VOCAL STRESS AND ACOUSTICS IN SCHOOLS - A PILOT STUDY

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1 INTRODUCTION

The acoustic design guidance and regulations for schools in the UK have been historically concerned with ensuring that pupils are able to learn effectively. This has meant that classrooms have been designed and considered as listening spaces with the focus on appropriate speech intelligibility for the children. However classrooms are also the working environment for teachers, and their suitability for speech, from a point of view of voice ergonomics, has not traditionally been a consideration.

Recent cases of chronic voice problems in teachers have received media attention[1] and have highlighted that the classroom is a workplace and as such the employer has a duty to protect the health of employees who use it. This would, logically, include the possible health implications of speaking in poor acoustic conditions.

Voice problems can have a wide range of impacts; there is the cost to the individual in terms of livelihood and emotional wellbeing, and also the impact on society at large. Teachers' absence can disrupt pupil learning and have a financial cost to the educational system through lost working days.

A study is currently being undertaken by London South Bank University into possible links between acoustic factors and speech levels in classrooms, the aim being to identify possible modifications to room acoustics to reduce the workload placed on the teaching voice.

This paper will outline the pilot work currently being undertaken and give details of the methodology being employed.

2 BACKGROUND

In order to establish how widespread voice problems are in the teaching profession, one approach is to consider those seeking specialist assistance. The Voice Care Network (UK)[2] established that of those attending voice clinics in the UK, 12% were teachers. As teachers form 1.5% of the population they would appear to be over represented as a demographic although this may be in line with other professions which involve a lot of speaking. There are around 520,000 teachers (full time) in the UK according to contemporary data[3] with the potential for a large number of individuals to be affected.

Such an approach may, however, not capture the full extent of the prevalence of voice problems. There may be individuals who do not seek medical assistance, or who leave the profession due to recurrent voice issues.

Many individuals suffer from occasional voice problems, which can cause the issue to be considered trivial or as an occupational hazard. It is noteworthy that there is no obligation for

teacher training courses to include any training on voice use despite the central role of the voice as the primary teaching tool.

A significant risk factor for voice problems is the overall speaking time (referred to as the Phonation Time). This is quantified as the length of time (seconds) for which the vocal cords are producing speech. Teachers inherently spend the majority of their working life gives oral instructions and guidance to pupils and therefore as speaking for extended periods simply cannot be avoided other risk factors also need to be considered.

An additional factor which is associated with the phonation time is the fundamental frequency (f_0) of the voice. This varies between individuals and a higher f_0 means that for a given speaking time the vocal cords will vibrate more times than for an individual with a lower f_0, and the voice system will therefore have a greater workload placed upon it. Women, on average, have a higher f_0 than men and as a result would be expected to have a greater vocal load for a given phonation time. Women make up 73% of teachers in England[4] and the additional vocal loading from higher f_0 could be an additional risk factor for this group.

Studies[5] indicate that when speech is generated at a higher sound pressure level (SPL) or for a higher f_0 then the resulting force or number of impacts, respectively, between the vocal cords, increases with an associated risk of voice fatigue and problems. This would suggest that teachers having to, for example, raise their voice for discipline reasons may be increasing the risk of vocal loading.

The acoustic environment in a classroom is determined by a number of different components. These include noise from external sources (e.g. traffic), noise from adjacent internal sources (e.g. the adjacent classroom activity via the separating wall), and noise from internal systems (e.g. data projectors, heating or ventilation equipment) as well as internal activity noise from pupils moving and talking. In addition to these sources the physical parameters of the room affect the way sound behaves in the space, in terms of the dimensions and proportions of the room, and the type and distribution of surface materials.

Speakers will tend to modify their voice pitch and level in response to the acoustical characteristics of a room[6]. These modifications are both subconscious and conscious. These changes can lead to higher vocal load for the same total phonation time.

3 METHODOLOGY

The UK has a wide range of classroom types ranging from Victorian era classrooms with little or no acoustic modifications, through to recently completed classrooms built to current, more onerous acoustic standards. 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 insitu measurements has been identified.

A number of sets of data are to be captured for each teacher to be 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.
2) Measurements during lessons of general noise levels in the classroom including those due to the teacher's voice and other noise sources .
3) Measurements of the teacher's voice level only whilst teaching during lessons.

The first two data sets are relatively easily collected, however determining the teacher's voice level in isolation required a novel approach.

It was considered that simply measuring the SPL from a fixed position in a classroom would not allow the voice level of the teacher to be accurately determined. This was due to extraneous noise from pupils and other sources, as well as the teacher possibly moving around the classroom affecting the measurement distance. Alternatives, for example, where the teacher was shadowed with a sound level meter, similarly were considered to have a substantial effect on how representative the classroom noise would be, as well asinfluences of voice directionality on gaining representative data.

In order to measure the speech level of the speaker only, it was identified that the voice could be measured 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 fitted accelerometer is shown in Figure 1 below:

Figure 1: The miniature accelerometer glued to the skin over the sternal notch[7]

The APM is calibrated prior to the measurements by using a microphone mounted at a fixed distance from the mouth. The participant provides sample speech utterances whilst the accelerometer is in place and a transfer function can be calculated. The calibration process is shown in Figure 2 below:

Figure 2: The calibration procedure using a microphone complete with distance guide[7]

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 SPL, f_0, and the total phonation time. The units are supplied with proprietary software which carries out analysis as well as allowing the raw acceleration and transfer function data between acceleration and equivalent SPL to be exported for analysis in other software.

A pilot study to develop the measurement methodology is currently being undertaken at a secondary school in the UK. The pilot work includes the measurement of four teachers teaching in classrooms with a range of acoustic conditions. The main variable between the different classrooms is the reverberation times. The classrooms are representative of the range of UK teaching classrooms and have reverberation times ranging from approximately 0.3 to 1 second (unoccupied) at mid frequencies.

The classrooms used in the pilot work are described in terms of reverberation time, room volume and the maximum number of pupils in Table 1 below:

Room	Reverberation time T_{mf} (seconds) [8]	Room Volume m^3	Maximum Pupil Capacity
Classroom 1	0.3	125	32
Classroom 2	0.4	118	32
Classroom 3	0.9	136	32
Classroom 4	1.0	171	32

TABLE 1. Details for classrooms used in the pilot study (unoccupied conditions).

In addition to the acoustic measurements a detailed questionnaire has been prepared which participants will be asked to complete. This requests details of their general health, vocal health, previous voice training and of any voice problems they have experienced throughout their career.

4 CONCLUSIONS

The pilot study work is ongoing at the time of writing; the intention is to present preliminary findings of the pilot work as well as provide further details of the large scale study to follow.

5 REFERENCES

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