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Vocal problems for teachers and school acoustics - a field study

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ABSTRACT

School acoustic design in the UK is traditionally concerned with the needs of the listener, rather than the voice ergonomics of the speaker. However, a recent survey undertaken by London South Bank University (LSBU) indicated that over 65% of the surveyed teachers had experienced voice problems during their career. This supports other studies suggesting that teachers have a significantly higher rate of voice problems than the general population. In an effort to better understand the influence of classroom acoustic design on the speech levels of teachers LSBU is currently undertaking measurements of teachers' voices in different classroom types. The measurements are being undertaken using an Ambulatory Phonation Monitor (APM) which measures voice parameters directly from the skin vibrations in the neck, thus eliminating the effects of other noise sources in the environment. The rooms involved are acoustically benchmarked separately to enable relationships between the voice data and acoustic parameters to be investigated.
This paper presents results of the field measurements to date, with a brief summary of the data collected to date from the teachers' questionnaire survey, and discusses some of the initial findings.

Keywords: Classroom, Teachers, Voice. I-INCE Classification of Subjects Numbers: 51.1.5, 63.3.

1. INTRODUCTION

For over a century school acoustics has caused concerns for users and acousticians. The need for good speech intelligibility and suitably low noise levels in educational spaces is now widely acknowledged as being essential for effective pupil learning.

In the UK there have been school guidance documents on acoustics for many decades, the current document at the time of writing, Building Bulletin 93 (BB93) (1) is undergoing revision and is expected to be replaced imminently. To date however, guidance for acoustics in educational spaces has concentrated mainly on the importance of the pupil hearing the teacher; the care of the teacher's voice, termed Voice Ergonomics, has not typically been considered.

In practical terms, for the acoustical design industry, there is a need for greater guidance on voice ergonomics in schools, and whether passive acoustic design can improve vocal comfort for teachers. To better understand the influence of classroom acoustics on voice levels field measurements have been carried out of teachers speaking in different classroom types.

Previous studies (2) indicate that teachers have an elevated prevalence of voice problems compared with the general population. The indications to date have primarily been drawn from looking at the break down of medical referrals for voice problems by profession. This approach may, however, under report the prevalence by ignoring those who experience voice problems but fail to seek treatment for a variety of reasons.

In order to seek more detailed information on the issue, the study described here involves both an objective survey of teachers' voice levels, plus an online questionnaire survey of teachers.

1.1 Current UK Acoustic Standards for Schools

The relevant BB93 requirements for primary and secondary school classrooms are shown in Table 1 for information:

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Table 1 – Acoustic requirements for classrooms under BB93

Classroom type	Reverberation time T_{mf} (seconds)	Unoccupied ambient noise level $L_{Aeq,\ 30\ minutes}$ dB
Primary school	<0.6	≤35
Secondary school	<0.8	≤35

T_{mf} referred to in Table 1 is the average of the reverberation times at 500, 1000 and 2000 Hz (to be consistent with the current UK standard (1))

The values above are to be achieved in finished but unoccupied and unfurnished rooms and in the case of the internal noise level exclude noise generated by teaching activities in the school itself.

It should be noted that these requirements are not retrospective and apply to new constructions only rather than existing schools, however BB93 provides the most suitable guidance for considering existing school buildings. BB93 describes the acoustic requirements in Table 1 as good minimum standards and states that on occasion higher standards will be necessary.

2. METHODOLOGY

2.1 Voice and Acoustics Measurements

In order to measure the voice parameters for teachers working in a range of classroom types, representative of the UK classroom stock, a method for field measurements has been developed. This methodology is described in detail in reference (3). In summary a number of sets of data are captured for each teacher studied including:

1) Acoustic measurements of the empty classroom or classrooms in which the teacher works. These include measurements of unoccupied internal ambient noise levels and reverberation times to determine the T_{mf} value.

2) Measurements during lessons of general noise levels in the classroom including those due to the teacher's voice and all other noise sources.

3) Measurements of the teacher's voice level only whilst teaching during lessons using an ambulatory phonation monitor (APM). This is a device which measures vibrations from speech using a small accelerometer fixed to the skin over the speaker's sternal notch. The APM is calibrated prior to the measurements by using a microphone mounted at a fixed distance (0.15 m) from the mouth. The participant provides sample speech utterances whilst the accelerometer is in place and a transfer function is then calculated allowing a speech level at 1 m distance to be extrapolated.

Following calibration the participant wears the accelerometer for their working day attached to a small unit on their waist. The APM monitors a number of speech parameters including equivalent A-weighted sound pressure level (LpA) and the fundamental frequency of the voice (f_0). In addition the APM measures the total phonation time, which is the total speaking time during the measurement excluding pauses, and the phonation % which is the proportion of the measurement period for which the teacher was speaking. The APM units are supplied with proprietary software which carries out analysis as well as allowing the raw acceleration data and transfer functions between acceleration and equivalent LpA to be exported for analysis in other software.

The participants measured in this study taught in a broad range of acoustic conditions, the mid frequency reverberation times (T_{mf}) varied from 0.3 seconds to 1 second in the classrooms and the unoccupied internal noise levels from 23 to 38 dB L_{Aeq}. The classrooms ranged from those constructed in the late 19th Century with high ceilings, large volumes, single glazing and no acoustic treatment, to classrooms refurbished to current BB93 standards in recent years. Figures1 and 2 show examples of older and more recent classrooms measured in this study.

Figure 1 –Typical UK classroom constructed in the late 19th Century

Figure 2 –Typical UK classroom constructed in the late 20th Century

2.2 Online Questionnaire

The online questionnaire survey of UK teachers is currently being carried out to investigate their experiences of voice strain and other voice-related problems, as well as perceptions of general noise and acoustics in schools. The questionnaire has been running since January 2014 and has been publicized via two teaching unions: the largest teaching union in the UK, The National Union of Teachers; and Voice – The Union for Educational Professionals.

The questionnaire is composed of 57 questions including a section on general health and wellbeing. It is anonymous and takes around 15 minutes to complete.

The anonymous nature of the questionnaire and the means of distributing the survey link means that the origins of the respondents are not known. Therefore it is reasonable to consider that there is a degree of bias in the self-selection process, in that those who are more interested in the topic of voice problems, perhaps as a result of personal experience of the issue, may be more likely to respond to the questionnaire. Despite this it is felt that the questionnaire can provide useful additional information on the topic where little has been known previously.

3. RESULTS

3.1 Voice and Acoustics Measurements Results

At the time of writing measurements have been undertaken of 14 participants, 10 female and 4 male. 4 teachers were in secondary schools (pupils aged 11-18 years) and 10 in primary schools (pupils aged 4-11 years). The results are summarized in Table 2.

Table 2 – APM measurement results

Participant Gender	Classroom parameters Reverberation time T_{mf} (seconds)	Classroom parameters Unoccupied ambient noise level L_{Aeq} dB	Voice parameters Average LpA dB 1 metre from mouth	Voice parameters Phonation time %
Female	1.0	28	57	22
Male	0.4	23	62	16
Male	0.3	24	60	18
Female	0.9	27	66	13
Female	0.5	29	63	26
Female	0.6	37	72	28
Female	0.9	38	75	26
Female	0.9	32	65	23
Female	0.8	32	68	18
Male	1.0	30	64	13
Female	0.4	29	58	18
Female	0.4	30	71	18
Female	0.7	35	79	18
Male	0.8	37	61	22

The distribution of the participants' voice levels are shown in Figure 3, categorized according to vocal effort (4) which indicates that the highest number of participants were in the 'normal' vocal effort group.

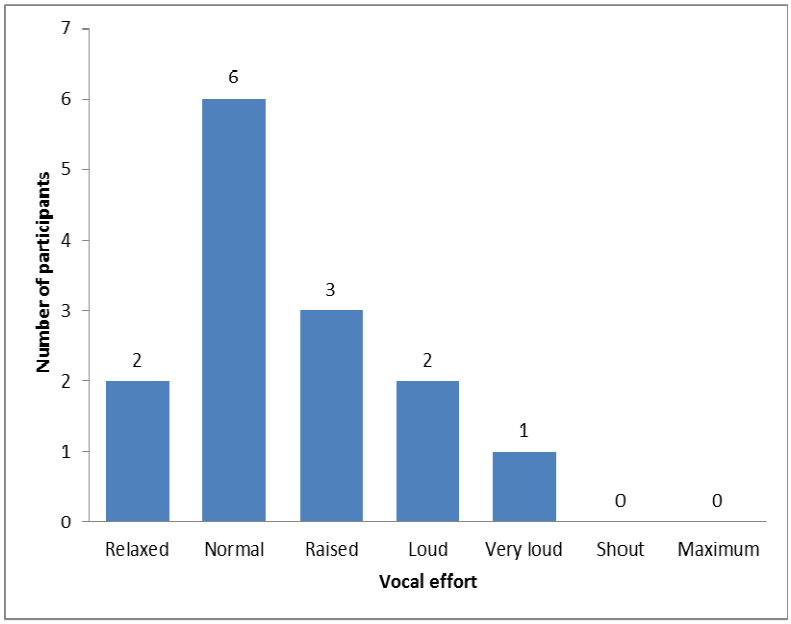

Figure 3 –Vocal effort category (4)

Although there is only a small sample of voice level measurements to date, the voice level data has been compared with the unoccupied ambient noise levels and mid-frequency reverberation times for the rooms. There was significant correlation between voice level and unoccupied ambient noise level (Spearman's $r = 0.62$, $p < 0.01$) but no correlation between voice level and reverberation time. Figure 4 shows a scatter plot of voice levels against unoccupied ambient noise levels.

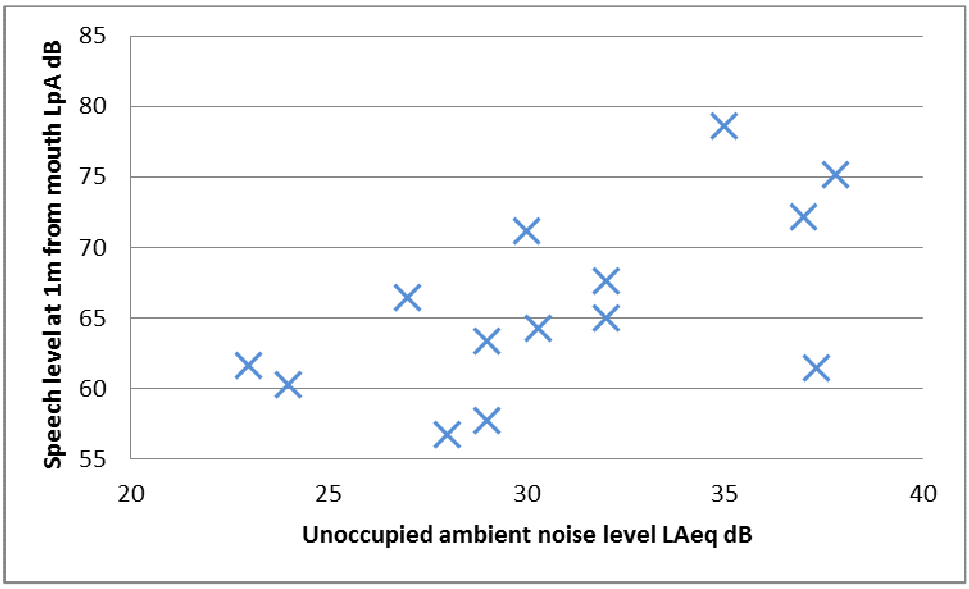

Figure 4 –Scatter plot of voice level and unoccupied ambient noise level

It has previously been found that lesson noise is related to unoccupied noise level (5), with higher unoccupied noise levels resulting in higher classroom noise levels. Hence it may be assumed that higher unoccupied levels will lead to teachers needing to increase their vocal effort to be heard in higher classroom noise levels.

3.2 Online Questionnaire Results

The online questionnaire is scheduled to remain open for responses until the end of 2014. To date the questionnaire has been completed by 127 respondents. The respondents comprised current (82%), former (7%) and retired (11%) teachers. As noted earlier the respondents were self-selecting and therefore may not be representative of the teaching population as a whole.

The full data analysis will be undertaken once the questionnaire is closed, however the initial data are discussed below.

79% of respondents considered voice problems to be a significant issue for teachers, with 69% having experienced voice problems during their teaching career. Of the respondents a significant proportion sought help from a General Practitioner (35%), Ear Noise and Throat Specialist (11%) or Speech Therapist (11%).

From an occupational health point of view 54% of respondents had remained at work while experiencing voice problems. 65% of respondents said that their voice feels tired at the end of their working day.

When considering teacher training, it is notable that in the UK there is no requirement for courses to include voice training. 56% of the teachers surveyed had never received any voice training, with 94% stating that training should be included in all teacher training courses.

Considering room acoustics, 61% stated that there were particular rooms in their school where it was difficult to make their voice heard; 39% considered that this was due to the room being too reverberant, with only 13% considering the problems were due to the room absorbing too much sound from their voice.

When asked about internal noise levels affecting their voice in the classrooms, the primary difficulty was perceived to be caused by internally generated noise in terms of noise from students in the same classroom (32%), students in the corridors (18%) and in other classrooms (16%) or classroom equipment such as projectors (20%).

Externally generated noise (excluding school noise such as playgrounds) was not subjectively considered to be a factor by the majority, with 34% finding it acceptable and 56% not noticing these sources.

4. CONCLUSIONS

The preliminary analysis of the APM measurements suggests that for teachers working in classrooms with different acoustic conditions there is no correlation between unoccupied

reverberation time and average speech level. However. the data showed a significant positive correlation between unoccupied ambient noise levels in the classrooms and the average speech levels of the teachers.

The data set is, however, small and there are multiple variables involved in speech levels, only some of which are likely to be related to the noise levels in the room or the room acoustics themselves, therefore further analysis is necessary along with an expansion of the data set.

The online questionnaire for teachers indicated that the respondents considered voice problems to be a significant issue for teachers, with a large proportion having experienced voice problems themselves. There was felt to be a need for compulsory voice training to be integrated into teacher training in the UK. In terms of room acoustics, internally generated noise and excessive reverberation times were considered to adversely affect the ability of teachers to make themselves heard.

The study is ongoing and further data will be gathered, thereby allowing more detailed analysis.

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REFERENCES

1. Department for Education and Skills. Building Bulletin 93 *Acoustic Design of Schools – A Design Guide*. London: The Stationary Office; 2004.
2. Comins, D. *Survey of UK voice clinics 2001/2*. Voice Care Network UK; 2002.
3. Durup N, Shield B, Dance S, Sullivan R. *Vocal strain in UK teachers: An investigation into the acoustic causes and cures*. Presented at International Congress on Acoustics, Montreal, 2013. ASA Proceedings of Meetings on Acoustics 19, 040141; 2013.
4. British Standards Institution. BS ISO 9921-1: 1996. *Ergonomic assessment of speech communication*. London: BSI; 1997.
5. Shield B, Conetta R, Cox T, Mydlarz C, Dockrell J and Connolly D. *Acoustics and noise in English secondary schools*. Proc Internoise 2013, Innsbruck; 2013.