

# Sound Environmental Design in Nursery Institutions focused on Floor Material

Saki Noguchi (1), Tadashi Konishi (2), Yasuhiro Oikawa (1) and Yoshio Yamasaki (1)

(1) Faculty of Science and Engineering, Waseda University, Tokyo, Japan  
(2) Acoustic Laboratory, Waseda University, Tokyo, Japan

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## ABSTRACT

To design educational environment in nursery institutions focused on sound environment, we report the result of sound environment investigation in the kindergarten and experimentally design focused on acoustic characteristics. To understand the environment from children's viewpoint that is different from adult's one and do feedback these knowledge to the design, we examine the design focused on children's hearing height and their behavioral pattern. Children's hearing height is greatly influenced by sound reflected from floor side and furniture side; therefore the experimental acoustic design using two kinds of carpets is done. The change of the acoustical characteristics is shown as a difference of reverberation time that the sound absorption of carpet is especially remarkable in 1-4kHz frequency bands. When the carpet is laid at the activity scene in the kindergarten, the effect of the sound absorption by carpet is little. Meanwhile, in the free activity scene that children act voluntarily, relations between children and the environment, specifically how to use the nursery room and their behavior themselves change greatly. Although there are few children who stay and act for a long time in nursery room at normal situation, we observed that the room is actively used as a place of make-believe play when the carpet A with short wool is laid and dynamic action such as running about or jumping when the carpet B with long wool is laid. As a result, the characteristics of the actual sound change greatly by the occurring sound caused by the behavioural change more than the acoustic characteristics.

## INTRODUCTION

Children in early childhood begin to be interested in the one other than oneself and interact with the surroundings voluntarily for the first time, so this age has been important time to develop sensibility and independence. The environment surrounding children greatly influences their development; especially sound environment affects the motivation of various behaviors and the comfort of conversational space, etc.

Though it tended to be thought deep-rooted traditionally that mothers have been assumed the role of taking care of their children in own family yet, in recent Japan, the environment surrounding preschooler has changed greatly as a mechanism of the society by changing society that the trend toward the nuclear family and women's participation in social activities.

On the current administrative side, it has been divided by the main purpose of facilities between *Nursery* as living space for children who cannot spend daytime with parent under the jurisdiction of the Ministry of Health, Labour and Welfare, and *Kindergarten* as learning space before compulsory education under the jurisdiction of the Ministry of Education, Culture, Sports, Science and Technology.

In such now a system, the facilities for young children have been managed based on the policy of each place and the facility regulation. But the sphere decided by regulation has been less than since the elementary school, therefore the design of facilities has been frequently original and varied. By contrast, because of deregulation that accompanied by the

increase in needs of the childcare space, there are many places where equipments are not good. Although physical environment surrounding children is essential, it's not keeping good actually. In recent Japan, we now face serious problem that the equipments of nursery facilities are minimum requirement. To preserve children's life space corresponding with each various communities, working on the creating environment focused on their view is necessary. The sound environment influences children's various learning activity greatly learnt from daily environment. Especially in early childhood when children learn basic behavior, to attach weight to the sound elements is necessary for them.

The research on music activity has been popular in the approach of the sound in nursery facilities. However, the research that focused on sound environment in daily life is a little. In Japan of recent years, it has been chiefly done research on the noise in nursery institutions, for instance, the acoustic design of nursery facilities by Sekizawa et al. [1] and the actual noise condition and the international comparison by Shimura and Fujii, et al. [2], etc. We researched on understanding of sound environment in the kindergarten from children's viewpoint to create it for learning activity in dairy surroundings and reported that the sound environment there was more varied than it in the school because the activity was variegated and each space was used multipurpose, etc. [3].

In this paper, we mentioned about the result of changes in acoustic performance and actual activity sound when experiment of acoustic design in the kindergarten focused on floor material that is supposed children are affected greatly is done.

**METHODOLOGY**

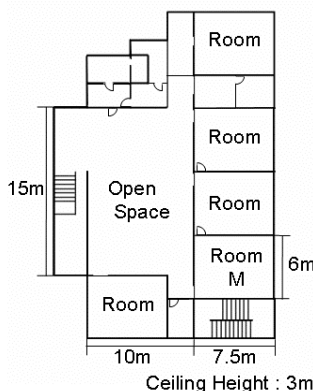
Understanding the change of the sound environment in the kindergarten by changing behavior when the environment design from the acoustic view was done, we measured acoustic characteristics and analyzed activity sound.

In Japanese educational facilities that are not only nursery field but also elementary school, it has been said that the indoor noisiness caused lack of sound absorptive finish. Especially in nursery facilities, it has been often proposed putting down mat as easy means to settle the noisiness there. Having its basis in this point, acoustic design using carpet that based on such point were experimented.

This experiment was done for M kindergarten located in city part in Tokyo. Table 1 shows institution outline and Fig. 1 shows the floor plan. Usually, the outdoor space like playground is often used at free playing time. However, because the part of playground in the M kindergarten is a form like the cliff, indoor space is mainly used at the free play. But in the city part of Japan that the facilities sites cannot be often secured enough, nursery facilities where outdoor cannot be used even at free playing time are not few.

**Table 1. Institution Outline**

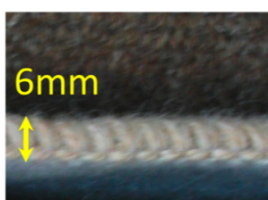
Location	Tokyo	
Surrounding area	Commercial district	
Construction	RC construction	
Floor construction	3F: 1,2F area	
Ceiling height	3m	
Number of kindergarteners	340 people	
Number of classes	3 years old	4 classes (110 people)
	4 years old	4 classes (120 people)
	5 years old	4 classes (110 people)
Management form	A day	9:30 - 13:30
	Half a day	9:30 - 11:30
Activity space	Class style	Nursery room, Open space
	Free nurse	Open space, Nursery room, Garden



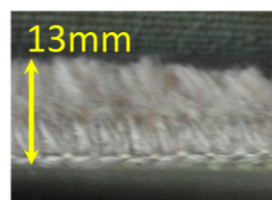
**Figure 1. Floor Plan**



**Figure 2. Experiment Scene**



(a) Carpet A: Wool



(b) Carpet B: Acryl

**Figure 3. Floor Materials**

**ACOUSTIC MEASUREMENT**

To understand the difference in the acoustic characteristics between in the scene of *Normal* and *Carpet laid*, we measured 1) Reverberation Time (RT) and 2) Floor Impact Sound.

Figure 2 shows the scene of the experiment and Fig. 3 shows floor materials used for design. Measurement setup in the experiment scene is shown in Fig. 4.

**1) Reverberation Time**

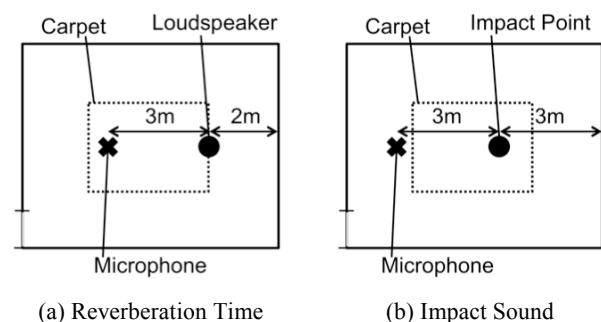
Figure 5 shows the reverberation time in nursery room. In Japanese elementary school, junior high school and high school, RT of each various spaces was recommended according to each purpose as academic standard [4]. In the classroom, the averaging time of middle frequency band (500Hz and 1kHz) is recommended 0.6 seconds for sound awareness. Nursery room is designed a little smaller than the classroom at the school, so the RT of M room is a little long.

It is shown that the effect of absorbing sound by carpet is large in the middle frequency range. It is a feature that the RT in 1 - 4kHz bands of both carpets A laid (Cp A) and carpet B laid (Cp B) are 0.2 seconds shorter than normal. In contrast, there is little change in 500Hz frequency band or less.

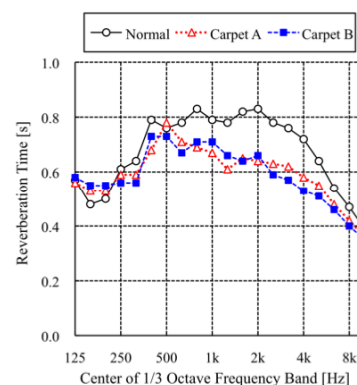
**2) Floor Impact Sound**

To investigate the change in the occurring sound by changing the floor material, the floor impact sound that occurred in something falling was measured and analyzed its frequency characteristics.

Impact source was golf ball (5g, light-weight impact source) fallen free from the height of 1m. Recording point was in the same room. This source was supposed the sound caused from the floor face in the actual activity scene like chair dragged, toy fallen etc. Figure 6 shows the result.



**Figure 4. Measurement Setup in the Experiment scene**



**Figure 5. Reverberation Time**

Though Cp A and Cp B are almost the same as the effect of absorbing air borne sound, the frequency characteristics of the sound occurring from the floor side are greatly different. The characteristic of the sound at Cp A is almost the same tendency as the case of Normal. This result shows that there is hardly a difference of the characteristic of the sound occurring when the light thing is fallen in case of Normal and Cp A. It is inferred that this result is caused by some factors that the carpet A is thin and the effect to cushion the impact is small because of the short length of pile, etc. On the other hand, carpet B with long pile functions as a material that cushions the impact and the characteristics of the sound is changed largely that sound pressure level goes down in the high frequency range especially more than 2kHz frequency band. Moreover, it is a feature point that the level goes up in 125 - 500Hz bands.

To be based on these results, the effect of absorbing solid-borne sound occurring in actual activity scene such as toy dropped to the floor is as follows. It is suggested that A-weighted sound pressure level in the room decreased when putting down material with long pile such as Cp B and didn't change so much when putting down not softened material such as Cp A. Considering that the level of the low frequency range doesn't change, it is supposed that the level of the solid-borne sound to the room adjoining the room on sound source side doesn't change so much though it is felt that the sound seemingly became small on sound source side. From an educational viewpoint, it has misgivings about "the loss of the consciousness that oneself is sound source". In another side, it is thought that it is not practical in the actual situation of the childcare to select the floor material like Cp B from viewpoints of hygiene and the air environment. Though it was shown that absorbing sound is effective as the architectural performance, it is suggested not to achieve the effect of absorbing sound easily from viewpoints of how to use the space and the activity purpose, etc.

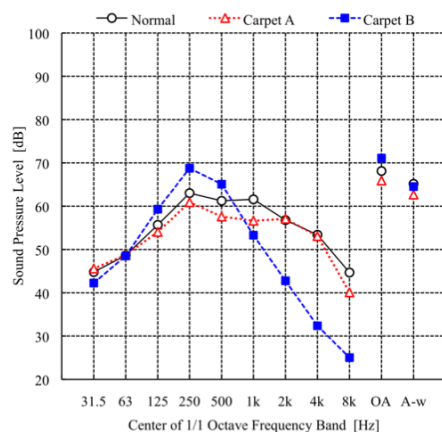


Figure 6. Impact Sound: Golf Ball

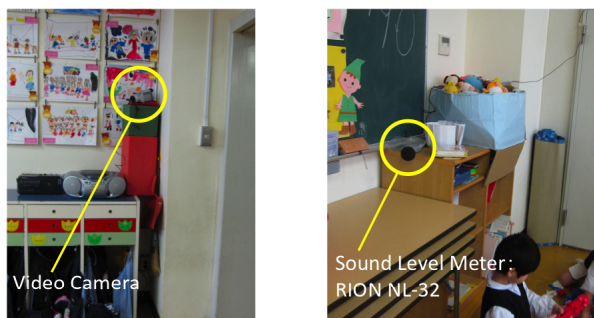


Figure 7. Recording Scene

## SURVEY OF SOUND ENVIRONMENT

In actual activity scene, the acoustic design was experimented and then the activity sound environment was investigated. This research were done for three days (1st day: Normal, 2nd day: Cp A, 3rd day: Cp B) in the five-years old children's nursery room that is the same as the one described in foregoing paragraph.

In this survey, we used the digital video camera and the sound level meter (RION NL-32) for recording. These animations were used for the behavioral observation and the sound data was used for the activity sound analysis. Figure 7 shows recording scene. Figure 8 - 10 show equivalent continuous sound pressure level and energy average of each activity scene.

It is a feature on the whole that the activity in the kindergarten changes in a short time. This feature is different from that in the school. It was observed that kindergartners were often lying and sitting on the floor, therefore it is supposed that they tend to act in the space near the floor that is lower than that of the adult.

The early childhood education is formed with 1) setting childcare that is such a class style chiefly guided by teacher and 2) free childcare that children independently play creatively. The result of investigation is as follows.

### 1) Setting Childcare

At the class, there are various activities such static one as reading and dynamic one as singing or dancing. To design the space for learning activity from acoustic viewpoint, we classified the activity style according to how interact with sound environment, and proposed *sound communication model* in the kindergarten [5]. In this paragraph, the scene of "Lesson" and "Playing" is mentioned.

The sound was analyzed as the equivalent continuous sound pressure level every ten seconds ( $L_{eq,10s}$ ). Figure 8 and 9 show the result and the activity scene. A-weighted sound pressure level ( $L_{Aeq}$ ) at the setting childcare time is almost the same at normal and carpet laid. Though the result of acoustic measurement indicates the difference by the situation of experiment in the foregoing paragraph, the result of sound analysis in actual activity scene shows little change. Teacher takes the lead chiefly at setting childcare scene, so the change of children's behavior pattern was not observed.

In the *Lesson* scene, it was observed that children listened talk with sitting on the floor and this is feature of their behavioral pattern. Especially at setting childcare scene, it is attached weight to settle children down to keep safety. Therefore "Storytelling" has been often adopted as an activity to make them so. A moderate silence is a necessary requirement for making the calm space. However, in this kindergarten, the level of  $L_{Aeq}$  is about 65 dB caused by the invasion sound from the frontal road etc. and low frequency range are especially remarkable.

The difference of the sound environment between normal and carpet laid is hardly confirmed as for the scene of *Lesson* (storytelling) and *Playing* (singing). It can be pointed out that as common features that the level of 500-1k Hz band (main band of teacher's voice) in *Lesson* scene and 1-2kHz band (main band of children's voice) in *Playing* scene are a little remarkable respectively.

In setting childcare, teacher working on children usually accelerates their behavior, so behavioral pattern and occurring sound caused by their behavior don't changed greatly.



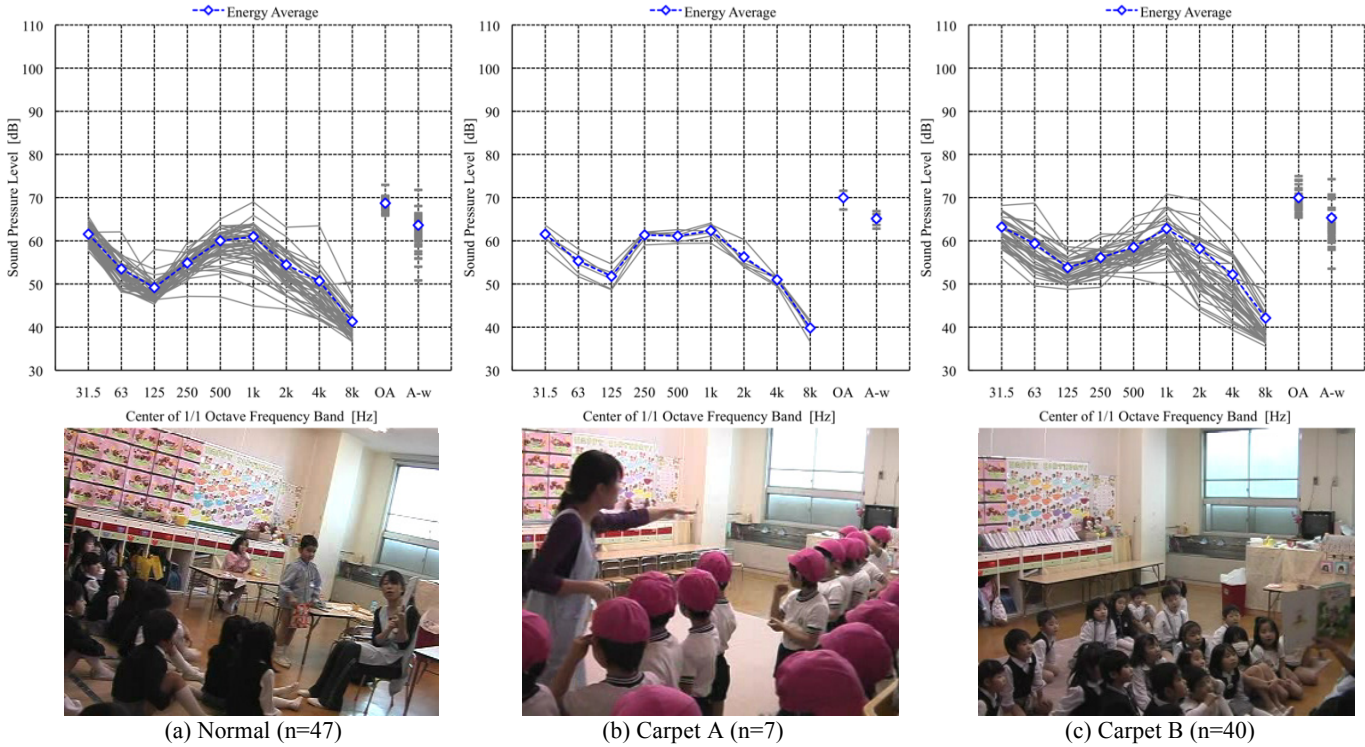


Figure 8. Sound Pressure Level and Activity Scene: Lesson

2) Free Childcare

In the early childhood educational area, the free playing activity is regarded as more important than the same as the class style activity. Usually, the outdoor space such as playground is often used at free nurse. In M kindergarten, the playground is a state of the cliff, thus it's a peculiar point that indoor space is mainly used at the free playing. However, nursery facilities where it cannot help doing similar operation are not few in the city part of Japan that cannot often take the lot area in facilities enough. Children sometimes go out and act freely at setting childcare in addition to after the lunchtime, going to and leaving the kindergarten time.

In this paragraph, it is described that the sound environment of activity scene for 30 minutes when children is going to kindergarten. Figure 10 shows the analysis of equivalent continuous sound pressure level every 1 minute ( $L_{eq1min}$ ).

Children are independently acting at free play, so they develop diversified playing in accordance with each their interest. The development of play in experimental situation tends to be greatly different by the difference of the floor material.

Overall, a lot of scenes that children acted near the floor were observed. Normally, it is frequently observed that children use desk or act while standing relatively. On the other hand, when the carpet is laid, it is a feature that children act lively using the carpet positively as the tool of playing. In the situation of Cp A, children liken the space where carpet A is laid to the living room, make new space by dividing there using *goza* (Japanese mat) etc., and unfold make-believe play in the space. In the case of Cp B, children use the space where car-

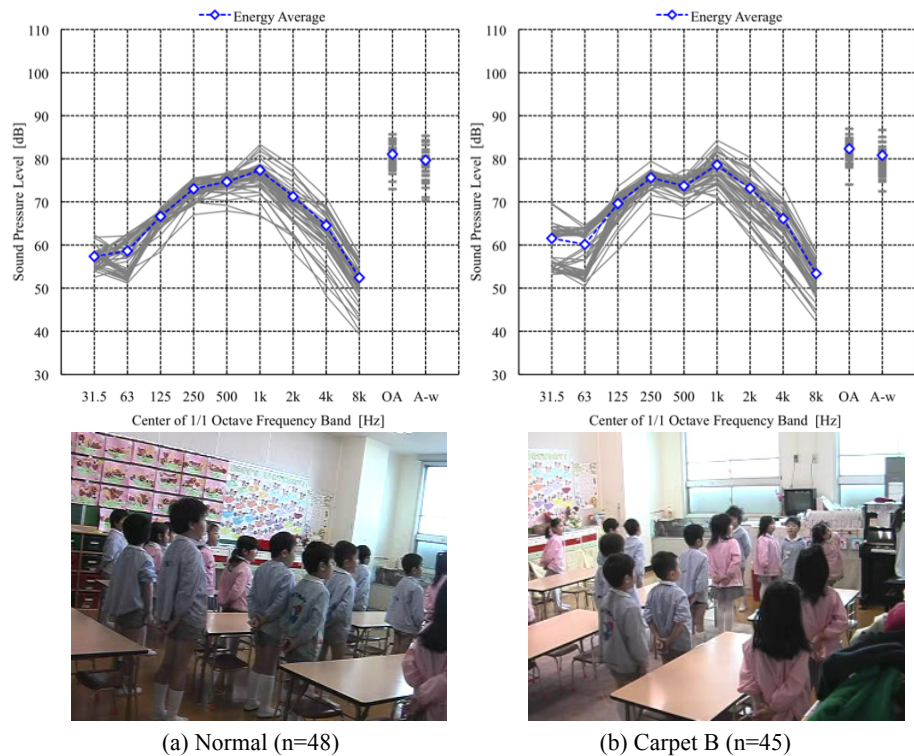


Figure 9. Sound Pressure Level and Activity Scene: Playing

pet B is laid as “relaxation space”, and the development of static play is observed as well as Cp A. In addition, the feeling of touching the carpet B is softer, a lot of the scenes that children act dynamically such as jumping into and rolling around the carpet are also observed.

The change of activity greatly influences the sound environment. The activity with speaking is active, and so the sound pressure level of 1-4kHz bands are larger for carpet laid than normal scene. In the case of Cp B, the sound pressure level of 63 - 250Hz bands tend to large because of the floor impact sound caused when running about or jumping there. In free childcare, the overall sound pressure level at

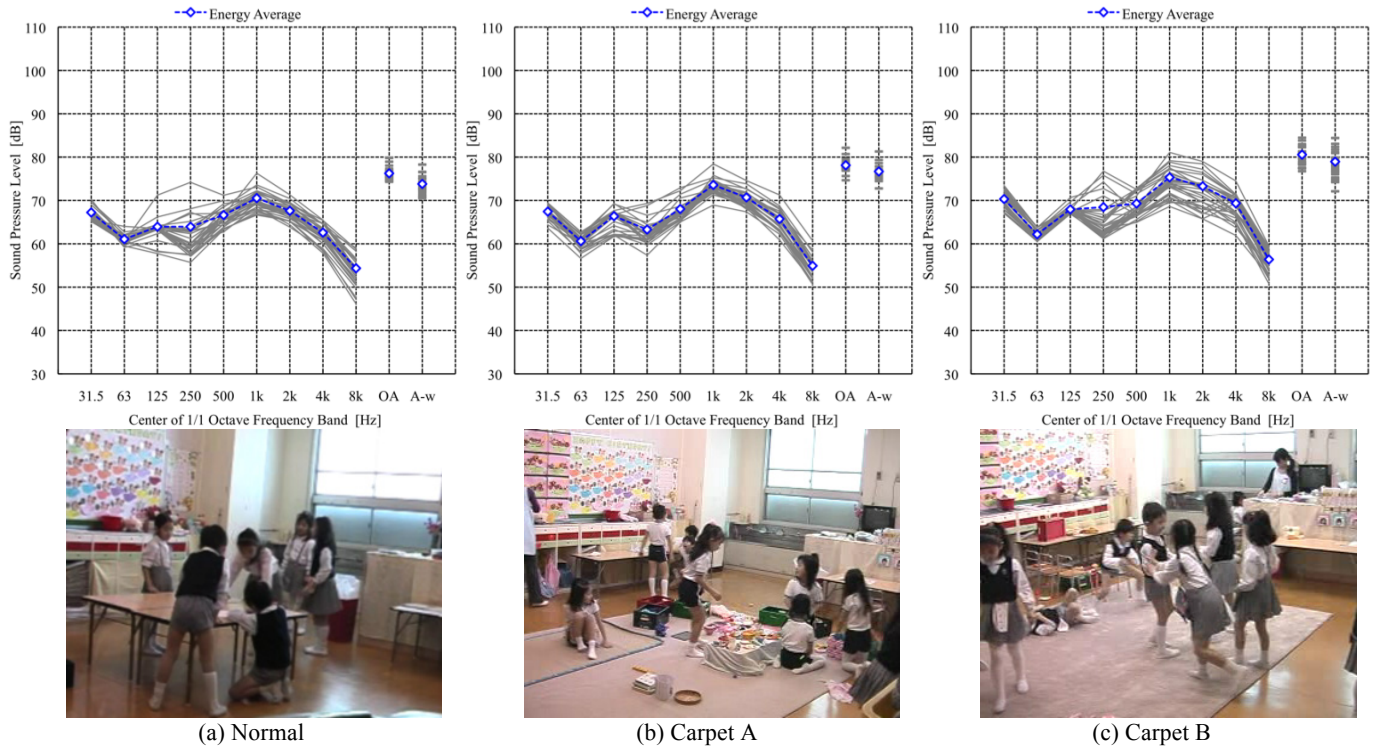


Figure 10. Sound Pressure Level and Activity Scene: Free (N=30)

carpet laid scene is larger than normal scene, especially the level of Cp B is the maximum.

From an educational perspective, it is suggested that the design “laying out the carpet” is useful as opportunities to develop the creative activities for children by interacting with fresh environment. On the other hand, the result shows that the sound pressure level become loud far from quiet, so the effect is not achieved as a design that intended decrease in loudness that had been pointed out up to the present.

## CONCLUSIONS

In this paper, the result of investigating the change of the acoustic characteristics and the actual activity sound when the acoustic design using two kinds of carpets was experimentally done was described. As a result, though the change in the acoustic characteristics was indicated as a difference of the reverberation time, the actual sound environment didn't change similarly and the effect of environmental change varied with each style of activity.

In setting childcare, it was clarified that the occurring sound hardly changed and the effect of absorbing sound was not achieved. Meanwhile, the scene of setting behavior that children and teacher arranged interior by using furniture within easy reach such as mat for creating calm space was observed. Therefore, it was suggested that the possibility that it was able to propose the design according to the activity purpose from acoustic point of view, e.g., setting the space for listening such as *den* at the scene of *Lesson*.

In free childcare, children whose behavioral pattern is greatly different from adults one are the main factor of the situation; thereby the activity caused there is not expected easily. From the viewpoint of the learning environment for children, it's suggested that the design using the material using furniture near children is effective as the attractive space for them because fresh activity was developed when the carpet was laid.

On the other hand, we suggested not being able to expect the effect of the decrease of noisiness by using simple sound

absorption materials. On the contrary, this result of actual scene shows an increase of the sound pressure level rather than a decrease.

In early childhood educational scene, children are the principal people who create the sound environment there. From now on, we will propose the design of the attractive space from children's viewpoint and the space according to the purpose of their learning activity.

## ACKNOWLEDGEMENTS

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