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Students' perceptions of school acoustics and the impact of noise on teaching and learning in secondary schools: Findings of a questionnaire survey

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Abstract

This paper will present the design and findings of an online questionnaire survey of 11‑16 year olds' impressions of their school's acoustic environment, and of an experimental study into the effects of typical levels of classroom noise on adolescent's performance on numeracy and cognitive functioning tasks. Analysis of the responses to the questionnaire found that pupils who reported additional learning needs such as hearing impairment, speaking English as an additional language or receiving learning support reported being significantly more affected by poor school acoustics than pupils reporting no additional learning needs. Pupils attending suburban schools featuring cellular classrooms that were not exposed to a nearby noise sources were more positive about their school acoustics than pupils at schools with open plan classroom designs or attending schools that were exposed to external noise sources. The study demonstrates that adolescents are reliable judges of their school's acoustic environment, and have insight into the disruption to teaching and learning caused by poor listening conditions. Furthermore, pupils with additional learning needs are more at risk from the negative effects of poor school acoustics.

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Keywords: high school acoustics; adolescents; hearing impairment; numeracy; classroom noise

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1. Introduction

Poor acoustic environments in schools are known to negatively affect pupils' learning and achievement [1-8]. Learners who are hearing impaired or who have other additional learning needs are at increased risk of the negative effects of poor school acoustics [9-10]. Furthermore, the negative impact of noise in schools is worse in schools featuring open-plan classroom designs or that are near to external noise sources [11-13]. To investigate the factors that determine the perception of the acoustic environment in high schools, an online questionnaire survey of 11- to 16-year-olds' impressions of their school's acoustic environment was developed. The questionnaire was designed with the aim of capturing the constantly changing learning environments and acoustical conditions that are characteristic of large high school sites, where pupils experience frequent changes of location, subject studied and levels of noise exposure.

2. Method

2.1. Design of the questionnaire

Based on previous research [14-16] and interviews with school teachers, special educational needs coordinators, hearing and hearing-impaired pupils, the questionnaire consisted 93 questions, divided into seven subscales: (i) Ease of Hearing in School Spaces; (ii) sounds and annoyance in the classroom, (sounds were grouped into three categories: sounds coming from within the classroom, sounds coming from outside the classroom and intermittent sounds made by machines/technology); (iii) sensitivity to annoyance by noise during learning activities; (iv) situations that made it hard to hear the teacher during lessons; (v) impact of noise on concentration, fatigue and learning; (vi) consequences of noise and poor listening conditions on student and teacher behaviour in the classroom. All numerical responses were in the form of a 5-point likert scale, in which 1 indicated low frequency or intensity of perception and 5 indicated high frequency or intensity.

2.2. Procedure

The questionnaire was adapted into an online format using SurveyMonkey.com. An electronic link to the questionnaire was then provided to the coordinating teacher. Pupils then completed the questionnaire as part of their regular Information and Communication Technology (computing) or Science lessons.

2.3. Participants

The questionnaire was returned online by 2588 pupils from six schools. Three-hundred and thirty three pupils (12.9%) reported receiving learning support; 146 pupils (5.6%) reported speaking English as an additional language; 137 pupils (5.3%) reported having a hearing impairment. Of these pupils, 96 (3.7%) reported a combination of two or more factors that might compromise hearing and learning in the classroom. Two-thousand and ninety five pupils (81%) reported no factors that might compromise hearing and learning in the classroom. Five of the six schools that returned the questionnaire were in the high-performance category. Three schools were of a cellular classroom design; three schools featured a mix of open-plan and cellular classroom designs.

3. Results

Table 1 displays mean ratings for ease of hearing in school spaces subscale. Ratings were on a 5-point likert scale bounded by 1 = "Always easy to hear" and 5 = "Always hard to hear" in response to the request "Please rate how easy or hard it is to hear your teacher in these places around the school". A within subjects, repeated measures ANOVA with school space as the dependent variable revealed that ease of hearing differed significantly across school spaces, F (11,2332) = 584.12, MSE = .39, p < .001 , pη2 = .22. Bonferroni corrected post hoc tests confirmed the following significant differences: dining area/canteen > the corridors > the sports hall > the assembly hall > design and technology rooms > the music room/s > the language classrooms (all ps < .001). There were no significant differences in ease of hearing ratings between ICT rooms, drama studio, art rooms, tutor/form rooms, science rooms or language classrooms.

Table 1: Mean Ratings on the "Ease of Hearing in School Spaces" Subscale (Ranked According to Mean Rating)

School space	N	Mean (SD)
Dining area/canteen	2411	2.54 (1.17)
Corridors	2463	2.4 (1.15)
Sports hall	2434	1.99 (1)
Assembly hall	2445	1.91 (0.95)
Music room/s	2265	1.83 (0.97)
Design and Technology room/s	2371	1.71 (0.85)
Language classroom/s	2359	1.63 (0.87)
Science room/s	2445	1.6 (0.82)
My tutor/form room	2469	1.59 (0.83)
Art rooms	2337	1.56 (0.8)
Drama studio	2313	1.53 (0.8)
ICT room/s	2456	1.52 (0.83)

Table 2 displays the frequency and annoyance ratings for sounds categorised according to origin. Frequency was judged in response to the question "How often do you hear these sounds in your lessons?" on a 5-point scale bounded by 1 = "In none of my lessons" and 5 = "In all of my lessons". Annoyance was judged in response to the question "How annoying do you find these sounds?" in which 1 = "Not at all annoying", 2 = "Annoying", 5 = "Extremely annoying". A repeated measures ANOVA with mean frequency ratings for each type of sound as the dependent variable revealed a significant main effect of type of sound F (2,4792) = 2718.65, MSE = 1391.1, p < .001 , $p\eta$2 = .53. Bonferroni corrected post hoc tests confirmed significant differences between the frequencies with which the 3 sound types were rated in the following direction: Sound generated in the classroom > Sound generated outside the classroom > Mechanical sounds (all ps < .001).

Pupils' ratings of annoyance to the sounds heard during lessons did were not related to the frequency with which the sounds were heard: sounds coming from inside the classroom and mechanical sounds elicited lower ratings of annoyance compared to sounds from outside the classroom. A repeated measures ANOVA with type of sound as the dependent variable revealed a small but significant effect of type of sound on annoyance ratings, F (2, 4688) = 95.61, MSE = .26, p < .001, $p\eta^2$ = .04. Bonferroni corrected post hoc procedures confirmed significant differences between annoyance ratings to types of sound in the following direction: annoyance to sounds from outside the classroom > annoyance to mechanical sounds > annoyance to sounds from inside the classroom (all ps < .001). In summary, pupils experienced the most frequently hear sounds as least annoying: infrequent and unpredictable sounds received the highest annoyance ratings.

Table 2: Mean Ratings on the Top Three Items on the "Sounds" and "Annoyance" Subscales

	Frequency		Annoyance	
	N	Mean (SD)	N	Mean (SD)
Sounds from inside the classroom				

Students talking quietly to each other in your classroom	2435	3.56 (1.25)	2365	1.58 (.98)
Student stalking loudly to each other in your classroom	2435	3.13 (1.15)	2365	2.40 (1.16)
Students moving about in your classroom	2435	3.05 (1.21)	2365	1.80 (1.07)
Computers or other equipment like projectors	2387	2.69 (1.21)	2339	1.71 (1.03)
Mean		3.11 (1.21)		1.87 (1.06)
Sounds from outside the classroom				
Students in the corridor outside your classroom	2435	2.67 (1.09)	2365	2.11 (1.15)
Students in classrooms near your classroom	2435	2.47 (1.20)	2365	2.00 (1.23)
Teachers in classrooms near your classroom	2435	2.45 (1.22)	2365	2.00 (1.23)
Sudden unexpected sounds (for example banging on doors, bins clattering)	2382	2.40 (1.12)	2335	2.20 (1.26)
Students outside your classroom (for example in the playground)	2435	2.40 (1.12)	2365	1.99 (1.13)
Sound that is coming through a loudspeaker in another room (music or video)	2435	2.34 (1.09)	2365	2.25 (1.24)
Mean		2.45 (1.14)		2.09 (1.21)
Mechanical Sounds				
Fans, blowers or heaters	2394	2.33 (1.06)	2343	1.76 (1.02)
Mobile phones (ringtones or any other sounds)	2387	2.29 (.98)	2334	1.93 (1.16)
Lorries, cars, buses, motorbikes	2390	2.03 (1.07)	2334	1.94 (1.13)
Sirens	2385	1.77 (1.07)	2332	2.28 (1.30)
Trains	2387	1.69 (1.09)	2332	2.28 (1.30)
Aircraft	2386	1.65 (1.00)	2332	1.89 (1.20)
Mean		1.96 (1.05)		2.01 (1.19)

The Impact of Classroom noise on Teaching and Learning

Responses on the remaining subscales create a detailed impression of listening conditions and the impact of noise in classrooms. For example, the situations identified as being the hardest in which to hear the teacher were when “other students are talking in my classroom” (mean = 2.38, SD = 1.2) and “when other students are making a noise in nearby classrooms” (mean = 2.24, SD = 1.19). The highest rated responses to impact of noise in the classroom subscale n response to the prompt “When it’s noisy or hard to hear in my classroom…” were “my concentration is easily broken” (mean = 3.24, SD = 1.32) and “I don’t learn as much as in a quiet lesson” mean (mean =2.86, SD = 1.32). Lastly, the activities during which pupils reported being most sensitive to the disruptive effects of noise were while “…doing a test or exam” (mean = 3.44, SD = 1.46) and when reading (mean = 2.84, SD = 1.39).

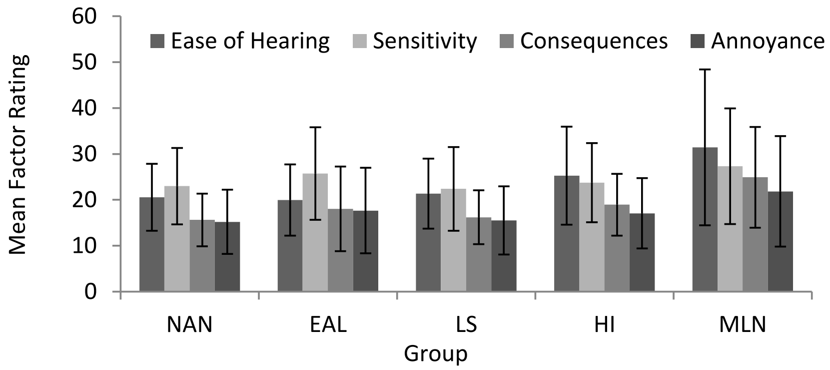
3.1. Effects of Additional Learning Needs and School

An exploratory factor analysis identified four factors which together accounted for 43.3% of the total variance. Factor 1 corresponds to ease of hearing in school spaces (Ease of Hearing); Factor 2 corresponds with individual sensitivity to annoyance by noise during learning activities (Sensitivity); Factor 3 corresponds with consequences of noise and poor listening conditions on hearing and understanding during lessons (Consequences); and Factor 4 corresponds with annoyance to intermittent sounds (Annoyance).

The mean scores on each factor for pupils grouped according to learning need are displayed in Figure 1. The effect of group on each of the four factors was statistically significant: Ease of Hearing, F (4, 2476) = 39.57, MSE = 62.44, p < 001, $p\eta^2$ = .06; Sensitivity, F (4, 2318) = 6.40, MSE = 74.42, p < .001, $p\eta^2$ = .01; Consequences, F (4, 2252) = 44.34, MSE = 37.62, p < .001, $p\eta$2 = .07; and Annoyance subscale, F (4, 2340) = 16.51, MSE = 53.76, p < .001, $p\eta^2$ = .03. In all cases, planned comparisons revealed that the mean ratings of the MLN group were significantly higher than, EAL, LS, HI and NAN groups and that the ratings of the EAL, LS, HI and NAN were significantly higher than the NAN group (all ps < 0.001, one tailed).

In addition to examining the effect of school across the four factors (Ease of Hearing, Sensitivity, Consequences and Annoyance), planned contrasts were used to compare responses from pupils in schools that possessed features known to compromise the acoustical conditions within classrooms to those from pupils in schools that did not possess such features. The acoustically compromised schools included those exposed to noise from a main road or railway line and those that featured large or open-plan classroom design (schools 3 - 6); non-compromised schools were not exposed to any of these potential noise sources (schools 1 and 2). The main effect of school was statistically significant on all factors: Ease of Hearing, F (5, 2475) = 11.32, MSE = 64.98, p < .001, $p\eta^2$ = .02; Sensitivity, F (5, 2317) = 9.50, MSE = 73.77, p < 001, $p\eta^2$ = .02; Consequences, F (5, 2251) = 14.27, MSE = 39.35, p < .001, $p\eta 2$ = .31; and Annoyance, F (5, 2339) = 11.682, MSE = 53.953, p < .001, $p\eta^2$ = .024. In all cases, planned contrasts showed that mean ratings were significantly higher in the acoustically compromised schools compared to non-compromised schools (p < 0.001 in all cases).

Figure 1: Mean Factor Ratings According to Pupils' Learning Needs (NAN = no reported additional learning needs; EAL = pupils reporting speaking English as an additional language; LS = pupils receiving learning support only; HI = pupils reporting a hearing impairment; MLN = pupils reporting multiple learning needs. Error bars represent standard deviations)



4. Discussion and conclusions

The above findings show that adolescent learners are sensitive judges of the acoustical qualities of their learning environment, and are able to reliably identify the acoustic conditions that interfere with their learning. Learners with additional learning needs such as speaking English as an additional language, having a hearing impairment or receiving learning support reported being significantly more affected by the negative effects of poor school acoustics. Pupils with combinations of additional learning needs were particularly sensitive to the effects of adverse acoustical conditions in school. Schools location and build also had an effect on pupils responses: schools that were exposed to additional noise from outside sources such as main roads and railways or internal intrusive noise typical of open-plan school designs (schools 3 to 6), produced significantly higher ratings on all of the four factors compared to schools that were not exposed to these factors (schools 1 and 2). A full discussion of the design and analysis can be found in the original publication [17].

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