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Some projects and ideas to promote good classroom acoustics

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ABSTRACT

In Switzerland requirements for classrooms were published in a revised building acoustic standard in 2006. Of course it is important that the knowledge represented by this standard shall be implemented, but how should this be done? In this paper some individual projects are presented, which should bring the topic to the attention of authorities, school officials, teachers and parents. One of these projects was started on the International Noise Awareness Day. The Swiss Acoustical Society presented a website where one could obtain instructions for a very simple acoustic test of classroom acoustics. Recorded sound samples can be transferred to the webmaster who replies with a short feedback concerning the acoustic quality of the room. On the website further information regarding classroom acoustics are available. Some further projects were initiated in connection with courses and theses at the Faculty of Architecture at ETH Zurich, at the School of Teacher Education, Aarau and two Matura schools. One of these projects will be discussed in more detail: Students at the ETH designed a school building in Costa Rica at reasonable costs. Two students investigated the effects of open windows during lessons by acoustic scale models.

1. INTRODUCTION

A. Acoustical Requirements in Switzerland

The acoustical requirements for classrooms and schools have been discussed at length in recent years. New research results show that a good acoustical environment in schools is fundamental in achieving good teaching and learning conditions. Various guidelines have been published, resp. standards revised. Requirements for background noise and reverberation time have been established. In the revised Swiss Standard SIA 181[1], which is based upon DIN Standard 18041[2] the recommended reverberation time for classrooms of 125 m^3 - 250 m^3 was set at approximately 0.4 - 0.6 seconds as a function of the room volume. The recommendations concerning background noise are given in DIN 18041 for noise stemming from outside of the room (traffic noise, noises from neighboring rooms) and technical noises (heating and air conditioning, projectors, etc.). For both types of noises the permissible equivalent A-weighted sound pressure level ranges from 30 to 40 dB(A) and is a function of the distance between the speaker and listener as well as whether the room is to be used by the hard of hearing or for instruction in foreign languages.

A guideline based on the mentioned standards was published by the Swiss Acoustical Society.[3]

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B. Implementation of the Knowledge

As mentioned above, the requirements for classrooms having conventional teaching forms are now quite clearly defined. The state of knowledge is readily assessable. However, this does not mean, at least for Switzerland, that newly built or renovated classrooms automatically fulfill the requirements. The standard is not a legal ordinance and it can be assumed that the requirements are not yet sufficiently known by builders, authorities and architects.

One problem is that in architecture materials are often employed which are sound-reflecting, such as concrete, stone slabs and large window surfaces. Here, it is necessary to supply good arguments for using architecturally effective sound-absorbing surfaces.

Thus for classrooms with conventional teaching forms, the question is how to convey current knowledge, respectively how the problem of poor classroom acoustics may be conveyed to the responsible positions. In the opinion of the author, a professional campaign is called for, directed at the authorities of elementary schools up to universities as well as teachers and parents. Unfortunately, in Switzerland this goal has not yet been achieved. Recently, a number of efforts have been made to make the most important concepts known. As the head of the working group "Room Acoustics in Classrooms" of the Swiss Acoustical Society and as a lecturer at the Swiss Federal Institute of Technology ETH Zurich, the author as been engaged (together with others) in various activities, such as:

- Lectures and publications to introduce the standard
- Cooperation with School of Teacher Education
- Supervision of thesis electives at an university (ETH)
- Supervision of projects at matura schools
- Presentations to the media, for example on Noise Awareness Day (Television, radio)

Some of these activities are described below in the hope of inspiring similar efforts elsewhere. It goes without saying that further research efforts in classroom acoustics are desired, especially with regard to new teaching forms which demand higher or at least different acoustical requirements compared to the usual frontal instruction.[4] In these cases a close cooperation between educational and acoustical sides should be encouraged.

2. SIMPLE ACOUSTIC TEST FOR A CLASSROOM (NOISE AWARENESS DAY 2009)

The most recent initiative in Switzerland was carried out by the Swiss Acoustical Society (SGA-SSA) on Noise Awareness Day 2009. On this occasion the SGA-SSA wanted to go beyond merely presenting information about the acoustics in classrooms. Therefore a simple test, free of charge, was offered on the Internet.[5] This test enables the acoustical properties of a classroom to be roughly estimated remotely, using only a few steps.

The relevant information may be found on the website of the SGA-SSA.[5] It requires that a sound recording of an impulse, respectively a detonation be made in a classroom. The recording is then transmitted to the SGA-SSA website. The SGA-SSA calculates the reverberation time from the recording and provides a rough estimate of the room acoustics. The evaluation is then conveyed in an e-mail.

As the sound recording device a PC with an external microphone or an MP3-Recorder or Wave-Recorder with an in-built microphone suffices. The impulsive sound source can be produced by hand clapping or bursting a balloon. The settings on the recording device or PC and the conditions for recording the impulse are fully and simply described on the website.

The website also lists the addresses of registered acousticians who may be of assistance in case the evaluation is negative. They may be called upon for further measurements and consultation

Until the present time (the middle of May 2009) the reactions to this media announcement on Noise Awareness Day have been only modest. To enhance the response it is planned to relate the information to wider circles (parents, teachers, etc.).

3. THESIS ELECTIVES AT FACULTY OF ARCHITECTURE, ETH ZURICH

Cooperation with architects is without doubt an important way to sensitize for the public for the problem of poor classroom acoustics.

Students of the Faculty of Architecture, ETH Zurich are required to write three elective theses in addition to their Masters Thesis. The following projects were developed in this connection.

A. Acoustical scale model measurements on a school design in Costa Rica

Within the framework of their design studies, two students of the Faculty of Architecture at ETH Zurich won the "Marty Innovation Award" for the project of a schoolhouse in Costa Rica. The goal of this competition was to design a schoolhouse under tropical conditions for 700 pupils in Northwest Costa Rica. An important criterion was low cost, i.e., the school building cannot fulfill standards which are commonly met in industrialized countries.

The main acoustical problem of the schoolhouse stems from the fact that windows must almost always be widely opened in order to provide sufficient air circulation. This leads to an undesired sound transmission from classroom to classroom and from the courtyard into the classrooms. A further challenge may be mentioned: In Costa Rica, for various reasons (cost, durability, earthquakes) buildings are covered with corrugated metal sheeting. This results in high noise levels during the frequent rainfall. In this project, through the use of a special vibration-damped layer, this noise was reduced. Of course the acoustical design of the classrooms is also a theme, whereby the financial situation must be considered here as well.

The main focus of the students was to study the influence of sound transmission through the open windows. Therefore, they decided to carry out acoustical model measurements with a scale of 1:16. A model sound source, microphone and a MLSSA[6] system was made available by the Laboratory of Acoustics, Empa Duebendorf. A wooden model was constructed containing a section of the one-story building, consisted of two neighboring classrooms and the joining corridor (see Figure 1 and Figure 2).

A variety of variants was investigated in the measurements. For example, the proportion of open window area was varied within the limits of the air circulation requirements. Then, small panels were mounted in a regular sequence with absorbing and reflecting designs. Furthermore, experiments with small individual panels were conducted.

At present, the study is not yet completed. However the results thus far show which measures are the most effective in consideration of the costs and design. For example, the closing of the first window opening near the separating wall yields good results. The remainder of the window area can be provided with a panel construction, whereby the user himself can determine an optimum between air circulation and sound insulation.

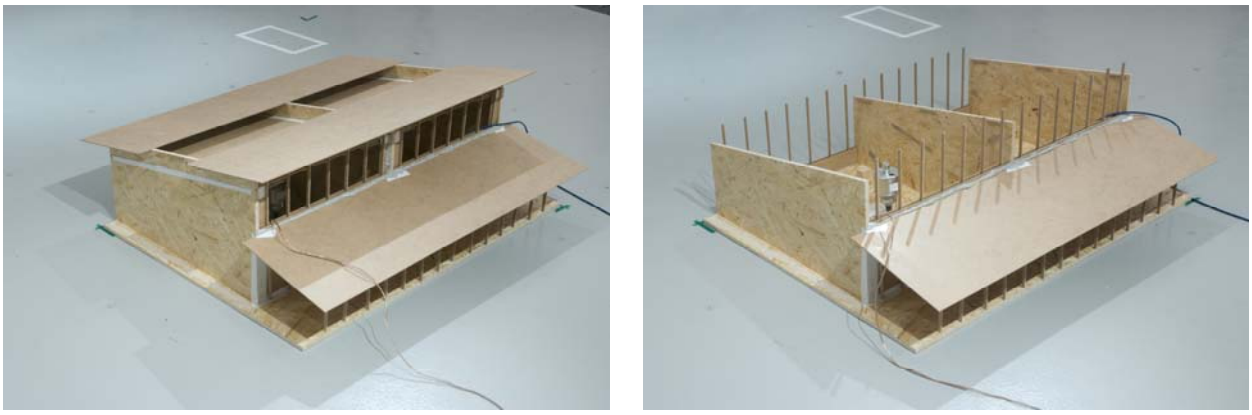

Figure 1: Scale model 1:16 of two classrooms. On the left with ceiling surface, on the right without ceiling

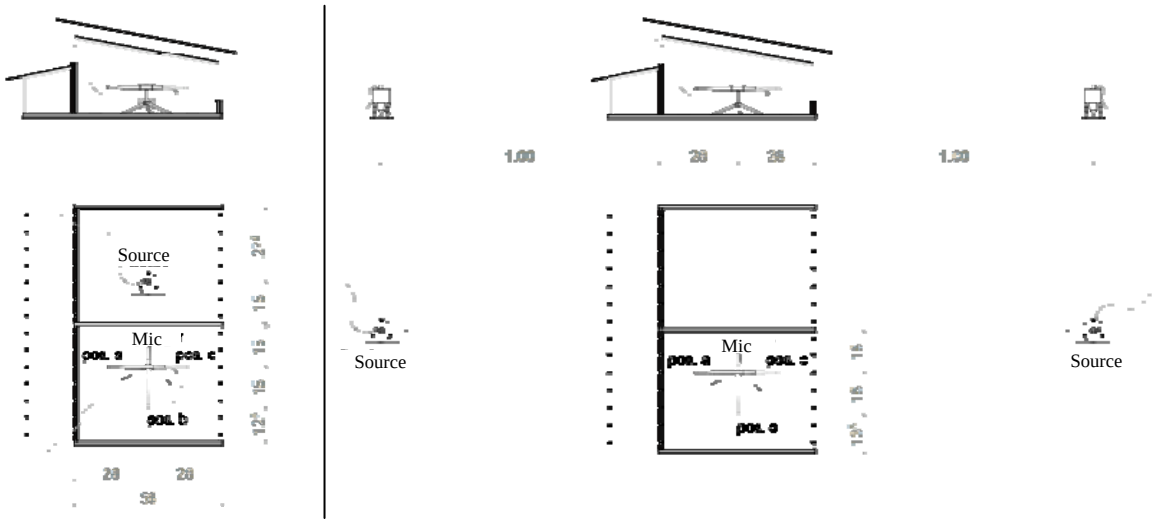

Figure 2: Positions of the source and receiver for the measurement of the sound transmission from room to room (left) and from outside to the room (right)

B. Room Acoustics of Classrooms with Different Shapes

In an earlier study related to a thesis elective and supported by a member of the Empa Laboratory of Acoustics, acoustical measurements were performed in various classrooms. It was found that the reverberation times were relatively short, in fact partly even shorter than the recommended values. As a supplement to the measurements, a questionnaire survey of the teachers was carried out by the author of this paper. The goal was to learn how the acoustics in the classrooms were accepted. The teachers stated that they were highly satisfied with the acoustical conditions, not only with regard to speech but also for playing music. However considering the interaction of all the senses and the influence of a living architecture, conditions for learning in the classroom should not be evaluated merely by the acoustical situation but also by the other sensory aspects of the room.[7]

4. COLLABORATION BETWEEN AN ACOUSTICAL LABORATORY AND A SCHOOL TEACHER EDUCATION

It is important to sensitize architects to the acoustical environment in classrooms. Of course, it is also imperative to involve the teacher as well. A successful cooperation was achieved between the Laboratory of Acoustics at Empa, Duebendorf and the School of Teacher Education, Aarau, both in Switzerland.[4]

At the School of Teacher Education the theme classroom acoustics was taken up within the framework of a series of presentations under the title "Music and Man". Many members of the college and interested external participants visited an evening lecture on classroom acoustics. Thereafter the material was made available for the entire semester.

In a so-called research studio students worked with the lecturer of the School of Teacher Education and the acoustical expert on the subject of classroom acoustics. The students realized that until now they had been unaware of the role that hearing plays in teaching. Thanks to the seminar, they were greatly sensitized to the theme hearing and began to pay more attention to the acoustical environment.

Another goal was that students should incorporate this theme into their diploma theses. A number of ideas was developed as to how to attack the problem of poor acoustics in schools within the framework of the School of Teacher Education. As an example, it was studied how simple methods[8] could be used to determine how many classrooms in the Canton Aargau in Switzerland do not fulfill the acoustic requirements. Furthermore, a concept could be developed as to how the topic could be brought to the attention of authorities, school officials, teachers and parents. The goal was to increase pressure to achieve a rapid correction of the defective rooms.

Eventually four students decided to devote their diploma theses to the question of classroom acoustics. In one of the projects the acoustics of different classrooms were investigated. In some rooms, including the one where the two students had taught, the requirements were not fulfilled. Therefore as an illustration, they decided to correct the acoustics in their own classroom. They wanted to show that even simple techniques can succeed in correcting the acoustics of a classroom (see Figure 3). Another project dealt with the acoustic problems involving a new teaching concept. Part of this concept is that the teaching of four groups of pupils takes place in three classrooms and in the corridor. The doors of the classrooms remain open and at the same time pupils work individually and in groups. In addition, a small group is instructed by a teacher. Suggestions for improving the acoustics were made, but unfortunately, for various reasons could not be implemented.

5. MEDIA PRESENCE

Finally there were a number of opportunities for media presence, with the purpose of increasing awareness to the problem of poor acoustics in classrooms. Aside from radio interviews, an episode of the science series "Einstein" on Swiss television should be mentioned. Here the topic "Acoustics of Classrooms" was discussed in detail.[9]

Figure 3: Replacing parts of the ceiling of a classroom by students themselves

6. CONCLUSIONS

The projects discussed here were initiated mainly by workers in the field of acoustics. They were carried out in the hope that they would stimulate a multiplier effect, namely that those directly involved (teachers, parents, educators) could be made increasingly aware of the problem. Thus, although the individual projects are certainly welcome, a decisive improvement can only be achieved if in a professional campaign school officials, teachers and parents can be addressed directly.

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