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Speech Intelligibility in Swedish Forests an Example of Good Classroom Acoustics

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ABSTRACT

For thousands of years we have developed our hearing in an outdoor environment full of natural sounds, as babbling brooks, wind from trees, bird songs and human voices. The problem is that students and teachers spend a major part of their time indoors, in a sound environment with very few natural sounds. The effect is problem for students to understand what the teacher is saying and voice problems for teachers. It is important that teaching places provide good speech intelligibility for listeners and good speech comfort for speakers. Being able to listen without effort is important for good learning and we know that incorrect room acoustics is a burden that impedes learning. An interesting teaching place is the Swedish forests, where we can talk to each other over long distances without having to raise our voice. I have made several listening tests in the forest and also measured the forest "room acoustics".

Keywords: Speech intelligibility, Reverberation time, Forest acoustics.

1. INTRODUCTION

For thousands of years we have lived outdoors and developed our senses in the outdoor environment. One of our senses, hearing works very good outdoors where natural sounds, as babbling brooks, wind from trees, bird songs and human voices are common. The problem is that we spend the major part of our time indoors, in an environment with very few natural sounds. Spending so much time indoors affects us a lot, especially pupils in the learning situation. In Sweden we can very often read articles in newspapers about how bad the acoustic environment is in our education premises. In recent years there have been several studies, reports and papers showing how the acoustic environment in Swedish schools affects students and teachers. HRF (Swedish association for hard of hearing people), published 2010 the report; "Kakofonien" [1]. This report shows that 67% of the teachers say that the sound environment is a problem. 44% say they often find it difficult to communicate with others in the classroom. Fredrik Sjödin shows in his thesis, "Noise in the preschool, Health and preventive measures" [2], the acoustic environment in Swedish preschools are the most troublesome safety factor. A poor acoustic environment that masks speech impedes the educational work, and this is a big reason for illness among preschool staff. Teacher's voices are an important tool in teaching and Viveka Lyberg Åhlander thesis, "Voice use in teaching environments Speaker's comfort" [3], shows that Swedish teachers often have voice problems. This leads to increased sickness absence with human suffering and huge costs. Robert Ljung shows in his thesis, "Room Acoustics and Cognitive Load When Listening to Speech" [4], what classroom acoustics affects student's ability to remember what

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they heard. This shows that ambitious teachers and motivated students' performance may be degraded by the acoustical properties in the classroom. My father, who worked as a teacher all his life, got a hearing loss in old age. It gave him great trouble to hear and communicate, especially indoors. One summer my father and I were walking in a forest, and suddenly I noticed that he did not hear that badly. He told me that in forests, he could often hear and communicate quite well, but almost never indoors.

– The only things I can hear indoors are vowels, and they carry very little information, he said.

In the autumn same year, I was in a forest picking mushrooms with my son, and then I noticed that he could hear what I was saying at long distance, even though I deliberately spoke with a low voice level.

Swedish school staffs often complain about the acoustic environment in classrooms, canteens and corridors. Instead of continuing to examine how bad the acoustic environment is in Swedish schools, I have tried to find schools with good acoustics for teaching and learning. I have asked Swedish teachers if they know any room or place with a good sound environment. Certainly there are Swedish schools with good acoustic environment, but the interesting response from teachers is that they often experience the best acoustic environment outdoors, in the forest. Therefore I have investigated how good the acoustic environment is in Swedish forests by making listening tests, and also measure the "room acoustics" in different forests.

2. METHOD

Since my son could hear my voice over long distances, I did a test to experience the speech intelligibility in the forest myself. I live in south Sweden where we have some nice forests far away from traffic roads, airports and railways, the only sounds that occur here are natural. I placed a speaker on a stand in the forest. With an mp3-player, I played an audio book and checked that the sound level 1 meter in front of the loudspeaker was 60 dBA. This corresponds to normal speech level.



Picture 1. Measuring sound level from the loudspeaker at 1 meter.

Then I took a chair and sat down 10 meters away from the loudspeaker and listened, I could easily understand all words.



Picture 2. Listening position in the forest.

It turned out that I could sit up to 20 meters away from the loudspeaker and still understand what was said. Background sound level, created by natural sounds like bird songs and wind from trees was 32 dBA. I have done the same test with different people, and all of them are astonished about how easy it is to hear a voice in the forest even when the loudspeaker is quite far away.

Sweden have a sound classification standard for schools, SS 25268 [5], the control of room acoustics is made by measuring the reverberation time according to EN ISO 3382-2 [6]. I have therefore made room acoustic measurements in some Swedish forests, and compared the result to the required values in SS 25268.



Picture 3. Measuring reverberation time in Pine Forest.



Picture 4. Measuring reverberation time in Fir Forest.

3. RESULT

I have measured the reverberation time in different forest types like; pine, fir and beech. The result is shown in figure 1.

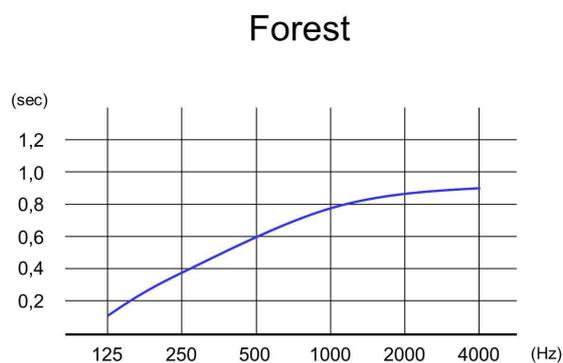


Figure 1. Average reverberation time in Swedish forest.

The reverberation time in the higher frequencies is quite long, but at 125 Hz there is almost no reverberance at all. In this environment the speech intelligibility is very good. Unfortunately this result is very unusual in Swedish classrooms. Very often the reverberation time in regular classrooms turns out to be like in figure 2.

Class Room

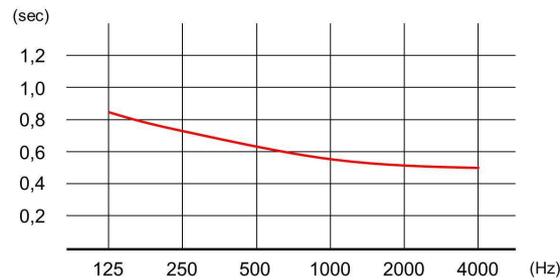


Figure 2. Average reverberation time in Swedish classrooms.

In typical Swedish classrooms the reverberation time is longer in the lower frequencies compared to the higher frequencies. The “reverberation time-curve” in classrooms is reversed to the “reverberation time-curve” in the forest.

The Swedish sound classification standard for schools, SS 25268 put requirement on reverberation time at different classes, class A,B,C and D. Class A is the best and class C is the Swedish authority’s requirement. The requirement in class C is shown in figure 3.



Figure 3. Required reverberation time in Swedish classrooms, class C

Comparing the results in the forest and the classroom, with the required “line” in figure 3 there are some interesting differences. The forest-reverberation time is under the “line” in figure 3, at 125 and 250 Hz, but over from 500 Hz and above. Typical Swedish classroom often fulfills the standard-requirement above 1000 Hz, but in the lower frequencies the reverberation time is often too long.

4. DISCUSSION

In a good classroom it is easy to hear what the teacher is saying. Wrong room acoustics makes it difficult for the students to hear, listen, understand and remember what the teacher said. Having bad room acoustics in classrooms is very negative because knowledge is "information you remember", and all schools want to give their pupils knowledge. Being able to listen without effort is therefore a prerequisite for good learning. Speech intelligibility in the forest is very good, despite a long reverberation time at the higher frequencies.

In almost all languages, the information in speech is associated to the consonants. Indoors, it is often long reverberation time in the low frequencies, so the room amplifies the low frequency vowels which then mask the consonants, and this degrades speech intelligibility. In the forest however, the

vowels are effectively suppressed and this prevents the masking of consonants.

My experience is when people complain of poor acoustics in classrooms, it is very often because the room has too little absorption in the low frequencies, especially at 125 Hz.

The speech intelligibility in the forest is very good, and since the “reverberation time-curve” in the forest is reversed to the “indoor-curve”, perhaps we should discuss:

Is it the lack of reflected vowels that creates good speech intelligibility in Swedish forests?

Are the reflected vowels the reason why pupils and teachers complain of bad room acoustics in classrooms?

Is reverberation time according to EN ISO 3382-2:2008 the right thing to measure to control the room acoustic conditions?

I have studied some national European standards (guidelines) and notes that they often allow a longer reverberation time in the lower frequencies in classrooms. Shouldn't it be the opposite in rooms where speech intelligibility is important?

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