The effects of classroom acoustics on primary and secondary school students and staff in Southwest China

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Summary

Classroom acoustics has significant effects on the teaching quality, especially in primary and secondary schools. The acoustic environment of 15 primary and secondary schools in Southwest China were measured, meanwhile 1417 students and 342 teachers participated in the questionnaire survey. The average background noise levels in unoccupied classrooms, without fan operation, of Sichuan and Guizhou province are 52.6 dBA and 54.6 dBA respectively, whereas the average reverberation time of Sichuan and Guizhou are 1.29s and 1.22s. 31.5% of interviewed teachers and 26.5% of students agree that the most important environmental factor to be improved in classrooms is acoustic environment. 29.8%, 21.7% and 29.6% of interviewed students believe that noise in classroom has very serious or serious impact on their memorable learning, interpretive learning and creative learning. 68.81% of the students consider noise may lead to inattention, while 60.9% of the students provide that noise could influence their learning efficiency. In terms of noise improvement strategies in the schools, more green areas are selected by more than half of the students, followed by noise barriers (44.4%) and soundproof windows (42.3%).

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1. Introduction[1]

Classroom is the place where teachers communicate with each other, and students acquire knowledge. The classroom acoustics environment has a direct impact on students' learning efficiency as well as their physiological and psychological comfort, especially in primary and secondary schools. In China, according to the relevant statistics of the education department. The activities of students in ordinary classrooms account for about 70% to 80% of the activities in schools. Therefore, the acoustic design of ordinary classrooms is essential as many schools are surrounded by loud and strong noise condition. Recently, the problem of the acoustic environment of the school classroom is being followed with more interest.

Speech intelligibility is an important indicator of the sound quality of a language hall (such as a classroom). Picard and Bradley[1] suggested that classroom background noise decrease with the increases of age of students. Noise was measured in grade two, grade six, grade seven and the second year of senior middle school by Zentall, Shawfen, Mcarthyn Slatern Bradley, and the noise values were 61dBA, 59dBA, 41.9dBA, respectively [2-4]. Reverberation time is another important acoustic index that affects the language intelligibility of classroom. In the process of studying the appropriate time of reverberation time, Bradley[5] suggested 0.7s as the appropriate reverberation time for the unoccupied classroom with the volume of less than 300 m^3, while Bradley and Bistafa[6] suggested that the 1kHz reverberation time for the no-idle classroom with the volume of less than 200m^3 should be 0.4-0.5s. Che-Ming Chiang[7] provided that reverberation time in traditional classrooms is better, while in Joint Classrooms it tends to be longer. The study of the influence of

classroom noise on teaching activities is also one of the main aspects of current research in this field. Several studies [5, 8] found that the ability of reading and writing of primary and middle school students in the classroom will be weakened due to the negative influence of noise. The adverse sound environment (such as noise exposure) has a strong correlation with the physiological symptoms (or fatigue degree) of the teachers' voice [9,10].

Although there have been many previous studies concerning the effects of noise exposure on students and teachers at school, there has been no large-scale detailed study of classroom acoustics of urban and rural areas in southwest China. The purpose of this study is to provide the basis for the acoustic design and reconstruction of primary and secondary school classrooms in Southwest China. The acoustical measurements were carried out in 15 schools. In parallel with the noise surveys described, the classroom acoustical environment was evaluated through questionnaire surveys of 1417 students and 342 teachers.

2. Method

2.1 Case study sites

15 primary and secondary schools in Southwest China were selected as the case study sites，with 8 schools in Sichuan Province and 7 schools in Guizhou Province. Compared with East China，the overall economy of Southwest provinces are still under rapid development，and the education level is relatively lagging behind, but the two regions also have a huge number of primary and secondary school students. The negative impact of outdoor noise is increasingly becoming a significant problem for local teachers and students, due to the intensive urban infrastructure construction. Table 1 shows basic information of the selected primary and secondary schools in Sichuan and Guizhou in this study, along with typical classrooms illustrated in Figure 1.

2.2 Measurement procedures

Background noise level (BNL) and reverberation time(RT) of 30 classrooms in 15 case study schools were measured during class time. There were three background noise indicators considered, namely BNL-A (indoor background noise with fan closed), BNL-B (indoor background noise with fan open), and BNL-C (outdoor background noise). A Bruel and Kjaer 2250 sound level meter and an omni-directional loudspeaker were chosen to conduct the RT measurement, and three receiver positions were placed in the classroom, as shown in Figure 1. Three type 1 sound level meters (Aihua AWA6228-3) were used to record the A-weighted BNL and 1/3 octave spectrum at the same time. The recorded data was processed to calculate averaged L_{Aeq}, frequency spectra. Each classroom was provided with 3 receiving points, which was 1.2 m above ground level, the specific position was shown in Fig.1, and the measurement time was 10 min.

2.3 Questionnaire survey

A total of 1759 valid questionnaire were collected from the students and teachers of 15 primary and secondary schools in Sichuan and Guizhou. Firstly, interviewees were asked to provide information about their gender, age, occupation, and grade. In the questionnaire, nine 5-point scale questions (Q5-Q6) as follows, 'Q5: What do you think are the most important environmental factors that need to be improved in the classroom?' 'Q6(a): How does noise interfere with students' memorable learning?' 'Q6(b): How does noise interfere with students' interpretive learning?' 'Q6(c): How does noise interfere with students' creative learning?' Similar answers were provided as 'not at all, slight, moderate, relatively severe, severe' for Q6(a), Q6(b), Q6(c). Moreover, three multi-choice questions were added in the end, among them, 'Q9: what the effects of noise in classroom on you are?' 'Q10: What measures can be taken to improve the acoustic environment in classrooms?'

Table 1.Selected primary and secondary schools in Sichuan and Guizhou.

Name of school		*Number of students*	*Volume(m^3)*	*Province*
Caotang Primary School	N1	48	199.7	Sichuan
Dongpo Primary School	N2	54	218.2	Sichuan
Songjiang Central Primary School	N3	56	176.3	Sichuan
Yanjiang No.1 Primary School	N4	64	160.3	Sichuan
Chengdu ShuHua Branch of ShiShi Union Secondary School	N5	28	238.4	Sichuan
Dongpo No.2 Secondary School	N6	40	97.4	Sichuan
Yanjiang No.2 Secondary School	N7	52	201.9	Sichuan
Chengdu Shude Secondary School	N8	49	207.6	Sichuan
Zunyi Xinpu Primary School	N9	33	219.6	Guizhou
Guiyang Shangyi Primary School	N10	54	180.5	Guizhou
Pingba Yifu Primary School	N11	68	163.3	Guizhou
Ninggu Primary School	N12	35	151.5	Guizhou
Ganhe Village Primary School	N13	39	138	Guizhou
Guiyang No. 2 Experimental Secondary School	N14	60	167	Guizhou
Zunyi No.4 Secondary School	N15	54	224.9	Guizhou

Figure 1. Photos of investigated primary and secondary schools in Southwest China

3. Results

3.1 Measurements

3.1.1 Background noise level

Figure 2 illustrates BNL-A, BNL-B, BNL-C of 15 primary and secondary schools in Sichuan and Guizhou. N1 to N8 are primary and secondary schools in Sichuan, among which N1 to N4 are primary schools, N5 to N8 are secondary schools. N9 to N15 are primary and secondary schools in Guizhou, and N9 to N13 are primary schools and N14 to N15 are secondary schools. Figure 2 shows that the background noise of all classrooms exceeds the limit specified in GB 50118-2010. For different regions, the average BNL-A in Sichuan (52.6 dBA) is lower than that in Guizhou (54.6 dBA). The average BNL-C and BNL-B in Sichuan (65.2 dBA, 60.8 dBA) are higher than those in Guizhou (64.9 dBA, 57.0 dBA). For different types of schools, in general the background noise in primary schools is higher than that in secondary schools. For example, the average BNL-C of classrooms in primary and secondary schools in Sichuan are 66.7 dBA and 63.7 respectively.

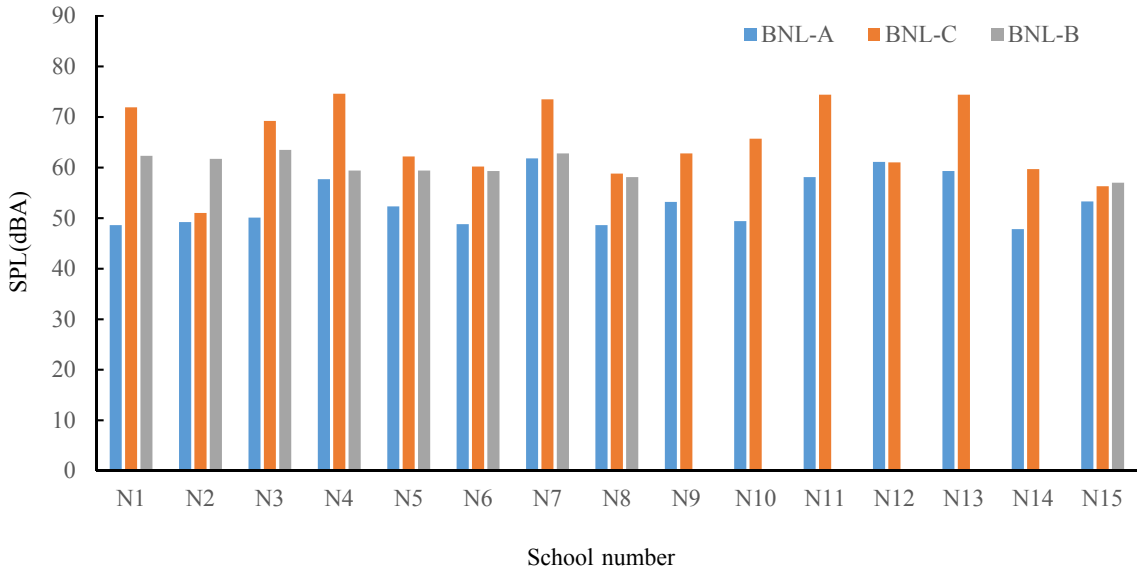

Figure 2. Background noise levels of 15 primary and secondary schools in Sichuan and Guizhou

3.1.2 Reverberation time

Reverberation time measured in different primary and secondary schools in Southwest China are presented in Figure 3. Figure 3 demonstrates that the reverberation time of 5 schools meets the requirements of GB50118-2010, including 2 in Sichuan (N7, N8) and 3 in Guizhou (N10, N14, N15). The value of reverberation time of N9 is the largest among all the groups, which is 2.42s and exceeds the limit by 142%. For different regions, the average RT in Sichuan (1.29s) is slightly higher than that in Guizhou (1.22s). For different types of schools, in general the reverberation time in primary schools is higher than that in secondary schools. The average RT of classrooms in primary and secondary schools in Sichuan are 1.40s and 1.18s respectively.

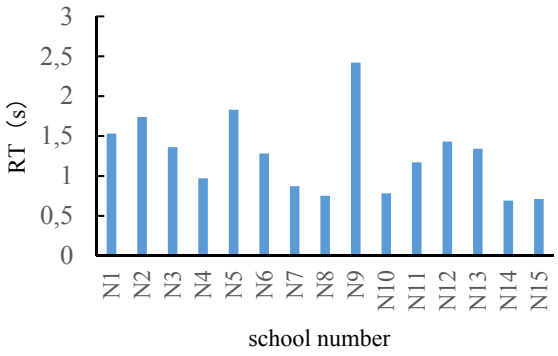

Figure 3. Reverberation time (500 to 1k Hz) for 15 primary and secondary schools in Sichuan and Guizhou

3.2 Questionnaire survey

Among the five main physical environmental factors displayed in Figure 4, 31.5% of interviewed teachers and 26.5% of students regarded the

acoustic environment as the crucial priority to be improved appropriately.

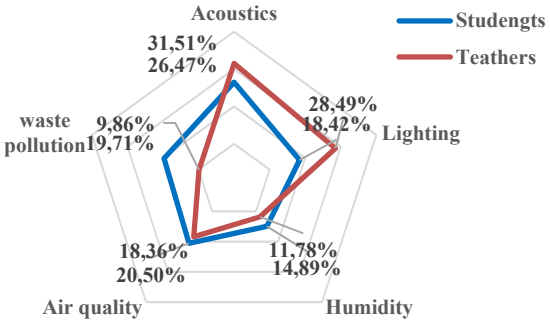

Figure 4. The result of Q5: the importance to improve physical environmental factors in the classroom

Figure 5 provides that 54.12% of the teachers and 29.81% of the students considered noise in classroom has severe or relatively severe impact on their memorable learning, whereas only 23.35% of the teachers regarded it has slightly or no effects. As is shown in Figure 6, more than half of the teachers (60.32%) believed that annoying sounds could make severe or relatively severe negative effects on interpretive learning, while more than half of the students (51.46%) considered that noise could make slightly or no negative effects on it. Figure 7 illustrates that 55.47% of the teachers and 29.62% of the students considered annoying sound has severe or relatively severe impact on their creative learning. It can be seen from Fig.5 to Fig.7 that teachers and students regard noise as important factor that affect memorable learning, interpretive learning, creative learning.

Figure 8 presents that the 'impaired concentration' (68.81%) and 'can't hear the teacher's lecture clearly' (60.97%) were regarded as the top influences that noise produced. At the same time, physical health of teachers and students can also be affected by noise, including 'palpitations' (15.71%), 'headache and dizziness' (10.44%), 'tinnitus' (7.27%). The results show that noise has a great effect on students' concentration, learning efficiency and moodiness, and also on classroom communication. In addition, noise has a physical and psychological burden on students. It is reflected in the fact that noise affects students' sleep, causes headache and dizziness, tinnitus, and irritability. To sum up, the bad acoustic environment in the classroom is extremely harmful to the physical and mental health of teachers and students.

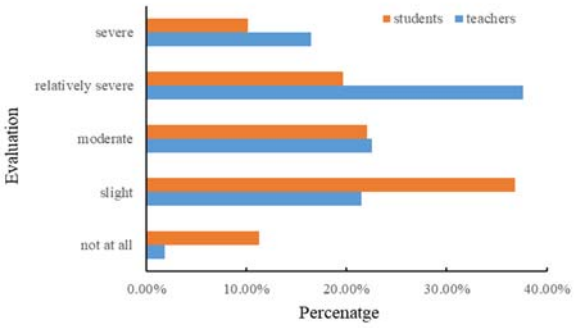

Figure 5. The result of Q6(a): effects of noise on memorable learning

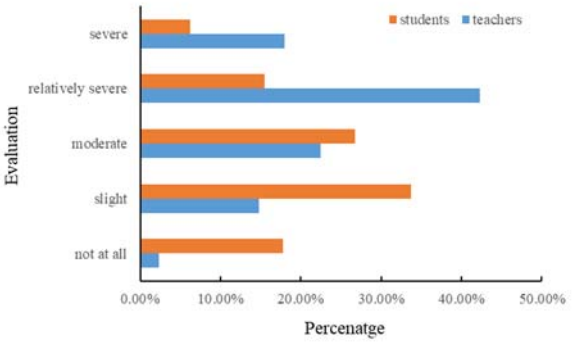

Figure 6. The result of Q6(b): effects of noise on interpretive learning

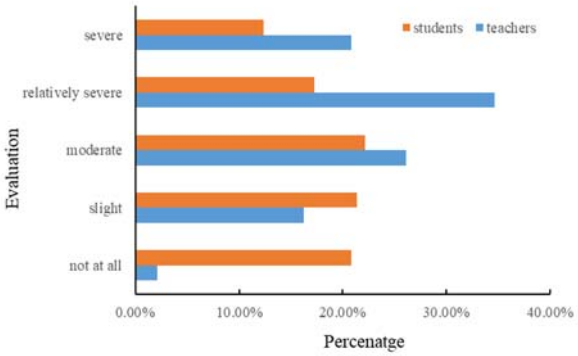

Figure 7. The result of Q6(c): effects of noise on creative learning

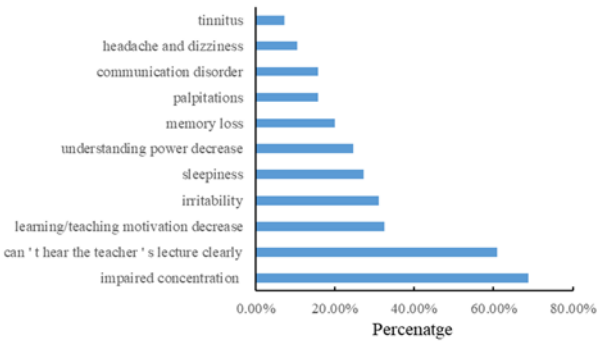

Figure 8. The result of Q9: effects of noise on physical and mental health

It can be seen from Figure 9 that 57.57% of the students chose the creation of a green belt, which accounts for the largest proportion; the noise barrier was in the second rank, which has a proportion of 44.39% of the students; 42.27% of the students chose to install high performance soundproof window; however, the option of change of exterior wall form was chosen by only 20.89% of the students. Setting the greenbelt is a sound environmental improvement measures, which are the popular with teachers and students. 'No tooting' (60.85%) was regarded as the most useful measure that improve the classroom acoustic environment. In addition, the noise barrier and the installation of high performance acoustic windows have high recommended ratio.

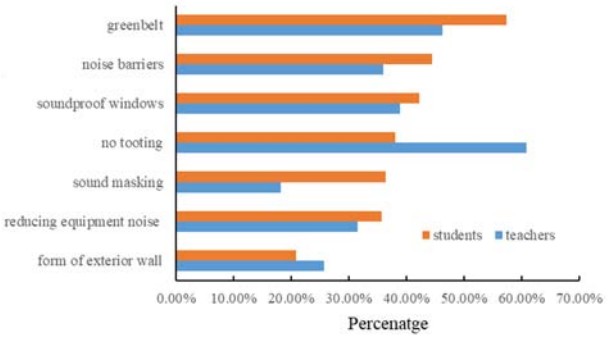

Fig 9. The result of Q10: measures to improve classroom acoustic environment

4. Conclusions

This paper investigated the acoustic environment of 15 primary and secondary schools in Southwest China and its effects on students and teachers, through a series of measurements and questionnaire survey. The results of measurements show that average BNL-C (65.2 dBA) and RT(1.29s) in Sichuan are higher than that in Guizhou (BNL-C 64.9dBA, RT 1.22s). No matter in Sichuan or Guizhou, the acoustic environment of primary school is worse than that of secondary schools, which will largely affect the pupils' mental and physical health. According to questionnaire survey, acoustic environment is regard as the most important factor to be improved by teachers (31.5%) and students (26.5%). Memorable learning, interpretive learning, creative learning are greatly influenced by noise in the classroom. Among the effects of noise on physical and mental health, the decrease of 'attention' (68.81%) and the decline of efficiency of 'attending a lecture' (60.97%) were considered as the top influences that noise produced. In terms of improvement measures for classroom acoustical environment, setting greenbelt (57.57%) and no tooting (60.85%) are recommended by students and teachers respectively.

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