Mathematics and Deaf Children: An exploration of barriers to success

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ABSTRACT

Consistent evidence from research studies between 1980 and 2000 indicates that deaf children lag behind hearing peers (by 2 to 3.5 years) in mathematics. This study seeks to explore the reasons for this persistent underachievement by focusing on results from the National Mathematics tests taken in the UK by all 14 year olds. The study analysed a sample of test papers with the aim of identifying ways in which deaf and hearing responses to the test items differed and possible explanations for these differences in terms of access to the mathematics teaching, assessment and curriculum provision. Findings from the project led to preliminary conclusions regarding the range of national test entry levels for deaf pupils, the types of linguistic issues they encounter, the learning strengths they demonstrate and their experience of mathematics curriculum provision. The concluding analysis raises significant questions about deaf pupils' access to mathematics educational provision and more specifically about the deaf experience of mathematics learning and how they perceive themselves as mathematicians.

Key words: mathematics, deafness, attainment, testing

INTRODUCTION

This study is concerned with deaf children's learning and achievements in mathematics. The majority of studies of the educational achievements of deaf children focus on language and literacy; relatively few look specifically at mathematical achievement. However, figures on deaf children's achievements in mathematics suggest that the area of mathematical ability is also an area of underachievement in the deaf school population. This small-scale study seeks to explore the reasons for this and identify learning, teaching and testing issues which may help to explain this persistent underachievement by looking specifically at aspects of 2002 Key Stage 3 National Curriculum Test papers from a national sample of deaf pupils.

BACKGROUND: RESEARCH INTO MATHEMATICS AND DEAF PUPIL ACHIEVEMENT

Consistent evidence from research studies between 1980 and 2000 indicates that deaf children lag behind hearing peers (by 2 to 3.5 years) in mathematics achievement tests (although the difference is less pronounced for maths than for reading which is from 3 to 7 years).The most comprehensive study relevant to the UK is that of Wood et al. (1986) who looked at 414 school leavers and compared their grades on the Vernon and Miller Graded Mathematics test with 465 hearing pupils of the same age. They found that the mathematical age of hearing school leavers was about 15.5 years, compared with the mathematical age of deaf pupils of 12.3 years. Unlike the data on reading achievement however it was found that 15 per cent had mathematics ages at or above their chronological age, whereas this proportion is negligible for reading age findings and indeed the actual range of achievement was equivalent to that of hearing pupils.

Many of the published research studies on mathematics look at mathematical achievement as part of wider studies of general educational performance where, most often, literacy is the main focus. This is useful to an extent because of the language skills required for access to mathematical information. Indeed, mathematics achievements tend to co-vary with literacy achievements in large studies where tests assume spoken and written English ability (i.e., most of the large US studies). However few studies provide specific information about the mathematical abilities of deaf learners *per se* or illuminate other factors such as learning experience and curriculum access (see Powers et al., 1998 for review).

Several studies have sought predictors of mathematical achievement. The most significant focus of this research has been the relationship between levels of hearing loss and mathematical achievement. Although hearing loss would seem to account in the main for the differences between deaf and hearing pupils, the degree of hearing loss does not itself correlate with attainment or shows only a very weak relationship in most of the studies (Nunes and Moreno, 1998a).

Where predictors are examined in terms of educational placement, differences are found which suggest better performance by deaf students in mainstream education than by those in special schools. However, analysis of the data in these studies reveals that there are other confounding variables, namely the difficulty of finding an appropriate cohort match across special school and inclusive settings (Zweibel and Allen, 1988; Kluwin and Moores, 1989; Holt, 1994).

It is also interesting that most studies report that deaf learners do progress in mathematics, although they neither catch up with their hearing counterparts nor fall behind as they get older. This points to the similar learning processes of deaf children to hearing children, suggesting that they experience delay in mathematical development rather than different or 'deviant' mathematical development. This is clearly illustrated in Nunes and Moreno's (1998b) study of deaf pupils' counting and computational skills.

Explanations for underachievement

Several possible explanations for deaf children's performance in mathematics have been proposed, all of which are likely contributors to this pattern of underachievement. One explanation centres on the early (preschool) learning experiences of deaf children and draws on research into ways in which early learning through interaction in the home environment can be disrupted. Hearing children hear mathematical talk from birth and most hearing children are involved in mathematical talk from early on (Gregory, 1998). Gregory explores how deaf children's early incidental learning of core mathematical concepts (e.g. counting, time, distance, size) may be impeded as a result of a deaf child's lack of access to parental commentary, explanations, instructions and conversation between others in the home. This is not to say that these concepts cannot be directly taught to young deaf children but that incidental learning and reinforcement opportunities are more limited.

One of the few studies which focuses on deaf children as learners of mathematics and their classroom experience explores further the importance of informal learning alongside the issue of access to curriculum concepts. Nunes and Moreno (2002) describe a successful intervention programme which focused specifically on core mathematical concepts, which most hearing children learn informally outside school, and ways in which they are represented in the school curriculum. The intervention materials also explored ways of presenting mathematical problems visually, using drawings and diagrams. Both of these intervention strategies were successful, thus providing clear pointers for support strategies which can ensure deaf children's access to the mathematics curriculum.

Other researchers (Hitch, 1983) have suggested a more specific focus on deaf children's experience of spoken language and the consequences for the development of inner speech which is seen as a means of mediating the processing of numerical information. It is suggested that deaf children's limited sub-vocal, covert counting strategies, which have been found to mediate hearing children's performance, might account for difficulties with computation and mental arithmetic. Deaf children's lack of auditory experience might also affect short-term memory skills and account for slower response time of deaf learners in addition and subtraction tasks and their poor memory for digits (Epstein et al., 1994). What we do not know is whether or not deaf children develop alternative strategies, perhaps based on their visual learning strengths, to process verbal information and mediate short-term memory tasks.

Despite the acceptance of the need to look beyond language issues to broader learning experiences, it cannot be ignored that the language of mathematics teaching and testing poses a barrier to success for deaf pupils. The language factor can be extrapolated in several ways. We have established that there is a relationship between reading competence and mathematical achievement (Pau, 1995) and we have discussed ways in which early access to mathematical conversation might be a contributing factor. There are other specific difficulties that need to be considered.

One is the nature of mathematical language. Gregory (1998) suggests that difficulties might include the identification of crucial connectives which deaf children find difficult to interpret, such as '*if*' and '*because*', which signpost readers through a mathematical problem. There are also a number of everyday words that are used in very specific ways in mathematics such as '*difference*' and '*high*', and there are specialist words which have to be learnt so that problems can be solved (e.g., *hypotenuse*, *denominator*). The most significant problematic language structures are those which also impose difficulties when reading performance is analysed. These include conditionals (*if*, *when*), comparatives (*greater than*, *the most*) negatives (*not*, *without*), inferentials (*should*, *could*, *because*, *since*), low information *pronouns* (*it*, *something*), lengthy passages (reliance on connectives), words that have different meanings within maths than they do in general usage (such as *difference*, *factor*, *product*), multiple ways of expressing single concepts, and abbreviations and symbols (Traxler, 2000).

Another issue is the mode of access to mathematical concepts. The development of sign bilingual education for deaf pupils raises a number of questions about mode of access to the curriculum. It is argued that because sign language is a visually–spatially organized language it should lend itself well to the teaching of mathematics particularly for concepts of size, location and spatial relationships (Gregory, 1998). We should therefore be looking at whether or not deaf pupils are accessing the mathematics curriculum in a way that is the most appropriate. This is not to say that all deaf pupils should be taught mathematics through sign language but rather that we should evaluate the extent to which the language of teaching responds to individual learning strengths. This is particularly pertinent for deaf sign language users who have been found to have a better ability to think spatially than hearing people (Braden, 1994, Bellugi et al., 1994). Nunes and Moreno (2002) explore this to some extent in their intervention programme, which uses drawing and diagrams to visually present mathematical concepts. This is a useful starting point as this study provides robust evidence that the pupils benefited from this visual emphasis.

Allied to this issue is the wider question of access to the full mathematics curriculum. This is a more contentious issue because it reflects on teaching approaches and teacher preparation. Previous research has already established that teachers of the deaf sometimes over-focus on language issues (Wood et al., 1986) and that this can compromise the wider content of the curriculum and the overall quality of the interaction and the learning environment. This issue resurfaces in recent studies into word problem solving activities within the mathematics curriculum context.

Marschark et al. (2002) argue that word problem solving activities involve generic thinking skills as well as just reading comprehension. The generic thinking skills outlined include selective attention, analysis, the ability to consider all information and use of analogies to known information to better understand the new problem. A relevant example of this is the use of story problems in mathematics as a way of providing a framework for developing children's problem-solving skills in their learning of new mathematical concepts. Pagliaro and Ansell (2002) argue that story problems allow learners to use their existing knowledge and experience (schema) to make connections with and respond to the new information (the mathematics problem). This study looked at the frequency and mode of story problem presentation and concluded that teachers tend to use story problems only when they consider that the children have the linguistic and mathematics skills to solve the problems. This means that challenges of problem-solving are not introduced as a part of the learning process but rather as opportunities to show *what* they have learnt. Consequently pupils do not develop problem-solving skills needed as a learning tool. In the light of this, the authors raise a number of questions about traditional approaches to teaching mathematics and teacher of the deaf preparation.

This notion of the relationship between pupils' problem-solving skills and teaching style and was further investigated in a study by Kelly et al. (2003). They found that deaf students exhibited unreflective behaviour, lack of persistence in working through difficult problems and difficulties in transferring learning from one context to another. The students performed well on tasks involving one dimension but performance dipped when two or more dimensions were involved. Kelly et al. investigated this through a teacher survey, which identified that teachers tended to focus on practice exercises and drill rather than true problem-solving, thus avoiding cognitively challenging aspects of word problem solving. As a result, deaf students were not being engaged in sufficiently challenging word problem situations.

An investigation into reasons for this pointed to three crucial issues, the first being that the majority of the mainstream teachers in the study had specific maths training as compared to less than half the teachers in special schools for the deaf. Kelly et al. therefore speculate that many teachers working with deaf pupils actually lack the specialist skills to teach the analytical strategies required to tackle the problem-solving aspects of the curriculum. Their findings also suggest that the belief that English language skills are the basis for most learning problems associated with deaf pupils leads to a focus on language teaching and indeed low expectations of pupils' abilities to access the wider mathematics curriculum.

This and related research stresses that deaf children's experience of and approach to problem-solving is a central issue in terms of access to the mathematics curriculum. Where previously we might have attributed this to linguistic competence and reading comprehension, it is clear from more recent research that deaf children's familiarity with problem structures is an added and sometimes overriding constraint (Frostad and Ahlberg, 1999).This is a crucial debate which does need to be explored within the UK context, including cases of access to the curriculum through both spoken English and BSL.

Gaps in the research

In summary, studies into predictors of attainment would suggest that attainment is not related to school placement or to gender or degree of hearing loss and that there is a need to look beyond these factors for the major determinant of mathematical ability. Early studies focused on attainment whilst later studies have begun to look at the thinking processes involved in mathematics and problem solving. Few studies explore the relationship between deaf experience and mathematics aptitude and teaching. The focus on hearing loss and communication has diverted our attention away from other classroom factors such as the quality of the teaching and individual learning strategies and experiences, including ways in which the use of sign language might provide an alternative to memorizing verbally encoded information.

Also, the study of children's mathematics performance usually forms part of larger enquiries into general educational performance. The focus of the mathematics is almost always exclusively arithmetic computation. We need research that looks at the deaf children's wider mathematical concepts rather than just arithmetic.

There is a general problem with accessing and collating data on deaf children's achievement in the UK, although new measures of identification are currently being considered to address this. We need a means by which we can track deaf pupil progress in the core curriculum subjects from baseline data and upwards. Without this comprehensive data it is impossible to gain a national picture, or identify patterns of deaf pupil achievement across the UK. This means that studies that are undertaken usually only involve small samples that lack a rich national context thus making conclusive findings and generalization difficult.

Project aims

This review has shown that there are several unresolved questions regarding the teaching and learning of mathematics in deaf education. These set the research context for this study. We need to be able to identify more precisely why deaf pupils lag behind their hearing peers in their mathematical attainment. The research undertaken to date points to several possible explanations which need to be explored further:

1. One goal must be to further elucidate the extent to which the language of mathematics (curriculum and assessment) poses a barrier to deaf pupils' success and where precisely these difficulties intrude.

2. The second area to explore is the learning experiences of deaf pupils; their exposure to the breadth of the curriculum and the degree of access to quality specialist teaching.

3. Finally, the increasing use of sign language in the learning context (very little research to date reports on this) and the potential for access to mathematical learning through this visual–spatial modality points to the possibility that deaf pupils may engage with mathematical concepts and develop learners' strategies which distinguish them from their hearing counterparts. We therefore need to identify deaf pupils' strengths, weaknesses and differences in the context of mathematical learning as compared with their hearing counterparts.

Research approach

These questions led to the identification of the specific focus for this small scale study. It is hypothesized that scrutiny of deaf children's performance in a test situation and comparison with relevant data on hearing children's performance will facilitate the identification of:

- particular areas of language difficulty for deaf pupils
- evidence of strengths and weaknesses with different aspects of the curriculum
- evidence of different approaches to mathematical problems.

This study was undertaken with the support of the Maths Testing and Development Team (MTDT) at the Qualifications and Curriculum Association (QCA). It provided the opportunity for a preliminary exploration of deaf pupils' performance on national mathematics tests and for comparison of aspects of their performance with the hearing sample analysed by QCA. The study involved scrutiny of a sample of deaf pupils' Key Stage 3 (KS3) National Curriculum Test papers using the analysis and coding framework used by QCA to analyse a national sample of all papers. At this stage we were interested in looking for similarities and differences between deaf and hearing pupils performance in terms of attainment, patterns of errors and identifiable areas of strength and weakness.

In England the age range for compulsory schooling is 5 to 16 years. This age range can be seen as four Key Stages (KS), KS1, ages 5 to 7; KS2, ages 7 to11; KS3, ages 11 to 14; and KS4, ages 14–16. The three core subjects of the national curriculum are English, mathematics and science. Each of the core subjects is made up of content arranged by levels of difficulty. Pupils across all four key stages study these core subjects. At the end of each of Key Stages 1, 2 and 3, there are National Curriculum Tests in each of the three core subjects that are taken by every child and following these, each child is given a particular level in each of the core subjects.

In mathematics there are tiers of entry. Thus the pupils to which this paper refers are at the end of KS3, aged 14, and are entered for mathematics at one of the tiers of entry, described by the levels of the content that is tested within that tier. The tiers are 3–5, 4–6, 5–7 and 6–8. It will be noticed that these tiers overlap. There are common questions between the overlapping tiers. It is up to the teacher to enter the pupils at the appropriate level according to either department or school policy.

Data collection

Data was gained from the BATOD survey 2000 about the location of deaf pupils in England who had completed the KS3 national National Curriculum Test in mathematics in June 2002. The exact number of deaf pupils in each establishment could not be given for reasons of data protection. We also acknowledge that the schools and units did not have sufficient prior warning of the research as this was an 'unplanned opportunity'. However, using the survey data we contacted 138 establishments, comprising 24 schools for the deaf, and 114 units.

We asked the schools and units contacted to return to us the marked KS3 mathematics test papers for their deaf pupils. In total we received 126 completed test papers. From this received distribution we selected a sample to ensure that it represented a balance of educational settings for deaf children in terms of inclusive or special school setting and communication approach. The sample selected was distributed as shown below:

Each year the MTD Team analyses a sample of 800 papers from the total KS3 population against a coding framework. The coding framework provides a detailed breakdown of each question and how pupils perform in terms of scores, error analysis and methods of working. The sample chosen is representative of the KS3 population so that the scores, errors and methods of

Table 1: Distribution of received papers across tiers

	Tier 3–5	Tier 4–6	Tier 5–7	Tier 6–8	Girls	Boys	Total pupils
	83	22	17	4	57	69	126
Boys	42	15	9	3			
Girls	41	7	8	1			

Table 2: Distribution of sample selected across tiers

	Tier 3–5	Tier 4–6	Tier 5–7	Tier 6–8	Girls	Boys	Total pupils
	30	22	17	4	31	42	73
Boys	15	15	9	3			
Girls	15	7	8	1			

working, as coded by the framework, can be taken to be representative of the KS3 population. The QCA publish a document which summarises the findings (QCA, 2003), but it does not publish the details of the coding framework.

Our researcher was trained by the MTD team in the use of the coding framework and she then coded the sample of deaf pupils' papers. The resulting analysis of the deaf pupil sample was then compared with the analysis of the national sample, made available to us by QCA. The papers of the national sample were not available because they had been returned to the schools from which they had been taken.

For the purposes of this study we intend only to report significant findings from our analysis of the coding results, as a full overview of the data is not relevant to the key findings. Since only the relevant sections from the codings are used in this paper the figures do not always amount to 100 per cent.

RESULTS

In the analysis of the coding outcomes, the most noteworthy discrepancies between deaf and hearing pupil performance have been grouped into the following four areas:

- language issues
- pupils' working methods
- written English responses
- 'difficult to teach' items.

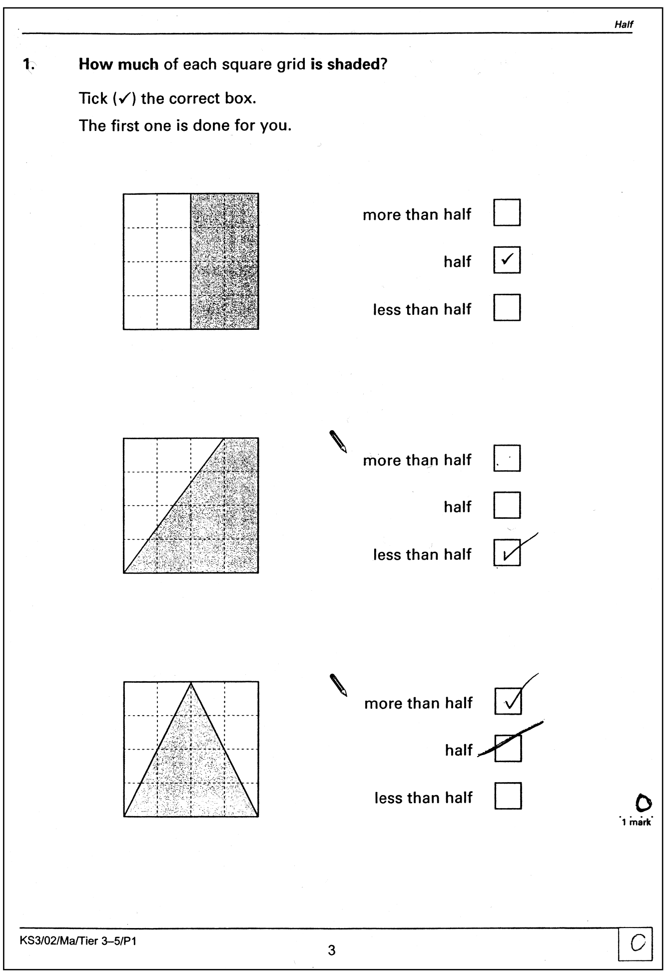
Each area is reported on below and examples are given of specific questions and comparative results from the deaf and hearing cohorts.

1. Language issues

For some questions there were indications of pupil difficulty regarding the recognition and interpretation of key mathematical language. In some instances particular difficulties seem to occur with certain phrases, such as '*more than*' and '*less than*'. Pupil performance also suggests that the identification of the key mathematical word in the question also caused difficulties where there were other language or layout distractions. A specific example of this is illustrated below.

Example 1: 'Half' Level 3–5 paper 1

The score difference on this question between the deaf and hearing sample indicates that deaf pupils were less successful with this than their hearing counterparts, although the difference is slight. More than half of the deaf sample scored 0 marks for this question (53%) whereas the proportions are reversed with the hearing sample in that 46 per cent were given 0 score. From the scores given below it is evident that the performance of the deaf cohort most closely matches that of the level 3 hearing cohort, i.e. the lowest attainers.



Example 1: Question 'Half'

Table 3: Scores on 'Half' question: comparison of deaf and hearing sample

Sample	Analysis code	0 marks	1 mark
Deaf sample (n=30)			
3–5 tier	Scores	53%	47%
Hearing sample (n=872)	Scores		
Level 3	Scores	46%	54%
Level 4	Scores	21%	79%
Level 5	Scores	17%	83%

Example 2: 'Olympic Games' Level 3–5 paper 1

This question provides an example of the difficulty with mathematical questions that were embedded in detailed written context. In this instance, the pupils had to read a great deal of information and then relate the key question back to the relevant information given. Research shows that one literacy problem experienced by deaf pupils is that of following the connected meaning of a written passage, as they often find it difficult to make sense of pronouns (*its*, *that*, *he*, *the*) when they are disconnected from the object or person to which they refer. This may be to do with effects that deafness has on the auditory short-term memory and its role in processing written language.

This question poses a particular difficulty because of the gap between the crucial information for the task and the key question, which is simply '*how many more*'? This question does not explicitly refer back to exactly what information is needed, i.e. what should be compared with what. The reader only makes sense of the question by referring back to the key information given in the earlier text.

Of the deaf cohort only 37 per cent achieved full marks for this question. From the level 3 tier of the hearing cohort only 23 per cent achieved full 3 marks but at level 4 more than two-thirds of the cohort gained 2 or more marks. What is particularly interesting is the difference in the method and errors shown. From the coding system used it was possible to identify that the most common error made by the deaf pupils was to show the totals of the medals but with no intention to subtract one from the other to show '*how many more*'. Thirty per cent of the deaf cohort did not do this, whereas from the hearing cohort only 4 per cent and 5 per cent at levels 3 and 4 respectively made this error.

Olympic Games

4. The Olympic Games were held in September 2000.
The Paralympic Games were held in October 2000.

The table shows how many medals the UK won.

	Gold medal	Silver medal	Bronze medal
Olympics	11	10	7
Paralympics	41	43	47

Altogether, the UK won more medals at the Paralympics than at the Olympics.

How many more?
Show your working.

$$\begin{array}{r} 41 \\ 43 \\ +\ 47 \\ \hline 131 \end{array} \qquad \begin{array}{r} 11 \\ 10 \\ +\ 7 \\ \hline 28 \end{array}$$

1
0
0
3 marks

KS3/02/Ma/Tier 3–5/P1 7 2

Example 2: Question 'Olympic Games'

Table 4: Scores of 'Olympic Games': comparison of deaf and hearing sample

Sample	Analysis code	0 marks	1 mark	2 marks	3 marks
Deaf sample (n=30) 3–5 tier	Scores	27%	20%	17%	37%
Hearing sample (n=872)	Scores				
Level 3	Scores	43%	13%	23%	23%
Level 4	Scores	17%	14%	21%	48%
Level 5	Scores	3%	4%	13%	81%

Example 3: 'Survey' Level 3–5/4–6/5–7 paper 1

Another example of a language barrier is found in the question 'Survey'. This question also involved the ability to clearly identify the mathematical task through careful reading of the question. The key item of vocabulary in the question about the school subjects is '*equally*', which qualifies the adjective '*popular*'. It has been shown that deaf readers often focus on key content words and vocabulary in reading and often miss the significance of certain adverbial or referential information. This might be attributed to a more limited vocabulary or again the pressure on the short-term memory resulting from compromised auditory experience.

Survey

19. Hakan asked 30 pupils which subject they liked best.

Subject	**Number of boys**	**Number of girls**
Maths	4	7
English	2	4
Science	3	3
History	0	1
French	1	5
	total 10	**total 20**

(a) Which subject did **20%** of **boys** choose?

Maths

0

1 mark

(b) Which subject did **35%** of **girls** choose?

Maths

1

1 mark

(c) Hakan said:

'In my survey, **Science** was equally popular with boys and girls'.

Explain why Hakan was **wrong**.

Some girls and boys don't like Science, but they are still equal.

0

1 mark

(d) Which subject **was** equally popular with boys and girls?

Science

0

1 mark

KS3/02/Ma/Tier 3–5/P1

22

Example 3: Question 'Survey'

In response to this question case it is understandable that a deaf reader might focus on the word '*popular*' but overlook the key word '*equally*'. Recognition and understanding of the term '*equally*' requires an additional calculation because of the difference in number between boys and girls. This is a good example of a specific mathematical task, which deaf pupils may well be capable of doing, but which causes difficulties because it is embedded in a language-rich context.

2. Pupil working methods and approaches

Throughout the analysis it became evident that the deaf cohort favoured vertical methods of working rather than mental calculation when tackling computational problems. In a question '*Computation*', the deaf cohort demonstrated more evidence of vertical methods of working. Some 63 per cent showed evidence of a vertical written method for this question and only 13 per cent had no working shown (mental calculation). In the hearing cohort there is much less evidence of vertical written method and more pupils were presumably tackling the question usually mental calculation.

One issue that this does raise is whether we can surmise that teachers of the deaf focus heavily on these mechanical skills, which are straightforward to teach and free of many of the linguistic difficulties of other areas of the mathematics curriculum?

A greater preference among the deaf cohort for showing written working was also shown in other questions where pupils were specifically asked to show their working. Such as in a question '*Car Parking*' where 100 per cent of deaf pupils showed their working as instructed but only 70 per cent of the hearing cohort.

There are several examples in the papers of areas where the deaf cohort efficiently tackle the problem shown, demonstrating their mathematical competence and gaining equivalent scores to the hearing cohort. These examples of parallel achievement were most notably found in questions where

Table 5: Pupil working methods and approaches: comparison of deaf and hearing sample

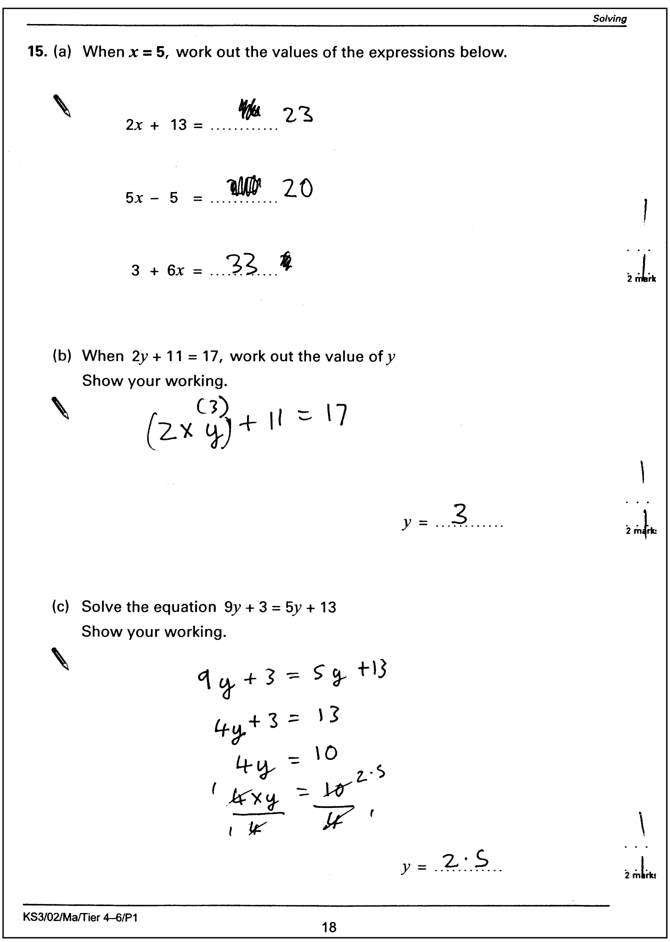
Sample	Analysis code	Mental calculation (no working shown)	Evidence of vertical written method	Personal written methods or Jottings
Deaf sample (n=30)				
3–5 tier	working method	13%	63%	13%
Hearing sample (n=872)				
Level 3		31%	26%	20%
Level 4		32%	37%	20%
Level 5	32%	58%	8%	

pupils were asked to do a straightforward solving task, which was not embedded in a rich language context.

Example 4: 'Solving' Level 4–6/5–7 paper 1

The example question below provides an appropriate example of this.

For part a of the '*Solving*' question 83 per cent of the deaf cohort gained the 2 full marks and in part b 91 per cent gained the 2 marks. This score profile interestingly reflects the level 6 scores of the hearing cohort (89% scored 2 marks on part a and 92% scored 2 marks on part b). We might speculate from this information that the deaf cohort do demonstrate strengths in methodical computational problems and that there is evidence that they have been successfully taught to tackle such problems. The barriers to equal levels of success on all of the questions seem to be the requirement to retrieve the key mathematical information from the text or to interpret and apply the mathematical information given.



Solving

15. (a) When $x = 5$, work out the values of the expressions below.

$2x + 13 =$ 23

$5x - 5 =$ 20

$3 + 6x =$ 33

1

2 marks

(b) When $2y + 11 = 17$, work out the value of y

Show your working.

$(2 \times \overset{(3)}{y}) + 11 = 17$

$y =$ 3

1

2 marks

(c) Solve the equation $9y + 3 = 5y + 13$

Show your working.

$9y + 3 = 5y + 13$

$4y + 3 = 13$

$4y = 10$

$\frac{\cancel{4} \times y}{\cancel{4}} = \frac{\cancel{10}^{2.5}}{\cancel{4}}$

$y =$ 2.5

1

2 marks

KS3/02/Ma/Tier 4–6/P1

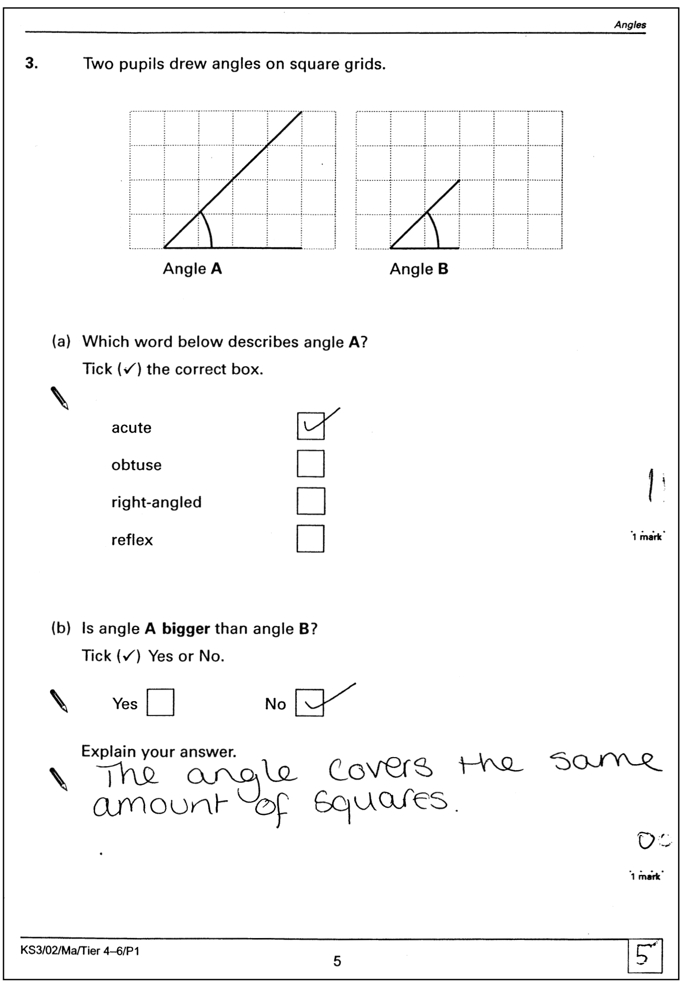
18

Example 4: Question 'Solving'

There were several other examples of the deaf cohort successfully solving the mathematical problem (e.g. the arithmetic or algebra) but not applying this knowledge to the rest of the problem. However we found that this response was not always unique to the deaf cohort. For example, both cohorts did well when asked to solve an algebraic problem but less well when asked to interpret and apply the information. This, amongst other examples, suggests that both cohorts successfully complete the areas of learning that have perhaps been more rigorously rehearsed and which do not require application or interpretation.

3. Written English responses

Some questions required extended written English responses or explanations to be given by the pupils. The question below provides one example of this.


Angles

3. Two pupils drew angles on square grids.

(a) Which word below describes angle **A**?
Tick (✓) the correct box.

acute ✓
obtuse
right-angled
reflex

1
1 mark

(b) Is angle **A bigger** than angle **B**?
Tick (✓) Yes or No.

Yes No ✓

Explain your answer.
The angle covers the same amount of squares.

0
1 mark

KS3/02/Ma/Tier 4–6/P1 5 5

Example 5: Question 'Angles'

Example 5: 'Angles' Levels 3–5/4–6 paper 1

Our analysis found that in these instances deaf pupils were more likely than hearing pupils to offer an incomplete or incorrect explanation or no explanation at all. In additional to this we found several instances where the marking was inconsistent. Some explanations from deaf pupils, although difficult to follow, were in fact correct but given 0 marks. An example of this is given below.

Example 6: 'Dropping litter' Levels 4–6/5–7 paper 1

For all questions that require written explanations a dip in the performance of the deaf cohort could be identified. On this 'Dropping litter' question a much smaller proportion of the deaf cohort gained full marks (this required two reasons to be given) than that of the hearing sample. An equal proportion

Dropping litter

13. This advert was in a newspaper.

It does not say how the advertisers know that 93% of people drop litter every day.

Some pupils think the percentage of people who drop litter every day is much lower than 93%.

They decide to do a survey.

(a) Jack says:

We can ask 10 people if they drop litter every day.

Give two **different** reasons why Jack's method might not give very good data.

First reason:

because the people might be equally the some.

0

1 mark

Second reason:

and it not much people

1

1 mark

KS3/02/Ma/Tier 4–6/P1 16 With permission from the *Keep Britain Tidy Campaign*

Example 6: Question 'Dropping Litter'

gained one mark for giving one reason but a higher proportion of deaf pupils were not getting a mark at all.

4. 'Difficult to teach' items

A final issue that this preliminary analysis raised was whether or not some items on the paper had actually been taught. This question arose in three particular questions on paper 1. One was a question on 'Negative numbers'. On this question only 11 per cent of the deaf cohort completed this correctly compared to 21 per cent, 29 per cent and 50 per cent of the hearing cohort at levels 4,5 and 6 respectively.

Another question which was not fully attempted was: 'Straight Lines'. The deaf cohort performance on parts b and c of this question indicated that 71 per cent and 50 per cent respectively omitted these items. Analysis of the hearing cohort shows that the numbers omitting section b were below 42 per cent at all levels but that for part c at levels 5 and 6 64 per cent and 49 per cent respectively omit this item. This might suggest that although it is a difficult question, the hearing pupils were more able to attempt the first item, whereas the deaf pupils generally did not; suggesting a lack of familiarity with this area of learning.

A question 'Locus' raised a similar issue about the possible lack of familiarity with this area of the curriculum. It interesting that the analysis of the coding for the response to each section of this question revealed that although a greater proportion of the deaf pupils omitted sections a (24%) and b (53%), the percentages omitting these sections in the hearing cohort were much lower. However, 100 per cent of the deaf pupils attempted section c (this matches the hearing cohort profile), suggesting that they were perhaps taught the ruler and compass construction (which can be taught in a very direct manner) but not how to apply the concept of Locus to a question on coordinates.

One interpretation for these findings could be that computation skills are a major teaching focus but some other areas of the maths curriculum are not so thoroughly addressed. This could be a time factor or an issue to do with patterns of inclusion and access to specialist teaching. It may also indicate areas of the maths curriculum which prove to be difficult to teach because of the level of language and concept development needed and the difficulties that this poses either for teaching though BSL or through English with or without sign support.

SUMMARY OF PRELIMINARY FINDINGS

Although the sample number for this study is relatively small, this phase of the project has yielded some useful pointers for the direction of the next phase. One of the immediate issues to be followed up is the national entry levels for deaf pupils and how these compare with the figures for hearing pupils. It is noteworthy that of the sample of the 126 completed papers received only four were at level 6–8. The majority of papers received were at the 3–5 level, even though many of the pupil scores on these papers were comfortably in the level 5 range. Whilst it is accepted that not all test papers were received and that this proportion cannot be generalized, the finding is significant enough to raise the question of whether or not this does indeed reflect a national trend.

A second finding is that the language of mathematics does seem to pose specific problems in certain contexts. Certainly in the test situation deaf pupils often missed crucial mathematical language or had difficulties with longer written questions where links between the key information and the actual question had to be inferred. Another language issue which came to light was the difficulty experienced by markers in being consistent where written explanations formed a part of the answer. Some deaf pupils gave correct explanations, albeit in unconventional written English, but were not given the appropriate mark for this.

Deaf pupils were better able to demonstrate their mathematical understanding and strengths where test problems were presented in a step-by-step format showing the mathematical procedure required at each stage. Where application or interpretation of mathematical information was required deaf pupils did less well. It should be noted, however, that this trend was also reflected in the data for the hearing cohort albeit not to the same extent.

From some of the gaps or 'non attempts' on the deaf pupils' papers, we might also speculate about certain 'difficult to teach' items. This needs to be followed up by discussion with deaf pupils about their familiarity with areas of the mathematics curriculum and where they perceive the greatest challenges to be. This would be complemented by discussion with the deaf and hearing adults involved about curriculum coverage and issues involved in teaching specific items through English or sign language.

The nature of mathematics testing at Key Stages 3 and 4 influences the pupils' access to the maths curriculum. Because maths is tested in tiers, pupils working at the lower tiers do not have the opportunity to learn the content presented for higher-tier candidates. The Third International Mathematics and Science Study (1995) and other international studies into maths achievement highlight 'opportunity to learn' as a major factor in mathematical achievement. They cite the rigid setting (and consequent limitation of the curriculum for 'less able' pupils) in our system as responsible for producing a profile of very high attainment for the top end and a 'long tail' of underachievement for the lower half of the cohort. It was striking in setting up the samples that a majority of pupils were working at levels 3–5 and very few at level 6–8 in this sample.

The lack of specialist mathematics teachers for deaf children may exacerbate these influences if the teachers themselves are not comfortable with content at higher levels of testing. In addition a focus on numerical skills and routine arithmetic may stem from a lack of wider mathematical knowledge and appreciation of the broader nature of the subject amongst non-specialist teachers.

Even in mainstream schools with units for deaf pupils, there may be some effect on access to the full curriculum since the practice of 'setting'(placing children in 'sets', or bands according to their ability) is more widely applied in maths than in any other subject. The link between 'bottom' maths sets and pupils with special educational needs seems strong.

The issue of teacher expectation and its reflection in pupils' attainment is crucial, as this influences the entry level for pupils and consequently the amount of the curriculum that the pupil has access to. Studies into girls' attainment in maths have shown that teachers were more likely, for example, to 'play safe' and enter girls at the intermediate tier of GCSE, thus denying them the opportunity to access the highest grades.

This study has provided sufficient information to shape the questions and research design of the next phase of the project. This follow-up research aims to investigate the current mathematics education provision for deaf pupils across a range of contexts and provide an insight into the deaf experience of access to that provision. More information is needed about the breadth of the mathematics curriculum provision offered to deaf pupils. In addition, further insight into how the language of instruction affects deaf pupils' access to the mathematics curriculum and how this impacts upon their expectation of themselves as learners of mathematics is required. A future goal therefore will be to extrapolate the deaf experience of the mathematics provision, focusing especially on the language of access and learner expectation.

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