

Acoustic Guidelines and Teacher Strategies for Optimising Learning Conditions in Classrooms for Children with Hearing Problems

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Abstract

Noise and questionnaire surveys have been undertaken in London primary schools; initial data indicated that teachers had few strategies for moderating the effects of noise and enhancing children's attention and listening in class. Current research involves identification of both the acoustic and educational barriers to effective classroom communication. Trainee teachers' knowledge and attitudes about the noise environment in the classroom and the needs of children who are hard of hearing were collected through a questionnaire. Noise surveys were carried out across a wide range of primary schools. The noise surveys have shown that children in London primary schools are exposed to higher levels of noise than recommended by current guidelines, but that internal school noise levels are in general dominated by the noise of children and classroom activity. Children were aware of the sound sources in their classrooms and higher noise levels adversely affected academic attainments. A significant proportion of the trainee teachers stated that no classroom activities required the specific avoidance of background noise. The trainees had received little training on the negative effects of noise, particularly for hearing-impaired children. The coping strategies identified by the trainee teachers to alleviate interference caused by noise in the classrooms focussed on the needs of individual children; but the specific strategies identified would be difficult to implement in UK primary classrooms.

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Introduction

In this paper we report data from a programme of work that examines noise in classrooms and the ways in which children's learning is affected by noise. We also consider the ways in which teachers are prepared for noisy classrooms and for meeting the needs of children who have hearing impairments. The data presented here raise significant challenges for providing inclusive schools and classrooms.

Classroom Noise Exposure

Classrooms can be very noisy places, making it difficult for children to hear and understand their teacher. It has been known for many years that noise can have a detrimental effect upon children's performance in academic tasks (see Shield and Dockrell 2003 for a review). Poor acoustic design in schools exacerbates the problems of noise and increases the difficulty of children hearing and understanding the teacher. The problem is particularly serious in primary schools where, at any one time, the majority of classrooms will include several children with some form of hearing impairment (Nelson 1977). Teachers are also affected by noise and poor acoustics. High noise levels and too much reverberation in a space mean that they have to speak at an unnaturally high level, causing voice and throat problems (Smith, Gray, Dove, Kirchner and Heras 1997).

The noise inside a classroom consists of noise transmitted from outside and noise generated within the classroom. The latter will include noise from buildings services (air conditioning, heating, light-

ing), noise from teaching equipment and noise of the children themselves.

Most London primary schools are exposed to high levels of external noise, mainly caused by road traffic (Shield and Dockrell in press). In a survey of 142 schools 65% of the schools were exposed to levels in excess of the World Health Organisation guidelines for noise outside schools, and 86% were exposed to road traffic noise (Shield, Dockrell, Asker and Tachmatzidis 2002). The most commonly occurring sources of noise are shown in figure 1 (Schools in west London exposed predominantly to aircraft noise were excluded from the study but see Stansfeld, Haines, Brentall, Head, Roberts, Berry, and Jiggins 2000).

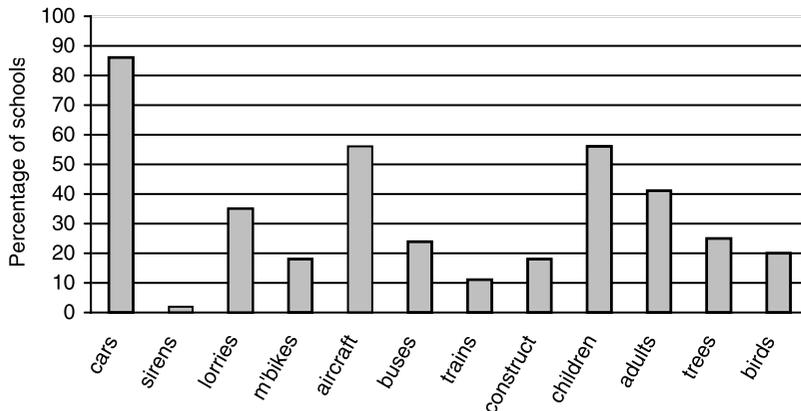


Figure 1. Commonly occurring noise sources outside London primary schools

However, noise levels inside the classrooms in this study were dominated by the noise of the children themselves and depended in general on the particular activities the children were involved in. External noise affected the noise inside a classroom only when children were engaged in quiet activities such as reading (Shield and Dockrell in press).

Impact on children's Learning and Performance

Children at school have consistently been found to be annoyed by chronic aircraft noise exposure (Evans, Hygge, and Bullinger 1995; Haines, Stansfeld, Job, Berglund, and Head 2001). In their study of the effect of high levels of aircraft noise Haines et al. (2001) demonstrated that annoyance levels due to aircraft noise were significantly higher among children in schools exposed to high levels of aircraft noise

compared with schools with lower exposure levels. In contrast, levels of annoyance due to road traffic noise both at school and at home did not differ significantly across the high and low aircraft noise schools.

Children may be aware of noise without necessarily being annoyed by it. A recent survey by Dockrell and Shield (in press) of over 2000 London primary school children aged 7 and 11 years, in schools exposed to a range of environmental noise sources, found that children were aware of, and some were annoyed by, specific noise sources. The older children were more aware of the noise, while the younger children found noise more annoying. The most annoying noise sources were trains, motorbikes, lorries and sirens, suggesting that it is intermittent loud noise events that cause most annoyance to children while at school. This was confirmed by the correlation between noise parameters and annoyance. The responses showed that children as young as 7 are aware of noise and its effects on their ability to hear, and that they have definite ideas about acceptable and unacceptable sound sources.

Children are not only aware of noise in their classroom but several recent studies have shown marked effects of internal noise on children's reading, numeracy and overall academic performance (Lundquist, Holmberg, and Landstrom 2000; MacKenzie 2000; Maxwell, and Evans 2000; Shield, Dockrell, Asker and Tachmatzidis 2002). Hetu, Truchon-Gagnon, and Bilodeau (1990) found a significant drop in children's performance, particularly in learning to read, when the background noise level interfered with speech. Mackenzie (2000) compared the performance of children in primary school classrooms that had been acoustically treated, thereby reducing background noise levels and reverberation times, with children in untreated classrooms. Children performed better in word intelligibility tests in the acoustically treated rooms, the improvement being particularly marked when other pupils were talking in the classrooms. Similar results were obtained by Maxwell and Evans (2000) in a study of pre-school children who had been exposed to levels in the classroom of 75 dB(A). Following acoustic treatment to reduce the noise the children's performance improved in letter, number and word recognition. In contrast, in a study of older children,

aged 13 and 15, working in levels of 58 to 69 dB(A) during mathematics classes there was a poor correlation between sound level and standard of work; however, there was a significant relationship between annoyance and the effect of noise on schoolwork.

Shield and Dockrell (in preparation) in comparing standardised assessment test scores (SATS) with internal noise levels in 16 schools found significant relationships between background (L_{A90}) noise levels in classrooms and test scores for several subjects (see figure 2 and figure 3). It was the older (age 11) children's English test scores that showed the strongest association with noise. A possible explanation of this result is that background speech in the classroom interferes with general processing of language. Any

relationship between noise and SATs is complex and involves many other factors such as language and social deprivation. However, the relationships between noise and SATs scores were still significant when these factors were taken into account. It was also noted that schools in areas of greater social deprivation (as indicated by the numbers of children having free school meals) had the higher external noise levels; this suggests that deprived children are doubly disadvantaged.

As yet the mechanisms that determine the impact of noise on performance are still underspecified. Shield et al. (2002) carried out a series of experimental investigations in schools to examine the ways in which different irrelevant sound sources interfered with children's processing of verbal and non-verbal tasks. Children's talk in the classroom had a detrimental effect upon the verbal (reading) task. A non-verbal (speed of processing) task was detrimentally affected by both classroom talk and environmental noise individually, the worst performance occurring in a combination of these two conditions. Significantly, children with special educational needs were differentially negatively affected by background children's talk on verbal tasks (reading and spelling).

Our studies to date indicate that noise inside a primary school classroom is largely determined by classroom activities and that children are aware of external noise while at school and find it annoying. Moreover, children's hearing and understanding of the teacher is affected by noise at school. External and internal noise has a detrimental effect upon children's academic performance at school and children with special educational needs are more seriously affected by noise than other children.

Designing Inclusive Environments

The philosophy of inclusive education now underpins many education systems. Driven to a large degree by human rights legislation it is argued that a child with special needs is entitled to be in mainstream education. Schools become inclusive by allowing the educational and social needs of a wider variety of children to be appropriately met alongside mainstream peers. Attempts to address inclusion underpin a number of government initiatives in the UK and in Europe more broadly, for example, the Special Educational Needs and Disabilities Act 2001 in the UK. The 2001 Act specifically "strengthens the right of children with SEN to be educated in mainstream

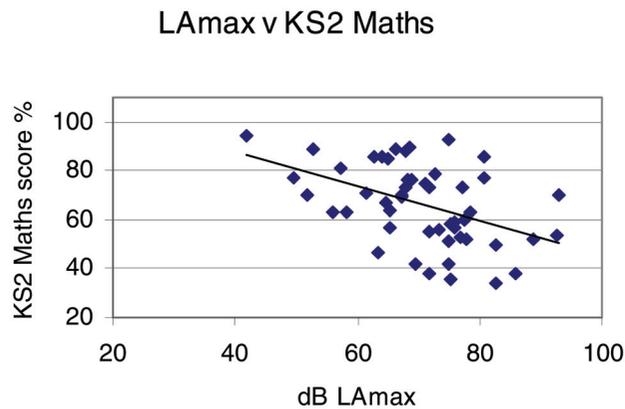


Figure 2. Relationship between external noise and KS2 Mathematics scores

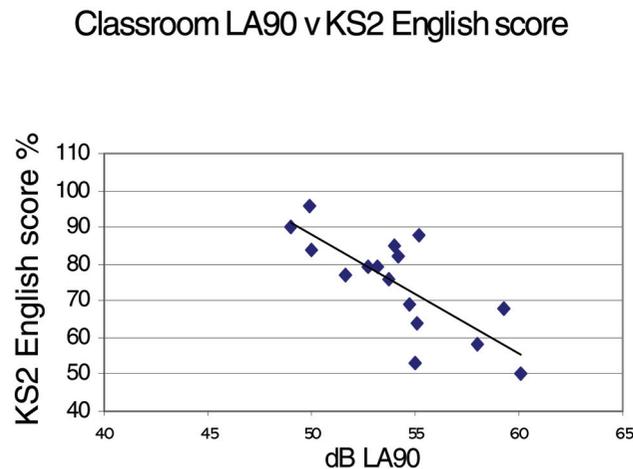


Figure 3. Relationship between internal noise and KS2 English scores

schools where parents want this and the interests of other children can be protected". This places an onus on schools and teachers to meet the needs of these children and to enhance the attainment of all pupils.

Three dimensions act in combination to enhance a schools' ability to provide a 'sound learning environment': technology, school buildings and teachers. In Britain legislation has recently been introduced which defines acoustic performance standards for new schools (Building Regulations/ Approved Document E, Building Bulletin 93) There are also a variety of technological innovations such as SFS and FM that can enhance learning environments (see this volume). Teachers also play a crucial role in this equation and successful teaching can be seen as the natural counterpart of successful learning. In the second part of this paper we consider teachers' ability to support learning in noisy classrooms and in situations where learning needs directly impact on acoustic dimensions. From a teacher's perspective providing a sound learning environment requires a) an understanding of the way noise can influence learning and attainment, and b) an awareness of the needs of learners with hearing impairments. Knowledge does not directly influence behaviour and it is therefore necessary to consider the teaching strategies used and the (potential) effectiveness of these strategies.

Teachers Perceptions of Noise in their Classroom Environments

Fifty-one teachers in 34 schools completed questionnaires on their attitudes to noise in their classrooms (12 in Year 2 and 39 in Year 6). Eleven of the teachers were male and 40 female. Over half the sample (59%) had more than five years experience, with 20 per cent having more than 20 years experience. For those who reported their age (39) there was a mean of 37 years (range 26–55).

In 20 schools the questionnaire was only completed by one teacher, there were two teachers in 11 schools and three teachers in the remaining three schools. This section reports descriptive information on the problems reported by the teachers, sound sources heard and whether the teachers felt that these sources affect children's concentration. The final section considers the impact of noise in the classroom and the strategies teachers implement to overcome the effects of noise.

School Environment

Teachers rated their schools in terms of the general noise environment. Ten reported their classrooms to be quiet or very quiet and 10 described them as loud; the remaining 60.8% were described as moderate. Teachers also rated the schools' internal and external noise environment and these data are presented in figure 4. Generally external environments were rated as louder than internal ones. Teachers were asked to comment on their own classrooms. Thirty-three per cent of the teachers reported that their classrooms were quieter than the average classroom. Eighty-five per cent explained this in terms of the classroom location. Only 15 per cent of the teachers reported that discipline was the key factor in explaining their classroom's relative quietness.

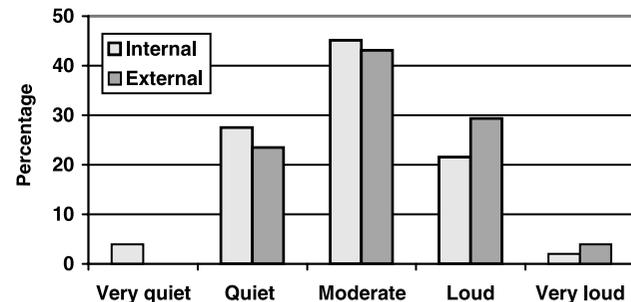


Figure 4. Teachers' reports of school noise environment

The majority of teachers reported that their schools had no noise policy (74.5%). For the schools that did have a noise policy it was described in relation to school discipline.

Environmental Noise

Teachers reported similar levels of hearing environmental noise sources as the pupils in the same schools, but teachers reported sirens more often than the children. The correlation between children's and teachers' rankings of sound sources was very high ($r = .945$, $p < .001$). Certain sounds were regarded as more likely to affect the children's concentration than others were. These data are presented in table 1. As the table shows, overall teachers consider external sound sources distracting to the children with certain sounds sources e.g. helicopters and sirens, being much more distracting than others.

Table 1. Impact of sound source on children's concentration

Sound source	Percentage of teachers reporting that children's concentration is affected by noise
Stereo	85.7
Helicopter	81.8
Sirens	69
TV	60
Phones	54.2
Musical instruments	53.6
Bus	50
Lorries	46.2
Trains	42.9
Cars	43.3
Animals	42.9
Motorbikes	37.5
Planes	27.8
Trees	6.3

Overall, 90.2 % of the respondents reported that outside noise affected the children's concentration. Many teachers believed that children with special educational needs were more affected than mainstream peers (68.6%).

Teachers often attempted to militate against the distracting effect of external noise by arranging quiet times. Although many teachers felt that noise levels impacted on most class activities (39.2%), an identical proportion felt the key effects were primarily on language based activities (39.2%). Teachers reported a limited range of classroom strategies to combat the effect of external noise sources. These included raising voices (33.3%), specific attention gaining strategies (21.6%), stopping teaching (17.6%) and ignoring the situation (3.9%). Nearly one-fifth of the respondents (17.6%) reported no specific strategies at all.

For the teachers in the current sample environmental noise was a key factor in their school lives. The location of classrooms within the school was seen as a critical factor in determining external noise levels. Nonetheless, the majority of teachers were affected by noise. Noise sources reportedly affected children's concentration and teachers possessed limited strategies to address these situations. Schools appeared not to have detailed noise policies (or the teachers were not aware of them). Yet the majority of teachers were complaining of problems with their

throats and voices. In sum, teachers felt external noise was distracting and could also serve to make the children noisier thereby beginning a negative and detrimental cycle.

Investigating the Views of Trainee Teachers: Classroom Practice, Noise and Diversity

Noise influences school performance yet teachers have few strategies to modulate the effects of noise levels. In this section we consider the ways in which trainee teachers understand the role of noise levels in teaching and learning.

Students completing a one-year post graduate programme in initial teacher training at two higher education institutes in England were asked to participate in the study. A total of 318 trainee teachers (42 male; 276 female) completed questionnaires at the start of their year of initial teacher training and 228 of these respondents completed a follow-up questionnaire at the end of their training year (35 male; 193 female). They represented diverse ethnic backgrounds with 51% classifying themselves as white. Fifty-one percent had some teaching experience at the beginning of the course with a quarter of those with teaching experience (22.9%) having worked as a teaching assistant in a mainstream school. Length of experience ranged from one month (12.3%) to more than 18 months (55%). All recorded experience was with children under the age of 11. Ninety eight per cent of respondents were attending full time courses with the remaining 2% attending part time courses.

Concerns about Teaching

Trainee teachers were asked to report their three main concerns at the beginning of the course. The majority of responses (26.5%) focussed on classroom management with discipline (20%) being the second most common response. Very few responses reflected concerns about meeting the needs of children with special educational needs (2%) and noisy environments did not feature in the trainees' concerns. This pattern of responses was similar at the end of training. However, at this point there was a marked increase in concern about discipline (43.1%) with concerns about classroom management also remaining high (18.5%). There was no significant difference across times in proportions of participants reporting

classroom management as their most significant concern ($X^2 = .767$, ns). However significantly more respondents highlighted discipline as a concern at the end of training ($X^2 = 31.34$, $p < .001$). Supporting the needs of children with special educational needs remained at a low level of concern (3%).

Supporting Effective Teaching

Trainees were asked to rate a range of factors that could support effective teaching. Thirteen factors had been identified from previous research and a review of the literature. Participants rated their importance on a seven-point scale from not at all effective to very effective. Participants' ratings at the beginning of the training course and at the end of training are presented in table 2.

As the table indicates there is a clear hierarchy of preferred strategies to enhance effective teaching. A repeated measures ANOVA indicated both an effect of time ($F(1, 509) = 6.939$, $p = .009$) and aspects of effective teaching ($F(1, 12) = 125.224$, $p < .001$). Although time accounted for little variance in participants' responses ($\eta^2 .01$), managing noise in classrooms was the only aspect that was rated more highly at Time 2 the remaining 12 variables were rate as less important at Time 2. The aspect rated (A1–A13) accounted for a large proportion of the variance in responses ($\eta^2 .20$). Comparisons between the different approaches

indicated that trainees rated these dimensions in three broad groups. A1, A2 and A3 differed significantly from each other and were rated significantly higher than all the other measures indicating that the trainee teachers placed most importance on these dimensions. All three aspects refer to individual child ability and behaviour. A4 to A11 were rated as equally important and more important than A12 and A13. A4 to A11 emphasise the match between activity and context, the latter including equipment, position and task. Thus trainee teachers placed greatest emphasis on aspects that were related to individual children's needs and attention in class as opposed to organisational features of classroom practice.

Comparisons between the two ratings over time revealed significant differences for only four measures. Trainees ratings of A2 maintaining children's attention ($F(1,545) = 6.427$, $p = .012$), A3 encouraging children to ask questions ($F(1,544) = 13.136$, $p < .001$), A6 the importance of age of the child and tasks matching ($F(1,541) = 7.942$, $p = .005$) and A13 having more than one activity going on at the same time ($F(1,542) = 7.584$, $p = .006$) were all rated lower on at the end of training. Both at the beginning (60.5%) and end of their course (62.2%) participants rated A1 as the most important aspect of effective classroom management while A13 was rated as the least important aspect of effective classroom management. Managing noise levels was rated as the least import-

Table 2. Ratings of aspects of effective teaching by trainee teachers

Aspect of effective teaching	Start of course M (SD)	End of course M (SD)	Change over time
A1. Match between child's ability and activities	6.7 (.62)	6.7 (.62)	
A2. Maintaining children's attention	6.5 (.71)	6.4 (.70)	$F(1,543) = 10.430$, $p = .001$
A3. Encouraging children to ask questions to clarify what is said	6.4 (.84)	6.1 (.91)	$F(1,543) = 19.390$, $p < .001$
A4. Avoiding distractions that affect the children	6.1 (.94)	6.0 (.88)	$F(1,543) = .173$, ns
A5. Teachers physical position in relation to class	6.1 (.94)	5.8 (1.36)	$F(1,540) = 1.794$, ns
A6. Age of the children matching tasks	6.0 (1.1)	5.7 (1.2)	$F(1,525) = 7.501$, $p = .006$
A7. Task and position of children in the class	5.9 (5.4)	5.6 (.95)	$F(1,539) = .888$, ns
A8. Use of equipment as a teaching aid	5.8 (.98)	5.7 (.99)	$F(1,544) = 1.263$, ns
A9. Managing classroom noise	5.8 (1.1)	5.9 (.99)	$F(1,544) = .032$, ns
A10. Task and organisation of furniture	5.5 (.99)	5.5 (1.01)	$F(1,534) = .000$, ns
A11. Time of day you set the tasks	5.5 (1.1)	5.4 (1.07)	$F(1,544) = 1.061$, ns
A12. Type of classroom	4.8 (1.29)	4.7 (1.28)	$F(1,543) = .036$, ns
A13. Having more than one activity ongoing	4.00 (1.4)	3.66 (1.47)	$F(1,542) = .130$, ns

ant strategy for 3% of respondents and this did not differ across time.

Noise in the Classroom

Despite the generally lower ratings for the noise reduction and physical features of the environment that may influence noise levels (A5, A7, A10, A11 and A13) 85% of respondents felt that there were classroom activities where it was important to avoid noise from outside and 89 % felt there were classroom activities where noise from the children should be avoided. In both cases there was a significant change by the end of the course, with more participants reporting that there were activities where noise from outside the classroom should be avoided ($X^2 = 5.7$, $p < .025$) and noise from children should be avoided ($X^2 = 4.4$, $p < .05$).

Participants reported a range of tasks and contexts where they felt external noise should be minimised or where noise from other children should be minimised. The tasks and contexts are presented as percentages in table 3. Cases are only included where more than 2% of the respondents mentioned a task or condition. As table 3 shows, on the whole, respondents did not differentiate between noise external to the classroom and noise from other children. Moreover, respondents were fairly consistent in the responses generated across both time points. Reading and tests feature as situations where noise should be avoided but less than 25 per cent of the participants held this view. Surprisingly few participants considered listening activity as time when quiet was

required. These responses suggest that noise in the classroom is not a salient dimension for trainee teachers and that they are not aware of the potential differential impact of noise sources across tasks.

Moderating the Effects of Noise

Trainees were asked to identify factors that would support effective teaching in conditions where it was necessary to moderate the effects of background noise. Eight factors were identified and participants rated their importance on a seven-point scale from not at all effective to very effective. Participants' ratings at the beginning of the training course and at the end of training are presented in table 4. As the table indicates there is a clear hierarchy of preferred strategies for moderating classroom noise. A repeated measures ANOVA indicated no overall effect of time of response ($F(1, 523) = 1.929$, ns) but a statistically significant difference between strategies ($F(1, 7) = 549.513$, $p < .001$), which accounted for a large proportion of the variance in responses ($\eta^2 .468$). Strategy 1 was rated statistically significantly higher than all other strategies. Strategies 2,3 and 4 did not differ statistically significantly but were rated higher than strategies 5 to 8. Strategies 5 to 7 did not differ significantly but were rated higher than strategy 8. Thus participants were more likely to consider individual children's needs and the design of the classroom as important dimensions for teaching when high levels of background noise were present. Both at the beginning and end of their course participants rated seating children according to their hearing or

Table 3. Tasks and teaching contexts where trainee teachers felt that noise should be avoided

		Noise from outside the class should be avoided		Noise from other children should be avoided	
		Start of course	End of course	Start of course	End of course
Tasks	Reading	22	19	22	12
	Difficult task	8	8	5	6
Teaching Context	Group work	2	7	3	9
	Whole class	6	8	12	13
	Individual written work	8	7	13	10
	Tests	17	24	14	14
	Listening activity	7	11	1	4

Table 4. Trainee teachers rating of strategies utilised for moderating noise

Strategies for enhancing teaching with high levels of background noise	Start of course M (SD)	End of course M (SD)
S1. Seating children according to their hearing/visual requirements	6.2 (1.1)	6.4 (.8)
S2. Aware of limitations of design of classroom	6.1 (1.05)	5.9 (1.1)
S3. Using visual cues to maintain silence	6.1 (1.2)	6.1 (1.0)
S4. Waiting for children to be quiet before speaking	6.0 (1.2)	6.3 (1.0)
S5. Writing down instructions before speaking	5.1 (1.6)	4.8 (1.6)
S6. Using overhead projector	5.1 (1.6)	4.6 (1.4)
S7. Keeping children occupied at all times	5.0 (1.3)	4.9 (1.3)
S8. Shouting to make yourself heard	3.0 (1.6)	2.80 (1.4)

visual requirements as the most effective strategy and shouting as the least effective strategy.

In addition a significant percentage of the respondents felt that children with special educational needs were more adversely affected by noise (95%). This was typically explained in terms of higher levels of distractibility (57%). There was no significant difference in the responses between those who had experience of children with special educational needs and those who did not ($X^2 = .089$, ns).

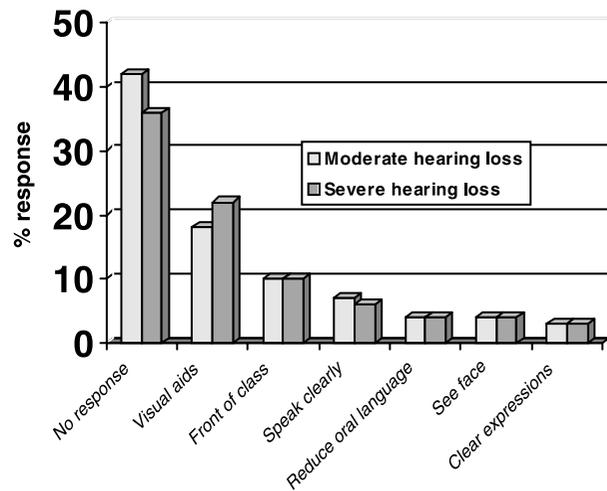
Thus trainee teachers appear to place a clear emphasis on understanding children's needs to allow appropriate and effective teaching. Recognition of differential learning needs place formidable demands on the teacher's knowledge and understanding of individual differences. To address this we now turn to trainee teachers' awareness of the needs of children with hearing impairments.

Children with Hearing Impairments

Fifty-one per cent of respondents reported no experience of children with hearing impairments, only 10% reported high levels of experience. The majority (92%) reported no training of any kind about hearing loss and hearing impairment. Moreover, 50% felt (erroneously) that it was quite unlikely or very unlikely that they would have a child with a hearing impairment in their classroom. Eighty-five per cent felt the design of the classroom would influence how well a hearing impaired child could hear. Ninety per cent indicated that they would change the way they taught if there was a child with a mild to moderate hearing loss in their class with 97% indicating they would do so if they had a child with severe hearing difficulties in their class.

Participants were asked to outline three ways in which they might modify their teaching strategies. These data are presented in figure 5. This question format generated a broad range of strategies (N = 16) but little consistency across responses. There were high levels of no responses. The predominant strategies were the use of more visual aids (42%), placing the child near the front (17%) and speaking clearly (9.8%). Responses did not differentiate across extent of hearing loss.

Participants were asked where they would seek advice about meeting the needs of children with hearing impairments. The majority (62%) indicated that they would approach the school's special educational needs coordinator or the head teacher (17%). There is no current data about levels of training in hearing impairment for these two groups. Only 2% indicated

**Figure 5.** Teachers' strategies for supporting children with hearing problems

that they would approach one of the national charities for children who have hearing impairments.

Conclusions

Our data indicate that noise is a serious problem in urban schools. Increased noise levels reduce academic attainments and different noise sources differentially impact on children's performance. Children with special educational needs appear to be particularly vulnerable to the effects of noise and the performance of children with hearing impairments can be particularly compromised. Yet teachers show little awareness of the importance of noise levels in their classrooms and the need to monitor noise for particular tasks and particular teaching contexts. These issues are further exacerbated by a lack of knowledge and training about hearing impairment and limited ways to include children in mainstream classrooms. The strategies that are proposed to address the needs of children with HI are limited when many of the children are in large classes (average primary class size 27.2 DfES, 2003¹) and spending the vast majority of their time working in groups (Blatchford, Kutnick, and Baines, 1999). Both of these factors are likely to increase noise levels and preclude identification and placing of children according to individual needs.

Acknowledgements

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¹ 16.3 per cent of pupils in primary classes taught by one teacher in primary schools were in classes of 31 or more pupils

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