



ACOUSTIC ERGONOMICS OF SCHOOL - A PREMISE FOR “MODERN TEACHING”?

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ABSTRACT

The main topic of this interdisciplinary examination about “acoustic ergonomics of school” is less the physical properties of the classroom than the problems of teaching reality in everyday school life. The investigation shed light on the topical educational trends and the associated teaching methods and communicative behaviour in the classes based on two primary schools with different basic pedagogical approaches.

In the first place we analyse how different teaching methods (direct teaching vs. student-centred teaching) affect basic (L_{A95}) and working sound pressure level (L_{Aeq}) in the classroom on the basis of 175 lessons. In the second place we investigate how an altered room acoustic (reverberation time and speech intelligibility) has an effect on the sound levels in the context of each teaching method.

For the first time we have a methodology with an extended data set with which not only to assess average lesson values but also to look directly into teaching phases which are dominated by certain pedagogical characteristics. The results provide the basis for further questioning about stress and work load in teaching (cf. Tiesler: Noise a stress factor?).

1 INTRODUCTION

Plenty of investigations into the phenomenon of "noise in schools" in recent years have shown without doubt that schools have become noisy places^{[1]; [2]; [3]}. However, unlike in conventional workplaces (such as in industry) the noise level in the "school workplace" is not determined by machinery or other external factors but by the people working there. It depends on the process of teaching itself and is generated by the working processes and the behaviour of each individual as well as the whole class community. Noise in schools occurs within the classroom. They do not cause it. Of course in the classroom as elsewhere the SPL is determined to a great extent by room acoustic properties. However without establishing a precise link to the actual events in the classroom, a purely structural approach to the classroom will necessarily remain only theoretical.

2 THE DIFFICULT QUESTION OF HOW TO REFLECT "THE REALITY OF TEACHING"

One should not overlook the fact that the educational system in many countries is changing as never before. This is shown not only in changes in the external school organisation but particularly in changed working practices. It is also about new teaching methods, of which "student-centred teaching" is generally counted as one, e.g. project work, weekly-plan teaching, pupil-centred working or workstation learning. The essential characteristic of this new teaching and learning culture is that pupils are more frequently working and learning independently - "autonomously". This leads not only to greater individuality of what is learnt but also changes the interaction within the classroom. The image of the teacher as a distributor of material; a conduit for preconceived knowledge, is receding. Pupils now need to spend more time on experiment, appraisal and discussion. Discussion groups, project groups and role-play locate the learning psychology approaches firmly in the everyday events of schools.

An essential concern in the recent study of the ISF (Institut für Interdisziplinäre Schulforschung; Institute of interdisciplinary School Research) of the University of Bremen about "Acoustic Ergonomics of School"^[4] is to evaluate the acoustic-physical properties of the classroom within as realistic a teaching context as possible. This requires a multi-dimensional observation however, which compares the key factors of pedagogy, room acoustics and in a further stage, occupational medicine in a real setting.

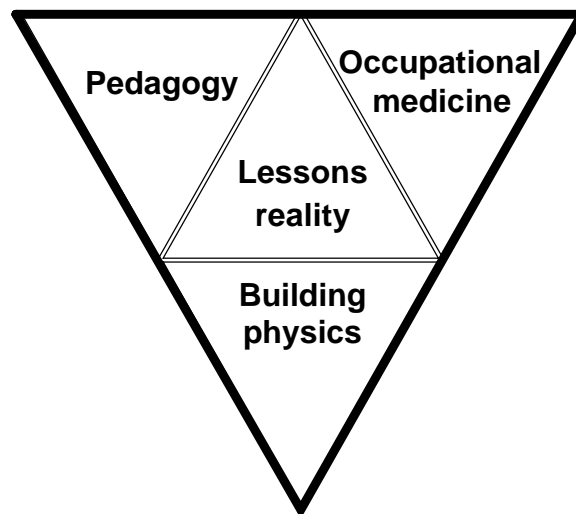


Fig. 1. The interaction of the different factors with respect to "Acoustic Ergonomics in Schools".

The Procedure

In two primary schools with different basic pedagogical approaches, pedagogical processes were broken down into teaching methods and the associated communicative behaviour. The two data sets each have a specific function within the analyses also based on their specific qualities. The data set from only one class in school 1 provided practically laboratory-style monitorable parameters. The same teacher taught the same class in the same classroom with almost the same timetable. The investigation period was free from unusual events. The only significant difference was change in the room acoustics which took place half way through the period. Based on recommendations from former studies^{[1]; [5]} the Reverberation Time was reduced from $RT=0.7$ s to $RT=0.4$ s. School 2 provided a considerably larger data set covering different classes, age groups, teachers, subjects and room acoustic conditions, underlining the nature of field research. In a first step we analysed the effects of different teaching methods on basic- (L_{A95}) and working SPL (L_{Aeq}) in the classroom on the basis of the data from a total of 175 lessons. In a second step we investigated how the room acoustics affected this level in the context of the respective teaching methods. A detailed time series analysis made it possible to evaluate not only hourly average values but also to look directly into teaching phases dominated by specific pedagogical features. The results form the basis for further ergonomic questions about stress in teaching (see also Tiesler: Noise a stress factor?).

3 INDIVIDUAL ASPECTS

As expected, both the work noise level and the basic noise level in both schools depended greatly on the room acoustics. The shorter the reverberation time and the better the speech intelligibility, the quieter the teaching events in the classroom. The relationship is strikingly linear (Fig. 2). Similar results are revealed by even preliminary investigations of other data sets

that showed a linear reduction of the basic SPL by around 1.6 to 2 dB. per 0.1 s reduced reverberation time^[6].

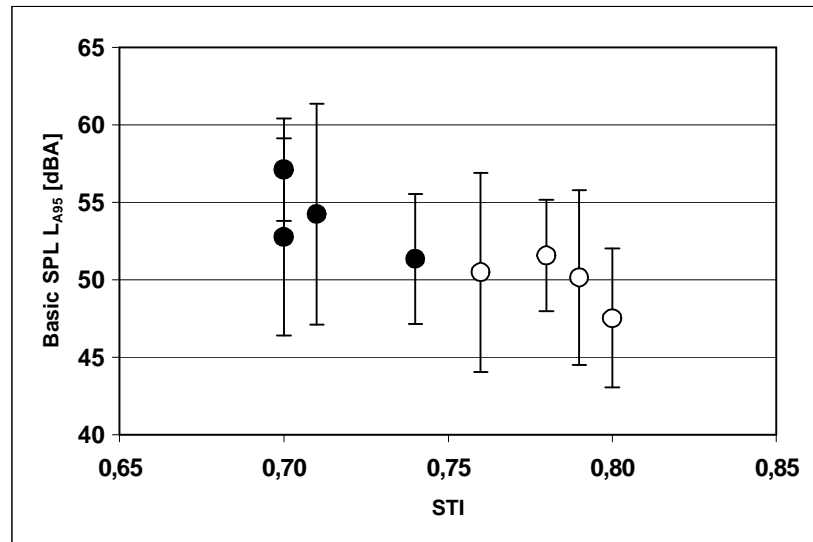


Fig. 2. The basic SPL in relation to the STI for the 8 classrooms of school 2 with different room acoustic properties; ground floor (●) with RT 0.6 – 0.7 s and top floor (○) with RT 0.4 – 0.5 s.

The reduction evidently arose not from a changed pedagogical behaviour or by the possibly assumed fact that pupils or teachers spoke quantitatively less with one another. The cause must therefore lie in a reduced speech volume amongst those involved. There was also another striking phenomenon. While in school 1 in particular the basic SPL rose by an average 10 dB over the morning lessons before the refurbishment, this rise largely vanished after the refurbishment^[4].

The assumption that student-centred teaching methods in themselves produce a higher working SPL than direct teaching methods was only partly confirmed by the present data set. Surprisingly in both schools the different teaching methods barely differ with regard to the shares of teacher- and/or pupil-generated speech. Direct teaching accordingly does not mean that the pupils are not involved in the teaching events while student-centred teaching for its part does not mean that the teacher stops talking.

4 INITIAL RELATIONSHIPS

Nevertheless, the respective teaching methods differed greatly with respect to their sensitivity to the influences of the room's acoustic working environment! The aforementioned dependence of the teaching noise level on the reverberation time and/or the speech intelligibility in the classroom was not the same for all teaching methods. In fact in school 1 the level reductions of an average 12 dB were more than double as high during student-centred working phases in comparison to before the refurbishment while the reduction observed during direct teaching phases was around 5 dB. If one assumes a physical level reduction of around 4

dB it becomes clear that during direct teaching phases a majority of the reduction is achieved by the physical absorption, while student-centred phases are particularly affected by a changed – quieter – behaviour of those in the room. The acoustic quality of the room is above-averagely significant during student-centred working phases. Student-centred phases after the refurbishment were on average even quieter than during conventional direct teaching (Fig. 3).

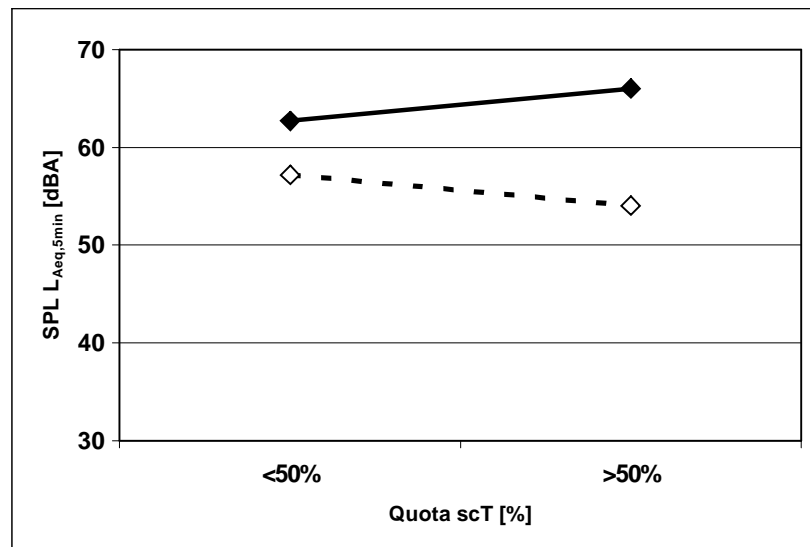


Fig. 3. Working SPL $L_{Aeq,5min}$ in relation to share of student-centred teaching (scT) before (●) and after (○) the refurbishment, school 1.

5 CONCLUSIONS

In the context of actual teaching methods we see a differentiated picture for today's classrooms. In fact the acoustic quality of the rooms (provided they satisfy the minimum requirements of DIN 18041-1968; recommended RT 0.7-0.8 s) is of no particular significance in traditional communication scenarios (one speaker, quiet listening). They function today as well as they did 50 years ago. We can also see however that even slightly reduced reverberation times of 0.6 s (approx. according to DIN 18041-2004) do not create optimum learning and working conditions for student-centred teaching methods. These are provided, however, by heavily attenuated classrooms with reverberation times of less than 0.5 s.

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