the two subquestions, the generalised findings are presented below. Referring back to the subquestions, the first was concerned with the pupil and the second the mathematics learning environment. Thus, the analysis initially focuses on specific issues concerning mathematics teaching and learning as prescribed by the National Curriculum for Mathematics. This is followed by an exploration of how the pupils in this study were supported in their alternative types of mathematics lessons. Summaries of the deductions from the practical element of the study are provided here ahead of the Discussion chapter which returns to detail from the Literature Review to compare and contrast the findings.

4.3.1: The Pupil

It was notable that some of the characteristics and manifestations of Asperger Syndrome, such as confidence levels, were wide and varied, with differing co-morbid learning disabilities given by some of the educators as the reason for this. But, according to my understanding of how neurotypical pupils behave, confidence levels vary amongst these groups too so this was not a surprising finding. Some of these differences were not analysed as I considered them to be largely unrelated to the particular foci of the enquiry. However, where two or more pupils exhibited similarly significant learning difficulties such as the commonly noted struggle to write legibly at fast pace, findings have been reported (albeit with caution at times). The clearly defined similarities of characteristic and learning style along with mathematics teaching and learning strategies have been fully analysed to produce an informative account.

Common Characteristics

Certain co-morbidities notwithstanding, all of the pupils observed had many similar personality traits. For instance, they were all nervous to varying degrees and quiet but aspiring to succeed. Eight out of the ten pupils included mathematics as one of their special talents. Eli from Epsom Boarding school, who was one of those on an accelerated learning path said: ‘One of my favourite bits was the lesson on calculus, I like integration particularly and finding the area under a graph. Some people find it difficult’. Observations of and interviews with the pupils demonstrated that they were generally intelligent and ambitious to go on to further study. ‘All of our AS pupils want to go onto computing and Games Development at the local university’ (Assistant Head at Glebe Street). Most of the in-school staff and professionals interviewed confirmed that their pupils were academically bright and articulate, and that levels of achievement could be high in mathematics.

While there were some matches in other personality traits found in the DSM-IV (1994), contrary to one particular stereotype which states that pupils with Asperger Syndrome ‘lack interest in sharing achievements’, some were keen to discuss their successes in mathematics and other subject areas with me: ‘I have a C in maths already’ (George).

Yet, despite their abilities, reference was also made to the difficulties that the pupils had with understanding rules and expectations in the classroom. The Assistant Head at Epsom Boarding School stated:

> The constraints of the National Curriculum for Mathematics make it extremely difficult for mainstream teachers to cope with the demands of the individual pupil with Asperger Syndrome. I can give many instances of boys reporting

their experiences of mainstream mathematics education prior to attending his school as fraught with difficulties and misunderstandings with teachers.

A TA and parent of a boy at the school concurred, stating that 'pupils with Asperger Syndrome are unlikely to fit well into mainstream education. They are often misunderstood by untrained teachers and find it difficult to follow the rules appropriately'. However, this was not something that I noticed in the extreme and no pupil mentioned it. With reference to Table 11 above, it was established that school type alone was unlikely to be the sole determinant of full involvement with mathematics tasks.

Observations and discussions showed that they all had friendship groups outside the mathematics classroom. However, one common feature that all of the sets of respondents recognised was the difficulty that the pupils often had in forming friendship groups with others in their mathematics classes. The observations confirmed that none of them showed any interest in making friends from within their mathematics classroom peer groups. One TA commented: 'I have not once worked with a pupil with AS who wanted to interact with other pupils in the class'. Peter, (from Garford University) said that the reason for this could have been that they feared: 'falling out with someone in the classroom, who might subsequently go on to bully them or encourage others in the class to do so'. However, I could not be sure of this as, besides Peter, only one pupil gave this as a reason: 'I do not like to sit with him as he is disruptive and intimidating. He is the bane of my life' (George from Glebe Street Academy referring to the other pupil with AS in his class).

Notably, at one school, conflict resolution featured strongly in all aspects of the school day. I observed several instances where positive negotiation techniques were used and noted that, for their pupils, it appeared to be effective. Bullying was said to have been virtually eliminated as a result. At two other schools, behaviour modification strategies, that made use of praise for relative achievements, and ignored the occasional mistake, were also deemed to have had a positive effect on interest in and participation with mathematics activities for the pupils. However, some of the professionals and one educator commented negatively on this: ‘This strategy is largely ineffective for pupils with Asperger Syndrome. It often precludes them from successful engagement with mathematics teaching and learning’ (TA at Drake Academy). Yet, I found evidence in the narratives which suggested that certain strategies, while they may not have proven effective for one student in one setting, could work for him or her in an alternative one:

> My pupil has to have two pencils, one sharpener, exactly three pens, a rubber and his one special calculator in Miss Scott's class before he can get started, but when he is in mine he needs none of this.
>
> (Teacher at Chelsea Mill)

Here, a different teacher and an alternative teaching strategy were explained as the most important factors for the student. Appropriately timed positive reinforcement, in this case, seemed to improve outcomes with the acceptance by the educator of any achievement being better than none.

During observations, I noticed that all of the pupils were adept at slipping in and out of their classrooms unnoticed and at all schools, conversations between the pupils, teachers and TAs were rare. The pupils remained largely silent throughout lessons and most of the instructions given by the TAs were non-verbal. Usually they simply pointed at sections of text or wrote instructions down. These TA to student actions may have formed over time as a mechanism to ensure that attention was not drawn to the pupils.

In contrast to the idea that pupils with Asperger Syndrome do not have theory of mind, I suspected that the anxiety I observed in the pupils during social interactions could have been a consequence of oversensitivity to the states of mind of others. 'I have noticed that he often glances up or across briefly when the teacher or certain pupils say or do something. At these times he seems to tense up' (Diary Entry).

The teachers of mathematics and TAs at most schools, including the two from the pilot phase, were asked to comment on which characteristics they thought were most common in the pupils with AS. In agreement, they stated that their pupils were introverted, had few friends, lacked spatial awareness and, despite a generally higher than average mathematical ability, struggled with certain aspects of the mathematics curriculum. However, like George, the pupils seemed unaware of relative challenges with mathematical topics: 'I am in an Accelerated Learning Group and have already got my GCSE' (George).

Most of the pupils observed exhibited signs of weakness with organisation and motor skills. The professionals said that, in terms of speed and accuracy in solving mathematical problems, assistance was always necessary to overcome difficulties stemming from motor skills, organisation and working at speed.

One of the educational psychologists explained: 'The typical profile of Asperger Syndrome is late diagnosis, usually after exam results, often English and mathematics, which are far lower than expected' (Dr Linden). But at some schools, such as Glebe Street Academy:

> …school support teams identify areas of weakness in undiagnosed Year 7 pupils and implement strategies to ensure that the pupils are not disadvantaged as a consequence.

(Assistant Head, Glebe Street Academy)

This school had a purportedly effective team of Teaching Assistants who were extremely knowledgeable about the needs of the pupils with Asperger Syndrome. Their teaching strategies (discussed in the following section) appeared capable of facilitating appropriate mathematics learning in the pupils; this was given as the rationale for the pupils' above average exam results.

Complex Problem Solving and Reasoning

Eight pupils were observed engaging in problem solving activities using a mixture of resources. With some overlap, three worked from a textbook, three were involved with practical work, four with real-life scenarios and five from a worksheet. But, despite their similarities, the group of pupils studied for this enquiry did not all interact with mathematics learning activities in the same way nor did they show similar levels of confidence when working through problem solving tasks. Some were more outgoing than others and, accordingly, more inclined to ask for assistance.

Rote recall was only seen in two of the pupils. Both were confirmed by their educators to be of lower ability in certain respects than the other pupils in this study so their needs might have been greater than those of the rest: 'Ian is brighter than the others in his group but still struggles with most mathematical topics compared to others who have a diagnosis of Asperger Syndrome' (TA at Inglewood Farm). This suggested that it might only be those lower down the ASD scale who relied on rote abilities to compensate for deficits elsewhere: 'I am not entirely convinced that Dan has Asperger Syndrome. He seems unable to answer questions even on simple mathematics without prior prompting and often answers in a parrot fashion' (Personal Diary Entry). Notably, regarding these two pupils' reliance on rote methodologies, in one case, in the mechanical repetition of how to simplify surds (this not always correct), and in the other when discussing how to measure lengths of wood, neither could apply the mathematics with any real understanding of its meaning or significance.

Yet, to speed up the process of complex problem solving, a certain amount of memorisation and routine recall is explained as necessary to begin a task (Headteacher at Epsom). When given a problem solving task which required adaptation of prior knowledge, in all cases, the pupils lost focus part way through their work. Sometimes this appeared to be a consequence of novel questioning that may have required assimilation and accommodation of new information. So, if rote capabilities were not evident in the other pupils, maybe they were unlikely to be able to access and adapt prior knowledge to solve novel problems.

The majority of the pupils were said to have difficulties with generalising from the specific. All struggled with understanding conceptual questions bar perhaps Eli who I saw engaging with practical real-world problems, Pure A level mathematics and exam practice, (although I did not see him learning all topics). James gave an example of one of his difficulties with mathematics problem solving: ‘By the time I get to the end of a fake real-life question, I have forgotten the beginning’. This, he said, made him lose interest in tasks based around theoretical questioning even when they incorporated real-life scenarios that he liked.

All of the professionals reported graded levels of weakness in their pupils ranging from inability to understand theoretical concepts through to confusion over complex mathematical ideas: ‘None of my pupils, even those with a great deal of common sense, has ever been able to work independently on problem solving activities’ (Professor Raymond). Yet, almost all of the pupils in this study were unequivocally able to enter into intelligent conversation with me. They were also capable of responding to mathematical questioning and contributing to one-to-one discussions with originality. This was particularly evident in Eli and George:

> I can tell you about matrices if you are interested (Eli);
>
> I definitely want to go onto college – it might be maths but I think it will be in computing. I have already started teaching myself Java.
>
> (George)

The narratives showed that some of the students were able to calculate, and manage concrete work at an advanced level: Eli has always been good at maths. I don't spend nearly as much time with him as I used to. Now that he has progressed to A level, he is flying' (TA at Epsom Boarding School). However, contrary to reports about and from George and Eli, some TAs said that they did not do well in examinations. The propensity to write just the answers without working out meant that their grades were substantially lower than those of their peers. If the answers were wrong, which the teacher at Jodrell Community College said they often were, they lost all the marks:

> This is because the pupils choose the wrong methodologies for the more complex parts of the questions and then just write down the answer they have in their head[s]. Because of not showing the working, they don't gain any working marks.
>
> (Teacher at Jodrell Community College)

Discussions with the professionals and accounts from the pupils regarding what made them lose the impetus to continue with activities largely agreed with my observational findings. Questioning them, it appeared that they often had problems with understanding instructions, particularly when questions were presented in a novel way. This meant that it was impossible to complete some tasks without guesswork. From observations of three students including James, lengthy wordy problems containing ambiguous terminology, such as:

‘Rosie and the other red hens were chased by the fox again last week. They normally lay two dozen eggs a week, but because of the scare they only produced three quarters of their normal production. How many eggs did they lay?’

were typical of the type of question that they found linguistically unclear. While James had no difficulty with the vocabulary, he wanted to know: ‘Over how long were the eggs laid and how many hens were there?’ He did not understand that he only had to say how many in total over one week (last week). It was impossible to be sure without further research but it might have been difficult for him to filter out unnecessary information at critical moments. However, in the case of Ian, the TA at Inglewood Farm explained that:

> In terms of accessing and using lots of information in problem solving tasks, Ian can work out at speed the numbers needed for computer games but he is really hazy about basic arithmetic in other situations.
>
> (TA at Inglewood Farm)

This suggests that, for some pupils with AS, high levels of accuracy with problem solving tasks is not affected by working at speed with an assortment of fast pace data. However, even when Ian could find the answer to a problem, he could not explain his reasoning with clarity. As he was one of those who was said to have been and appeared to be, in some respects, of lower ability than most of the others, it could have been that he was using savant–like skills, although this was not clear.

Rapid Processing

In over half of the pupils, there was no obvious evidence of rapid processing. One professional's view on working at speed is that:

> Their major strengths are in mathematics, (but not shape and space), knowledge of vocabulary, spelling and definitions of words. My current student's main weaknesses are linked to processing information at speed, rather than memory and recall, with his foremost area of underperformance found to be reading comprehension (see Appendix 16). He is accurate when allowed to progress at his own pace though.
>
> (Dr King)

He went on to explain that a rare form of dyslexia causes the problem with comprehension and that he has not been able to find a way to speed up this process. But a parent of one of the case study pupils confirmed that some autistic people lower down the ASD scale are able to develop advanced skills in seemingly rapid processing at a very early age. Her youngest child, aged 4:

> …acts as my SatNav. Whenever we go to a particular venue more than twice, he can tell me the route and how far we have left as we drive along but he can't do anything else quite so successfully and I know his limitations.
>
> (Parent of Harry)

While two pupils did appear to have excellent recall skills in mental calculation tasks, there was no clear evidence that they were using processing skills said to be typical of mathematical savants however. In those who wrote just the answer without showing calculations, it could have been that they were using unconventional methodologies but it was not possible to tell. None of the case study pupils was asked to explain how they calculated mentally but, when asked to write down their calculation methodologies, they all needed prompts and hints on how to lay out the working. I was not sure if this was because they could not do it alone or that they felt obliged to mimic teacher taught procedures rather than show their own methodologies. Nevertheless, although I did not see any obvious demonstration of excessively superior mathematical rapid processing skills, the evidence often being implicit, neither did I see extreme weakness. Although they were slower in writing down answers than were the neurotypical pupils, this appeared to be a consequence of faulty motor skills rather than difficulties with mental processing.

One TA explained that, because of their unique capabilities in processing at speed, once they understood a problem, they found it ‘quite frustrating to have to wait until the teacher had explained it fully to the rest of the class’ (TA at Glebe Street Academy). I noticed in observation that, although few of the pupils looked at their teachers while they were being given instructions, there were fleetingly rapid glances at the board to indicate that they were listening at key moments during teacher expositions. I also noticed that, although they quickly lost interest in lengthy problems, they could scan short texts with speed before writing down an answer. This was a clue that they might have been processing some information at high speed and that, as long as the question was short, these fleeting glimpses were enough to absorb all the necessary facts for solving a problem. In the opinions of some educators, ‘a large proportion of these pupils become disengaged in some mathematics lessons because of a low boredom threshold’ (TA at Glebe Street Academy). Indeed, if such momentary or peripheral glimpses did allow them to gather a substantial amount of relevant information and understanding rapidly, waiting for the rest of the class to catch up could have been a primary reason for boredom and distraction. However, some were said to leave school with below average results because, in addition to the tendency to avoid showing working out, they sometimes found the pace of a typical mathematics classroom too fast. A TA stated that:

> Because my students are disorganised and find it difficult to work independently, they are sometimes relegated to lower ability streams where it is felt that they might be better off. There they can work at a slower pace and have a greater chance of success as there is almost always access to at least one other Teaching Assistant in each lower ability class.
>
> (TA at Inglewood Farm)

Yet, for one of the reported lower-achievers observed, the consequence of being in a lower ability group meant that, in my view, the classwork provided did not present sufficient challenge. Further 'being in this class [meant] that he [would] not be entered for higher mathematics examinations and this [could] ultimately impact on his future educational and employment choices' (TA at Arlidge Academy). However, it was impossible to know in such a short space of time if he naturally worked at a slow pace or if his mathematics educators had allowed him to.

<u>Perseverance</u>

I observed some pupils at times working through mathematics problems relatively effortlessly, and I had to assume that at least two of them were high achievers as both were taking early entry examinations in mathematics. Pupils' perseverance levels were reasonably high at four of the schools, (two specialist and two mainstream). In all of these cases, there was clear rapport between pupil and educator combined with apparent pupil interest in mathematics. Eli commented: 'I like it here. And I can do as much maths or art as I like'. Eli was the most confident and appeared to make the most progress as evidenced by his clear understanding of the tasks in all sessions. He was also the most communicative so maybe his advanced linguistic skills had allowed him to ask for help when needed.

While there were relatively high levels of perseverance with problem solving tasks in evidence in half of the other pupils in the study, these were not always clearly linked to mathematics learning. For instance, Dan's engagement came from spending just half of the lesson in the mainstream class and much of the rest of the day in the Unit: 'I love it in the Unit. I can play with my jigsaws and on the computer'.

Many of the pupils who were working without assistance were easily distracted, often by themselves. To exemplify, Ian stated: 'I'm not really interested in this stuff but I do like politics so would do the work then. I have no interest whatsoever in becoming a carpenter or anything to do with wood'. Throughout this enquiry, I found that, for a number of reasons, low levels of perseverance with mathematics tasks were common. In the case of Ian, who was particularly easily distracted, he often became sidetracked during basic mathematics lessons, even though they were practical and real-world based. Thus, he would spend the time discussing his main interests which, along with politics, included dogs: 'Do you have a dog? I don't but I intend to later'.

Findings from this subsection suggest that both difficulties with understanding mathematics and over-simplistic mathematics tasks can create the conditions that encourage distraction. There were several examples of pupils working independently where this was demonstrated, (see Appendix 14: Diary Entries). However, although this was comparable to the neurotypical pupil's response in similar circumstances, most of the professionals and one of the pupils in this study stated that, with help, it was relatively easy to get the AS learners back on track. Targeted support allowed the pupils with Asperger Syndrome to circumvent specific learning-related problems in the mathematics classroom and progress as much, if not further, than their peers: ‘My helper rephrases complex sentences and unfamiliar stuff for me. She is always there if I need her. But I don’t need her as much now that I am doing calculus which I am good at’ (Eli).

As a consequence of the findings here, it seemed to me that adaptive support practices could facilitate the development of mathematics learning skills and perseverance with tasks. To consider this further, the next section explores the various experiences of the pupils with AS relative to specific teaching approaches.

4.3.2: The Environment

This subsection reviews the findings from the practical data collection element of the study on the mathematics classroom environment. In the UK, most pupils were observed in their mainstream mathematics classrooms. However, as some professionals believed that pupils with Asperger Syndrome should be educated outside mainstream as in the USA, other observations took place in alternative settings. All of the policies provided by the schools in the UK and the USA on the ways in which pupils with Asperger Syndrome should be educated were informed by governmental guidelines and legislation. Most of the teachers and Teaching Assistants were fully supportive of the pupils with Asperger Syndrome although, as explained throughout this thesis, some of the individual educator’s beliefs about what Asperger Syndrome was differed from the advice given in their schools’ policy guidelines.

As previously mentioned, although resource provision is considered here, matters relating to school type have not been included in the analysis. Any information surrounding contrasting settings, such as mainstream or independent, is provided for contextual reasons only.

Assisted Learning

In seven cases, there was no interaction between teacher and pupil. At three of the schools, the pupils were largely left to work independently and this meant that at times they got into difficulty with some of the mathematical activities. The reasons given by the teachers for avoiding contact included limited understanding of the syndrome and a belief that it was 'solely the job of the TA to motivate and engage the pupil' (Teacher at Arlidge Arts Academy). At some of the schools where the teachers left the AS students to work alone, it was evident from the narratives that some of them based their planning (or what I perceived to be non-planning) for the students with Asperger Syndrome on the belief that their IQ levels were within the normal to genius range. Several supposed that the pupils were capable of working independently to a high standard under any circumstance. One teacher explained:

> He always seems to know what he's doing so I often just leave him to it. If he finishes early, then that's fine. As long as he has completed the work done by the rest of the group, no problem. I don't mind him just sitting there.
>
> (Teacher at Flynn Road)

In two of the schools, there was evidence, albeit marginal, that the pupils were independently able to work to their educators' broad mathematics learning expectations. This appeared to be a consequence of the relationships they had with their teachers. According to the TA at one of the mainstream with a specialist unit schools, a combination of the right support and teaching which incorporated a special interest was the key to facilitating development of appropriate mathematics learning skills:

> Geometry support involved making papier mâché dinosaur heads - with some tricky calculations - and then, [for one of these pupils whose special interest was in learning about syntax], presenting a one-page scenario to the rest of the class using imperatives, simple and complex sentences. Living geometry, living grammar and kids having fun. The two boys in question learn and succeed, accessing the same knowledge as the rest of the class and impress the class to boot. Now how's that for valued-added mainstream? However, luck of the draw. Same school, different teacher, last year. The pupils sat in the back of the class, disturbed no-one and stagnated. No investment, fear, no interest - I'm talking about the teacher.
>
> (TA, Drake Academy)

The teachers at four of the schools adopted a more hands-off approach, providing no personal support and leaving the pupils to work independently or with their TAs, where available. Only at three schools were there any interactions with mathematics teachers in evidence. The pupils in these cases appeared to genuinely appreciate the relationships they had with their teachers at all three schools. There was evidence of higher than average interest in learning mathematics albeit, for one, marginally. The teachers were fully involved with their AS pupils. At one school, the pupil was fascinated by the plastic animals and the interactive whiteboard used in the lesson so, although learning levels were minimal, interest in these particular mathematics tasks was great. At another, where the teacher was very much involved, there was a great rapport between pupil and teacher and this appeared to be a catalyst in encouraging the pupil regardless of teaching resource or topic. Overall, there were four male teachers in this study, two of whom had clearly defined supportive roles with their pupils. One of these teachers had a particularly special affinity with his pupil, sitting with him when he got into difficulty. At a different school with a supportive teacher/ TA mix, the teacher encouraged his pupil through fully inclusive practice by simply treating him like the other pupils in the class and asking questions of him as much as anyone else while the TA adopted a Vygotskian approach. The pupils certainly appeared more confident and more interested in a topic when there was teacher-pupil rapport in evidence. Most preferred working with the adults in their classrooms over other pupils.

Conversely, at the one school where the teacher of mathematics was transparently irritated by the pupil's perceived lack of expertise, stating: 'He never seems to be able to keep up with the rest of the class' (Arlidge Arts Academy), the pupil appeared to be aware of the teacher's animosity towards him. My view was that this could have been the cause of what seemed like heightened anxiety levels in the boy. He was also the least interested of the study group in mathematics learning, this possibly due to the simplicity of the task together with the attitude of the teacher. His physical dyspraxia was evidently at the root of his difficulty and his teacher seemed oblivious to this condition, citing his 'continual lack of perseverance' as, in her view, an unjustifiable problem.

At Chelsea Mill, where the teacher admitted personal weakness in mathematics stating that: 'I am employed as an all-rounder with History and English my strengths and mathematics as my worst subject', the pupil's levels of comprehension were variable. He had some difficulty in understanding the tasks and the teacher could not explain them. It was not clear whether his difficulty stemmed from his mathematical insecurity or from the confusing teaching style of his educator but I suspected the latter.

Poor behaviour and unwillingness to participate were reasons given by some of the teachers for making little effort to engage with the pupils. However, my observations suggested that the students were not being difficult. It was, my belief that the teaching medium was the catalyst. Group tasks or situations where self-directed study was required were shown to be particular areas of weakness: ‘I hate my stupid brain, it won’t think!’ (Peter from Garford University).

At the schools where there was the least evidence of participation with mathematics activities during lessons, the teachers and TAs were the least involved. Six pupils had a TA but just three worked well with theirs. Three pupils had no Teaching Assistants. Uniquely, one pupil had two TAs although they were shared amongst the group of 5 pupils. At one mainstream school with a unit, one TA was permanently assigned to the pupil regardless of subject. The TAs at two schools stayed with their respective pupils all day. Five pupils had one TA each. However, the TA at one school appeared to be assigned elsewhere and did not work with the observed pupil at all while the other four employed a Vygotskian style of ZPD support. Two schools employed TAs according to specialism. Each would be assigned to one student in one subject area and did not accompany him or her around the school. All of the TAs were female. As stated, at two schools, the male teachers managed the pupils well in terms of encouragement and support but, at another two, the female teachers did the same which suggested that teacher gender was inconsequential to this study. I suspected that teacher involvement might have been the reason that one TA’s detachment from the pupil with AS in her class. Another pupil had TA input but no interaction with the teacher. At one school, although the teachers were different throughout the day, the TA remained constant in mathematics. One school employed an in-school psychologist who was always on hand should a pupil need time out.

This school also employed a male corridor monitor so that anxious students leaving classrooms could be:

> accompanied to other learning zones. These can be anywhere in the school or grounds. I am a mathematics specialist who is employed for the explicit purpose of engaging 'runaway' pupils in some kind of practical mathematical activity no matter where they are. Mathematics as a topic was selected because the Headteacher believes it to be the subject most likely to engage the pupils and reduce their anxiety.
>
> (Monitor, Epsom Boarding School)

Once, I observed the monitor taking photographs with a pupil who had earlier run out onto the field. This 'morphed' into a lesson on ratio and enlargement in which the pupil very quickly became absorbed, seemingly instantly forgetting his earlier distress.

Conversely, at one of the mainstream schools, flexibility was not an option:

> When the bell rang to warn that the next lesson was about to start, George bumped into the trolley that was not in his way, sending reams of paper into the air. The incident left him in a state of great distress but his TA took him to his next lesson regardless. (Diary Entry)

During the pre-pilot stage, another pupil was observed in a similar state of unhappiness, this time prompted by a change of seating plan. Despite his age, he spent the entire lesson crying, and was only once visited by the teacher who hastily retreated when it transpired that the only way she could solve his problem was to allow him to return to his usual seat. This she was not willing to do as she saw it as ‘backing down’.

In the two schools where specialist mathematics TAs were employed, both had comprehensive support systems in place for the pupils and both Teaching Assistants were fully involved with their respective pupils when needed. One school had a roughly equal balance of teacher and TA input with the pupil rarely left to his own devices. This appeared to be particularly effective. Both TAs circulated their classrooms, and were ostensibly shared amongst their groups so, in each case, although there was minimal and occasional input, it was tactically planned according to need: ‘We are advised to circulate rather than remain with the pupil. Additionally, we are only with them in maths lessons so that they can maintain their independence’ (TA at Glebe Street Academy). Rarely did these TAs sit next to their students and my observations suggested that the pupils benefitted more from this approach than when provided with intense full-time support. A personal view was that it made the students feel less conspicuous and accordingly they found it easier to merge into their groups. To explain the ZPD practice further, at Glebe Street, the reasons given by another of the TAs for using this strategy were:

> Firstly, the pupils do not like to draw attention to themselves; secondly, most of the time they do not need assistance; and thirdly, constant support does not promote independence.
>
> (TA at Epsom Boarding School)

All of the professionals and some of the pupils commented on the benefits of TA provision, even those who had had little training. They were described as vital to ensure that the pupils could overcome hurdles, work at a similar rate and achieve as much as their peers. The most effective TAs were reported by the in-school educators as those who had added specialisms in mathematics and conflict resolution.

The TAs at half of the schools were very much involved. At the schools, (one mainstream with unit and two specialist), where the pupils and TAs worked well together, the respective pupils appeared to be highly motivated and worked solidly throughout their mathematics lessons. At the last Ofsted inspection of one of the schools, particular reference was made to the support given by TAs:

> Teaching assistants provide skilled support in lessons. Members of staff have a clear overview of pupils' individual education needs and there is a seamless approach to the 24-hour integrations of the residential provision and education.
>
> (Ofsted, 2010)

One parent, (also a TA at the school) added: 'This school provides my child with the best education possible. At long last he is happy to go to school' (Epsom Boarding).

Observations at several of the schools showed that not all TAs were fully supportive however. Those who could not understand the mathematics tasks themselves sometimes simply removed the pupils from the classroom when the work was beyond them; then, according to one TA 'the problem went away' (Drake Academy). Another TA's limited mathematical expertise meant that she repeatedly misinformed her pupil. In the special needs unit at her school, teaching methodologies were variable, not just because of the apparently inadequate mathematical knowledge of the teaching assistants but also of the unit's teachers. According to one pupil's sister, some of those assisting the pupils with Asperger Syndrome completed their work for them, maybe 'to make their own lives easier, [which did] little to encourage independence'.

> And, of course, these pupils are all too willing to let this happen – it allows them to retreat into their fantasy world for longer periods of time. It's a stress management tool.
>
> (Peter)

Only half the schools employed TAs specifically for the pupils with AS. This was a surprising finding as pupils with AS can 'sit for the entire hour in the most raucous of classrooms saying nothing and moreover, without guidance, doing nothing' (Pre-pilot Diary Entry). Peter's experience of mathematics classroom support was variable:

> The theory is that a mainstream school should have enough support staff and differentiated teaching and all that, but in reality, schools don't have all that and that is why I struggled.

Prior personal experience confirmed that there were not always enough members in support teams to assist all of the pupils all of the time and when TAs were absent, there was rarely cover provided which left the pupils in a vulnerable position.

Finally, my observations demonstrated that, where TAs were provided, there was rarely any interaction between teacher and TA. It appeared that the teacher and TA each had his or her own agenda and there was little knowledge of the other's objectives. The teacher at one of the schools commented:

> If you're asking me to be totally honest, I would say that the reason that teachers like myself find that TAs reduce stress levels is that you can get them to take out the disruptive element and let us get on with teaching.
>
> (Teacher at Arlidge Arts Academy)

Others left the TAs to their own devices citing time as a constraint:

> I never had the time to show my appreciation of the TAs in my classroom; and, worse, I found it extremely difficult to get a minute to discuss my plans for the lessons that they were to be involved in.
>
> (Teacher at Inglewood Farm)

The narratives indicated that some teachers avoided contact with the pupils with AS simply because they either had TAs or because they were insecure in their knowledge of how to support the pupils. Notably, severe teachers and TAs were shown to have a very negative effect on the pupils with Asperger Syndrome, tending to limit the pupils' involvement with genuine mathematics learning. This was irrespective of topic or teaching medium.

<u>Group Work</u>

One notable point of interest which emerged from the narratives was the common notion of underachievement in pupils who worked alone: 'When he is working independently he definitely underachieves. Without guidance, he can sit all day doing nothing much' (TA at Arlidge Arts Academy). Significantly, when I compared levels of participation with mathematics tasks for pupils with AS to those in the neurotypical groups in their classes, they were certainly lower. Four of the pupils stated that they preferred to work alone and observations of the others in their mathematics classrooms indicated that, rather than engage in social interaction, they too tended to avoid contact. All pupils, when they could select where to sit, always chose the back row, or as near as they could get, and the majority sat alone. One sometimes sat with another member of the group and one always sat next to another pupil with Asperger Syndrome, this engineered by the TA and not through choice: 'I don't like him and he doesn't like me' (George). Only at this school were the two boys with Asperger Syndrome working together for the entire lesson: 'They have to sit together so that I can help them at the same time' (TA at Glebe Street Academy). There was no conversation between the two and, as indicated, it later emerged that there was some animosity between them. One said that the other was intimidating and 'by being made to sit together, I am made to appear as though I am similar to him in behaviour' (George).

There were several reports of bullying in the educators' narratives, even apparently amongst the autistic subgroups, and this was said to be an instrumental factor in the evident lack of participation in group work. One of the educators explained that 'some pupils target others who show any type of weakness, not only in normally developing communities but also within the groups of pupils on the autistic spectrum' (TA at Drake Academy). Another stated that 'this can have a particularly adverse effect on the pupil with AS but we make use of a system to avoid these sorts of conflict' (TA at Epsom Boarding School).

There was no evidence at any of the schools of the pupils with AS successfully managing group activities. This indicated that, in addition to intrinsic difficulties with mathematics learning, they were further disadvantaged in their refusal of opportunities for peer support. However, enforced interaction with their peers, far from maximising potential, was found pre-pilot to significantly limit the learning of mathematics. One lesson, incorporating functional mathematics, required the pupil to cost the construction of an outdoor swimming pool with his team. The pupil sat on the periphery and refused to get involved. And, common to general findings in all schools, the rest of his group made no effort to include him. While the neurotypical pupils at his school were observed discussing problems with their peers, the pupil with AS never did and this could have been a reason for his 'lower than average skills with problem solving' (Teacher at Margaret Barclay School). It was clear that the enforced group activity did not achieve the levels of engagement that the teacher had hoped for. Michael simply refused to participate and became increasingly distressed as the lesson progressed. It made me feel extremely uncomfortable and it was difficult not to intervene.

When working in groups, one common theme that emerged was that the pupils were unhappy if a group was imposed upon them. Some said that they liked to work alone and others with their friends but none liked to work with a randomly selected group of pupils: ‘I don’t mind working with my friend but I don’t have anyone in this class or even at this school’ (Andy). The narratives revealed that they actively sought to sit alone and work in silence. Like the statement by George earlier, Ben wrote: ‘I don’t like other people in my class and they don’t like me’ (see Appendix 14.2). One mention was made of the preference for working with adults and my observations confirmed that most were more inclined to converse with and work with adults than their peer groups. However, this was only true when there was a clear rapport between the pupil and the teacher or TA.

The students seemed to enjoy mathematics providing that they could progress at their own pace. But the group work situations did not usually allow for own pace working, particularly if the other members of the team are working at a faster or slower rate. Additionally, when there was a great deal of activity and noise, as is typical in group tasks, the end result could have been increased anxiety and thus loss of concentration. If, as has been suggested, they are hypersensitive to noise, (Assistant Head at Epsom Boarding School) then group work could have been overwhelmingly distracting.

Practical Mathematics

Only at Hamilton Road School and Inglewood Farm were entire lessons based around practical mathematics. Both of these schools' intakes comprised mainly students with low-functioning and classic autism (with the occasional AS student, according to the Headteachers). At Hamilton Road, the staff seemed to have excellent awareness of the capabilities of AS pupils but, despite this, according to Harry's mother, 'levels of learning were quite low due to over-reliance on low-level teaching tasks such as simple counting and grouping'.

Conversely, Tarsia style and computer-based mathematics lessons were both suggested by the pupils in the pilot phase as effective teaching methodologies to enrich their experiences in the mathematics classroom:

> '[Tarsia puzzles are] challenging and interesting' (Andy);
>
> 'I love computers and I can type better than I write' (Ben).

In both cases, a possible explanation could have been that there was no need to write anything down. Handwriting was reported as and observed to be a significant problem for many of the pupils (see Appendix 5: Student Charles' Classwork). Poor coordination, dyspraxia and organisational difficulties were evident in most and all of these could have been the cause of untidy and badly organised written work. There was just one pupil out of the ten who appeared to have good visual-spatial skills. This was Dan, whose special interest and talent was in completing jigsaw puzzles. Observation of him working on one showed that his fine motor skills were excellent. However, it may have been that targeted coaching had helped him to gain these skills. According to the Headteacher at Hamilton Road, it is possible to overcome spatial and motor weaknesses: 'Harry has been trained over a substantial period to overcome his spatial difficulties; otherwise he too would struggle with some practical activities'. At another school, rather than ignore problems of spatial awareness, practical geometry was incorporated into most lessons to facilitate mastery with this part of the curriculum. However, even the pupil at this school had difficulties with both fine and gross motor skills. Practical tasks requiring motor dexterity were said by some TAs to be demoralising for them. One stated: 'my pupil finds it embarrassing to be unable to write legibly' (TA at Arlidge Arts Academy) and one pupil said that 'motor problems cause me pain. My hand and arm begin to ache if I have to write and people laugh at my writing style' (George). One of the professionals explained that his experience of the condition suggested that the pain was a consequence of the strain of trying to write legibly.

Motor control deficits were noted in several pupils, Andy with his colouring in difficulties, (see Appendix 4), George when he knocked over the trolley of papers, Harry struggling in manipulating plastic animals for grouping, and Ian in the woodworking shed. One further pupil, Charles, was said to have had great difficulties with physical control in lessons. Student Peter vividly recalled an incident from a practical mathematics lesson some years earlier. The lesson involved measuring reaction times by dropping a ruler and timing how long it took to catch it:

> I hated that experiment. I kept missing or dropping the ruler and my results were so far removed from the others in the class that I looked stupid and my group found it hysterically funny. I wanted to die.
>
> (Peter)

At the specialist boarding school, the Head reported:

> None of my pupils with AS like sport for reasons interpreted by my teachers as stemming from motor weakness, and so sports such as football have been

> removed from the curriculum in favour of snooker and rock climbing. Both of these are linked to the geometry part of mathematics curriculum, which is another area of weakness for the pupils.
>
> (Heat at Epsom Boarding School)

Although the pupils were said to have difficulties in these areas too, they enjoyed them more as they did not have to demonstrate team skills so were more inclined to persevere.

Finally, in respect of computer-based mathematical activities, in all schools, the pupils observed working on them quickly became distracted from the tasks in exactly the same way that they might when working through a standard textbook problem. At one of the specialist schools, the pupils with AS could not understand the instructions for the personally chosen computer-based individual tasks and, without teacher input and no TA to help, they all floundered, (see the *Rosie and the Eggs* problem above). All became agitated when working alone on these tasks, most getting more and more anxious as the tasks became increasingly difficult. Eventually the entire AS group lost interest and refused to complete the work, with James reverting to the textbook which he saw as easier to manage:

> The first three questions I understood. They were easy. But now I am stuck. I keep getting the wrong answer and can't move on because of it. With the textbook, I can just skip the question if it's too hard.
>
> (James)

The observation that most of the pupils could spend an entire lesson on one question, as the software would not allow the participants to move on until the question was answered correctly, was certainly, in my opinion, an inefficient and ineffective use of time. The pupils observed working in computer-based learning environments were just as confused as those in traditional classroom settings and there was no observational evidence that the participatory learning outcomes were any different. All of the pupils demonstrated confusion with finding the appropriate strategies needed to answer the questions correctly. Their approaches to problem solving largely involved random guesswork and repeated use of the same incorrect methodologies. And for multiple-choice questions, they simply randomly selected answers without any thoughts of planning, organising or sequencing.

Another pupil spent his time searching the Internet for topics of personal interest rather than completing the required mathematics tasks. And, because some mathematics lessons in the Unit at one school consisted of simply playing computer games, with no input from the staff: 'Fridays are DS days. We are allowed to play on the DS Nintendo hand held computers during mathematics sessions', there was no external encouragement for Dan to work on any practical mathematics tasks.

Real-World Learning

Real-world teaching was fully embedded at four of the schools and marginally applied at most of the others. Inglewood always taught mathematics from a real-life perspective in various settings from the pottery studio to the woodworking shed and the students went on to sell the items they made in their own shop. This idea was devised to ensure that the students would all be able to manage in real-world situations once they left school or college. However, at this school, where the mixed age group students were in the woodworking shed practising measuring skills on pieces of wood for the band saw, as previously mentioned, the pupil with Asperger Syndrome continually distracted himself from the task by talking to me about anything but the work. This was partly, I believed, a consequence of the task's over-simplicity.

At another school, provision included the teaching of real-world practical mathematics from a historical perspective. The TA stated that this method of teaching benefitted all of her AS students. According to her, they were all fascinated by the origins of mathematical topics and learning about subject specific terminology. Examples of this style of teaching and learning included:

> teaching mathematics from the point of view of the early mathematicians. For instance, an introduction to geometry begins by explaining that it arose through a specific need in ancient Egypt, the re-establishment of planting boundaries after the great Nile flood and goes on to define the word geometry: ''geo" stands for earth, and "metry" for measure.
> (TA at Epsom Boarding School)

Real-world teaching appeared to be the most successful strategy for promoting interest in a topic provided it was realistic and practical. Lengthy, pseudo-real-world questions such as the one about *Rosie and the Eggs* seemed less likely to interest the pupils. At one school, the pupil was far more involved with the section of the lesson that was based around running a shop than the part that comprised working from a textbook. Even though some of the questions in the book were written in such a way as to purportedly imitate real life scenarios, their superficiality seemed to be something that the pupils with Asperger Syndrome were uncomfortable with. It was explained that, as for many visual learners, the pupils engaging in real-life practical work found mathematics learning easier if they were able to recall genuine mental images: 'I like it when we do real-life work that covers other subjects like art too. It makes it easy for me to remember' (Eli). However, when the real-world practical tasks incorporated group work, as observed in the pre-pilot functional mathematics lesson, the AS pupils were unlikely to participate. Thus, it appeared that practical real-world activities were constructively supportive of mathematics learning but not when they were contrived or involved other pupils in group work.

4.4 Summary

To summarise the major findings:

- All of the case study pupils showed some sign of impairment as noted in the DSM-IV (1994) and DSM-V (2013)
- All pupils sat at the back of the room if they were not teacher or TA directed
- They all sat alone except for one case when the pupil was told by the TA to sit with another pupil with AS and one pupil who sometimes chose to sit with a friend
- Most of the sessions in six schools were didactically led
- The majority of the sessions in six schools were worksheet and textbook-based
- In four schools, all sessions were practical and incorporated real-life scenarios. These were creative, sometimes one-to-one and often involved technology
- All pupils exhibited difficulties with complex problem solving activities and reasoning
- Rapid processing was not directly observable but most were not able to work at speed either on paper or via the computer
- There was no real evidence in any of the pupils of savant capabilities
- Eight out of ten professed to, or appeared to, enjoy mathematics

- The pupils were most interested in real-life practical mathematics
- Six out of ten pupils remained on task (some with support)
- Four of them received targeted help to complete the tasks
- Only one pupil appeared to work successfully independently
- No-one wanted to work with a group
- Just two pupils were reported to achieve outcomes on a par with the rest of their groups
- It was said to be possible to remedy spatial awareness difficulties with ongoing specialist training
- Only in three instances was there any interaction with the class teacher
- Half of the pupils had dedicated TAs all of whom were female
- Three of them worked well with their TAs
- Computer mathematics was no better than a textbook resource in improving mathematics learning skills
- Mathematics specialist TAs were the most able to support the pupils in the development of appropriate mathematics learning skills

Significantly, at the two schools in the study, where the TAs were mathematics specialists, the pupils appeared to be supported the most in all sorts of ways regardless of mathematical topic, teaching strategy or environment. According to the analysis, interaction and development of mathematics learning skills were the greatest where all members of staff had been trained in how to manage aspects of behaviour associated with Asperger Syndrome and where there were various types of mathematics teaching specialists (TAs and teachers) on hand at all times. Lessons that did not adhere rigidly to the National Curriculum and incorporated, for instance: animal husbandry, photography, alternative sports or even computer games seemed to improve interest in mathematics learning. However, while this combination of strategies appeared to work best in unison, I was aware that some might not have been practical in a mainstream school (Assistant Head at Epsom Boarding School). Yet, there were opportunities for individualised teaching and learning in mainstream mathematics lessons as noted at some of the schools where the pupils were provided with targeted assistance.

It appeared that pupils with Asperger Syndrome could be taught largely the same mathematical materials as the rest of their peer groups albeit with specialist support. Perseverance seemed to largely depend upon the assistance received from mathematics specialist Teaching Assistant. Yet, in mainstream education, although TAs allowed for personalisation and differentiation, they sometimes provided alternative rather than additional support. Further, certain types of TA support were found to encourage separation and dependence as seen at certain schools where the TAs were not trained in mathematics and were solely attached to the pupil rather than circulating. These TAs tended to concentrate more on task completion than developmental opportunities and academically demanding tasks. In summary, the specialist TA, mathematically trained was more successful than the all-rounder normally assigned to the pupil. The pupils were certainly more confident and appeared more able to work independently when this type of TA was available when required.

The findings emerging from the practical research period have led to a comprehensive understanding of the mathematical difficulties encountered by pupils with Asperger Syndrome. They have provided, for me, an insight into how certain environmental issues and teaching methodologies can contribute to development of learning skills in the mathematics classroom. The pupils in this enquiry all had academic potential and those who had personal IEPs (Individual Education Plans) appeared able to achieve as much as their peers with targeted support. Teaching and learning strategies explained in some of the narratives as able to assist the pupil with AS in mathematics lessons are summarised below. Most of these are not topic specific:

- Changing parts of the mathematics curriculum to suit
- Provision of the right type of teacher
- Provision of a suitably trained mathematics specialist TA
- Allowing the pupils with AS to work at their own pace
- Allowing them to work alone as necessary
- Incorporating certain digital technologies with personal support into the lessons. However, there is evidence that, while computer-based work alone can initially be motivational, it is not solely responsible for supporting development of mathematics learning skills
- Basing practical mathematics lessons around genuine real-life concepts
- Being given a challenge (although only the pupils say this. It would probably have to be the right type of challenge and not a ‘wordy’ problem).

The next chapter discusses the findings from this section in greater depth and returns to the literature to establish if findings from my practical data collection phase match those from any previous writings. This is then followed by conclusions based on both the Analysis and Discussion chapters.

Chapter 5: Discussion

5.0 Introduction

The overall aim of this enquiry was to determine what mathematics learning is like in the classroom for secondary aged pupils with Asperger Syndrome. Part of the focus was to establish how instrumental psychodynamic and environmental factors could be on the mathematics learning experience for AS pupils. The practical elements of the research and subsequent analysis were informed by decisions made following the literature review to verify or counter findings from previous research and to fill the gaps in the work of other researchers. Below, I critically appraise the works of some of these authors in light of my findings.

Within existing literature, I found that researchers such as Asperger (1944), Barber (1996) and Bölte et al. (2010) had explored individual elements of somewhat complex strategies for teaching pupils with Asperger Syndrome. In reviewing some of their work, none appeared to have specifically investigated how the entire framework of dynamic factors feeding into the contemporary mathematics classroom might combine to shape the experience of mathematics learning for pupils with Asperger Syndrome. My intention, therefore, was to examine the mathematics classroom from the viewpoint of the modern AS pupil with particular foci on the interactions between innate (or self-directed) processes, the learning environment and the pupils themselves.

Much of the early work for this research project involved looking at descriptions in historic and contemporary research literature of the variety of symptoms associated with Asperger Syndrome (Rodd, 2015). Subsequently, I visited schools to ascertain whether or not the condition's symptoms could be defined as absolute (Asperger, 1944; Rodd, 2015). It was extremely important that the pupils selected for my study conformed to a standard definition of AS. As I was intending to show what life in the mathematics classroom was like for a pupil with AS, the findings needed to relate only to this one group of pupils with a shared set of needs. Yet, arriving at a definitive comprehensive set of common traits proved to be a challenge and to some degree outside the scope of this study. It was particularly problematic given the controversy over the issue around diagnosis and treatment discussed by clinicians and researchers from psychology and other fields (such as Attwood (2007); see also Table 1).

Some researchers, Asperger (1944) for instance, proposed that within the autistic group alone there are greater differences pupil to pupil than similarities while others argued that there are few, maybe just relating to motor skills (Schopler et al., 1998). While Asperger (1944) believed that motor clumsiness was synonymous with AS, Lyons & Fitzgerald (2005) suggest that motor deficit can be found in pupils with all types of ASD. However, it could be argued that the findings of Lyons & Fitzgerald (2005) came through targeted selection of, or even misdiagnosis within, the study group (Attwood, 2007). For me, there was no way to determine the reliability or validity of their study. Their research, or indeed any of the studies I reviewed, could have been founded on data from pupils with AS or a mix from across the spectrum.

Adding to the challenge, I discovered that it is believed that there are even wider ranging characteristic differences just within the AS subgroup (Asperger, 1944) than are found in other autistic and neurotypical groups (Rodd, 2015). Because of this, I inferred that I might not be able to find a way through observation alone to decisively distinguish the pupil with AS from others on the spectrum. However, during the course of the initial part of the study, I was able to identify certain key characteristic qualities said to define ASD pupils and this somewhat simplified the categorisation process for me.

Comorbidities aside, Asperger (1944) argued that good verbal skills in conjunction with weak motor dexterity were clearly defining features of Asperger Syndrome (Klin et al., 2000). Schopler et al. (1998) further suggested that the major differences between AS individuals and others on the continuum were that all autistic individuals with poor motor skills, impaired executive function, higher IQ and pedantic speech should be labelled as having Asperger Syndrome and, if not, then they had to lie somewhere else on the scale. The majority of my pupils exhibited idiosyncratic motor and verbal skills (ibid.; Klin et al., 2000) but, although I could make comments on IQ and executive function these qualities were not easy to measure in the time I had available so discussion of these too is outside the scope of this study.

This chapter begins by addressing how the material arising from my practical research phase compares to the accepted philosophy on teaching mathematics to AS pupils. The personally interpreted findings from the data accumulated are critically appraised and supported by pertinent theoretical research literature. A summary comprising a selection of significant personal theories to verify, counter or expand upon the results of previous research studies forms the second subsection. Here, based upon the evidence, I provide a comparative overview of various teaching and learning strategies used to shape the mathematics learning experience for pupils with Asperger Syndrome. Through the analysis of the case data, several significant themes emerged in respect of: the pupil, the National Curriculum for Mathematics and the learning environment. These themes are carried through to this chapter and form the main body of this part of the work, namely: common pupil characteristics; complex problem solving and reasoning; rapid processing;

perseverance; assisted learning; group work; practical mathematics; and real-world learning.

In the penultimate section, I explore some of the limitations that might have influenced the outcomes of this research and justify choices made. These include challenges relating to sampling and the methodology, omissions and anomalies. Finally, I offer recommendations for expansion of the study to cover areas pertinent to but beyond the scope of this study. These include research into the use of alternative and more contemporary digital technologies in mathematics teaching and learning. Conclusions emerging as a result of this study are to be found in the final chapter.

5.1 The Relationship between my Findings and Existing Research

To support the main research question, the two subquestions, repeated below, are:

a) How compatible are some of the common traits attributed to pupils with Asperger Syndrome with contemporary mathematics teaching and learning strategies?

b) What aspects of the secondary classroom environment could be perceived as supportive of mathematics learning for pupils with Asperger Syndrome?

These questions have been addressed in the following subsections, with subheadings originating from the Analysis chapter added for clarity.

5.1.1: The Pupil

<u>Common Characteristics</u>

Observations of the pilot case study pupils' gait and classwork, confirmed to me that they probably had weak motor skills, gross and fine (Klin et al., 2000). They both appeared physically and emotionally fragile. They were verbally capable and appeared to have higher than average intelligence (Frith, 1991) but they were generally unable to complete tasks independently (Attwood, 2007). They had some problems with organisation during mathematics activities (NAS, 2015) and I found that their speech was overly formal, particularly for their age (DSM-V, 2013). In a number of ways I considered their traits very similar to this pupil's:

> His posture was slouched, his shoulders slumped, with the shoulder blades protruding. Otherwise his appearance was unremarkable […] Most of the time, he spoke very slowly, dragging out certain words for an exceptionally long time.
>
> (Asperger, 1944:42)

The questionnaire responses of the two pilot study pupils alongside the accounts from professionals and Peter, the university student, provided support for some of the significant definitions found through the literature review of characteristic traits in pupils with Asperger Syndrome. These included lack of enthusiasm for group work (NAC, 2009), trouble with forming relationships in the classroom (Morris, 2008), but a preference for computer-based activities (Jackson, 2002), and an overall interest in mathematics learning (Baron-Cohen, 2008). Despite certain variations in character (Asperger, 1944; Rodd, 2015), these attributes alone minimally indicated to me that the pupils were distinct from other groups on the spectrum (Schopler et al., 1998) and this allowed me to enter into the study with a certain degree of confidence in my ability to recognise AS from the outset.

To concur with Asperger's (1944) and Schopler et al.'s (1998) and contrary to Lyons and Fitzgerald's (2005) definitions of AS alone, I did find evidence during my preliminary observations, of pupil-to-pupil similarities within the AS subgroup such as awkward mannerisms and movements (DSM-IV, 1994) that I did not see in others on the spectrum. In addition, in determining if the pupils had AS or lay somewhere else on the continuum (Barahona-Correa & Filipe, 2016), I noticed through observation that pupils from other autistic subsets, (although not the classically autistic), in general tended to be more gregarious and less anxious than those in the AS group (Pomeroy, 1998; Nordqvist, 2015). However, despite qualitative differences of character such as degrees of self-confidence (Attwood, 2007), I found as the study progressed that motor dysfunction was an observable way of recognising pupils with AS from the start (Asperger, 1944).

Furthermore, contrary to the assertion in the DSM-V (2013), some of the AS pupils from the study group did want to engage in discussion about their achievements in mathematics and other areas of the curriculum. Some of them such as George and Eli even initiated the conversations (Volkmar & Klin, 1998), were keen to talk about their special interests and engaged in two-way discussions (Lyons & Fitzgerald, 2005). These findings were clearly in contrast to Frith and Happé's (1994) account of people with Asperger Syndrome talking one-sidedly about their special subjects. It did appear true, as Frith states, that AS students are 'distinguishable from others on the spectrum by a desire to communicate and be part of the social world…' (1991:20). But I question her observation that 'their desire to communicate is often demonstrated in their tendency to talk incessantly about their pet interest' (ibid.:21). I found that they did not talk unremittingly about just one topic (Szatmari et al., 1989). Most did listen, responded to questions and were able to enter into conventional dialogues (Symington, 2008), albeit, for some, reluctantly (Asperger, 1944). Moreover, as the exchanges with the pupils demonstrated, they all had more than one, sometimes many, interests (Asperger, 1944; Jackson, 2002). They were genuinely able to enter into an intellectual discussion on a given topic with some level of expertise (ibid.) rather than, as suggested by Snyder and Mitchell (1999), simply mechanically.

Furthermore, contrary to Frith's (1991) view that pupils with AS lack common sense, I found no evidence to support this; and while Schopler et al. (1998) say that AS pupils can find the learning of mathematics challenging, I heard or saw nothing to indicate that the pupils themselves felt disadvantaged. In conversation with the majority, they appeared to be fully capable of understanding the world around them and how they fitted into it (Van Krevelen, cited in Williams, 1995). Finally, in contrast to Asperger's (1944) suggestion that intrinsic motivation would be lacking, while I was not researching specific reasons for their interest in mathematics, most of the pupils did demonstrate clear enthusiasm for learning the subject (Baron-Cohen et al., 2001).

The conclusions from the initial part of the enquiry suggested to me that, despite the gap in time since Asperger's work with the AS pupil (1944), there were more similarities than differences between his group of pupils and mine. While it was not possible to categorically state that one comprehensive set of characteristics clearly delineated the pupil with AS, some fundamental qualities such as weak motor skills (Schopler et al., 1998; Klin et al., 2000) and idiosyncratic use of language (Asperger, 1944, Wing et al., 2011) appeared to still exist. These traits were clearly evident in eight out of ten pupils in my study.

On balance, since the work of Asperger (1944) and Frith (1991), maybe the few differences between their pupils and mine in relation to common sense and motivation, for instance, were simply a consequence of differentiated and targeted, personalised support in the contemporary classroom (Bedford, 2010; Walter, 2012; Mintz in Miesenberger, 2014). However, I did wonder how previous researchers had decided upon whom to include in their study groups and whether this could have accounted for the differences. Had they selected AS individuals only or had they included others from across the spectrum? This was not something that I could determine nor was an investigation into their practices part of my study. Nevertheless, I was aware that the discrepancies in AS definitions that I encountered during the literature review could simply have been a consequence of their individual choices.

Moving on to the main part of my study, The National Curriculum for Mathematics (2013) is reviewed in the following subsections with some of the issues already mentioned revisited and linked to its specifications.

Complex Problem Solving and Reasoning

The National Curriculum for Mathematics (2013) proposes that adaptability is necessary for complex problem solving tasks. Yet, I found little evidence in the pupils observed of either adaptability (ibid.) or the ability to focus to the exclusion of all else (Frith, 1991). Kennedy et al., (2006) highlight self-distraction and the DSM-V (2013) identifies aversion to change to explain my observation of pupils at an impasse, unable to continue with a task without appropriate guidance (Alborz et al., 2009; Blatchford et al. 2009). The DSM-V (2013) further suggests that for pupils with Asperger Syndrome, their adherence to rigid routines means that flexibility is not a common trait. Frith (1991) expands on this idea, saying that flexibility requires the ability to focus which, she says, is not easy for AS individuals. As the majority of the case study pupils were regularly distracted, the work of Frith (1991), Kennedy et al. (2006), Hale (2008) and the NAS (2015) on the subjects of distraction and inflexibility seem to supports the finding. Four of the study group spent a large proportion of each lesson talking with me about their interests or seemingly focusing on anything other than the task (Asperger, 1944; DSM-IV, 1994; DSM-V, 2013). For example, at times Ian was distracted because of, according to him, his lack of interest in the lesson's topic and at others through a desire to discuss his outside interests.

Just three of the study pupils were fully engaged with the mathematics activities most of the time, and this was regardless of how complex or superficial the tasks appeared to me to be. This finding might initially appear to contradict Asperger's (1944) argument that pupils with AS find everyday mathematics dull and Attwood's (2007) that the more complex a task, the more difficult the pupil with AS finds it to concentrate. However, my observation only applied in 3 out of the 10 cases and could have been simply because, for these pupils, mathematics as a whole irrespective of topic was of special interest (Jackson, 2002). Spending such a short amount of time with them and knowing little of their past prior to secondary school, it was not possible to state with conviction the reasons for the differences in engagement with mathematics learning (Baron-Cohen et al., 2001). Although, most of the pupils said that they liked mathematics, I could not conclude that a preference for mathematics in itself was the only and definitive reason for enthusiasm and perseverance. Asperger (1944) says that when lessons are linked to an area of special interest (Jackson, 2002), performance levels can be extraordinary, but, based upon the narratives, it was my view that early and ongoing support and training (Bedford, 2010; Walter, 2012) had contributed to their ability to persist rather than any other factor.

In respect of the rest of the study group, as Asperger (1944) also states, not all of the pupils who liked mathematics had perseverance levels to match. I noticed that for the pupils who appeared distracted and anxious (Asperger, 1944; Kim et al, 2000), this was always when they had been provided with seemingly novel tasks. Perhaps dislike of change (DSM-IV, 1994; DSM-V, 2013; NAS, 2015) had affected the ability to adapt to unfamiliar mathematics questions (FPLD, 2002). According to Inhelder & Piaget, (1958), in order to modify existing knowledge (National Curriculum for Mathematics, 2013), they would have had to combine the novel elements of each question with prior knowledge, and adapt accordingly. In light of this, maybe for a significant proportion of the study group, the inability to adapt was a causal factor of complex problem solving difficulties (DSM-V, 2013). A number of the pupils who were observed working on tasks for which prior knowledge had to be modified (Inhelder & Piaget, 1958) all struggled at some point during the process. Some randomly selected answers or inappropriate ways of working (O'Brien, 2006) although I was not sure if they simply wanted to rush through the questions to get to the next level, like they did with computer games (Jackson, 2002), or they genuinely had no idea how to prioritise and sequence (National Curriculum for Mathematics, 2013). Ultimately, interest in the tasks waned and they gave up altogether (Atherton, 2013).

It was said by his educators of one of the case study pupils, Eli, that he could be fully or excessively talented in one specific field such as algebraic theory (Asperger, 1944) but no matter how much training he received, he could not always transfer such expertise to novel or practical situations (ibid.). Although Attwood (2007) and Walter (2012) argue that training helps pupils with AS, Asperger (1944) says that because AS pupils' ways of learning are unconventional, standard training practices do not work: 'They are not set to assimilate and learn adult's knowledge' (ibid.:70) in the way that normally developing children might (Carter, 2009). In common with advice from the NAC (2009), attempts to force assimilation and accommodation aptitude, which one TA described as 'shoe-horning', reportedly caused her pupils with AS to lose previously established skills.

For the group of pupils working on computer-based activities, it might have been that limited assimilation and accommodation skills (Frith and Happé, 1994) were the cause of the same poor technique being used again and again (Attwood, 2007). In support of the information supplied by the TAs, Attwood (2007) argues, that weak abilities in this area could have had a two-fold damaging effect on their capacity to progress with mathematics learning. Firstly, as Bissonette (2009) points out, and I noticed in the case study pupils working on computer-based tasks, they were often unable to select the right strategies to answer novel questions. Secondly, when prior knowledge could not be adapted to fit the new contexts, as I observed, and confirmed by the TAs, the pupils, Charles for example, sometimes omitted the familiar parts of questions too.

According to Lakoff and Nunez (2000), the difficulties with comprehension of mathematical concepts, as observed in half the pupils, might have lain in how they mentally manipulated mathematical ideas. Failure to ignore all matters of concrete realism and instead being able to develop a feel for the conceptual metaphor, they say, is the key to managing novel mathematics. Lack of this ability was suggested by some TAs as one reason for limited perseverance and subsequent underperformance in pupils (ibid.) and is a view shared by Jordan and Powell (1995), who state that people with Asperger Syndrome often have great difficulty with generalising from the specific. Yet, the capacity to generalise is required repeatedly for mathematics tasks (The National Curriculum for Mathematics, 2013) so, if unattainable it is highly probable, according to Attwood (2007), that learned processes can only be made use of again in the identical situation.

The findings of Lakoff and Nunez (2000), Jordan and Powell (2005) and Attwood (2007) could explain why my pupils failed to find the correct strategy to solve the computer-based tasks assigned to them. Given a novel setting or scenario, inability to adapt existing knowledge to make it fit a new set of circumstances might have meant that each subsequent learning opportunity appeared unique to them.

Jordan and Powell (1995) claim that the challenge of functioning in a novel educational setting is like:

> trying to learn a complicated dance, when you do not know what dancing is, when you cannot hear the music and when, just have you have managed to imitate one step of your partner's, you find that the dance has moved on, the rhythm has changed and so (perhaps) has your partner.
>
> (p.31)

Dennis, Lazenby, & Lockyer (2001) further argue that difficulties relating to the use of conceptual metaphors can adversely affect mathematical understanding. Yet, contrary to the often cited lack of imagination in pupils with AS (DSM-V, 2013), to concur with Asperger (1944), some of the pupils did seem capable of finding ways to develop advanced abstract mathematical thinking skills without the need for imagery from the real world. Observing Eli at work on an A Level Core paper indicated that his abstract reasoning skills were no different to those of the neurotypical (ibid.) in my view. However, the problems I saw him working through may not have been novel so I cannot say with certainty that he was independently fully capable of processing new mathematical information (Inhelder & Piaget, 1958).

Finally, although three pupils in the study demonstrated 'superficially perfect expressive language' (Gillberg, 1991:1), the link between understanding the question and knowing how to solve was not entirely clear. Maturation discrepancies between the pupils with Asperger Syndrome and the neurotypical might help to explain this observation (Nordqvist, 2015). While they appeared to be intellectually mature, which Asperger (1944) suggests is common in AS pupils, Attwood (2007) states that their social developmental immaturity could have been a major reason for the inability to fully comprehend how to adapt their existing knowledge from prior learning to fit each new scenario (Inhelder & Piaget, 1958).

Rapid Processing

There was a common misapprehension amongst some teachers and also amongst certain researchers that pupils with Asperger Syndrome are mathematical savants (Hill, 1978; Sacks, 1978; Sullivan, 1992) and that they are able to work independently on any mathematical problem. As Hill (1978), Sacks (1985) and Sullivan (1992) predict, there were some pupils in this study who were capable of relatively fast mental calculations; however, I could not be certain that this was indicative of the types of rapid processing suggested as evident in some classically autistic pupils (Asperger, 1944; Treffert, 1989; Snyder & Mitchell, 1999; Griswold et al., 2002). Through access to lower fundamental processing, some pupils with autism are said to be able to rapidly equipartition groups of numbers (Snyder & Mitchell, 1999). This suggests that if mental mathematics is an area of special interest, they might be able to calculate at speed (Jackson, 2002). However, this ability is thought to be more likely to correspond with classic autism (Asperger, 1944; Treffert, 1989; Griswold et al., 2002) and I saw no evidence of this in any of the case study pupils. My findings appear to concur with Sullivan's (1992) research which indicates that the unique talents of a savant are confined to autistic pupils who have lower levels of functioning elsewhere. As there was no genuine evidence of this characteristic in any of the case study pupils, it further strengthened my belief that the pupils observed were from the AS group and no other (Griswold et al., 2002).

The larger proportion of the pupils in this study appeared to be autonomously capable of logical thinking and, according to the narratives, this was said to be just one of their talents (Asperger, 1944).

Yet, while I found no substantial evidence of the type of fast information processing described by Snyder & Mitchell (1999), one TA explained that her pupil (George) was able to read and understand selected texts at speed. For this reason, she said that she had no reason to engage in dialogue with him. She had discovered that when she pointed to or highlighted relevant words in a question, George would glance briefly at the text and that was all that was needed for him solve the problem. This brought to mind Asperger's (1944) account of one of his cases:

> When somebody was talking to him he did not enter into the sort of eye contact which would normally be fundamental to conversation. He darted short 'peripheral' looks and glanced at both people and objects only fleetingly. (Asperger, 1944 in Frith, 1991:69)

Asperger (1944) noted that these darting looks are common in AS individuals (Frith, 1991) which could explain George's TA's account and my own observations of momentary glances from the study group pupils. Much of their rapid processing of data could have been a consequence of their 'peripheral field of vision. Thus, [perhaps] they [had] perceived and processed a surprisingly large amount of the world around them' (Asperger, 1944 in Frith, 1991:69).

Corresponding to this finding, according to the TAs, the pupils tended to dislike routine mundane mathematical tasks unless they were specifically related to a special interest (Asperger, 1944; Jackson, 2002; Mintz, 2008). This, they said, stemmed from their ability to process mathematical information at speed (Asperger, 1944). Verified by my observations and the narratives, signs of boredom or distraction did become more apparent when a teacher explained a mathematical concept to the class in what seemed to me a laborious manner (Asperger, 1944). 'Discrepancies between IQ scores and teacher-rated academic achievement suggested that [some of] the teachers and TAs underestimated the academic abilities of [these] children' (Roth et al., 2009:4). Some TAs reported that the pupils with AS could pick up concepts quickly once a mathematical methodology had been explained to them (Asperger, 1944). Because of this, they said that procedural instructions which were perceived as too drawn out, as at Ian's school, created the conditions for disinterest and distraction (ibid.). On one of his subjects Harro, Asperger (in Frith, 1991:53) explains that there were plenty of times when he 'shut off completely' and these episodes were linked to the types of questions asked of him. If he was not interested, he would act as though the question had not been asked, ignoring the enquirer completely. But, as with some of my study group, according to their TAs, once engaged, the work produced was said to be very good indeed. Notably, in several of my pupils, like Eli, it was explained that levels of performance bordered on the extraordinary when they were provided with challenging tasks that related to their special interest (ibid.; Jackson, 2002). However, most could not work on them independently (Simpson et al., 2001). Furthermore, there was no clear evidence that the activities were new to them. What I observed may simply have been an expression of repetition or rote (Snyder & Mitchell, 1999).

Finally, while some of the pupils in my study had good verbal communication skills and 'talked like […] adult[s]' (Asperger, 1944:39), they tended to write slowly and rarely kept up with the rest of the class. 'Writing was an especially difficult subject, as

[…] expected, because of […] motor clumsiness' (ibid.:49). Handwriting was untidy and, at times, illegible which meant that they often left the mathematics classroom with a barely accurate record of what had happened there (Wing, 1980; Frith, 1991). As reported by some of the teachers, the pupils found homework and examinations based on the theme of a lesson challenging because of limited motor dexterity (Attwood, 2007). To add to this, Asperger explains (1944) that the lower than average marks which they were often said to gain in examinations is a consequence of their reluctance to write down anything other than a final answer.

On reflection, while there was some evidence to indicate superior skills in problem solving as Roth et al. (2009) suggest, none of the pupils in this study showed any obvious talent in processing calculations at super-fast speed. Recognising that task completion was often slow (Carter, 2010), in part because of motor difficulties, the findings specified in this subsection agree with Schopler et al.'s assertion (1998) that motor skill deficit is indeed indicative of a pupil with AS.

So, with the TDA (2010) stating that the 'curriculum is not immovable' and 'is there to be changed' (p.5), and that objectives do not have to be the same for all, it was explained by a large proportion of staff as reasonable for some students to work at a different pace, 'on different activities, or towards different objectives, from their peers' (ibid.:6).

Perseverance

One prominent theme on the subject of mathematics learning, lack of perseverance with mathematics problem solving tasks, permeated this enquiry. Throughout this chapter under other theme headings, I have specified my understanding of some of the reasons for low levels of perseverance. Therefore, for brevity, not all are repeated in this subsection.

Various combinations of factors for low perseverance were reported or observed in most pupils. These included greater than average difficulties relating to: processing speeds (Carter, 2010), aspects of mathematics tasks relating to physical manipulation (Schopler et al., 1998), lengthy questioning (Attwood, 2007) and handwriting (Asperger, 1944). Furthermore, according to the professionals interviewed, low levels of interest had a major impact on perseverance for AS pupils (Jackson, 2002). My observations confirmed some of these and provided further examples that appeared to be quite common in the AS pupils (Asperger, 1944). During these observations, I also found evidence of anxiety (Kim et al., 2000; Warnock, 2010), weak motor skills (Schopler et al., 1998; Klin et al. 2000; Attwood, 2007), and variable linguistic capabilities (Sherman, 1979; Wing et al. 2011). Although several educators mentioned examples of rapid processing in the pupils with AS, others suggested that low processing speeds because of idiosyncratic problem solving methodologies (Roth et al, 2009; Carter, 2010) might have been an alternative reason for lack of perseverance. Evidenced by observations and confirmed by educators' accounts, a range of these factors did appear to influence perseverance. Indeed they were some of the reasons given by the Assistant Head at one of the schools for no longer supporting certain components of the National Curriculum for Mathematics (2013).

In some schools, however, increasing the amount of self-managed work daily or weekly was presented as a potential strategy to enable development of skills for perseverance with problem solving (Grandin, 2006). A schedule showing each step of a task (Howlin, 1997), with pictures if necessary, was said to improve self-management for some of the pupils (ibid.) including Dan and Harry. As confirmed by Grandin (2006), their use was said to support independence (NAS, 2015).

As reliance on memory was reported as problematic for the pupils with AS (Hale, 2008), sometimes tasks were described as difficult to manage or a homework assignment completely forgotten about (Attwood, 2007). As a result, aide-memoires to assist with problem solving (Sousa, 2008) used by some of the TAs, were said to promote greater levels of perseverance for the pupils working alone on mathematics tasks. However, contrary to the findings of Howlin (1997), Grandin (2006) and Sousa (2008), TAs explained that the intellectual maturity of some of the more able pupils, like Eli, (Asperger, 1944) meant that they could make sense of sometimes-difficult instructions without the need for schedules. It was suggested, though, that this only applied when tasks were related to a topic they enjoyed, one of their special interests (Asperger, 1944; Jackson, 2002) so does not entirely negate the findings of Howlin (1997), Grandin (2006) and Sousa (2008). Corresponding with the findings of researchers such as Asperger (1944) and Frith (1991) regarding ways to assist the pupil to maintain focus, no pupil bar Eli, worked fully autonomously with originality or perseverance in the mathematics lessons observed. Most either had targeted help or appeared to require it (Klin et al, 1995; Attwood, 2007).

Some studies have shown that distributing learning in a little and often fashion (Landauer and Bjork, 1978) is a useful strategy for overcoming problems with recall (National Curriculum for Mathematics, 2013). Landauer and Bjork’s (1978) reinforcement of learning technique could have been the rationale for some of the educators choosing to provide work for the pupils which I considered to be somewhat repetitive. Through their research (ibid.), they found that testing is important to memorising and shortening the time between tests can improve retrieval until learning is secure. Marsh et al. (2007) add that multiple-choice tests are particularly good for improving long term recall while other studies suggest that short answer tests work better (Landauer and Bjork, 1978). Through my observations, I found that the latter appeared to be beneficial when the respective questions were also short and to the point. However, recalling the computer work that James was provided with, the multiple-choice questions allowed him to repeatedly randomly select incorrect answers; so, in my view, this style of testing was less effective at facilitating retention (ibid.).

Reviewing my findings, perhaps the three pupils who remained on task with their problem solving activities and who appeared to be able to reason logically had been working on areas of mathematics with which they were familiar and for which they had received extensive support (Bruner, 1968; Baker, 2007; Bedford, 2010; Walter, 2012). Maybe their educators wanted to demonstrate to me where their pupils could do well rather than where they were less able (Davidson, 2010). Or it might simply have been that the TAs had learned that the certainty of a familiar activity over the unfamiliar was less stressful for their pupils (Bedford, 2010). Had these pupils been presented with novel tasks, perhaps they too would have shown the same kinds of difficulties that I had noted in the rest of the study group (Hale, 2008; Bissonette, 2009; NAS, 2015).

Through the discussion so far, I have attempted to demonstrate that, for a number of practical reasons, mathematics learning was generally a complex process for the AS pupils. However, I have not determined just one specific reason for problems encountered. These appeared to differ pupil to pupil. For instance, as suggested by Hale (2008) and the NAS (2015), some pupils like Ian were easily distracted while others like James focused too much on one part of a question (Baron-Cohen, 2013). As the reasons for these behaviours were psychodynamic, measuring them was beyond the means of this study. Therefore, I have made assumptions based upon my knowledge of possible reasons for low levels of task completion. I tend to agree with Bissonette (2009) that lengthy questions and the ways in which they were posed confused most of the pupils. Several pupils struggled with understanding the language in long problem solving tasks (Sherman, 1979). Thus, this could have been a major factor in their inability to select appropriate calculation methodologies (O'Brien, 2006) needed to work out an answer.

Notably at some schools, it did seem sensible to be responsive to the needs of the pupil with AS (Asperger, 1944) and to scrutinise mathematical texts to ensure that all ambiguous wording and questions are removed or changed (Sherman, 1979; Attwood, 2007). Through the practical research, I identified some TAs who were adept at choosing appropriate vocabulary and mathematical language carefully and who seemed able to eliminate mathematical misunderstandings (Baker, 2007). At the schools where the pupils were most interested in and involved with their mathematics learning, the 'theory of instruction […] addressed the ways in which a body of knowledge [could] be structured so that it [would] be most readily grasped by the learners' (Bruner, 1966:40). Interestingly, for some of the AS pupils like Eli and George, as Jackson (2002) explains, once a topic had become of special importance, they could, using personal idiosyncratic methodologies, work with seeming high levels of interest on it to the exclusion of all else. Concurring with Asperger (1944), the educators maintained that if their pupils with AS hit upon an effective strategy and continued with its use, achievement levels could be exceptional.

To conclude, many of my arguments concerning the nature of complex problem solving abilities, reasoning, rapid processing and perseverance here are based upon personal perceptions of the underlying psychodynamic processes that contributed to observable events. I was aware though that intrinsic qualities could not in isolation describe the experience of mathematics learning in the classroom for pupils with AS. Therefore, in order to supplement the findings, the following subsection identifies the links between existing research literature and the contemporary complex, dynamic learning environment.

5.1.2: The Environment

Assisted Learning

Many of the pupils in this study were reported to have successfully coped with early mathematics without assistance (Baron-Cohen et al., 2009). But, with secondary education much more regimented along with most examinations demanding coherency and superior problem solving skills (NAC, 2009), they had begun to fall behind (Baron-Cohen et al., 2009). One pupil in particular who had been a high achiever at primary school was reported by the Assistant Head at his secondary school to have found many of the assessment strategies at his previous mainstream secondary school to be excessively demanding and unachievable (Attwood, 2007). According to the NAC (2009), one of the biggest and most traumatic hurdles faced by a teenager with AS when s/he reaches secondary school is the change in style of assessment. Given that examination questions differ substantially year on year, this could be one reason why results from summative assessments were said by their educators to be typically lower than for the rest of their peer groups (Attwood, 2007). Nevertheless, from my in-school observations, my views differed from Morrison's (2010) in that I found that school type was not in isolation material to the experience of mathematics learning. Rather, a combination of factors (Attwood, 2007) to include specially trained TAs (Blatchford et al., 2009) seemed to provide the richest experience for pupils with AS (Alborz et al., 2009; Silas, 2010).

Significantly though, disregarding school type, if support was not provided, and pupils were expected to work independently, I found that most struggled (Attwood, 2007; DfE, 2012). This was regardless of teaching medium (ibid.). Only a couple of the observed pupils worked autonomously (Simpson et al., 2001) while all of the others relied heavily on adult assistance (Asperger, 1944; Walter, 2012). At two of the specialist schools, Epsom Boarding and Inglewood, where the pupils were 'aided by intense one-on-one assistance to help them' (Lange, 2010:1) in all kinds of ways, it was stated that, because of their early training programmes and TA assistance, the AS pupils had become more confident in social situations (Bedford, 2010). It was also said, as Bedford (2010) suggests, that because they had had TAs for a substantial length of time and were aware of reasons for their differences from an early age (Kim et al., 2000), anxiety was not such an overwhelming factor in their lives. As I had not met any of them before, I could not personally confirm these statements to be true, but, having observed two of the pupils, Michael from the pre-pilot stage and George, in states of distress (Roberts & Prior, 2006), I was not entirely convinced by these accounts. Nevertheless, apparent levels of interest in mathematics learning for most of the pupils who had TAs were certainly greater than in those without (Blatchford et al., 2009) so I acknowledge that this may have been a consequence of the focused training programmes provided from an early age (Bedford, 2010). According to the TAs, as Asperger (1944), Lange (2010) and Walter (2012) suggest, their pupils' understanding of mathematics and independent working had definitely improved as a result of targeted coaching.

Yet, some of the general Teaching Assistants, who lacked confidence in their own mathematical abilities, as argued by Blatchford et al. (2009), said that they could not provide full support for the teaching of mathematics. Although they reported job satisfaction, they generally felt that lack of training and poor communication had hindered them in their work (ibid.). They stated that pupils and teaching staff seldom spoke to them or understood their roles and this had a negative effect on their esteem (ibid.). According to two of the TAs and one SENCO, any discussions tended to be in the corridor between lessons or, more often, not at all. Furthermore, the teachers had typically received no training in how to work with support staff (ibid.) and the more time the pupil spent with the TA, the less individual attention was provided by the class teacher:

> TAs' interactions with pupils, compared to teachers' interactions with pupils, [tended] to be more concerned with the completion of tasks rather than learning and understanding, and the TA [tended] to be reactive rather than proactive.
>
> (ibid.:2)

In accordance with the findings in the Blatchford et al. report (2009) into the usefulness of Teaching Assistants in the classroom, I too found that, while the majority of TAs generally appeared to have a positive effect on the teachers' workloads, in some schools, they did little to enhance the school experience of the pupils they were meant to support (Alborz et al., 2009). In agreement with Asperger's (1944) view, if either too little or too much attention was paid to the pupils like Andy and Dan respectively, the less interested in mathematics tasks they appeared to be. When left to work independently, they all struggled with the tasks and when the TAs stayed with them for the entire lesson, the pupils relied too heavily on them to do the work for them (Kirkup and Irvine, 2009). In respect of the former, as noted in James, being left to flounder with a complex mathematical task appeared to be a major reason for low perseverance levels (Attwood, 2007). And in relation to too much support, Dan, for instance, might not have been working autonomously; he might simply have been copying in the rote fashion suggested by Snyder & Mitchell (1999) to be more typical of the pupil with some other type of ASD.

The observations of teachers and TAs who I considered to be too soft or too severe such as, respectively those at Drake Academy and Arlidge Academy, further confirmed Blatchford et al.'s (2009) finding, that some TAs were unable to support the pupils in the development of important mathematics learning skills. While one pupil, Dan, appreciated the assistance of his 'too soft' TA, according to Peter it was likely that he had become aware that she allowed for an easy escape from the mathematics classroom setting (Asperger, 1944; Stillman, 2010). Equally, the educators who were indifferent to the needs of the AS pupil or overly punitive such as the teacher of Andy also caused the pupils to lose momentum (Asperger, 1944). To return to Asperger's 1944 guide to intervention, he pointed out that pre-school Ernst would not follow any of the rules set by his strict father or his lenient mother and stated that it is important to get the affect just right:

> All educational transactions have to be done with the affect 'turned off'. The teacher must never become angry nor should he aim to become loved […] These children often show a surprising sensitivity to the personality of the teacher [and so the educator should] show kindness towards them [and] humour.
> (Asperger, 1944:48)

At two schools, I observed staff communicating with the pupils with the 'affect turned off' (Asperger, 1944, in Frith, 1991:47) and this was non-verbally as well as verbally. The non-verbal exchanges often comprised simply pointing to text and all verbal advice was given in an objective controlled manner using the same monotone as the pupils (Asperger, 1944). The specialist Teaching Assistants assigned to the AS pupils at these two schools also used Vygotsky's ZPD (1978) and had been thoroughly trained in how to provide mathematics support (Blatchford et al., 2009). They were responsive to the pupils' needs, delivered the appropriate amount of support and, according to the TAs and teachers, helped the pupils to achieve as much, if not more, than their peers (Alborz et al., 2009). Seemingly as a consequence, the pupils were rarely off task and appeared to be fully involved in the activities most of the time. One of these schools, Epsom Boarding, had been rated by Ofsted as outstanding. It was reported to have achieved this grade because 'staff had very clear information about the young people's varying needs and the differences in the interventions they needed to help them achieve their potential' (Ofsted, 2010:2).

Some educators at other schools mentioned that because of pupil inflexibility, they found it more difficult to teach new mathematics to the AS students than they did to the neurotypical pupils (Asperger, 1944). Yet, despite the potential difficulties in educating the pupils, which some staff explained as daunting (ibid.), humour, willingness to try new approaches and an awareness that it could take a long time to hit upon the right strategy were talents that other TAs and teachers appeared to possess (Alborz et al., 2009). The development of useful mathematics learning skills noted at some of the schools appeared to correlate, in part, with these abilities in the staff (ibid.). I acknowledge that correlation does not imply causation. Rather I conclude that, based upon my findings and existing research literature, they are likely to be some of the reasons (Asperger, 1944; Frith, 1991; Alborz et al., 2009). It was clear then that the pupils were able to become attracted to mathematics for its own sake and to acquire the enthusiasm to complete mathematics tasks (Jackson, 2002) if they had a special rapport with their educators. '[Their] choice of special interest may [have been] determined by one, presumably emotionally charged, moment in a relationship' (Tantam, 1991:160) and this could have been generated by their mathematics teachers and TAs. Perhaps these pupils had been encouraged to reach a high level of emotive feeling for mathematics simply through an affinity with the teacher, and this had helped to make mathematics become an area of expertise for the pupil with AS (ibid.; Jackson, 2002).

Where a teacher or TA had an affinity with the pupil, the pupils 'respond[ed] favourably' (Dewey, 1991:197), whereas the students observed whose work had been found fault with (Rodd, 2011) or who were ignored appeared to quickly lose their impetus (Asperger, 1944). At Arlidge Academy where the teacher appeared to make little effort to disguise her irritation at Andy's lack of dexterity with a simplistic practical activity, it was clearly noticed by him. As Asperger (1944) says, pupils with AS are very aware of their surroundings and the feelings of others. I believed that this had negatively affected his behaviour as a consequence (Dewey, 1991; Tantam, 1991; Rodd, 2011). Asperger (1944) advises that the teacher should only have considered criticism, verbal or non-verbal, if fully accepted by the pupil. It appears that TAs or teachers whose teaching strategies were based on the assumption that the pupils were emotionally or behaviourally different appeared to be detrimental to mathematics learning (Morse & Moniz, 2010). Being overly punitive, showing impatience, appearing over-concerned or ignoring the pupil (Webber and Scheuermann, 2008), all of which I observed during this enquiry, appeared to deter the pupils from mathematics learning (Asperger, 1944).

Conversely, in the schools where mathematics specialist TAs were deployed, the pupils participated most in mathematics activities (Alborz et al., 2009). One was a specialist school for boys with Asperger Syndrome only and the other, a mainstream school where all pupils with Asperger Syndrome were taught in the classroom with other pupils. While the boy at the former seemed to be more confident, this might have been his natural temperament or perhaps it was a consequence of his specialist schooling. I could not tell but, comparing the involvement of both boys with their respective mathematics tasks, there was no real difference between the two. The main common feature, however, was provision of mathematically trained TAs (ibid.). Irrespective of general setting, I surmised that this was potentially the only influential factor (ibid.). The TAs at both schools had some constructive, although different, strategies in place to facilitate interest in mathematics learning for their AS pupils (Bruner, 1966; Vygotsky, 1978; Jackson, 2002; Bedford, 2010). There was clear evidence that, possibly because of their training in the delivery of subject specific support programmes, the TAs had a positive effect on the well-being and interest in mathematics for the pupils with Asperger Syndrome (ibid.; DCSF, 2008). In both cases, the TAs' input helped to 'lead to outstanding achievements' (Frith, 1991:14). Throughout their time at their respective schools, the boys were said to have shown consistently high levels of mastery in mathematics and both were on accelerated learning paths (Asperger, 1944). This was a crucial finding that I believed could determine the future of training programmes for mathematics specialist TAs (DCSF, 2008; Alborz et al., 2009; Blatchford et al., 2009). The TAs said that they compensated for the boys' impairments in mathematics learning by acting as executive secretaries (Attwood, 2007) and, as a consequence, the pupils were rarely off task (Asperger, 1944). Thus, I concluded, consistent with the findings from Alborz et al.'s (2009) study, that the pupils with AS did appear to benefit most from the support of a mathematically trained assistant in the mathematics classroom.

Group Work

O'Brien (2006) proposes that some problems with mathematics learning are simply a consequence of dislike of group work (Barber, 1996). Frith (1991) explains that mental processing takes an enormous amount of energy and concentration and that distractions from others may not be easily tolerated. So, although Asperger (1944) states that pupils with AS want to join in with a peer group, Frith's (1991) account explains a potentially key reason for some of the pupils I observed preference to work alone (Barber, 1996).

Although they were said by their TAs to have a higher IQ than the general population (Ozonoff et al., 1991; Schopler et al., 1998), albeit unmeasured, their social immaturity (Asperger, 1944) might have been the cause of their inability to integrate with others (Bogdashina, 2005) in ways that might have allowed them to better apply their mathematical knowledge in a variety of practical contexts (Attwood, 2007). One pupil said that he liked to work with the help of the TA but was very shy and found it difficult to mix with the rest of the class (ibid.; Frith, 1991; Nordqvist, 2015). This was irrespective of whether the group comprised the neurotypical or other students with AS and appears to agree with the idea that the pupil whose IQ is in the higher bracket experiences greater difficulties with socialising or interacting with any of their peers (Baron-Cohen et al., 2001).

Previous studies have found that 'social interaction plays a fundamental role in the development of cognition' (Vygotsky, 1978:57). However, accounts from two of the pupils indicated that poorly managed enforced group activities or co-operative learning in mathematics lessons can disadvantage higher ability students (Clark & Baker, 2006). Two further pupils, who had chosen not to participate in elective group work, said that they could work well enough alone (Barber, 1996). Yet, of these four who actively chose to work independently, in my view, just one, Eli, demonstrated similar levels of expertise and success in the lesson as Vygotsky (1986) and Kagan (1994) say he would have in a group; and this was, I suspected, a straightforward consequence of working with his TA (Asperger, 1944). Morris (2008) explains that a buddy system is an effective strategy for the pupils in the mathematics classroom, encouraging them to discuss problems and hence work with relative success on mathematical tasks (Kagan, 1994). So, with the support of their peers and sharing of ideas, they might have found problem solving easier (Vygotsky, 1986). But, as explained at several schools, this could have proven difficult to implement. Firstly, the teacher would have had to identify someone in the particular class who would work with the pupil in question (Attwood, 2007); then the AS student would have had to interact with the proposed buddy (Barber, 1996).

In conclusion, it seems that the social interactions required for group work activities (Vygotsky, 1986) deter pupils with Asperger Syndrome from participating. But, despite this, working in pairs is suggested to be the key for pupils with anxiety disorders (Asperger, 1944; Jarvis, 1987). One-to-one interaction is advocated as an aid to the pupils engaging in mathematics problem solving activities (Vygotsky, 1986). As the majority of those with Asperger Syndrome do enjoy the company of some of their peers (Asperger, 1944) but do not know how to initiate or maintain a friendship, finding such a friend could be crucial to improving the development of mathematics learning skills (Jarvis, 1987; Vygotsky, 1986). But, as found with Michael and George, if the peer is incompliant and unwilling to participate or has limited social skills himself then this repudiates the advice of Morris (2008) that peers can model good practice and be an aid to learning. Nevertheless, according to Morris (ibid.), a carefully chosen partner can help to alleviate stress and, crucially, aid the student's integration within the mainstream classroom. The NAC (2009) say that the staying ability of a peer could encourage greater levels of perseverance with tasks and, as observed at a number of the schools, this could be a mathematics specialist TA with extra training in, at the very least, conflict resolution (Alborz et al., 2009). Where group activities were organised using an adult as a buddy, I found, contrary to the observation in the DSM-V (2013), that the pupils like Ben could respond to and initiate conversations (Volkmar & Klin, 1998). But this was only when sessions were fully structured and teacher-led rather than unstructured (Lewis, 2009).

Therefore, although working collaboratively with another pupil might have been awkward as Barber (1996) points out, when an adult took the role, the pupils could work as well as anyone else in a group situation (Vygotsky, 1978). According to Alvarez (1992) and Sinason (1992) (cited in Mintz, 2008), this finding is not unusual. They say that, although pupils with AS can be rigid in certain situations, this inflexibility is a defence mechanism and that they are perfectly capable of relatively normal functioning in the right circumstances.

Practical Mathematics

Part 1: Physical work

Poor spatial perception could have been a cause of motor skill deficit observed in the study pupils (DeMyer, 1976; Wing, 1981; Klin et al., 2000; Austin Psychological Assessment Centre, 2009). Mental and physical manipulation challenges resulting from dyspraxia have been recorded by some researchers like Klin et al. (2000) and refuted by others such as Billington, Baron-Cohen and Bor (2008). Van Hiele (1999) suggests that all pupils need help with development of visual-spatial skills, but that the assistance required by the pupil with AS is much greater (Ghaziuddin &

Mountain-Kimchi, 2004). Notably, Asperger (1944) found that the rarely spontaneous motor movements for the pupil with AS take excessive conscious effort. Thus coordination comes only as a result of great levels of concentration and is not natural to them (ibid.:57). There were times when I observed the pupils sitting rigidly seemingly staring into space. The question for me was whether this was a symptom of anxiety relating to their surroundings (Kim et al., 2000; Warnock, 2010) or a consequence of the effort required to focus on what for the neurotypical was suggested as standard procedure (Frith, 1991; Roth et al., 2009, Ward et al., 2009). According to Frith (1991), Roth et al. (2009) and Ward et al. (2009), all social, motor or other typical routine tasks with which neurotypical pupils seem to have little difficulty, have to be thought through thoroughly before being carried out. But, as reported by their educators, because of limited skills in these areas, the pupils all struggled to show their full cognitive potential in practical group tasks (Szatmari et al., 1989; Fitzgerald & Corvin, 2001; Hoekstra et al., 2009).

In all but two pupils, I found evidence of difficulties related to motor dexterity and spatial awareness (Attwood, 2007), a view shared by Schopler et al. (1998) and Klin et al. (2000). Some of the evidence came from noticing how one pupil perceived his proximity to other objects, some from observation of writing skills and some from educators' accounts. Asperger (1944) stated that Ernst was in a constant state of distress resulting from his dyspraxia which, because of the way he held his pen, created endless arguments with his teacher. Reminding me of the relationship between Andy and his teacher, Ernst ultimately refused to work as a result and learned virtually nothing.

At one of the case study schools, none of the students was allowed to use the electrical woodworking equipment because of their reported difficulties with motor skills and spatial awareness. Yet, a TA mentioned how, as Asperger (1944) highlighted, for one pupil simply a change of teacher had resulted in great achievements with both spatial and practical work. At another school, it was explained to me that one of the two pupils who seemed to be more confident with spatial perception tasks had a relatively good standard of expertise as a consequence of his ongoing specialist reinforcement training (Bedford, 2010; Walter, 2012).

From these accounts, and the observation at the school where Harry was engaged in grouping activities in order to overcome difficulties with spatial awareness (Baron-Cohen & Jolliffe, 2001), I realised that opportunities could be provided to conquer these problems (Bedford, 2010) and that training probably ought to be personalised to fit the pupil (Silas, 2010; Warnock, 2010). These findings argue against the accounts of Szatmari et al. (1989), Fitzgerald & Corvin (2001) and Hoekstra et al. (2009) in relation to cognitive potential with practical activities. Conversely, they provide support for the belief that, while students with AS can find certain elements of the mathematics curriculum challenging (Sherman, 1979; Attwood, 2007), they are able to participate in practical activities with the right assistance (Bedford, 2010).

Part 2: Computer-based work

Computer aided instruction was suggested by Xin (1999) as a potentially effective mechanism for teaching all students including those with special needs. Because of this, I had initially hypothesised that computers and the Internet were the way forward for teaching mathematics to those with Asperger Syndrome. However, inconsistent with the findings of Bölte et al. (2010:156) who reported that technology facilitates learning in people with an ASD, and Berninger and Richards (2009) who say that its use supports memory weaknesses, my observations showed that there were only beneficial outcomes through its use for the lower functioning autistic individual (TDA, 2010). The pupils lower down the ASD scale in the periphery at two schools spent most of each lesson playing relatively fast pace computer games, which the TAs said was so that they could reinforce spatial awareness and general mathematics skills (Berninger and Richards, 2009; Learnanytime, 2010). Conversely, I only saw one pupil with AS (Eli) playing a fast pace game which necessitated some rapid calculation skills, and this was after school in his own time. In the classroom, the purportedly interactive mathematics tasks that I saw the AS pupils working on were no different to those provided in the traditional setting via textbook (National Curriculum for Mathematics, 2013).

In respect of facilitating group work and communication opportunities for pupils with Asperger Syndrome, although O'Brien (2006) states that software can provide the circumstances for pupils to discuss and peer assess each others' efforts, observations of the pupils who could choose to work together or independently at the computer contradicts this finding. They all worked alone and, without assistance, they all struggled to understand the requirements of the tasks. This conflicts with Xin's (1999), O'Brien's (2006), and Bölte et al.'s (2010) assertions that computer aided instruction is particularly useful for those with Asperger Syndrome. My evidence from the schools in this enquiry showed that there were no improvements in problem solving capabilities solely as a result of computer use. As with any other kind of teaching and learning medium, the pupils could only manage their own learning when there was a personal assistant on hand to prompt and advise (Alborz et al., 2009; Blatchford et al., 2009). Although Mintz (2013, cited in Silton, 2014) suggests that independent learning can be easily facilitated through personal smart phone applications, as this type of technology was not in widespread use in schools when I conducted my research, I was not in a position to evaluate its utility. Nevertheless, his finding tallies with mine in some respects. Despite observing that the pupils with AS using the computer often looked to the teacher or me to help with understanding rather than the application, I noticed that, for pupils elsewhere on the ASD scale, feedback provided via the computer was preferred to teacher intervention (ibid.).

Mintz (in Miesenberger, 2014) explains that the personal attachment pupils have with their mobile phones means that if teaching materials which match the pupils' own interests and learning styles are provided via apps, then they are more able to independently manage learning tasks. Conversely, the computer-based applications I saw being used were intended to support entire ASD groups rather than personalised according to the needs of the individual pupil. In hindsight, the tasks and feedback were too generalised and perhaps more suited to those with other expressions of autism. Maybe the greater number of pupils in the schools with other ASDs over those with Asperger Syndrome had determined the one-size-fits-all provision. Having said this, the differences between his findings and mine may have depended on the ages or types of pupil observed, the subject taught, or the type of technology and computer software employed and would require further research.

So, to conclude, while the use of computer-based technology can allow for potentially more interesting practical lessons and therefore some initial pupil impetus (Jackson, 2002), for the pupils in this study it did not prove to be any more beneficial than other media in terms of aiding development of mathematics learning skills.

Real-World Learning

Staff at one school explained that most of their teaching revolved around the real-world element of the curriculum. Through action research they had found that the AS pupils were more likely to remain on task with genuine applied activities. At two further schools, although the traditional elements of their mathematics syllabi were followed, they too incorporated real-world mathematics as much as they could under constraints of the curriculum.

However, according to their educators, unlike Inhelder and Piaget's (1958) normally developing pupil, the students with Asperger Syndrome, were not always able to adapt their real-world knowledge to accommodate new learning. Although, with support, they appeared to be able to manage all kinds of mathematics, when I assisted the pupils with the language of complicated problems, real-world or otherwise, I found no evidence to indicate this aid enabled them to autonomously solve later tasks (Sherman, 1979).

According to the TDA, some:

> …students with an [ASD] are stereotyped as being really good at mathematics, [but] if they have particular skills, these are often isolated and cannot be used in any practical or real-life situation.
>
> (TDA, 2010)

The DSM-V (2013) suggests that people with Asperger Syndrome tend to lack imagination and this is a view shared by the DFES (2009) and by Sherman (1979). It is also argued that pupils with Asperger Syndrome are unable to transfer their mathematical knowledge to real-world problems (ibid.). But absence of real-world imagination was not evident in any of the case study pupils except for one. Although imagery based on a fictional scenario appeared to have been a difficult concept to grasp (Grandin, 2006), where teaching based on real-world models was delivered (Baron-Cohen & Craig, 1999; Austin Psychological Assessment Centre, 2009), the pupils certainly seemed able to visualise them provided that questions relating to them were relevant, concise, precise and straightforward. When I repeated Baron-Cohen & Craig's 1999 task on how to make a toy elephant more exciting (see Chapter 2: Literature Review) with Peter, the university student, I asked why he chose Option i), 'give him a hat or make his ears bigger', over Option iv), 'the elephant could fly or read bedtime stories', to which he responded 'because the Option iv) examples can't really happen can they?'

At the case study schools where the real-world strand of the National Curriculum for Mathematics (2013) was applied, there was some evidence that it was useful to the pupils with Asperger Syndrome (Attwood, 2007; Sousa, 2008). Providing the tasks were not over-simplistic, and did not incorporate group work (Frith, 1991; Barber, 1996) or manufactured lengthy questions as advised by Frith (1991), Attwood (2007) and Bissonette (2009), to agree with Stephenson (2010), real-world practical lessons with a cross-curricular perspective were found to be the most able to maintain pupil focus. This was, I surmised, at least minimally, due to a preference for reality over fiction (Grandin, 2006).

Although I did not attempt to identify the exact reasons for the DFES' (2009) and the TDA's (2010) emphasis on the lack of real-world problem solving skills in pupils with AS, I suspected that their research might have been based upon trials using pseudo-real life theoretical tasks like the 'Rosie and the Eggs' question. As discussed, because this was not a genuine mathematics problem from the real world and incorporated imprecise language, the pupils quickly became confused by its meaning and its purpose (Sherman, 1979; Attwood, 2007).

When genuinely realistic tasks were separated from the pseudo-real-world textbook problems, the pupils in this study understood and appeared to enjoy the former better. I found that their knowledge was not fragmented as suggested by Frith in 1991. Most, like Ben, Eli and Ian, were able to autonomously combine knowledge and experience to make sense of genuine real-life mathematics questions (Baron-Cohen et al., 2001). While I acknowledge that, without assistance, this was only when the questions were short and genuinely realistic, it does appear that the DFES' (2009) suggestion that pupils with AS are unable to apply mathematical knowledge to real-world problems may not be entirely correct. Although the findings of the DFES (2009) and Sherman (1979) imply that the real-world element of the National Curriculum for Mathematics disadvantages the pupil with AS, maybe this is simply because of the use of nominal realism in typical mathematics problem solving tasks and activities (Baron-Cohen & Craig, 1999).

5.2 Summary of Teaching and Learning Strategies in the Mathematics Classroom

There follows a summary that explains how teaching and learning for pupils with Asperger Syndrome can be adapted to ensure that the pupils are adequately supported when working through mathematics activities. The issues discussed so far are expanded on in this section and linked with personal suggestions gleaned from this piece of research on how appropriate teaching strategies can support mathematics learning.

So, what then is life like for pupils with Asperger Syndrome in mathematics classroom? A number of issues corresponding to the data collected in response to the subquestions have been analysed in depth and then reviewed in this chapter. Much of the analysis and discussion for the first subquestion focused on pupil psychodynamics while the second addressed the web of interactions in the mathematics learning environment.

Through analysis, discussion and links with the Literature Review chapter of the observations and supporting narratives, this summary reports on the major findings. Some of these correspond with the results of prior studies relating to pupils with Asperger Syndrome and intervention strategies suggested by previous researchers as effective in the mathematics classroom while some differ in certain respects. My own research has produced evidence to supplement existing knowledge. By comparing the findings from my enquiry with existing literature, a range of personally derived theories on how to support mathematics learning and potentially solve any problems of disaffection for pupils with AS in the mathematics classroom are presented below.

On the face of it, there were four major findings to come out of this enquiry, elements of which I had found in other studies but not linked together or specifically related to the teaching and learning of mathematics for pupils with Asperger Syndrome.

One notable finding was that practical rather than theoretical real-world teaching was more useful than any other type of strategy in helping the pupils to learn mathematics (Baron-Cohen & Craig, 1999). A range of techniques such as the genuine real-life teaching from an appropriate practical perspective, as evident in four of the case study schools, were used to assist in developing useful memorisation strategies for pupils with AS. ‘New learning that is meaning based has been linked to long-term retention in memory’ (Sousa, 2008:56), so it seems crucial that examples of genuine real-world mathematics, possibly linked to the pupil’s special interest, are incorporated into the individual's personalised curriculum. Conversely, linguistically challenging faux real-world questioning was shown to be confusing or distracting for AS pupils and often led to limited progress as I suspect the TDA (2010) also found.

Secondly, regardless of learning environment and irrespective of teaching style or methodology, one major factor emerged as fundamental to maintaining and enhancing development of learning skills in the mathematics classroom for pupils with Asperger Syndrome. This was that a mathematically trained specialist Teaching Assistant was the most valuable resource provided for the AS pupils (Alborz et al., 2009; Blatchford et al., 2009)

Thirdly, the specialist Teaching Assistant who adopted a Vygotskian ZPD (1978) approach was found to be appropriately supportive of the pupils to help them to maintain momentum. A strategy that bypassed a proven learning difficulty and enabled the pupil to develop mathematics learning skills was shown to be achievable through specialised targeted personal assistance (Bourdillon and Storey, 2013).

And finally, refuting the findings of researchers such as O'Brien (2006) and Bölte et al. (2010), the use of a computer did not encourage or assist the pupils more than any other type of teaching methodology. Although this medium initially appeared to be appealing, as with alternative teaching and learning resources to help with overcoming weaknesses, a Teaching Assistant was just as necessary. Despite the assertion by pupils that they liked lessons incorporating electronic software (TDA's SEN Manual, 2010), the evidence showed that for computer-based resources to be appropriately utilised, the pupils had to be supervised and assisted throughout. Although, as Jackson (2002) mentions, they may have liked using the computer as it was quicker for them and allowed them to write legibly, it did not mean that they were able to make sense of the set problems any better than when they were from a textbook.

On one final note, provision of challenging activities was put forward by some pupils as influential to them. A pupil at one school stated that rote learning and textbook mathematics were exclusively for low-achievers. I believed that he considered this style of teaching to be beneath him (Asperger, 1944). As the rest of his class appeared happy to accept (or perhaps had become conditioned to) these teaching methodologies, I suspected that this meant that he thought them to be low-achievers compared to him (Frith, 1991). However, I add this finding with caution as I found no evidence that complex problem solving activities altered the experience of mathematics learning for pupils with AS. In all cases, targeted assistance was found to be essential. Without support, complex tasks were shown to be a challenge for most pupils. For the variety of reasons discussed throughout this chapter, none managed to complete them independently (Attwood, 2007).

These summarised recommendations are tentatively suggested. The findings here are not meant to be prescriptive or to demand that all educational practitioners should transform their teaching practices as a result. Rather, they are presented to allow the professional to select 'relevant research [that] informs [their personal practices],' (Elliott, 2001:567). Accordingly, these findings are intended to supplement the teacher's autonomy to make professional decisions on personal practice as they do not, and indeed cannot, provide one catch-all strategy for all pupils with Asperger Syndrome.

5.3 Limitations

Through this study, I thoroughly evaluated the various strands of the mathematics classroom for pupils with AS. The research was conducted in relatively disparate educational settings and in each location there was a minority of pupils with the condition. Decisions had to be made about who to include in the study, how to record observations and narratives, and whether or not some of the data should be disregarded. Issues of sampling, data collection methodology and management of the findings were potential sources of misinformation within the final conclusions. So naturally, there were several concerns, the most significant of which are examined below.

<u>The Literature Review</u>

Firstly, before embarking on the main study, it was essential that I made some judgments based on defining characteristics in the spectrum of disorders. Within the AS subgroup alone I had expected to find characteristic variations. Any significant inconsistencies would have meant that I could not definitively argue that issues related to the learning of mathematics would be similar in all pupils with Asperger Syndrome. A substantial proportion of the preliminary research comprised researching which defining traits existed. Some authors' use of the terms autism and Asperger Syndrome interchangeably made analysis of the literature difficult at times. In some cases, which condition they were referring to had to be established through further reading. In others, the detail from the literature was of little use to the study because I could not clearly identify the disorder to which the authors' findings applied. This also meant that I had to consider the possibility that, where my findings contradicted those of other researchers, it could have been that they, rather than I, had been investigating a different type of pupil.

Secondly, I was unable to check every finding from the theoretical review. For instance, I could not ascertain how my pupils would have managed with Behrmann's (2006) and Attwood's (2007) composite picture tasks as I had never intended to enter into experimental research. Significantly, though, observation of the one pupil who was said to have some ability in this area does contradict their work. However, he was an anomaly in that he appeared to be lower down the ASD scale so it would not have been sensible to use this one finding as a counterproof.

Therefore, some aspects of findings from the literature review were not revisited for the analysis or beyond.

<u>Research Design</u>

The research design in respect of the data collection methodologies, I believe, had the greatest potential to affect the results of the enquiry. There were two elements in my model that could have weakened the quality of the findings.

The first was the decision not to use recording equipment. Although, I considered personal handwritten accounts essential to ensure that the data collected were derived from the most naturalistic settings possible, several verbal and non-verbal events would inevitably have been missed as a consequence. In hindsight, knowing that pupils with Asperger Syndrome are probably hyper-aware of their surroundings (Asperger, 1979), perhaps my covert data collection methodology served little purpose. If the pupils were aware of being observed, then the actions and reactions witnessed may not have been as typical as it was initially hoped.

Secondly, the questionnaires and the verbal question sets were not the same for all respondents and interviewees. Thus, any presumed homogeneity in the categorisation of the various narratives could have been flawed.

However, the reasons for the various choices have been explained in the Methodology chapter and the results peer checked so if other researchers were to follow my model, their findings should be largely similar.

Sampling

There were two contrasting concerns about the sample size. On the one hand, across an entire population, 10 (or 12 if the pre-pilot pupils are included) was quite a small group. The narrow range of participants might not have allowed for the full array of perceptions of learning mathematics for pupils with Asperger Syndrome to be ascertained. This meant that I might not have been able to determine a full and definitive generalisation of what the mathematics classroom was like for the AS pupils. On the other hand, for an in-depth case study, the sample was relatively large. In retrospect, perhaps an enquiry involving just one pupil at one institution over a longer period of time would have ensured that the results of the research were more closely aligned with the single-case studies conducted by other researchers such as Baron-Cohen et al. (2001).

Secondly, perhaps I should not have relied on the judgments of Headteachers for selection of pupils. At least one, probably two pupils were not similar enough to the others in the enquiry and the inclusion of data relating to them might have weakened the analysis. While one of them was able to discuss some topics reasonably logically, it quickly became clear that he had less common sense and ability than most of the others in this enquiry. His characteristics did not seem to fit entirely with the definition of Asperger Syndrome, (see Appendix 1). On the surface his arguments seemed logical but generally they lacked depth. He often just repeated the same thing over and over. Asked a relatively simple mathematical question, he could rarely answer and seemed to have no mechanism to find the solution.

Thirdly, the ages of the pupils ranged from 11 to 18. Matters related to the relatively wide range of ages could have had a significant impact on the findings. If the pupils' interest in or understanding of mathematics changed as they matured, any differences which were purely age related would undoubtedly have impacted on any seemingly homogenous findings.

Lastly, the limited amount of time I could spend in the schools, this because of circumstance rather than design, meant that I did not manage to speak to as many educators as I would have liked about their experiences of teaching and learning for pupils with Asperger Syndrome, (Eisner, 1992). However, I am aware that this is typical of this type of study. It is not always easy to get at all available sources and so sampling is the norm in enquiries where there are wide ranges of people and settings to be investigated.

Interpretation

Firstly, the potential for inconsistencies between existing theories and my findings could have been a consequence of the wide range of pupils and educational settings used in my enquiry.

Further, despite triangulation of methods, there was always potential for differing interpretations of an event. While I had very clear views on defined observable behaviours, it was not necessarily guaranteed that other researchers would have had the same perception of any one particular incident. Moreover, a substantial amount of data came from narratives rather than observations. This secondary data in the form of verbal accounts from individual educators was necessary for triangulation purposes but could not be fully relied upon as true. They may also have had a personal agenda or have misinterpreted a behaviour because of a set personal belief about pupils with AS.

Finally, other researchers involved in a similar enquiry might choose a different methodological route based on their own experiences and motivation, subsequently producing an alternative set of findings to those arising from this study.

Bias

One element of the study that I had no control over was linked to the narratives. I had to take what people said on face value as I had no means of verifying the authenticity and the impartiality of their views.

Additionally, with regard to personal observations, selective memory, as a consequence of my data collection methodology in relation to recording equipment, could have reduced the strength of the analysis.

Further, I may have inadvertently implied that my findings were more significant than those of other researchers by overstating the results.

The potential for bias or impartiality was a concern throughout the various stages of the enquiry, from deciding upon which questions to ask through to writing up field notes, analysis and interpretation (Kemmis and McTaggart, 1981). Nevertheless it was anticipated that the triangulation of methods, namely various types of observation, interview and questionnaire alongside peer checking would provide a substantial amount of evidence from which to determine the validity of the findings.

Discarded data

There follow two examples that are intended to justify my decision to omit some of the data from the analysis. Firstly, there were reports by some educators that the first-borns in this study were mathematically more able than the others. This confirms findings generally, namely that ‘first-born children score significantly higher in IQ tests than their younger siblings’ (Khamsi, 2007:1). The reason is explained as social rather than biological, with parents dedicating more of their time to their older children's needs (Rohrer et al., 2015). Therefore, in this respect, there was no significant difference between pupils with Asperger Syndrome and neurotypical learners and, for this reason, I chose not to research it further.

Secondly, a large proportion of the description of Professor Raymond's students was disregarded as he believed that, despite diagnosis, few, if any, of them genuinely had Asperger Syndrome. According to Raymond, reasons for errors typically included the screening tools used, the capabilities of the people diagnosing, and the necessity to find an educational establishment for pupils who did not fit the expected norm (Attwood, 2007). He said that he often worked with pupils who had erroneously been labelled as having Asperger Syndrome and that the capabilities of his pupils would not necessarily reflect those of the pupils sought for my study. Hence, in view of the fact that the analysis could have been affected, I had to be selective when choosing which of his accounts to make use of which could be construed as personal interpretative discrimination.

5.4 Recommendations for Further Research

In addition to the already mentioned adaptations that might have improved my results, there is a need for further development of this enquiry. As my research progressed, I was faced with many new issues that emerged in connection with ongoing findings. Therefore, to further refine the work, I recommend that supplementary research be undertaken in the following areas. These, I consider to the most capable of producing useful and pertinent evidence to extend my study:

1) A comparison of the teaching strategies in other subject areas could determine whether or not the findings of this study were peculiar to mathematics learning only. This would be a good indicator of how the pupil connects with different subjects and

could definitively show whether or not mathematics is the only specialist area in which they can excel (Baron-Cohen et al., 2008);

2) In respect of technology-based teaching and learning, a more contemporary review of hand-held applications software (Mintz, in Miesenberger, 2014) would be beneficial. The computer-based programmes I observed were too general and not differentiated;

3) As there were no girls in the study, it is not clear whether they would have reacted in the same ways to the various tasks. Therefore the research study could be repeated for female pupils with Asperger Syndrome to ensure that the recommendations are applicable to both genders;

4) Contrary to some accounts, one finding was that some of the pupils with AS did not see themselves as underachievers. Rather they believed that they were more able than their peers in mathematics. This was a significant anomaly in perception and one that could be further investigated;

5) It would be informative in a follow up study to revisit the four pupils who were the most similar to one another. They could be re-interviewed to capture changing perceptions and abilities as these can vary as people mature. For instance, their views on how much of an influence spatial awareness at various stages has on their abilities to manage practical activities could be investigated;

6) Finally, a natural progression of this work could include an investigation of attainment scores for those with: limited intervention, ZPD provision, or a fully structured programme of support in place. A thorough enquiry based in schools that have specific but differing policies for pupils with Asperger Syndrome, to include provision of mathematically trained TAs and a flexible curriculum could provide a

more targeted comparison of the various types of support. From this, links between the mathematics teaching methodologies of TAs and attainment could be more extensively analysed.

Chapter 6: Conclusions

6.0 Introduction

Following extensive research, both practical and theoretical, this final chapter summarises the main findings and, through reference to the Analysis and the Discussion chapters, presents answers to the main research question. As there was no hypothesis to consider for this enquiry, the conclusions are based upon the most significant findings to emerge from the research. The chapter is split into four sections, the first of which provides an overview of contemporary approaches to teaching pupils with Asperger Syndrome. The second section answers the main research question: 'What is the secondary mathematics classroom like for pupils with Asperger Syndrome?' Thirdly, the contributory findings that came out of the study are combined with implications for practice and, finally, a summary of recommendations for future practice is provided.

6.1 Current Policy and Practice

Modern educationalists have concluded that, vital to the inclusive classroom, provision of real non-hypothetical educational strategies should be based upon the individual (Hargreaves, 2007). Hence, although the research studies of Piaget and his contemporaries continue to inform certain pedagogical philosophies, they no longer have such a significant influence on educational policy and development (ibid.). As an alternative, the relatively recent evidence-based practice allows teachers, TAs and SENCOs to opt for whichever methodology best suits their pupils and setting (ibid.). With this in mind, I investigated the policies for working with pupils with AS in modern mathematics classrooms at various institutions. As a consequence, I established that school to school there was substantive variance of practice and that, in some cases, procedures were still largely influenced by outdated guidelines. However, this finding did not impact negatively on my study as these inconsistencies allowed me to compare and contrast a wide variety of practices with a view to determining which appeared to be the most appropriate.

6.2 What is the Secondary Mathematics Classroom Like for Pupils with Asperger Syndrome?

The findings from the enquiry verified a number of common characteristics in pupils with Asperger Syndrome, and confirmed some of the specific difficulties they face in the mathematics classroom. These included working independently, problem solving and linguistic misunderstandings. In addition to contributory evidence in support of previous findings, this study also uncovered some interesting new facts about the ways in which pupils with Asperger Syndrome work with problem solving activities in mathematics lessons.

In response to the first subquestion, it became clear throughout this enquiry that, although pupils with Asperger Syndrome have many similarities, there are qualitative differences (Rodd, 2015) in 'personality and […] special interests which are often outstandingly varied and original' (Asperger, 1944:67). While it was possible to broadly categorise certain aspects of their behaviour and find definitive links between personality traits, no two pupils' characteristics were absolutely identical and neither were some of the behaviour patterns in the mathematics classroom. Therefore, qualitative judgments based on these pupils' varying mathematical capabilities had to be made. For instance, to ensure that the conclusions of the study would have implications for the majority of pupils with Asperger Syndrome, I decided to take some of the detail pertaining to one individual (who was least like the other pupils) out of the analysis.

However, despite the wide and varied characteristics and manifestations of Asperger Syndrome, most were academically bright and articulate, and in some respects seemed similar to any neurotypical pupil. As they could ably engage in discourse about and offer opinions on subjects such as mathematics, their mathematical weaknesses were not immediately obvious. And, at times there was clear evidence of lack of interest in mathematics learning. This was shown to vary according to teaching methodology and type of mathematics task provided. Asperger (1944) explains that:

> …even mathematics lessons were problematic when, given his special talent in this area, one might have expected an easier time. [But, when] a problem turned up which happened to interest him at that moment, then he 'tuned in' and surprised us all by his quick and excellent grasp. [However,] ordinary mathematics – sums - made for much tedious effort.
>
> (Asperger, 1944:49)

The research findings indicated that the pupils were more enthusiastic in mathematics lessons which incorporated real-life cross-curricular practical mathematical activities than those based on artificial real-world problem solving tasks. Conversely, while computers were functional for some of the pupils in that they helped them to bypass certain motor difficulties and speed up response time in mathematical tasks, they were not the panacea thought by many to facilitate understanding of how to solve mathematical problems. The pupils with AS all needed guided assistance with problem solving tasks irrespective of teaching medium.

Because the pupils with Asperger Syndrome could not always assimilate and accommodate new material and, because they found some areas of mathematics challenging at times, directed support was crucial. Constructive provision ranged from assistance with understanding questions in problem solving tasks through to targeted support to overcome obstacles related to spatial awareness. Because of the sometimes considerable difficulties that the pupils faced in the mathematics classroom, a mathematics specialist TA was critical to create a bridge between pupil disadvantage and potential. The TA, through working closely with pupils with AS, was well placed to decide upon the most suitable and personalised means of support. The TA's management of the pupil, provision of appropriate resources and establishment of the correct environment was able to set the pupils on a par with their peers. Significantly, when the TA had had specific training in how to teach mathematics along with an understanding of conflict resolution, she or he was better equipped to develop individual teaching strategies. Furthermore, it was established that those who adapted their teaching styles according to circumstance were the most able to ensure that their students stayed on task. Despite initial sometimes prolonged setbacks, the pupils were capable of perseverance with mathematics problem solving tasks under the right circumstances and it was evident that the use of time in the mathematics classroom was improved through provision of targeted personal support.

The findings further demonstrated that pupils with AS are likely to remain focused for longer in highly structured mathematics classrooms with flexible, accessible teachers. With respect to the teachers, there was no one specific approach that encouraged the pupils to develop skills associated with mathematics learning. Rather a mixture of strategies appeared to be the catalyst. Some educators' mathematical intellect, calm nature and humour alone seemed to change the dynamic in the classroom. Teachers who showed an interest in the pupils appeared to contribute greatly to their development of mathematics learning skills.

One overarching conclusion of the study was that there were no significant differences in the learning of mathematics as a consequence of school type. The pupils with Asperger Syndrome acted and reacted similarly in both mainstream and specialist schools. Additionally, it was established that they were as unlikely to form friendship groups with other pupils with AS as with their neurotypical peers.

Nevertheless, they did not regard themselves as different or unusual. They wanted to fit in and disliked it intensely when attention was drawn to them. Thus, if a mainstream school can successfully accommodate pupils with AS, then this could provide the opportunity for them to make and maintain essential friendships from the wider population and, through access to collaborative work via integration with small friendship groups, help them to learn how to function as a member of a multi-faceted society.

6.3 Implications for Practice

The major findings to emerge from this research are summarised in this subsection and combined with implications for practice.

6.3.1 The Pupil and the Curriculum

To provide strategies that aid perseverance and facilitate collaborative participation (Vygotsky, 1986) for students with Asperger Syndrome, both of which, according to the National Curriculum for Mathematics (2013) are of great importance to the education of all learners, maybe the teaching of mathematics needs a more contemporary transformation. To truly cater for this group of special need pupils, the mathematics curriculum perhaps ought not to be about administering a multi-faceted programme of study under the misapprehension that it can create a homogenous society. Certainly, if mathematical capability is impaired in one area but superior in another, tapping into the area that can be developed rather than the part that cannot might be the key to replenishing and, perhaps more importantly, increasing the bank of mathematicians for the future. Where there is compelling evidence that a particular educational strategy is ineffective, even detrimental, then perhaps mathematics educators should concentrate on a more fluid curriculum to make it accessible to all. At times, complete sections of a syllabus might need to be replaced by something more suited to pupils with Asperger Syndrome. If the pupils cannot assimilate and accommodate one particular topic from the mathematics syllabus, it should not affect their grades.

Historically, the mathematics curriculum has not remained static. Over the years, themes have fallen in and out of favour. Perhaps then the mathematics curriculum need not comprise the myriad topics it does now. For instance, the curriculum (2013) stipulates that problem solving and investigational study tasks should be incorporated within mathematics lessons. Yet, students with Asperger Syndrome can find it difficult to make meaningful connections between concepts when questions are too detailed. While the curriculum places great importance on skills such as ability to decipher lengthy problems as evidence of proficiency with specific mathematical topics, it might be that few of these students will gain worthwhile qualifications. Although the new mathematics curriculum is more flexible, the outdated examination system is still largely based upon the ideals of the 20th Century. To fully engage with the needs of the 21st Century, it has to adapt too. It should not demand, as the only indicator of success in mathematics, demonstration of skill in all areas.

To summarise, the removal of advanced reasoning and lengthy 'real-world' riddles in favour of a shift towards a mathematical core curriculum made more relevant to the pupil with Asperger Syndrome and to include links with the common special skills of these students could be the way forward.

6.3.2 The Environment

The primary findings have shown that the progress of pupils with Asperger Syndrome can be improved through the use of appropriate resources to include personal support. In particular, I have identified that subject trained Teaching Assistants are vital to improving the mathematical skills of students with AS. Furthermore, the TA who utilises a Zone of Proximal Development (Vygotsky, 1978) approach to support produces higher than the norm levels of success for the AS pupil. ZPD allows the pupil to develop at a personal pace whilst factoring in the option of an executive secretary to get past an insurmountable block (Attwood, 2007).

Secondly, pupils with Asperger Syndrome generally appear to be more likely to persevere in compact environments where classes are smaller, there is teacher support and special interests are incorporated into mathematics lessons. However, perhaps surprisingly, high levels of interest in mathematics learning are shown to be independent of the type of educational establishment, (specialist or mainstream).

Thirdly, the pupils are more inclined to participate in activities when they are practical and convincingly based on mathematics in real life. Conversely, lengthy simulated real-world investigational tasks, no matter how they are presented, do not aid interest or perseverance. The reasons for this are three-fold: the questions are seen as unnecessarily protracted; the problems are considered to be unrealistic; and the questions posed incorporate confusing language. This is an enormous potential concern for teaching in mathematics lessons as many mathematics sessions now feature lengthy problem solving activities. To make them fully accessible to the pupil with Asperger Syndrome, personalised adaptations and a TA to act as a peer are essential.

Finally, contrary to popular opinion, although computer-based learning can initially help pupils with Asperger Syndrome to develop interest in a task, the use of general computer software as a teaching resource in a mathematics lesson does not appear to improve perseverance with respective activities.

6.4 Summary

A hybrid teaching and learning environment incorporating real-life cross-curricular practical activities in which the mathematics specialist TA and teacher operate a ZPD (1978) style of support, and where integrated questioning is succinct and precise, has the potential to promote interest in mathematics along with associated development of mathematics learning capabilities for pupils with Asperger Syndrome.

Yet, although school type does not appear to be necessarily significant, the mathematics learning experience can change according to the individual classroom environment or a pupil's stage of development, sometimes cyclically. Therefore, along with provision of a mathematically trained TA or buddy, the pupils' specific needs should be regularly revisited and teaching and learning strategies revised.

As suggested in the final section of the Limitations section, the findings from this enquiry could be used as a basis to inform future studies. Evidence-based practice as a research model has the potential to identify significant new strategies to improve the field of mathematics education for pupils with Asperger Syndrome. This evolutionary research approach could be increasingly useful if newer and more complex neurobiological disorders emerge as a natural consequence of the ever-changing environment, and so would concur with Hargreaves' (2007) dynamic research model for the future.

References

Alborz, A. Pearson, D., Farrell, P. and Howes, H. (2009) *The Impact of Adult Support Staff on Pupils and Mainstream Schools – A Systematic Review of Evidence*. [Online] Available from: www.dcsf.gov.uk/research [Accessed: 14th September 2010]

Armstrong, M. (1980) *Closely Observed Children; The Diary of a Primary Classroom*. London: Chameleon

Asperger, H. (1944) *Die 'Autistischen Psychopathen' im Kindesalter* [Autistic psychopathy in childhood]". Archiv für Psychiatrie und Nervenkrankheiten (in German) 117: 76–136. Translated from German by Frith, U. (Ed.), *Autism and Asperger Syndrome.* Cambridge: Cambridge University Press: 184-206

Asperger, H. (1979) *Problems of infantile autism*. Communication 13, 45-52. [Online] Available from: http://www.autismuk.com/home-page/history-of-autism/hans-asperger-definition/ [Accessed: 26 November 2015]

Atherton J. S. (2013) *Learning and Teaching; Resistance to Learning.* [Online] Available from: http://www.learningandteaching.info/learning/resistan.htm [Accessed: 26 December 2015]

Attwood, T. (2007) *The Complete Guide to Asperger's Syndrome*. London: Jessica Kingsley Publishers

Austin Psychological Assessment Centre (2009) 'ASD*', APA weblog.* [Online] Available from: http://www.apacenter.com/category/autism-spectrum-disorders/ [Accessed: 21st December, 2015]

Baker, S. (2007) *Math Strategies for General and Special Education Students with Autism Spectrum Disorders*. [Online] Available from: http://www.medicine/uiowa.edu/autismservices/mathstrategiesslides.pdf [Accessed: 10th November 2010]

Barahona-Correa, J.B. & Filipe, C.N. (2016) A Concise History of Asperger Syndrome: The Short Reign of a Troublesome Diagnosis, *Front. Psychol.* 6:2024. [Online] Available from: http://journal.frontiersin.org/article/10.3389/fpsyg.2015.02024/full. [Accessed: 12th April 2016]

Barber, C. (1996) The integration of a very able pupil with Asperger Syndrome into a mainstream school, *British Journal of Special Education*. [Online] Available from: http://dx.doi.org/10.1111/j.1467-8578.1996.tb00938.x. [Accessed: 12th September 2011]

Baron-Cohen, S. (2008) *Autism and Asperger Syndrome: The Facts*. London: OUP

Baron-Cohen, S. (2009) The Short Life of a Diagnosis. *The New York Times*. [Online] Available from: http://www.nytimes.com/2009/11/10/opinion/10baron-cohen.html [Accessed: 14th September 2010]

Baron-Cohen, S. (2013) Interview. In: *The Curious Case of the Dog in the Night-time: from Page to Stage*. BBC2, 10 October 2013

Baron-Cohen, S. & Craig, J. (1999) Creativity and imagination in autism and Asperger Syndrome. *Journal of Autism and Developmental Disorders*. 1999, 29, 319-326. [Online] Available from: http://www.ncbi.nlm.nih.gov/pubmed/10478731 [Accessed: 30th September 2010]

Baron-Cohen, S. & Jolliffe, T. (2001) A test of central coherence theory: Can adults with high-functioning autism or Asperger Syndrome integrate fragments of an object? *Cognitive Neuropsychiatry*. 2001, 6, 193-216

Baron-Cohen, S. et al. (2001) The Autism-Spectrum Quotient (AQ): evidence from Asperger Syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, 31, 5-17

Baron-Cohen et al. (2009) Prevalence of autism-spectrum conditions: UK school-based population study. *The British Journal of Psychiatry*.194, 500–509. doi: 10.1192/bjp.bp.108.059345. [Online] Available from: http://bjp.rcpsych.org/content/194/6/500 [Accessed: 30th September 2015]

Bedford, D. (2010) Conversations with Erica Clifford (Personal communication: 2010)

Behrmann, M. (2006) Seeing it differently: visual processing in autism *Trends in Cognitive Sciences 2006* Jun: 10(6): 258-64

Benbasat, I., Goldstein, D. K. and Mead, M. (1987) The Case Research Strategy in Studies of Information Systems. *MIS Quarterly*, 11 (3), 369-386

Bernard, H. R. (2006) Research Methods in Anthropology. *Qualitative and Quantitative Approaches (4th Ed).* Walnut Creek, CA: Altamira Press

Berninger, V. & Richards, T. (2009) Brain and Learning. In: Anderman, E. and Anderman, L. (Eds.) *Psychology of Classroom Learning: An Encyclopaedia,* Volume 1, 15 – 22. Detroit MI: Macmillan Reference USA

Billington, J., Baron-Cohen, S. and Bor, D. (2008) Systemizing influences attentional processes during the Navon task: *An fMRI study Neuropsychologia* 46 (2008) 511–520. [Online] Available from: www.elsevier.com/neuropsychologia [Accessed: 9th October 2010]

Bissonette, B. (2009) ‘Mathematical questions’ *Forward Motions weblog*. [Online] Available from: http://www.forwardmotion.info/archive/nl_oct09.html [Accessed: 9th August 2009]

Blatchford, P., Bassett, P., Brown, P., Martin, C., Russell, A., and Webster, R. (2009) *The Deployment and Impact of Support Staff in Schools (Strand 1, Waves 1-3, 2004, 2006 and 2008)*. [Online] Available from: www.dcsf.gov.uk/research. [Accessed: 14th September 2010]

Bogdashina, O. (2005) *Theory of Mind and the Triad of Perspectives on Autism and Asperger Syndrome: A view from the Bridge*. Tyne and Wear, UK: Athenaeum Press

Bölte, S., Golan, O., Goodwin, M. & Zwaigenbaum, L. (2010) What can innovative technologies do for Autism Spectrum Disorders? *Autism* 2010 14: 155. [Online] Available from: http://aut.sagepub.com/content/14/3/155.full.pdf+html [Accessed: 30th September 2010]

Bourdillon, H. and Storey, A. (2013) *Aspects of Teaching and Learning in Secondary Schools: Perspectives on Practice.* Kindle Edition. New York**:** RoutledgeFalmer

Bragdon, A. & Gamon, D. (2010) *The Brainwaves Centre*. Allen D. Bragdon Publishers, Inc. [Online] Available from: www.brainwaves.com/puzzles_selfTests.html [Accessed: 30th September 2010]

Bruner, J. S. (1966) *Toward a theory of instruction*. Cambridge, Mass.: Belkapp Press

Burton, D. (2009) 'Ways pupils learn', in S. Capel, M. Leask and T. Turner (eds) *Learning to Teach in the Secondary School: A Companion to School Experience*, 5th edn, London: Routledge

Butterworth, B. (2002) Mathematics and the Brain: Opening Address to the MA. *The Mathematical Brain*. London: Macmillan

Carter, R. (2009) *The Brain Book*. London: Dorling Kindersley

Carter, R. (2010) *Mapping the Mind*. London: Phoenix

Chiang, H. & Lin, Y. (2007) *Mathematical ability of students with Asperger Syndrome and high-functioning autism: A review of literature*. [Online] Available from: http://aut.sagepub.com/content/11/6/547.abstract [Accessed: 17th August 2010]

Clark, J. & Baker, T. (2006) Collaborative learning in diverse groups: a New Zealand experience. In: *Proceedings of the 17th ISANA International Education Conference* [CD ROM]: 5 – 8 December 2006, University of NSW, Sydney, Australia. Sydney: Conference

Cohen, L. et al. (2011) *Research Methods in Education*. Oxon: Routledge

Cumine, V., Dunlop, J. & Stevenson, G. (2010) *Asperger Syndrome: A Practical Guide for Teachers*. Oxon: Routledge

Davidson, M. (2010) 'You're a failure – now get over it'. *The Daily Telegraph*, 30th August 2010

DCSF (2008) Department for Children, Schools and Families, *Personalised Learning: A Practical Guide*. [Online] Available from: <https://www.education.gov.uk/publications/standard/publicationdetail/page1/DCSF-00844-2008> [Accessed: 17th June 2011]

DeMyer, M. (1976) Motor, perceptual-motor and intellectual disabilities of autistic children. In: Wing, L. *Early Childhood Autism*. Pergamon: Oxford: 169 - 196

Dennis, M., Lazenby, A. L. & Lockyer, L. (2001) Inferential language in high-function children with autism. *Journal of Autism and Developmental Disorders*, 31, 47–54

Devlin, K. (2000) *The Math Gene*. London: Orion Books

Dewey, M. (1991) Living with Asperger's Syndrome. In: Frith, U. (Ed.) *Autism and Asperger Syndrome.* Cambridge: Cambridge University Press: 184-206

DfE (2012) *Teaching Assistants.* [Online] Available from: http://www.education.gov.uk/schools/performance/news.html [Accessed: 19th December 2015]

DfE (2015) *The SEN and Disability Code of Practice* [Online] Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/398815/SEND_Code_of_Practice_January_2015.pdf [Accessed: 19th January 2016]

DFES (2009) *Autism and mathematics* [Online] Available from: http://www.dfes.gov.uk/curriculum numeracy/access/autistic [Accessed: 9th August 2009]

Dyspraxia Foundation (2013) *Can my child have both autism and dyspraxia?*. [Online] Available from: https://www.dyspraxiafoundation.org.uk/questions/ child-autism-dyspraxia/ [Accessed: 19th December 2015]

Edwards, A. D. & Westgate, D.P.G. (1994) *Investigating Classroom Talk*. London: Falmer Press

Ehlers, S. and Gillberg, C. (1993) The Epidemiology of Asperger Syndrome. *Journal of Child Psychology and Psychiatry*, 34: 1327–1350

Eisner, E. (1992) Objectivity in Educational Research. *Curriculum Inquiry*, Vol. 22, No. 1 (Spring, 1992): 9-15: Blackwell Publishing

Elliott, J. (2001) 'Making evidence-based practice educational' *British Educational Research Journal*, Vol. 27, No5, 2001: 555-74.

Elliott, J. & Adelman, C. (1975) The language and logic of informal teaching. *The Ford teaching project, Unit 1*, *patterns of teaching.* Norwich, UK: University of East Anglia, Centre for Applied Research in Education

Fitzgerald, M. & Corvin, A. (2001) Diagnosis and differential diagnosis of Asperger Syndrome *Advances in Psychiatric Treatment.* 7: 310-318

FPLD (Foundation for people with Learning Difficulties) (2002) *Count us in: the report of the committee of inquiry into meeting the mental health needs of young people with learning disabilities*. London: Mental health foundation

Freisleben-Cook, L. (2004) ‘What is Asperger Syndrome?’ *OASIS@MAAP*. [Online] Available from: http://www.udel.edu/bkirby/asperger/aswhatisit.html [Accessed: 19th January, 2011]

Frith, U. (1991) *Autism and Asperger Syndrome*. Cambridge: Cambridge University Press

Frith, U. & Happé, F. (1994) *Autism Beyond Theory of Mind: Cognition*. US National Library of Medicine, 50: 115–132

Ghaziuddin, M. et al. (1994) Is clumsiness a marker for Asperger Syndrome? Journal of Intellectual Disability Research, 38, 519 – 527. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

Ghaziuddin, M. & Mountain-Kimchi, K. (2004) Defining the intellectual profile of Asperger Syndrome: Comparison with high-functioning autism. *Journal of Autism and Developmental Disorders:* 34, 279–284

Gillberg, C. (1991) Clinical and Neurobiological aspects of Asperger Syndrome in six family studies. In: Frith, U. (Ed.) *Autism and Asperger Syndrome*. Cambridge: Cambridge University Press: 122-146

Gillberg, C. & Ehlers, S. (1998) High Functioning People with Autism and Asperger Syndrome. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*, New York, Plenum Press, Ch. 5

Gillberg, I. and Gillberg, C. (1989) Asperger syndrome - some epidemiological considerations: A research note. Journal of Child Psychology and Psychiatry, 30, 631 – 638. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

Grandin, T. (2006) *Thinking in Pictures: Autism*. London: Random House

Griswold, D. E. et al. (2002) Asperger syndrome and academic achievement. *Focus on autism and other Developmental Disabilities:* 17, 94-102

Guba, E.G. & Lincoln, Y. S. (1981) *Effective evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches*. San Francisco: Jossey-Bass

Haddon, M. (2004) *The Curious Case of the Dog in the Night-time*. New York: Random House

Hale, H, (2008) *My World is Not Your World*. Canada: Archimedes Press

Hammersley, M. (1987) Some notes on the terms reliability and validity*. British Research Journal*: 13(1), 73–81

Hammersley, M. (1992) *What's Wrong with Ethnography?* London: Routledge

Hammersley, M. (2007) *Educational Enquiry, A Study Guide.* Margate: Thanet Press Ltd

Hargreaves D. (2007) Teaching as a research-based profession: possibilities and prospects. In: Hammersley, M. *Educational Research and Evidence-based Practice*. London: Sage Publications: 3-17

Hill, A. L. (1978) Mentally retarded individuals with special skills. In: *International review of research in mental retardation, vol. 9* (ed. N. R. Eller). NewYork: Academic Pan: 277- 298

Hoekstra, R. A., Happé, F., Baron-Cohen, S. & Ronald, A. (2009) Association between extreme autistic traits and intellectual disability: insights from a general population twin study. *The British Journal of Psychiatry* (2009) 195, 531–536. doi: 10.1192/bjp.bp.108.060889. [Online] Available from: http://www.autismresearchcentre.com/docs/papers/2009_Hoekstra_etal_BJP.pdf [Accessed: 24th September 2010]

Howlin, P. (1997) *Autism, preparing for adulthood*. London: Routledge

Inhelder, B. & Piaget, J. (1958) *The Growth of Logical Thinking from Childhood to Adolescence.* London: Routledge and Kegan Paul

Jackson, L. (2002) *Freaks, geeks and Asperger Syndrome: a user guide to adolescence.* London: Jessica Kingsley Publishers

Jacobsen, P. (2009) Surviving the Executive Functioning Demands of High School, *The Autism Society*. [Online] Available from: http://www.education.com/reference/article /executive-function-high-school-asperger/ [Accessed: 10th November 2010]

Jarvis, P. (1987) Meaningful and Meaningless Experience: Towards an Analysis of Learning from Life. *Adult Education Quarterly*, 37, 164-172

Job, B. & Morley, D. (2003) *Key Maths Statistics*. Cheltenham: Nelson Thornes

Jordan, R. & Powell, S. (1995) *Understanding and Teaching Children with Autism.* Chichester: Wiley

Joyce, H. (2001) Natural born mathematicians. *Plus Magazine, Issue 19 University of Cambridge, Millennium Mathematics Project*. [Online] Available from: http://www.mathematicalbrain.com/ new.html [Accessed: 9th December 2010]

Kagan,S. (1994) *Kagan cooperative learning. 2nd ed*. San Clemente CA: Kagan Publishing

Kawulich, B. (2005) Participant Observation as a Data Collection Method [81 paragraphs]. Forum *Qualitative Sozialforschung / Forum: Qualitative Social Research*: 6(2), Art. 43. [Online] Available from: http://nbn-resolving.de/urn:nbn:de:0114-fqs0502430, https://www.uni-hohenheim.de/i490a/lectures/M4901-410/3.2.pdf [Accessed: 6th August 2009]

Kemmis, S. (1988) Action Research. In: Keeves, J. P. (ed.) *Educational Research Methodology and Measurement.* Oxford: Permagon: 42-49

Kemmis, S. & McTaggart, R. (1981) *The Action Research Planner*. Victoria: Deakin University Press

Kennedy, D.P., Redcay, E. & Courchesne, E. (2006) Failing to Deactivate: Resting Functional Abnormalities in Autism. *Proceedings of the National Academy of Sciences of the United States of America*: Vol. 103, No. 21 (May 23, 2006): 8275 - 8280. Published by: National Academy of Sciences. [Online] Available from: www.jstor.org/stable/30049210 [Accessed: 17th August 2010]

Khamsi, R. (2007) First Born Children are the Cleverest. *New Scientist, Science* (DOI:10.1126/science.1141493). [Online] Available from: https://www.newscientist.com/article/dn12102-firstborn-children-are-the-cleverest/ [Accessed: 4th August 2013]

Kim, J. A., Szatmari, P., Bryson, S. E., Streiner, D. L. & Wilson, F. J. (2000) The Prevalence of Anxiety and Mood Problems among Children with Autism and Asperger Syndrome. *Autism*, 4(2), 117-132

Kirby, B. (2001) *The OASIS Guide to Asperger Syndrome*. New York: Random House

Kirkup, J. and Irvine, C. (2009) 'Sack 40000 teaching assistants says government report', *The Daily Telegraph*, 28th September, 2009

Klin, A. et al. (1995) Validity and Neuropsychological Characterization of Asperger Syndrome: Convergence with Nonverbal Learning Disabilities Syndrome. *Journal of Child Psychology and Psychiatry* 36(7): 1127 – 40. [Online] Available from: https://www.researchgate.net/publication/14358794_Validity_and_Neuropsychological_Characterization_of_Asperger_Syndrome_Convergence_with_Nonverbal_Learning_Disabilities_Syndrome. [Accessed: 9th March 2015]

Klin, A., Volkmar, F. R. & Sparrow, S. S. (2000) *Asperger Syndrome*. New York: The Guildford Press

Lakoff, G. & Nunez, R. (2000) *Where mathematics comes from*. New York: Basic Books

Landauer, T. K. and Bjork, R. A. (1978) On keeping track of the present status of people and things. In: Gruneberg, M. M, Morris, P. E. & Sykes, R. N. (Eds). *Practical Aspects of Memory*. London: Academic Press: 625–632

Lange, N. (2010) Autism breakthrough? MRI tests shown to be highly accurate at diagnosing disorder in new study. *NY Daily News*. [Online] Available from: http://www.nydailynews.com/lifestyle/health/2010/12/02/2010-12-02_ [Accessed: 3rd December 2010]

Learnanytime (2010) *Games: Spatial Awareness* [Online] Available from: http://www.learnanytime.co.uk/Mind%20Games/Spatial%20Awareness.htm [Accessed: 30th June 2015]

Lewis, A. (2009) Methodological issues in exploring the ideas of children with autism concerning self and spirituality. *Religion, Disability and Health* 13 64-76 ISSN 1522-8967 print/ 1522-9122 [Online] Available from: DOI 10.1080/ 15228960802581446 [Accessed: 24th May 2015]

Lyons, V. & Fitzgerald, M. (2005) *Asperger Syndrome: A Gift Or A Curse?* New York: Nova Science Publishers

Long, W. (2007) *Asperger's Case Studies*. [Online] Available from: http://www.drbilllong.com/Autism/Asperger.html [Accessed: 30th September 2010]

Marsh, E. J., Roediger, H.L., Bjork, R.A. & Bjork, E.L. (2007) The memorial consequences of multiple-choice testing. *Psychonomic Bulletin and Review*, 6, 194 – 199

Mason, J. (2001) *Researching Your Own Practice: The Discipline of Noticing.* London: Routledge

McDougle, C. (1998) Repetitive Thought and Behaviour in PPD. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

Merriam, S.B. (1998) *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass Publishers

Mesibov, G. B. & Shea, V. (1996) Full inclusion and students with autism*. Journal of Autism and Developmental Disorders:* 26(3), 337-346

Mesibov, G. B. et al. (2008) *The Ziggurat Model: Framework for Designing Comprehensive Interventions for Individuals with High-Functioning Autism & Asperger Syndrome.* Kansas: Autism Asperger Publishing Company

Miesenberger, K. et al. (2014) Computers Helping People with Special Needs, 14th International Conference ICCHP 2014 Paris. Proceedings: Part I. London: Springer

Mintz, J. (2008) Working with children with Asperger's Syndrome in the mainstream classroom: A psychodynamic take from the chalk face. *Psychodynamic Practice Vol. 14, No. 2,* May 2008, 169–180

Morris, B. (2008) *Some Basic Strategies for the Classroom, Education & Autism Spectrum Disorders*. [Online] Available from: http://www.autism-help.org/autism-education-school-effects.htm [Accessed: 4th November 2010]

Morrison, W. (2010) Conversations with Erica Clifford (personal communication, August 2010)

Morse, M. & Moniz, S. (2010) IEP Planning and Educational Recommendations for Children with Asperger's and High Functioning Autism. *Autism Spectrum Disorders - Disorders of Attention Diagnostic and Comprehensive Care*. *[*Online] Available from: www.myoutofcontrolteen.com/files/Aspergers_PDF_XIII.pdf [Accessed: 24th July 2011]

NAC (2009) Evidence-based Practice and Autism in Schools. *National Autism Center*. [Online] Available from: http://www.nationalautismcenter.org/reports [Accessed: 3rd March 2010]

NAS (2015) *Autism* [Online] Available from: http://www.autism.org.uk [Accessed: 17th December 2015]

Nauert, R. (2008). Stress Affects Learning and Memory. *Psych Central*. [Online] Available from: http://psychcentral.com/news/2008/03/ 12/stress-affects-learning-and-memory/2031. html [Accessed: 18th November, 2015]

Nordqvist, C. (2015) *Medical News Today*. [Online] Available from: http://www.medicalnewstoday.com/ [Accessed:10th September, 2015]

O'Brien, T. (2006) *Observing Children's Mathematical Problem Solving with 21st C Technology*. [Online] Available from: http://www.handheldlearning.co.uk/content/view/24/0/ [Accessed: 8th December 2010]

Ochs, E. (1979) *Developmental Pragmatics.* London: Academic Press

Oxford English Dictionary (2010). Oxford: Oxford University Press

Ozonoff, S. (1998) Assessment and Remediation of Executive Dysfunction in Autism and Asperger Syndrome. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

Ozonoff, S., Rogers, S. J. & Pennington, B. F. (1991) Asperger's Syndrome: Evidence of an empirical distinction from high-functioning autism. *Journal of Child Psychology and Psychiatry*, 32, 1107-1122

Patton, M. Q. (2002) *Qualitative Research & Evaluation Methods*. CA: Sage

Piaget, J. (1954) *The Construction of Reality in the Child*. New York: Basic Books

Polanyi, M. (1959) *The Study of Man.* Chicago, IL.: University of Chicago Press

Pomeroy, J. (1998) Subtyping Pervasive Development Disorder. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

QCDA (2010) *GCSE Standards*. [Online] Available from: http://www.qcda.gov.uk/24956.aspx, [Accessed: 2nd April 2010]

Risley, R. (2009) Diagnostic School Review. *International Electronic Journal of Elementary Education,* Vol.1, Issue 2, March

Roberts, J. M. A. & Prior, M. (2006) A review of the research to identify the most effective models of practice in early intervention of children with autism spectrum disorders. *Australian Government Department of Health and Ageing*. [Online] Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/mental-child-autbro-toc~mental-child-autbro-intro [Accessed: 4th November 2010]

Roberts, P. et al. (2006) Reliability and validity in research. *Nursing Standard,* Volume 20, No 44: 41-45

Rodd, M. (2011) Inclusion in Practice: Special Needs Pupils in Maths. In: *Learning to Teach Mathematics in the Secondary School*. Oxon: Routledge:189-205

Rodd, M. (2015) Conversation with Erica Clifford (Personal communication: 9th January, 2015)

Rohrer, J. et al. (2015) 'Examining the effects of birth order on personality'. *Proceedings of the National Academy of Sciences.* 112 (46): 14224–14229

Romanczyk, R., Lockshin, S. and Navalta, C. (1994) Autism: Differential Diagnosis, In Matson, J. *Autism in Children and Adults.* California: Brookes/ Cole Publishing

Roth, I. et al. (2009) *The Autism Spectrum in the 21st Century. Exploring Psychology, Biology and Practice*. Plymouth: OUP

Sacks, O. (1985) *The man who mistook his wife for a hat*. London: Duckworth

Safran, S. (2001) *Asperger Syndrome: The Emerging Challenge to Special Education, Exceptional Children* [Online] Available from: https://www.researchgate.net/publication/268206832_Asperger_Syndrome_The_Emerging_Challenge_to_Special_Education [Accessed: 30th September 2010]

Schofield, J. (1990) Increasing the generalisability of qualitative research, In: Hammersley, M. *Educational Research and Evidence-based Practice*. London: Sage Publications: 181 - 203

Schopler, E. (1996) Are autism and Asperger Syndrome different labels or different dsabilities? *Journal of Autism and Developmental Disorders, 26,* 109 - 110

Schopler, E. et al. (1998) *Asperger Syndrome or High Functioning Autism?* New York: Plenum Press

Schutte, J. (2010) Creativity and adults with autism. In: *AHEADD weblog 2010*. [Online] Available from: http://aheadd.org/blog/creativity-and-adults-with-autism [Accessed: 14th November 2011]

Sherman, J. A. (1979) Predicting mathematical performance in high school girls and boys. *Journal of Educational Psychology*, 71, 242-249

Silas, D. (2010) *Warnock & SEN*. [Online] Available from: http://www.specialeducationalneeds.co.uk /Useful Information/SEN-EducationInfo/warnock.html [Accessed: 20th September 2010]

Silton, N.R. (2014) Innovative Technologies to Benefit Children on the Autism Spectrum. Global: IGI Global

Simpson, R. et al. (2001) Inclusion of Learners with Autism Spectrum Disorders in General Education Settings. *Topics in Language Disorders*: April/May/June 2003 - Volume 23 - Issue 2 - p 116–133. [Online] Available from: http://journals.lww.com/topicsinlanguagedisorders/Abstract/2003/04000/Inclusion_of_Learners_with_Autism_Spectrum.5.aspx [Accessed: 19th December 2015]

Snyder, A. W. & Mitchell, D. J. (1999) *Is integer arithmetic fundamental to mental processing?: the mind's secret arithmetic.* Australia: Centre for the Mind, Institute of Advanced Studies

Sousa, D. A. (2008) *How the Brain Learns Mathematics*. Thousand Oaks, CA: Corwin Press

Stephenson, S. (2010) Montessori Philosophy & Practice: Invention, Geometry, Math. *Child of the World, Montessori from Three to Twelve Years.* [Online] Available from: http://www.michaelolaf.com/CWcontents.html, [Accessed: 8th December 2010]

Stillman, W. (2010) *The Everything Parent's Guide to Children with Asperger's Syndrome*. MA: Adams Media

Sullivan, R. C. (1992) Rain Man and Joseph. In: Schopler, E. & Mesibov, G. B. (Eds) *High-functioning individuals with autism*. New York: Plenum Press: 243 - 251

Swann, J. et al. (2003) *Research Methods in Education*. Oxford: The Alden Group

Symington, R. (2008) Asperger's Diversity. *NCETM*. [Online] Available from: www.ncetm.org.uk/ Def ault.aspx [Acessed: 25th November 2014]

Szatmari, P., Brenner, R. and Nagy, J. (1989) Asperger's syndrome: A review of clinical features. *Canadian Journal of Psychiatry*, 34: 554-560

Szatmari, P. et al. (1989) Asperger's Syndrome and autism: Comparisons on early history and outcome. Developmental Medicine and Child Neurology, 31, 709-720. In

Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

Szatmari, P. et al. (1990) Asperger's Syndrome and autism: Neurocognitive aspects. Journal of the American Academy of Child and Adolescent Psychiatry, 29, 130-136. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

Szatmari, P. et al. (2007) The use of genetic epidemiology to guide classification in child and adult psychopathology. *International Review of Psychiatry* 19 (5): 483–96

Tantam, D. (1988) Lifelong eccentricity and social isolation II. Asperger's syndrome or schizoid personality disorder? British Journal of Psychiatry, 153, 783 – 791. In

Tantam, D. (1991) Living with Asperger's Syndrome. In: Frith, U. (Ed.) *Autism and Asperger Syndrome.* Cambridge: Cambridge University Press: 184-206

TDA (2010) *Practical Strategies for PGCE students.* [Online] Available from: www.tda.gov.uk [Accessed: 1st July 2010]

TDA SEN Manual (2010) Special educational needs and/ or disabilities *Training Toolkit.* [Online] Available from: http://dera.ioe.ac.uk/id/eprint/13811 [Accessed: 1st September 2010]

Treffert, D. A. (1989) *Extraordinary people*. New York: Harper & Row

Tweed, L. et al. (2009) *Interventions for Autism Spectrum Disorders*. Maine: Children's Services Evidence-based Practice Advisory Committee

Van Hiele, P. (1999) Developing Geometric Thinking Through Activities that Begin with Play. *Teaching Children Mathematics*, February 1999: 310 - 316

Van Krevelen, D. (1971) Early infantile autism and autistic psychopathy. *Journal of Autism and Childhood Schizophrenia,* 1971 Jan-Mar:1(1):82-6

Volkmar, F. & Klin, A. (1998) Asperger Syndrome and Nonverbal Learning Disability. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

Volkmar, F. et al. (2005) *Handbook of Autism and Pervasive Developmental Disorders, Diagnosis, Development, Neurobiology and Behaviour.* New Jersey: Wiley and Sons

Vygotsky, L. S. (1978) Interaction between Learning and Development. In: *Mind in Society: The development of higher psychological processes*, (Trans. M. Cole). Cambridge, MA.: Harvard University Press: 79-91

Vygotsky, L. (1986) Thought and Language. Kozulin, A. (Ed. and Trans.) *A Biography of Ideas.* Cambridge Mass.: MIT Press

Walker, M. (2007) Action Research and Narratives: 'Finely aware and Richly Responsible'. *Educational Action Research,* Vol 15, No.2, June 2007: 295 – 303

Walsh, E. (2015) *Aspergers in Higher Education: Facts and Advice to Educators* [Online] Available from: www.nuigalway.ie/.../documents/aspergers_syndrome.doc [Accessed: 20th November 2015]

Walter, R. (2012) *Asperger Syndrome* [Online] Available from: http://kidshealth.org/WellerCenter/en/parents/asperger.html?view=ptr [Accessed: 20th June 2012]

Ward, J., Sagiv, N. and Butterworth, B. (2009) The impact of visuo-spatial number forms on simple arithmetic. *Cortex*, 45 (10). pp. 1261-1265. ISSN 0010-9452. [Online] Available from: http://dx.doi.org/10.1016/j.cortex.2009.03.017 [Accessed: 19th December 2015]

Warnock, M. (2010) 'Cynical Betrayal of my Special Needs Children', *The Daily Telegraph:* 18th September 2010

Webber, J. and Scheuermann, B. (2008) *Educating Students with Autism: A Quick Start Manual*. Austin, Tx.: Pro-Ed

Wenger, E. (1998) *Communities of practice: learning, meaning and identity*. Cambridge: Cambridge University Press

Williams, D. (1996) *Like Color to the Blind: Soul Searching and Soul Finding.* New York: Times Books

Williams, K. (1995) Understanding the Student with Asperger's Syndrome: Guidelines for Teacher. *Focus on autistic behaviour*, Vol. 10, No. 2: Pro-ed Inc.

Wing, L. (1980) Childhood autism and social class: A question of selection. *British Journal of Psychiatry*, 137: 410~417

Wing L. (1981) 'Asperger's Syndrome: a clinical account'. *Psychol Med 11* (1): 115–29. doi:10.1017/S0033291700053332. PMID 7208735. [Online] Available from: http://www.mugsy.org/wing2.htm [Accessed: 31st May 2011]

Wing, L., Gould, J., and Gillberg, C. (2011). Autism spectrum disorders in the DSM-V: better or worse than the DSM-IV? *Res. Dev. Disabil.* 32, 768–773. doi: 10.1016/j.ridd.2010.11.003

Wolff, S. (1998) Schizoid Personality in Childhood. In Schopler, E. Mesibov, G. & Kunce, L. (1998) *Asperger Syndrome or High Functioning Autism*. New York: Plenum Press

Woods, P. (2005) *Successful Writing for Qualitative Researchers.* London: Routledge

Xin, J. F. (1999) Computer-assisted cooperative learning in integrated classrooms for students with and without disabilities. *Information Technology in Childhood Education*, 1, 61–78

Yin, R. K. (2003) *Case study research: Design and methods (3rd ed.*). Thousand Oaks, CA: Sage

Yin, R. K. (2009) *Case study research: Design and methods (4th ed.)*. Thousand Oaks, CA: Sage

Yu, L. (2010) *Methods*. [Online] Available from: http://www.lianneyu.com/methods.html [Accessed: 24th December 2011]

Appendix 1: DSM-V (2013)

Autism Spectrum Disorder 299.00 (F84.0)

Diagnostic Criteria

A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by the following, currently or by history (examples are illustrative, not exhaustive, see text):

1. Deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.

2. Deficits in nonverbal communicative behaviours used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.

3. Deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behaviour to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers.

B. Restricted, repetitive patterns of behaviour, interests, or activities, as manifested by at least two of the following, currently or by history (examples are illustrative, not exhaustive; see text):

1. Stereotyped or repetitive motor movements, use of objects, or speech (e.g., simple motor stereotypies, lining up toys or flipping objects, echolalia, idiosyncratic phrases).

2. Insistence on sameness, inflexible adherence to routines, or ritualized patterns or verbal nonverbal behaviour (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take same route or eat food every day).

3. Highly restricted, fixated interests that are abnormal in intensity or focus (e.g, strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interest).

4. Hyper- or hyporeactivity to sensory input or unusual interests in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).

C. Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities, or may be masked by learned strategies in later life).

D. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.

E. These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and autism spectrum disorder frequently co-occur; to make comorbid diagnoses of autism spectrum disorder and intellectual disability, social communication should be below that expected for general developmental level.

Table 2 Severity levels for autism spectrum disorder

Severity level	**Social communication**	**Restricted, repetitive behaviours**
Level 3 "Requiring very substantial support"	Severe deficits in verbal and nonverbal social communication skills cause severe impairments in functioning, very limited initiation of social interactions, and minimal response to social overtures from others. For example, a person with few words of intelligible speech who rarely initiates interaction and, when he or she does, makes unusual approaches to meet needs only and responds to only very direct social approaches	Inflexibility of behaviour, extreme difficulty coping with change, or other restricted/repetitive behaviours markedly interfere with functioning in all spheres. Great distress/difficulty changing focus or action.
Level 2 "Requiring substantial support"	Marked deficits in verbal and nonverbal social communication skills; social impairments apparent even with supports in place; limited initiation of social interactions; and reduced or abnormal responses to social overtures from others. For example, a person who speaks simple sentences, whose interaction is limited to narrow special interests, and how has markedly odd nonverbal communication.	Inflexibility of behaviour, difficulty coping with change, or other restricted/repetitive behaviours appear frequently enough to be obvious to the casual observer and interfere with functioning in a variety of contexts. Distress and/or difficulty changing focus or action.
Level 1 "Requiring support"	Without supports in place, deficits in social communication cause noticeable impairments. Difficulty initiating social interactions, and clear examples of atypical or unsuccessful response to social	Inflexibility of behaviour causes significant interference with functioning in one or more contexts. Difficulty switching between activities. Problems of organization and planning

overtures of others. May appear to have decreased interest in social interactions. For example, a person who is able to speak in full sentences and engages in communication but whose to- and-fro conversation with others fails, and whose attempts to make friends are odd and typically unsuccessful.	hamper independence.

Appendix 2: DSM-IV Criteria AS (1994)

Diagnostic Criteria for 299.80 Asperger's Disorder

A. Qualitative impairment in social interaction, as manifested by at least two of the following:

1. marked impairments in the use of multiple nonverbal behaviours such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction
2. failure to develop peer relationships appropriate to developmental level
3. a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g. by a lack of showing, bringing, or pointing out objects of interest to other people)
4. lack of social or emotional reciprocity

B. Restricted repetitive and stereotyped patterns of behaviour, interests, and activities, as manifested by at least one of the following:

1. encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus
2. apparently inflexible adherence to specific, non-functional routines or rituals
3. stereotyped and repetitive motor mannerisms (e.g., hand or finger flapping or twisting, or complex whole-body movements)
4. persistent preoccupation with parts of objects

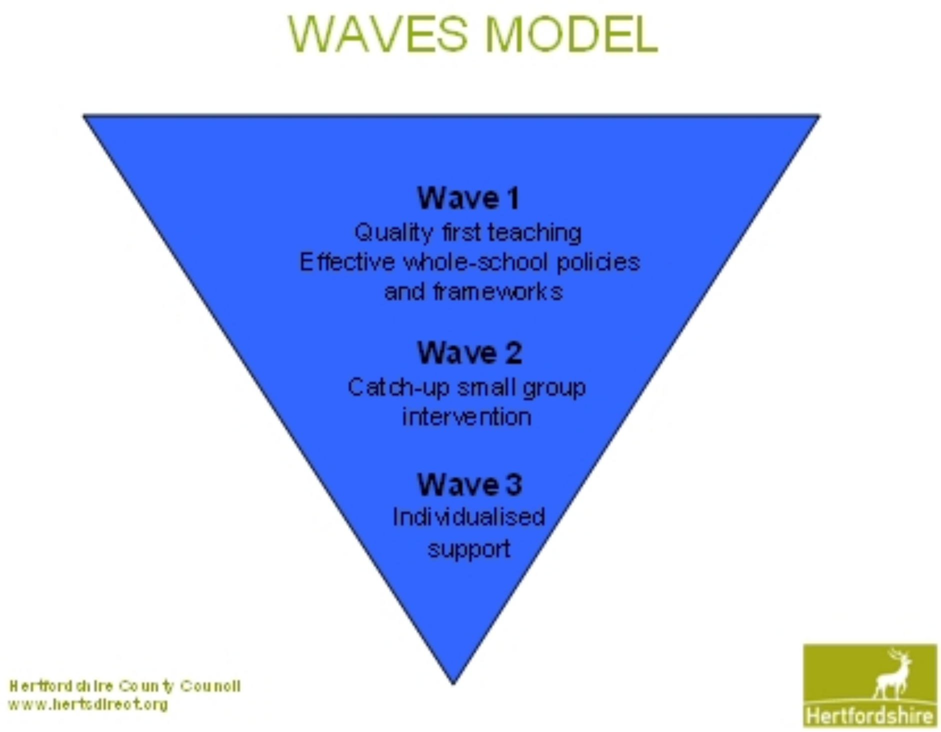
C. The disturbance causes clinically significant impairment in social, occupational, or other important areas of functioning

D. There is no clinically significant general delay in language (e.g., single words used by age 2 years, communicative phrases used by age 3 years)

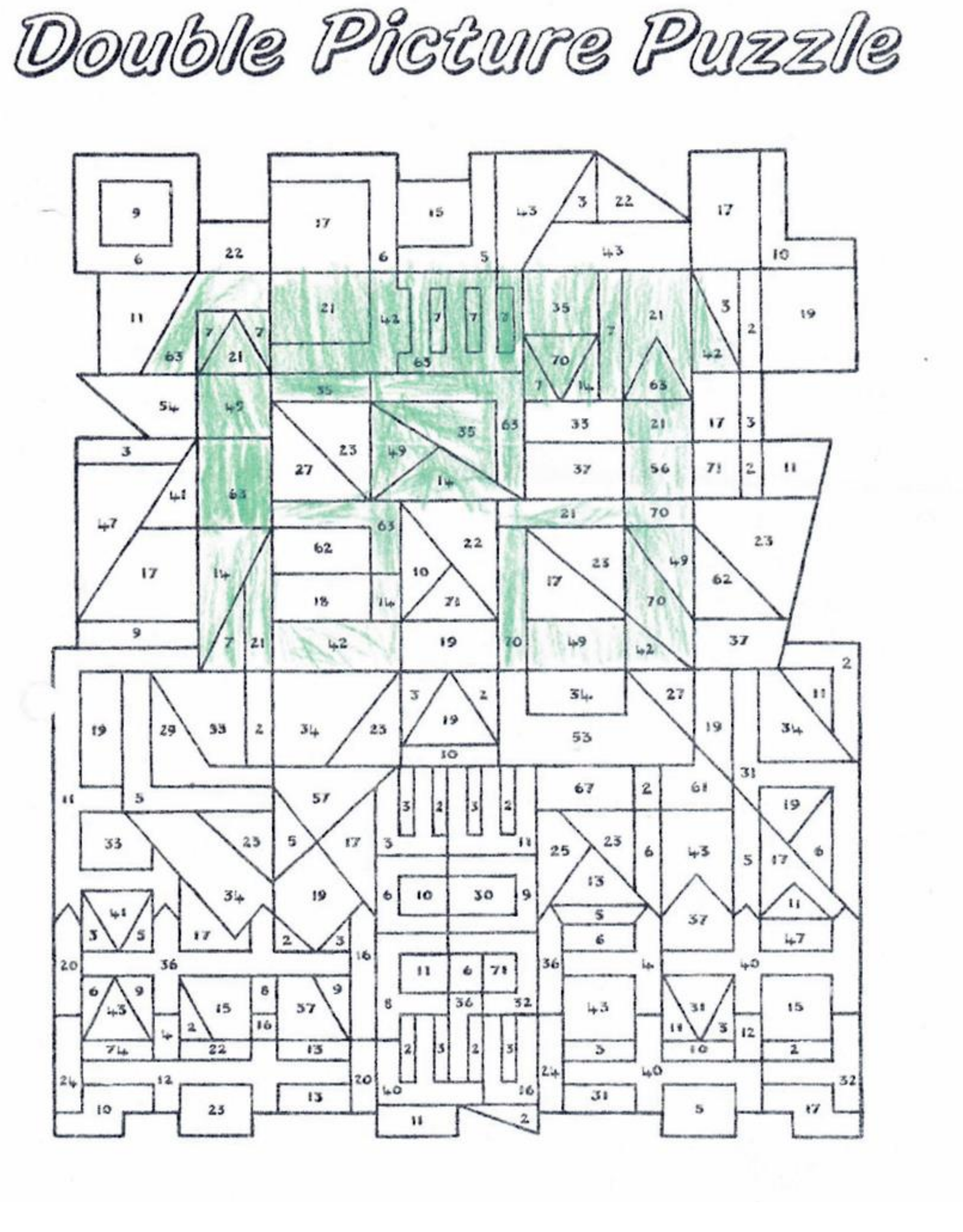
E. There is no clinically significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behaviour (other than social interaction), and curiosity about the environment in childhood

F. Criteria are not met for another specific Pervasive Developmental Disorder or Schizophrenia

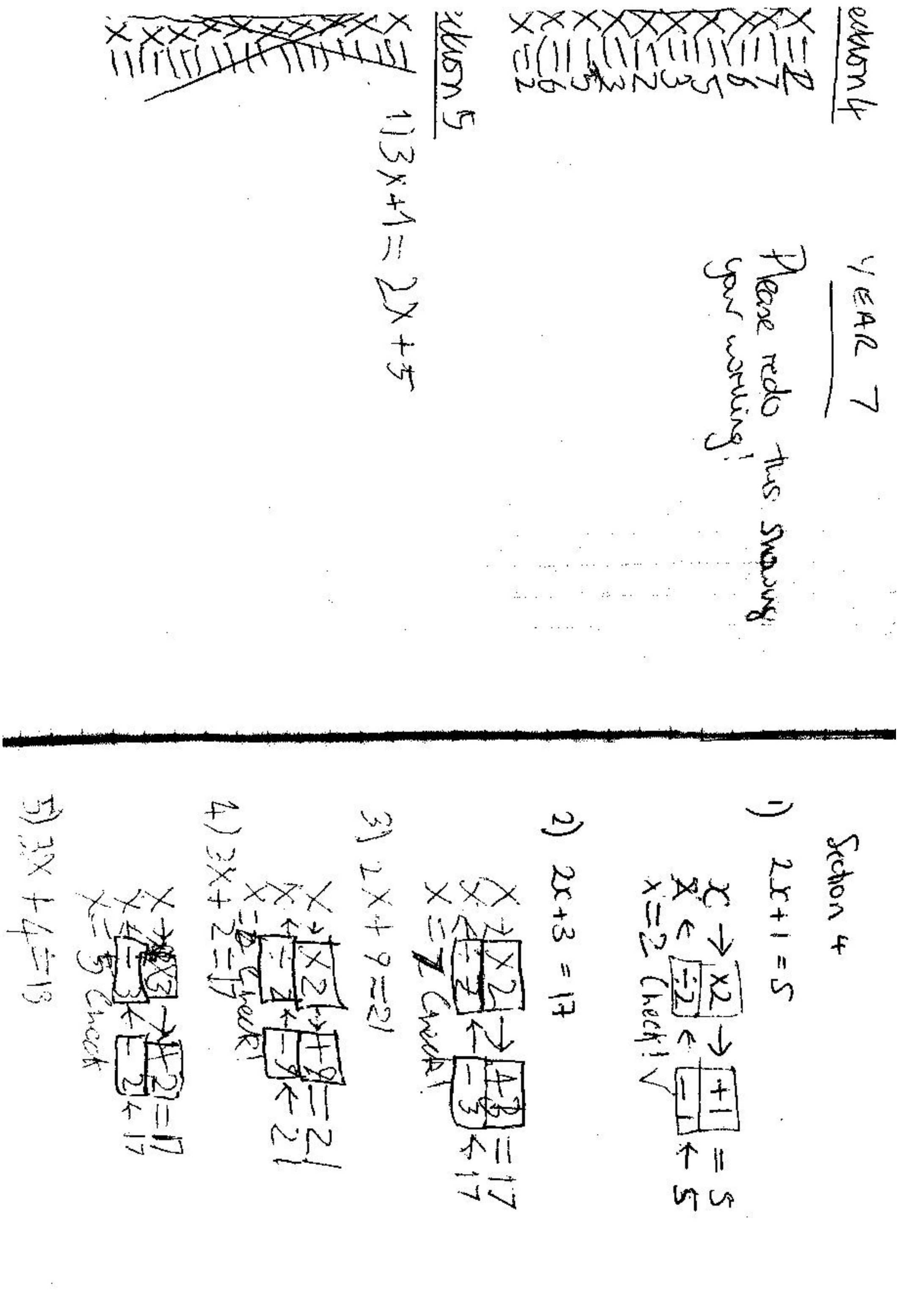
Appendix 3: Waves, 1, 2 and 3



Appendix 4: Puzzle Picture – Pupil Andy



Appendix 5: Student Charles' Classwork



Appendix 6.1: The Teacher of Mathematics at Arlidge Arts Academy

Characteristic	TICK
Part of a friendship group	
Few friends	✓
No friends	
Talkative	
Silent	
Independent	
Independent worker	
Contented	
Shows signs of depression	✓
Skilful with language	✓
Skilful with written work	
Determined	
Actively seeks assistance	
Knowledgeable	✓
Shouts out in class	
Appreciates help	
Is polite	✓
Avoids eye contact	✓
Good communicator	
Likes routine	
Shows impaired coordination skills	✓
Displays weakness in fine motor ability	✓
Displays weakness in gross motor ability	✓
Pedantic monotonic speech	
Any sensitivity (smell, taste, touch, sound, visual)	✓
Finds it difficult to understand what is required	✓
Has advanced spatial capabilities (e.g. geometry)	
Is deficient in spatial skills	✓
Signs of introversion	✓
Extroverted	
Likes own company	
Chatty	
Capable	
Flamboyant	
Aware of condition	
Understands condition	
Lacks vital understanding of some terminology	✓

Appendix 6.2: TA at Arlidge Arts Academy

Characteristic	**TICK**
Part of a friendship group	
Few friends	
No friends	✓
Talkative	
Silent	
Independent	
Independent worker	
Contented	
Shows signs of depression	
Skilful with language	
Skilful with written work	
Determined	
Actively seeks assistance	
Knowledgeable	✓
Shouts out in class	
Appreciates help	
Is polite	✓
Avoids eye contact	✓
Good communicator	
Likes routine	✓
Shows impaired coordination skills	✓
Displays weakness in fine motor ability	✓
Displays weakness in gross motor ability	✓
Pedantic monotonic speech	✓
Any sensitivity (smell, taste, touch, sound, visual)	✓
Finds it difficult to understand what is required	✓
Has advanced spatial capabilities (e.g. geometry)	
Is deficient in spatial skills	✓
Signs of introversion	✓
Extroverted	
Likes own company	
Chatty	
Capable	
Flamboyant	
Aware of condition	
Understands condition	
Lacks vital understanding of some terminology	✓

Appendix 6.3: Teacher at Bowman Hill

Characteristic	TICK
Part of a friendship group	
Few friends	
No friends	✓
Talkative	
Silent	
Independent	
Independent worker	
Contented	
Shows signs of depression	✓
Skilful with language	Sometimes
Skilful with written work	
Determined	Sometimes
Actively seeks assistance	
Knowledgeable	✓
Shouts out in class	
Appreciates help	✓
Is polite	✓
Avoids eye contact	✓
Good communicator	
Likes routine	
Shows impaired coordination skills	✓
Displays weakness in fine motor ability	✓
Displays weakness in gross motor ability	✓
Pedantic monotonic speech	✓
Any sensitivity (smell, taste, touch, sound, visual)	Don't know
Finds it difficult to understand what is required	✓
Has advanced spatial capabilities (e.g. geometry)	
Is deficient in spatial skills	✓
Signs of introversion	✓
Extroverted	
Likes own company	
Chatty	
Capable	
Flamboyant	
Aware of condition	Don't know
Understands condition	Don't know
Lacks vital understanding of some terminology	✓

Appendix 7a: Letter of Introduction

Dear Sir or Madam,

I am a conducting some research into how pupils with Asperger Syndrome connect with and integrate themselves into mathematics lessons. I am proposing to develop a set of strategies to improve their educational prospects in mathematics and would be grateful if you would allow me into your school, at a time convenient to you and your staff, to interview teachers and Teaching Assistants involved with the education of those with an ASD (Autistic Spectrum Disorder). The process should not take longer than 15 minutes each.

I wonder if you would also consider allowing me the opportunity to examine how these pupils interact with the educational setting. In addition, I am keen to observe pupils who may not have been formally diagnosed but who display unusual (relative to the accepted norm) behaviours. I have set out on the next page some examples of such behaviours which might assist your staff.

My intention is not to intrude upon any classroom practices or to become in any sense invasive. Any reports generated as a result of this research will be forwarded for your perusal, and all ethical matters outside your control will be scrupulously managed by me; I shall certainly respect your right to anonymity.

If, following preliminary observations, it appears that it might be useful to investigate further, and you are willing, perhaps you would allow me to return at a later date.

The age(s) of the pupils are immaterial; any help you can offer will greatly assist me in accumulating data for this study.

If you have any questions, please do not hesitate to contact me via mail, email or my direct line at any time.

Thank you for your consideration in this matter and kind regards,

Erica Clifford MEd

(Garford University)

(Ph.D student, Warwick University)

Asperger Syndrome is distinguished by a pattern of symptoms rather than a single disorder. It is characterized by:

Qualitative impairment in social interaction;

Stereotypical and restricted patterns of behaviour, activities and interests;

Intense preoccupation with a narrow subject;

One-sided verbosity;

Restricted prosody;

Anxiety;

Possibly OCD;

Physical clumsiness (associated with dyspraxia).

You may also have noticed differences in:

Sensitivity;

Eating habits;

Educational achievements;

Gait.

There might be no evidence of clinically significant delay in cognitive development or general delay in language; language skills may even appear to be advanced.

Appendix 7b: Letter of Introduction

Erica Clifford
School of Education
G*****d University

01111 733557

eda11@********

Dear +++++++++

I have been given your name by xxxxxxxxx and wonder if you might be able to help me. I am a conducting some research into how pupils with Asperger Syndrome connect with and integrate themselves into school life. I am proposing to develop a set of strategies to improve their educational prospects and would be grateful if you would allow me into your school, at a time convenient to you and your staff, to interview teachers and Teaching Assistants involved with the education of those with an ASD (Autistic Spectrum Disorder). The process should not take longer than 15 minutes each.

I wonder if you would also consider allowing me the opportunity to examine how these pupils interact with the educational setting. In addition, I am keen to observe pupils who may not have been formally diagnosed but who display unusual (relative to the accepted norm) behaviours. I have set out on the next page some examples of such behaviours which might assist your staff.

My intention is not to intrude upon any classroom practices or to become in any sense invasive. Any reports generated as a result of this research will be forwarded for your perusal, and all ethical matters outside your control will be scrupulously managed by me; I shall certainly respect your right to anonymity.

If, following preliminary observations, it appears that it might be useful to investigate further, and you are willing, perhaps you would allow me to return at a later date.

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Intense preoccupation with a narrow subject;

One-sided verbosity;

Restricted prosody;

Anxiety;

Possibly OCD;

Physical clumsiness (associated with dyspraxia).

You may also have noticed differences in:

Sensitivity;

Eating habits;

Educational achievements;

Gait.

There might be no evidence of clinically significant delay in cognitive development or general delay in language; language skills may even appear to be advanced.

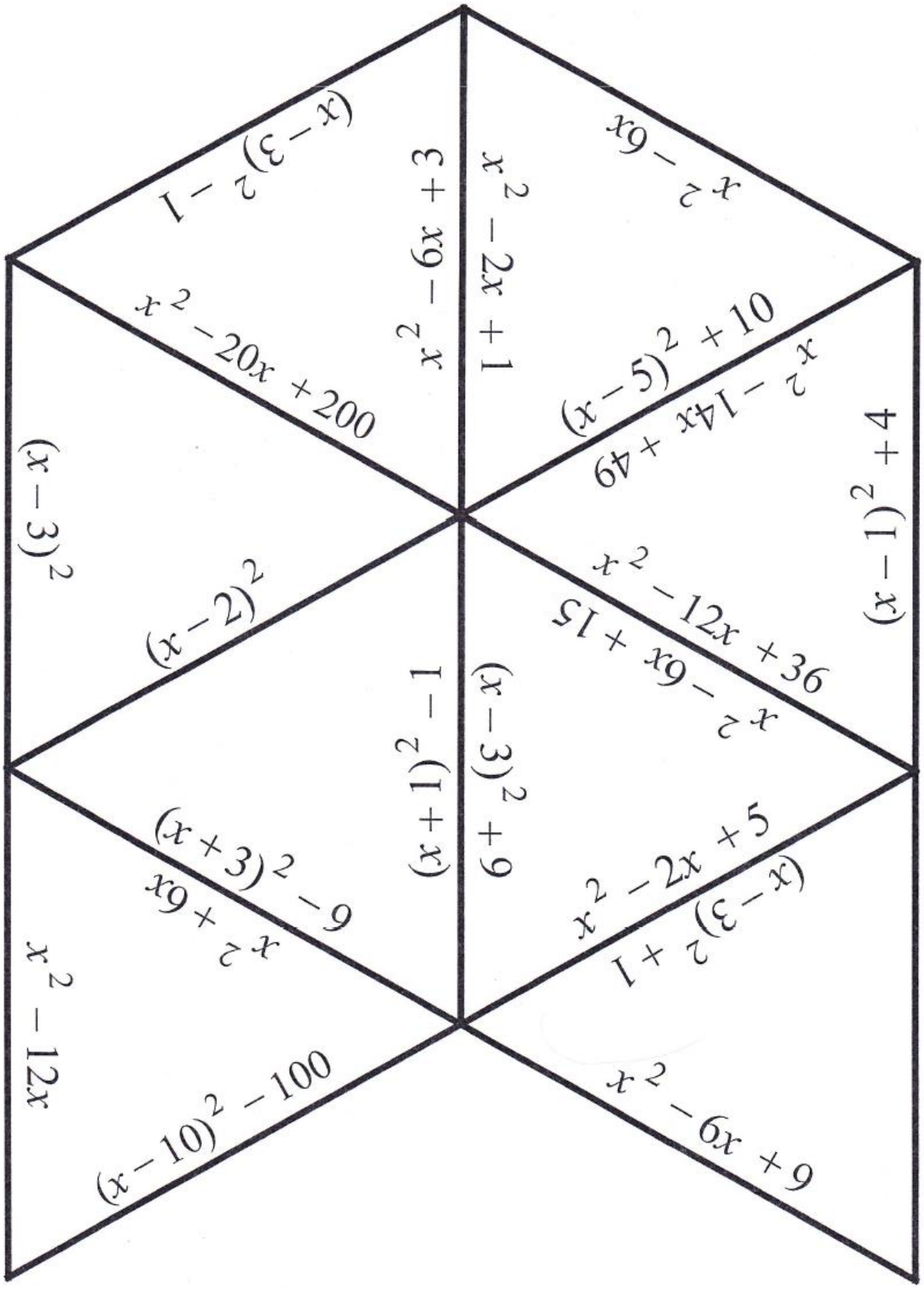
Appendix 8: Examples of Mathematics Work Shown to Pupils

Tarsia;

Worksheet;

Real-life worksheet;

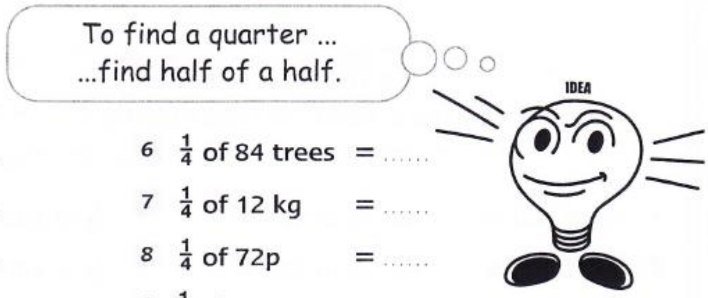
Board game.



$(x-3)^2-1$
x^2-6x+3
x^2-2x+1
x^2-6x
$x^2-20x+200$
$(x-5)^2+10$
$x^2-14x+49$
$(x-3)^2$
$(x-2)^2$
$(x-1)^2+4$
$x^2-12x+36$
$x^2-6x+15$
$(x+1)^2-1$
$(x-3)^2+9$
$(x+3)^2-9$
x^2+6x
x^2-2x+5
$(x-3)^2+1$
x^2-12x
$(x-10)^2-100$
x^2-6x+9

Fractions of quantities

1 Halves and quarters



1 $\frac{1}{2}$ of £48 = ...

2 $\frac{1}{4}$ of £48 = ...

3 $\frac{1}{2}$ of £60 = ...

4 $\frac{1}{4}$ of £60 = ...

5 $\frac{1}{4}$ of 20 cm = ...

6 $\frac{1}{4}$ of 84 trees = ...

7 $\frac{1}{4}$ of 12 kg = ...

8 $\frac{1}{4}$ of 72p = ...

9 $\frac{1}{4}$ of 804 m = ...

10 $\frac{1}{4}$ of 644 m = ...

2 Other fractions

Example

1 $12 = 3 \times 4$ so $\frac{1}{3}$ of 12 = ...

2 $12 = 6 \times 2$ so $\frac{1}{6}$ of 12 = ...

3 $15 = 3 \times 5$ so $\frac{1}{3}$ of 15 = ...

4 $20 = 5 \times 4$ so $\frac{1}{5}$ of 20 = ...

5 $\frac{1}{3}$ of 18 = ...

6 $\frac{1}{3}$ of 21 = ...

7 $\frac{1}{3}$ of 30 = ...

8 $\frac{1}{3}$ of 15p = ...

9 $\frac{1}{5}$ of 20 = ...

10 $\frac{1}{5}$ of 30 = ...

11 $\frac{1}{5}$ of 25 = ...

12 $\frac{1}{5}$ of £50 = ...

13 $\frac{1}{6}$ of 24 = ...

14 $\frac{1}{8}$ of 24 = ...

15 $\frac{1}{10}$ of £50 = ...

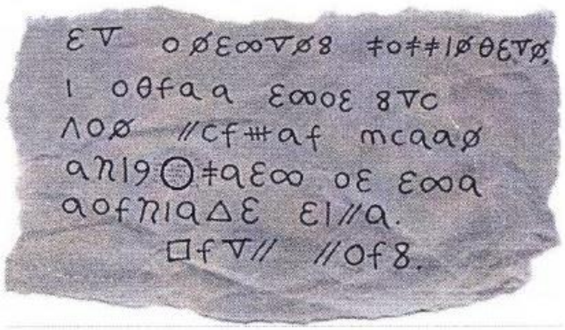
16 $\frac{1}{10}$ of £30 = ...

The Enigma Project

Taking codebreaking, mathematics, intrigue and strategy into the classroom and beyond

The Babbington Plot

The following note has been coded using the cipher actually used by Mary Queen of Scots.
Can you crack it?



Frequency table

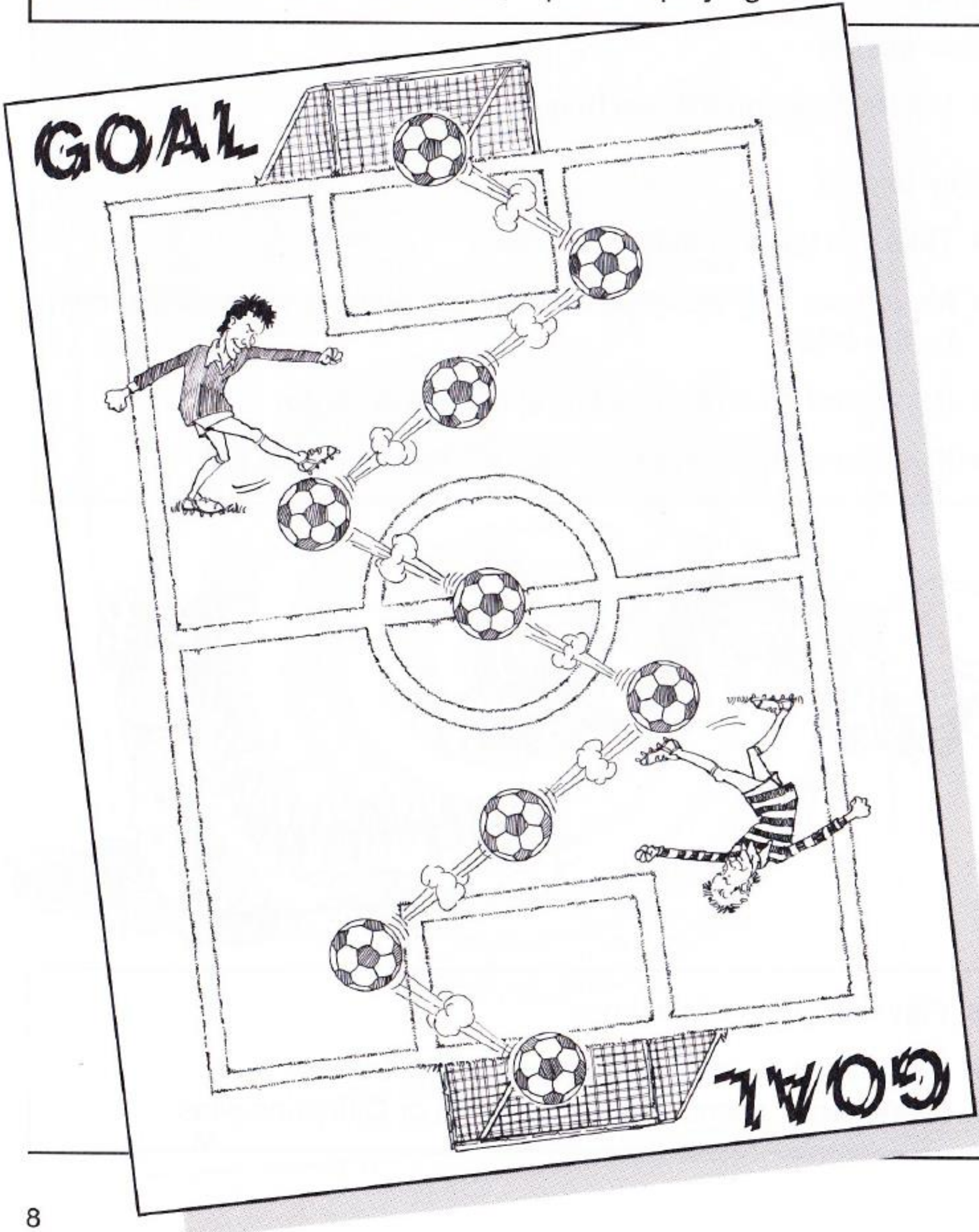
Symbol	Tally	Frequency
I		
Δ		
Ø		
O		
8		
C		
≠		
∞		
θ		
$\overline{\nabla}$		
f		
//		
m		
9		
q		
η		
ε		
□		
‡‡		
^		
	Total	81

GOAL

A game for 2 players.

What you need

The board, a counter for the ball, a pack of playing cards.



What it's about

This game is rather like hockey or football.

Aim of the game

To score more goals than your opponent before time runs out.

Rules

How to start

- Place the ball in the centre circle.
- Give one player a *red* Ace, 2, 3, 4, 5, 6, 7, 8, 9 and 10.
  Give the other player a *black* Ace, 2, 3, 4, 5, 6, 7, 8, 9 and 10. (The rest of the cards are not used.)

How to move the ball

- Look at your cards.
- Now each choose a card and put it face down on the table.
- Both of you turn your cards over at the same time.
- If you have the higher value, move the ball one step towards your opponent's goal.
- Now each choose another card and put it face down on the table. Compare them as before.

Scoring goals

- You score when the ball reaches your opponent's goal. Then you replace the ball in the centre circle.
- Time runs out when both players have used up their ten cards. The person who has scored the most goals is the winner.

- Play the game a few times.
- Each time you play, write down, on the back of your 'Comments' sheet, whether the red or black team wins.

Appendix 9: Interview with Professor Raymond - SEN Service senior psychologist

Me: Thank you for agreeing to talk to me.

R: No problem

Me: I wonder if you could tell me a bit about the diagnostic process.

R: Well, some pupils you'll find are, without doubt, Asperger's and others you might wonder if they really do have the syndrome.

Me: Is this because of patchy diagnosis?

R: I'm not sure why but maybe it has something to do with misunderstanding the condition. Can I help with a specific question?

Me: I'm interested in how the pupils connect with mathematics teaching and learning.

R: I work with 4 in schools and three are low functioning – not what you might call high fliers. They are all boys

Me: What do they think of mathematics?

R: None of my pupils has ever been able to work independently on problem solving activities even those with a great deal of common sense. The majority of mine at the moment don't really like mathematics. They will do anything to avoid it. They aren't very good at it. It is probably their worst subject. Well, they aren't really good at literacy either but they are more motivated to work on that than mathematics.

Me: So you have never come across a girl with AS?

R: There is one girl who is diagnosed as having Asperger's. She likes her X Box. I think she would play that all day if she could. She too is low functioning.

Me: How does she get on in mathematics lessons?

R: She is a school refuser, she doesn't go at all now – it made her anxiety levels worse. We are trying to educate her at home.

Me: That's a shame because I would think that she would be better able to learn social skills at school. How old is she?

R: She is 15. She isn't very mature. I have a son of 10 who is on a par with her. He is obsessed with similar games on his Xbox. I would say that they both have similar levels of maturity.

Me: Well thank you very much for your time and getting back to me.

R: Not a problem. Get back to me if you need information on any other schools.

Appendix 10: Interview with Dr Linden - Diagnostic Service

L: Much of my work involves adults with Asperger Syndrome. Many times, I can make the diagnosis from the start. The way the person is.

Most of these people come with a parent. I always ask the parent to complete a questionnaire before the day. Dependent on the results of the interview, I might refer to this to make the diagnosis but usually it is very apparent. By the time the people are referred to me, they have been through various stages of subdiagnosis and there is often little doubt.

These are the questions I might select from and my interviews will be semi-structured:

Do you understand why you are here?
What difference would a diagnosis make to your life?
What do you feel about social interaction?
Where do you spend most of your spare time?
Is your bedroom tidy, chaotic or organised chaos?
What are your hobbies?
Do you like to read?
What are your favourite books?
What kinds of music do you like?
Are you taste sensitive?
What is your favourite food?
Do you notice unusual smells?
Do you notice ambient noise?
How do you cope with sporting activities?
Do you enjoy writing?
Have you any routines?
Do you like change?
Do you like to plan activities in advance?
What did you do for you last birthday?
What kinds of presents do you ask for at Christmas and birthdays?

Appendix 11: Example of Interview Question Subset

Do pupils arrive here in Year 7 or can they come at any time in their school life?

How many AS pupils do you cater for?

What do you understand by the term AS?

Are you provided with guidelines with regard to their teaching?

Do you have extensive IEPs to help with provision?

What kind of support to you feel is vital to improving the school experience for pupils with AS?

What kind of support do you think is necessary for improving engagement for these pupils?

Do you make use of ICT for them?

Is it beneficial?

Do you link maths with their personal interests?

Does this improve teaching and learning?

Which subject would you say that these pupils like best?

What are the reasons for that in your view?

Are there any outstanding successes (or resounding failures)?

Is there anything else that you would like to add?

Appendix 12: Diary Entries Extract

At Chelsea Mill Science and Technology College, the interview with the Assistant Head was conducted on the way to the classroom while the one teacher was in private in her classroom.

At Drake Academy, both interviews were privately held in the specialist Unit.

Epsom School arranged for a separate facility for each interview so all were privately conducted.

Flynn Road School's Head spoke privately in his office but the teacher's interview took place in his classroom while the pupils were practising tests.

The interview with the Assistant Head at Glebe Street Academy was quite lengthy but was in the corridor outside the classroom and the interview with the TA took place in the specialist Unit after the lesson.

The Headteacher at Hamilton Road spoke at length in an ante-room while other members of staff looked after the children.

At Inglewood Farm School, the Head spent a considerable length of time going through answers to all the questions in her office, and later the teacher was interviewed in the classroom while his students were assisted by the TA.

The Headteacher at Jodrell Community School talked for a while in the Reception area and continued on the walk to the classroom while the teacher spoke in front of her pupils in class.

Appendix 13: Ethics Approval Form

THE UNIVERSITY OF WARWICK
Institute of
EDUCATION

notes + speak to
Erica.
[illegible].
It is approved.

Hi Mary.
This needs your
sig. and Geoff
recommends you
so over his

Application for Ethical Approval for Research Degrees
(MA by research, MPHiL/PhD, EdD)

Name of student
ERICA CLIFFORD

MA By research	EdD	PhD
		X

Project title **A study into the effects that teaching assistants have on the learning and attainment of students with Asperger's Syndrome in the mathematics classroom.**

Supervisor **P Johnston Wilder & Mary Briggs**

Funding Body (if relevant)

Please ensure you have read the Guidance for the Ethical Conduct of Research available in the handbook.

Methodology
Please outline the methodology e.g. observation, individual interviews, focus groups, group testing etc.

Observation;
Questionnaires;
Individual interviews with pupils, teachers, teaching assistants, parents and any other related parties;
Group testing and evaluation of practice.

Participants
Please specify all participants in the research including ages of children and young people where appropriate. Also specify if any participants are vulnerable e.g. children; as a result of learning disability.

The research will involve children and young people aged 0 to 20 with autism/ Asperger Syndrome. There should be research opportunities in State Primary,

What action is proposed if sensitive issues are raised or a participant becomes upset?

To cease collecting data from that participant and to offer further participation optionally at a later stage

Integrity

How will you ensure that your research and its reporting are honest, fair and respectful to others?

Ask for it to be checked by a third party for discrepancies.

What agreement has been made for the attribution of authorship by yourself and your supervisor(s) of any reports or publications?

Include names of each person who has contributed to any publication in order of contribution in time. 7

Other issues?

Please specify other issues not discussed above, if any, and how you will address them.

6

Signed

Research student Date 29/11/09

Supervisor Date 3/12/09

Action

Appendix 14.1: Andy from Arlidge Arts Academy

Year Group	7	8	9	10	11	12	13
	x						

1 = Not at all
5 = Very much

	1	2	3	4	5
Do you enjoy mathematics lessons?			x		
Do you find mathematics difficult?		x			
Do you like working in groups?	x				
Do you like to work in a pair?				x	
Do you enjoy working on your own?					x
Do you like to work in silence?					x
Do you enjoy textbook maths?			x		
Do pictures in textbooks help you to understand questions?				x	
Do you like worksheets?			x		
Do you like worksheets with real-life questions?			x		
Do you like mathematical games involving Tarsia?				x	
Do you like board games such as this one?		x			
Do you like computer maths?				x	
Do you like computer games which incorporate maths?				x	
(*See Appendix 8 for examples shown to students*)					

Which would you choose as your favourite?

Tarsia puzzle

Which would you choose as your least favourite?

Textbook exercise

Why do you like the task you chose as your favourite?

It's challenging and interesting

What is it that you don't like about your 'least favourite' choice?

It's boring, easy and more suited to lower levels

What is it that makes mathematics lessons interesting for you?

Challenging work

What is it that makes lessons boring for you?

Rote work

What is it that makes mathematics easy for you?

I would like something on 3D programming – matrices.

What is it that makes lessons difficult for you?

Competition – I don't like that sort of thing – not against real people anyway

What is it about working alone~~/ in a pair/ in a group~~/ in silence that you like?

I just like to be on my own

What is it about ~~working alone~~/ in a pair/ a group/ ~~in silence~~ that you dislike?

I don't mind working with my friend but I don't have anyone in this class or even at this school.

Appendix 14.2: Pupil Ben from Bowman Hill

Year Group	7	8	9	10	11	12	13
	x						

1 = Not at all
5 = Very much

	1	2	3	4	5
Do you enjoy mathematics lessons?				x	
Do you find mathematics difficult?		x			
Do you like working in groups?	x				
Do you like to work in a pair?		x			
Do you enjoy working on your own?					x
Do you like to work in silence?					x
Do you enjoy textbook maths?		x			
Do pictures in textbooks help you to understand questions?			x		
Do you like worksheets?			x		
Do you like worksheets with real-life questions?				x	
Do you like mathematical games involving Tarsia?			x		
Do you like board games such as this one?	x				
Do you like computer maths?					x
Do you like computer games which incorporate maths?				x	
(*See Appendix 8 for examples shown to students*)					

Which would you choose as your favourite?

Computer maths

Which would you choose as your least favourite?

Board Games

Why do you like the task you chose as your favourite?

I love computers and I can type better than I write

What is it that you don't like about your 'least favourite' choice?

You have to play games with other people and I don't like other people usually

What is it that makes mathematics lessons interesting for you?

The teacher

What is it that makes lessons boring for you?

The teacher

What is it that makes mathematics easy for you?

A good teacher

What is it that makes lessons difficult for you?

A bad teacher

What is it about working alone~~/ in a pair/ in a group~~/ in silence that you like?

I don't like the other people in my class and they don't like me

What is it about ~~working alone~~/ in a pair/ a group/ ~~in silence~~ that you dislike?

Ditto

Appendix 15: Partial Transcript of Conversation with George from Glebe Street Academy

George: 'I've just been to Science, Chemistry to be exact – not my favourite subject. I have it again after break. I don't like sitting next to him [*points to the pupil with AS who is running around shouting and swearing*]. He always causes trouble.'

Me: 'He seemed OK in maths earlier'

George: When?

Me: Perhaps you didn't notice me. I was in the lesson sitting at the back.

[*there was no response to this but I am sure that he had seen me and that is why he decided to speak to me when he saw me again at break time*]

George: I live in S…..n. I have just moved and I am right next to W…… School. I don't know why I don't go there but it's probably better that I'm here. They have more facilities for me here.

Me: What's your favourite subject?

George: I only like logic subjects like ICT and maths.

Me: What do you want to do at college?

George: I want to do something with databases. I have a C in maths already.

[At this moment the other boy diagnosed with Asperger Syndrome rushes past and screams 'You failed your maths" to which the pupil flushes and responds that he passed it second time round]

George: I've been moved down in English.

Me: Are you reading the Anthology at the moment?

George: No – just poetry. I don't know why, perhaps I'm not entered for the exams – I don't know [He begins to look distressed so I change the subject]

Me: After college, will you go to university?

George: Oh no – I'll get a job then.

Me: Do you know what you want to do?

George: No, not really.

Me: Have you been here since Year 7?

George: Yes

Me: Do you always sit with B..?

George: Yes, he won't leave me alone – he's the bane of my life. It's so loud in that other room [points to the so-called sensory room]. I can't wait to leave; just one more year of hell.

[The bell goes and he goes off to help his TA for that lesson wheel a trolley. Unfortunately, he seems to have some kind of motor difficulty and, as he pushes it, everything slips off the back– thousands of papers which he then has to pick up while other pupils stampede by].

Appendix 16: Psychologist King's Assessment of Student Mark

Above average; Belowaverage

TECHNICAL APPENDIX: TEST RESULTS
(Wechsler, D. (1997) *Wechsler Adult Intelligence Scale-III.*

Above
Below

SUMMARY MEASURES:
M's performance is compared with that of all individuals of the same age. These results are expressed as standard scores, which have an average value of 100. Scores of 69 and below are Very Low; 70-79 are Low; 80-89 are Below Average; 90-109 are Average; 110-119 are Above Average; 120-129 are High; and 130 and above are Very High.

Verbal IQ	116
Performance IQ	92
Full Scale IQ	106

INDEX SCORES:
These are further groupings of M's subtest scores to illustrate the major dimensions of ability and learning. The different indices control for the influencing effects of other abilities or cognitive processes to provide a purer measure of four facets of intellectual functioning.

Verbal Comprehension	118
Perceptual Organization	99
Working Memory	113
Processing Speed	84

INDIVIDUAL SUBTEST SCORES:
Results are expressed, as scaled scores: these range from 1 to 19, with 10 the average and percentile scores.

Verbal subtests
VOCABULARY
Scaled score 16
Percentile 98
The individual is asked to give the meanings of some words.

SIMILARITIES
Scaled score 11
Percentile 63
A test of verbal reasoning in which the individual must say why two things are alike (for instance, and orange and a banana).

ARITHMETIC
Scaled score 11
Percentile 63
Questions involving orallly presented simple mental arithmetic must be answered to examine working memory and core mathematical skills

DIGIT SPAN
Scaled score **12**
Percentile **75**
In this test of immediate verbal working memory, digits are repeated forwards and backwards by the client after a presentation time of one per second.

INFORMATION
Scaled score **13**
Percentile **84**
The individual must respond to general knowledge questions of a factual nature.

LETTER NUMBER SEQUENCING
Scaled score **14**
Percentile **91**
This test requires the manipulation and sorting of verbally presented letter and number information. It is a test of auditory item memory, working memory and sequencing skill.

Performance subtests

PICTURE COMPLETION
Scaled score **7**
Percentile **16**
Here the individual must say which important part of a picture is missing.

DIGIT SYMBOL-CODING
Scaled score **6**
Percentile **9**
This task requires the individual to supply symbols to digits according to a key. The number correct within two minutes is credited.

BLOCK DESIGN
Scaled score **11**
Percentile **63**
Coloured blocks must be arranged to reproduce the patterns presented on a card to assess visual spatial processing

MATRIX REASONING
Scaled score **12**
Percentile **75**
In this task the individual must select the next picture that completes the displayed set. It is a test of non-verbal reasoning.

SYMBOL SEARCH
Scaled score **8**
Percentile **25**
The individual must search for one of two symbols in a target set. It is a test of speed of processing and accuracy in a non verbal setting

SUPPLEMENTARY TESTS:

A number of further tests were given to assess one or another aspect of diagnostic importance or educational achievement. None are included in the WAIS-III.

Supplementary diagnostic tests

The Sentence Completion Test (Hedderly).	**Raw Score**	**Average Score**
This test requires the individual to complete a sentence given an initial word or phrase.	92	15

The **Wechsler Individual Achievement Test second edition (WIAT II)** provides a measurement of an individual's literacy skills, and provides percentile and standard scores and uses the FSIQ from the WAIS to predict the level of expected performance.

Subtest	**Percentile**	**Standard Score**	**Predicted Score**	**Difference**	**Significant (Y/N)**	**Frequency**
Word Reading	79	112	104	8	Y	25
Reading Comprehension	32	93	105	-12	Y	15<>10
Spelling	91	120	104	16	Y	10<>5
Pseudoword decoding	75	110	104	3	N	>25

Reading fluency: 2nd quartile