The effect of soundscape on the students' perception in the high school environment

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ABSTRACT

In 2014, ISO 12913-1 standard was established for the conceptual soundscape framework to assess soundscape studies. According to this framework, soundscape process includes the examination of acoustic environment and its sound sources, and their influences on the humans' auditory sensation, as to react that, humans' interpretation of auditory sensation, responses and outcomes. Aim of the study is to create this conceptual soundscape framework in high-school environment and to examine the effect of soundscape on the students' perception. The study was conducted in two spaces as classroom and computer laboratory with 30 students in Bilkent High School; Ankara. To understand acoustic environment, in-situ measurements were conducted. Moreover, semi-structure interview results were evaluated to understand the students' perception of soundscape. Generated conceptual framework revealed different relations between students' perception and sound preferences. Students mostly expect to hear speech in classroom whilst computer fan sound in computer laboratory. Moreover, the most positive sound sources are birds singing in classroom whilst laughter in computer laboratory. Speech is found as most negative sound source in both spaces. Students responded these sound sources with positive approaches such as promoting the relaxation, interaction and with negative approaches such as distraction and annoyance.

Keywords: High School, Soundscape -INCE Classification of Subjects Number: 56.3

1. INTRODUCTION

Acoustical conditions in educational spaces have always been a worldwide issue because children of a certain age spend most of their times in educational spaces. In that sense, it is vital to ensure good acoustical conditions which may lead to the efficiency of learning environment, and hence, the efficiency of communication (1, 2). High sound levels make students exhausted leading to waste their cognitive abilities resulting loss of attention and distraction from the content of the class (3). Apart from acoustic conditions, listening is an ability which may be evaluated as a duty of student (3) because it is one of the psychological functions that defines the perception of people towards environment (4). It means that the satisfaction towards the environment depends on not only acoustic environment conditions but also the sound perception of the students or more commonly known as the 'soundscape' approach.

Soundscape is firstly introduced by Murray Schafer in 1977. After gaining great importance in the field of acoustics, ISO working group proposed a definition as the''perception and understanding of an acoustic environment, in context, by the individual, or by a society (5)." To assess the soundscape, several studies examine the effects of sound by only analyzing acoustical parameters of the space. However, evaluating the soundscape is generally about the subjective understanding of the people rather than representing objective parameters (6-9). Therefore, an interdisciplinary approach is a need to examine the effects of sound as to analyze all possible relationships and a conceptual framework was established in 2014 as ISO 12913-1 standard to evaluate the concerned relationship between acoustic environment and interpretation of auditory sensation (10). In that context, Grounded Theory seems to be an appropriate method to create a comprehension and a conceptual framework between acoustic environment and interpretation of auditory sensation (5).

Therefore, this research aims to represent the existing high school acoustic environment and to examine the interpretation of auditory sensation towards it. To create a conceptual framework between them, grounded theory approach is used. Lastly, this research intends to express the soundscape

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perception differences between selected areas in high school environment.

2. METHODOLOGY

2.1 Case Study Setting

Bilkent High School is chosen which is located in east side of Bilkent University Campus in Ankara. Two different functional spaces are defined as classroom and computer laboratory. Number of sound sources and the content of lesson are main criteria to select these study areas because computer laboratory class has more interactive lesson content than regular classroom lesson. Moreover, they have different sound source environment when compared their lesson requirements. To minimize the spatial differences, classroom and computer laboratory are selected similarly in terms of area sizes and location of spaces in the plan of the school. Computer laboratory is located between corridors without connection with outside and classroom is also located among three corridors and lateral façade. Computer laboratory has 55 m^2 area having around 15 students whilst classroom has 49 m^2 area having around 15-18 students. All measurements and interviews are conducted after obtaining required permissions from the relevant authority of school.

2.2 Objective Measurements

To represent the acoustic environment of high-school environment, Equivalent Continuous A-Weighted Sound Levels (LAeq), Reverberation Time (T30), and Speech Transmission Index (STI) are measured. Equivalent Continuous A-Weighted Sound Levels (LAeq) are measured in unoccupied and occupied conditions as one-class hour time intervals, using Bruel & Kjaer Sound Level Meter type 2230. During LAeq measurements, sound level meter is located in the center of both spaces at the height of 120 cm. For the reverberation time measurements, four receiver and one source points are defined as seen in Figure 1 and it is measured in an unoccupied condition as one-minute time intervals, using Bruel & Kjaer Sound Level Meter type 2230 and Bruel & Kjaer omni-directional loudspeaker at the height of 150 cm.
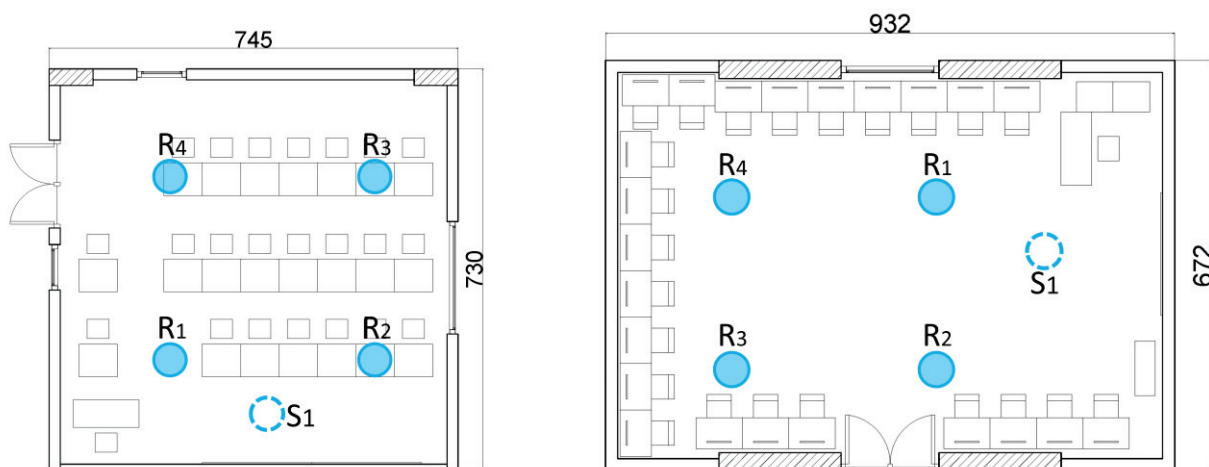

Figure 1 – Receiver and source point in classroom and computer laboratory plan view

2.3 Subjective Surveys

As a qualitative research method, semi-structure interviews are chosen to create a conceptual framework and to evaluate interpretation of auditory sensation of students, using Grounded Theory research method. Semi-structure interviews were conducted until data reached the theoretical saturation point (11). 16 classroom and 14 computer laboratory students were interviewed during class hours in two school days. Interviews ranged from 4 to 14 minutes in duration. Semi-structure interview questions are covering some topics as identification of recognized sound, an indication of positive and negative sound sources, sound preferences, sound perception and satisfaction. The data are recorded and transcribed verbatim. Transcriptions were later coded to derive themes and categories related to each space.

3.   RESULTS AND DISCUSSION

3.1   Objective Results

Mean value of Equivalent Continuous A-Weighted Sound Levels (LAeq) are measured as 62.6 db for classroom and 64.9 db for computer laboratory. The fluctuations between measured hours are shown in Figure 2.
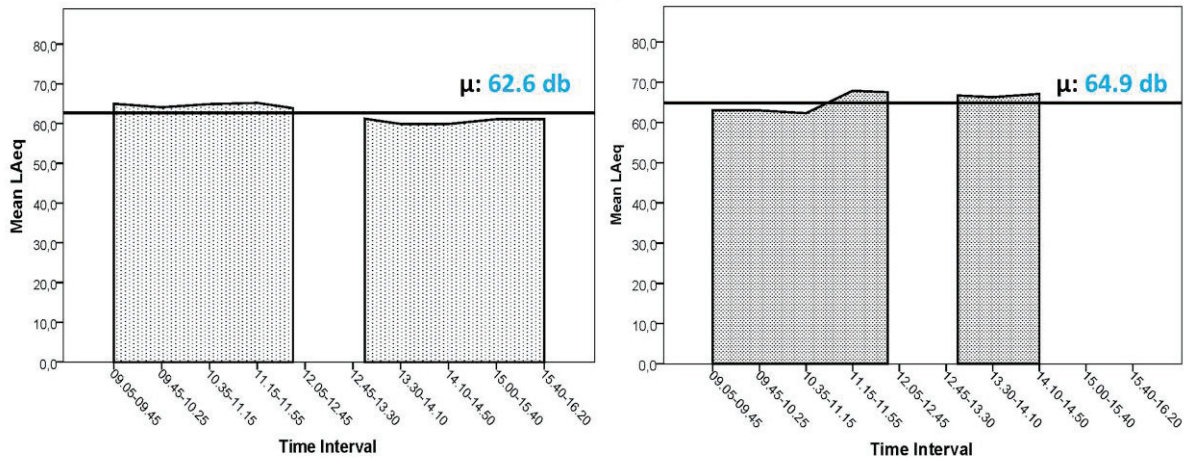

Figure 2 – Equivalent Continuous A-Weighted Sound Levels in classroom and computer laboratory

It can be said that speech is the most outstanding sound for working spaces and the common frequencies of speech are considered between 500 Hz to 2000 Hz in octave band (12). As indicated in literature, required reverberation time should be between 0.6 and 0.8 in mentioned frequencies (13). Reverberation Time (T30) results were found above recommended values that can be seen in Figure 3 and Table 1.
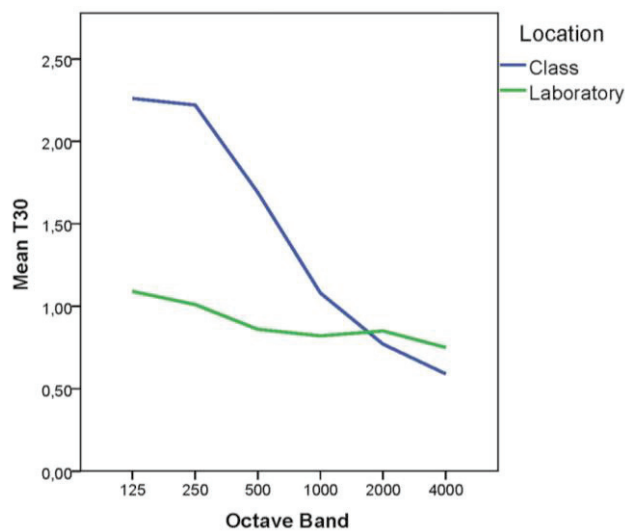

Figure 3 – Reverberation Times (T30) in classroom and computer laboratory

Table 1 – Reverberation Times (T30) in classroom and computer laboratory

Space	125	250	500	1000	2000	4000
Classroom	2.39	2.26	2.23	1.69	1.08	0.78
C.Laboratory	1.1	1.01	0.9	0.8	0.85	0.76

The mean Speech Transmission Index (STI) values were measured quite similar as 0.63 db for classroom and 0.61 for computer laboratory. According to the Speech Intelligibility Scale, above 0.6 values are accepted as having good or excellent speech intelligibility (14). STI results of spaces show that both spaces have good speech intelligibility.

3.2   Subjective Results

After transcribing the interviews, data was evaluated to derive themes and categories. In open coding step, data was divided into key terms to understand the general idea what data is about. These created key terms were questioned by making some comparisons and linkages with the each other in axial coding step. Merging terms generated categories and consequently sub-categories. This method helped to create a conceptual framework that will give information about the soundscape perception of students in high-school environment.

This study generated one conceptual framework for both spaces as classroom and computer laboratory because results of spaces showed similar patterns within each other. Therefore, one conceptual framework was established to show perceptual understanding of students in high-school environment. Figure 4 shows the conceptual framework that is composed of eight main categories. These categories are sound sources &sound levels; acoustic environment, soundscape perception, soundscape preference, coping methods, responses, outcomes, and intervening factors. Soundscape perception is defined as a core category that forms all categories and their relationships between each other. The categories and their relationships will be analyzed in detail in next chapter, each category of the framework will be supported by CS (classroom student), and LS (laboratory student) comments to show the differences and similarities between categories.
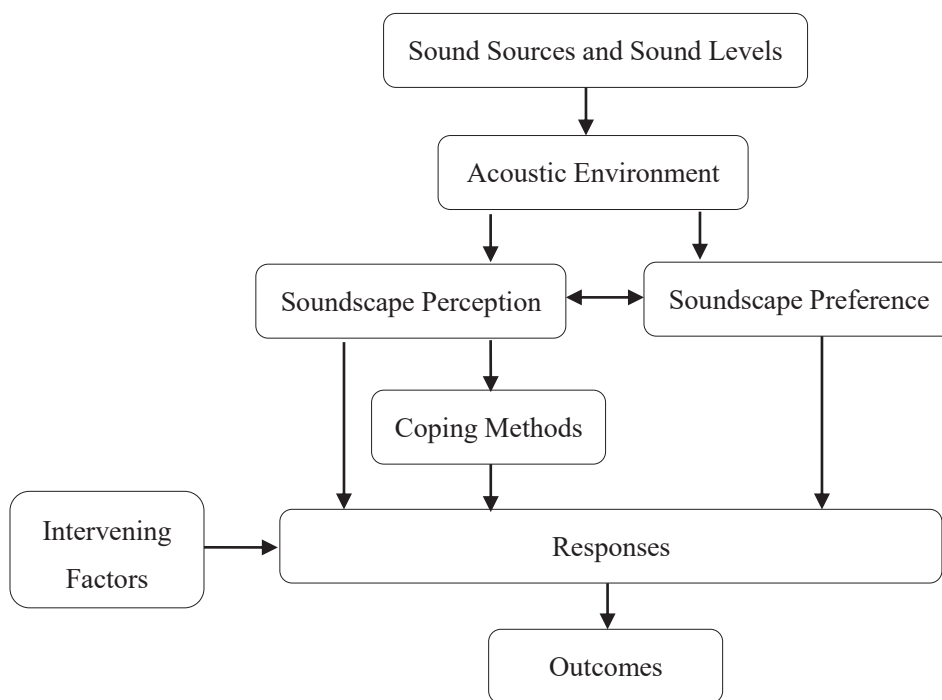
Figure 4 – The conceptual framework for high-school environment

3.2.1 Sound Sources & Sound Levels

In order to understand identification of recognized sound, students were asked to define what they expect to hear when they think their classroom or computer laboratory environment. Frequently said sound sources are listed in Table 2.

When compared to the answers of students in classroom and computer laboratory, results are found different. Classroom students are said most frequently heard sound source is speech (n=13) whilst computer laboratory students said computer fan sound (n=12). Actually, this result is expected due to their different environmental conditions. To explain sound environment in detail, roadway traffic, laughter and birds singing can be given as examples of outstanding dominant sound sources in

classrooms and keyboard sound, ventilation sound, speech in computer laboratory.

Moreover, sound levels are also important part of the perception of sound sources because same sound sources are perceived differently in different sound levels. Generally, students do not prefer to hear high sound levels because they interpret the high-level sound as a noise even if they like to hear in their learning environment. In addition, even if the acoustical measurements values are higher than recommended ones, some students are happy with their learning environment, and it shows that sound levels are not enough to explain the perception of the students.

CS: My ideal is average. If the environment is so quiet, you feel a little sleepy but in high levels of sound, it is almost impossible to understand the lesson.

Table 2 – Soundscape expectation in classroom and computer laboratory

Classroom	Computer Laboratory
Speech	Computer Fan
Laughter	Projection Fan
Corridor Speech	Electrical Ventilation
Footsteps	Electrical Installation
Roadway Traffic	Key Clicking –Mouse
Air Traffic	Keyboard Sound
Birds Singing	Speech
Rain Sound	Laughter
Projection Fan	Corridor Speech
Electrical Installation	Footsteps
Electrical Ventilation	Chair Wheel Sound
Phone Ringing	

Students were asked to list their sound sources that do not belong to their environment. Roadway traffic (n=12) in classrooms and corridor speech (n=5) in computer laboratory are said mostly as background noise. However, students in computer laboratory mostly said that they do not perceive any background noise due to the location of computer laboratory. In addition, some students define background noise as a wanted situation.

CS: I generally perceive background noise as a positive thing because it makes me feel that life goes on in outside. I feel better when I feel connection with outside.

3.2.2 Acoustic Environment

In order to evaluate the perception of soundscape, it is important to understand acoustical conditions of related spaces. The acoustical measurement results of both spaces showed that although LAeq and T30 values are measured above recommended values; STI is recorded as recommended range as mentioned in the section of objective results. The statistical results can be seen in Table 3.

3.2.3 Soundscape Preference

Students were asked to define their preferences for their learning environment because indication of wanted and unwanted sound sources is necessary to understand the preferred high school environment. When asked, students mostly preferred to hear music as a wanted sound in their learning environment as indicated in Table 3. However, students defined their preferences in terms of the context of lesson. For example, students generally prefer to work with music if task requires less effort or the lesson is based on applied method. Therefore, computer laboratory students preferred music more compared to classroom students in their learning environments.

LS: It depends on the situation. If I need to work something very serious, I prefer quiet environment but if I am doing my performance study, I can listen classical music unless it is not in high level.

Moreover, quiet environment were generally perceived differently because it does not mean that lack of negative sound results in the positive environment (15). As indicated in literature, the answers about quiet environment have both positive and negative approaches as,

LS: Actually, I prefer the quiet environment but I am not trying to say that everybody should be quiet and we just hear the fan of computers. It is not also a good silence. I am talking about the deathly silence. I just want to hear the teacher's speech in necessary situations.

CS: I prefer to hear the teacher's speech and a little speech and laughter. I also want to hear outside noise because I do not like quiet environment, but high levels of sound are also bad.

3.2.4 Soundscape Perception

To understand the sound sources perception of students, students were also asked to define positive or negative sound sources in their environment. Results showed that positive or negative sound sources are determined according to the association with environment, social and cultural preference of the user and mood of the user. The most positive sound sources are birds singing (n=13) in classroom whilst laughter (n=7) in computer laboratory as seen in Table 3. Speech is found as most negative sound source if we evaluate only statistical value. However, speech is a controversial sound source to classify whether it is perceived as a positive or negative sound source. Some students are accepted speech as a part of the environment, and some students do not want to hear speech in lesson.

CS: For example, speech of my friends. Sometimes it is positive and sometimes it is negative. It changes according to the lesson. We are in an important lesson such as electricity in physics. I have to learn in lesson and I do not except to talk in that moment. However, in a boring lesson, speech of my friends helps me concentrate the lesson again.

Table 3 – Results of classroom and computer laboratory in selected categories

Categories	Classroom	Computer Laboratory
Sound Sources & Sound Levels	Speech	Computer fan sound
Acoustic Environment	LAeq = 62.6 db RT > 0.6 STI = 0.63	LAeq = 64.9 db RT > 0.6 STI = 0.61
Soundscape Preference	Music – wanted sound	Music – wanted sound
Soundscape Perception	Birds singing- positive Speech - negative	Laughter - positive Speech - negative

3.2.5 Responses

As seen in the conceptual process of soundscape in Figure 4, all categories actually are about the soundscape perception. After sound sources distribute space and time, our brain starts to detect and understand the acoustic environment; and creates responses towards it. This process composes our perceived environment. Classroom and computer laboratory environment does not give very different responses towards the acoustic environment. The answers of students were analyzed as positive responses, negative responses and neutral responses. Sound sources resulted in positive responses such as promoting the relaxation, interaction, comfort, attention, concentration, motivation and mood or negative responses such as distraction, disturbance, annoyance, loss of concentration, loss of productivity.

CS: If the classroom is so noisy, I cannot feel motivated or cannot concentrate on the lesson because in a noisy environment, how can I be productive? I do not know.

LS: In a quiet environment, I feel very relaxed and stay focused the lesson. After that moment I do not concentrate on the environment, I concentrate on my lesson.

CS: If we analyze general perspective, it depends on the person. Some people become very annoyed about noise, and some people raise the noise without feeling any disturbance. For me, there is nothing new.

Apart from positive, negative and neutral responses, students used also some emotional terms to define their feelings towards sound sources. It shows that sound perception is about not only the sound levels, but also emotions.

CS: I prefer to hear music while working. It is relaxing and it makes me happy. When I feel happy, I work harder.

3.2.6 Coping Methods

Another important part of the conceptual model is coping methods because students who are exposed to sound sources improved some solutions to handle with the conditions because if the sounds are accepted, understood and habituated; the soundspace perception shows more positive approach

(16). Both classroom and computer laboratory students sometimes accepted sound within the environment as it is or they tried to find solutions to handle it.

LS: There are always some talks and laughter in lesson, but I do not feel bad about it. I think they are part of this environment.

CS: If there is so much noise, I put my head to table, and try to isolate myself from environment. After then, I try to stay focused on my lesson.

3.2.7 Outcomes

Outcomes are also seen as a part of conceptual framework as a long-term consequences of soundscape perception. It may be analyzed in two sections as physical outcomes or long-term outcomes. Results showed that perceived sound resulted in physical outcomes such as headache, fatigue and long-term outcomes such as lesson failure.

CS: If I cannot hear my teacher clearly, my desire to listen is decreasing. Maybe, I am thinking that I understood the lesson. Actually, I do not. I understand this situation after I failed the exams.

CS: When I heard variety of sounds, I have a headache.

3.2.8 Intervening factors

Physical factors have an effect on the soundscape perception and change the context in which soundscape was generated. These factors are found as some environmental factors such as lighting, heating, odor; spatial factors such as location; formal factors such as insulation and user factors such as behavioral tendency, background information and mood. The effects of these factors can contribute the perception of soundscape as positive or negative.

CS: Heating is very important because the environment becomes very stuffy. In these circumstances, I cannot listen.

LS: It is very stuffy because we are in the underground. We cannot take daylight, it makes me very encompassed.

CONCLUSIONS

This article aimed to create a conceptual model that reflects perceptual construct of soundscape in high school environment. The study revealed eight categories that explain the factors affecting the perception of students in high school environment. In sound sources & sound level section, classroom students mostly expected to hear speech whilst computer laboratory students expected to hear computer fan sound. Moreover, students mostly preferred to hear music as a wanted sound in their learning environment. According to students' perception, the most positive sound sources are birds singing in classroom whilst laughter in computer laboratory. Speech is found as most negative sound source in both spaces. In responses section, it is seen that sound sources resulted in positive responses such as promoting the relaxation, interaction, comfort, attention, concentration, motivation and mood or negative responses such as distraction, disturbance, annoyance, loss of concentration, loss of productivity. To handle with these responses, students sometimes improved a coping method such as habituation, isolation. Responses resulted in long-term outcomes such as lesson failure. Moreover, intervening factors such as heating, lighting, background information were also found important in soundscape perception.

In addition to that, results confirmed that it cannot be evaluated by regarding the objective measurement parameters alone. Study should be analyzed within the content and interpretation of sound coexisting with objective parameters. Moreover, perceptual understanding of the soundscape depends on not only the individual perception but also the context of physical and social environment.

This study is important to create the conceptual framework in high school environment and to contribute literature as a case study example on soundscape approach. This study will hopefully create awareness among future researchers to investigate other possible relationships in learning environments to increase the students' satisfaction and lesson performance.

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REFERENCES

1. Lubman D, Sutherland L, editors. Good classroom acoustics is a good investment. International congress on acoustics ICA; 2001; Rome, Italy

2. Karabiber Z, Vallet M. Classroom acoustics policies–An overview. Acta Acustica (Stuttgart). 2003;89(12).

3. Hagen M, Huber L, Kahlert J, editors. Acoustic school design. Forum Acusticum; 2002; Sevilla, Spain.

4. Liu F, Kang J. A grounded theory approach to the subjective understanding of urban soundscape in Sheffield. Cities. 2016;50:28-39.

5. Brown AL, Kang J, Gjestland T. Towards standardization in soundscape preference assessment. Applied Acoustics. 2011;72(6):387-92.

6. Kang J. Numerical modelling of the sound fields in urban streets with diffusely reflecting boundaries. Journal of Sound and Vibration. 2002;258:793–813.

7. Kang J. Urban sound environment. London; New York: Taylor & Francis; 2007.

8. Kang J, Yang W. Acoustic comfort evaluation in urban open public spaces. Applied Acoustics. 2005;66: 211–29.

9. Kang J, Zhang M. Subjective evaluation of urban environment: A case study in Beijing. International Journal of Environment and Pollution. 2009;39:187–99.

10. ISO 12913-1:2014(E) Acoustics - Soundscape - Part 1: Definition and conceptual framework. Switzerland2014.

11. Strauss A, Corbin J. Basics of qualitative research. Newbury Park: Sage; 1998.

12. Acun V. Investigating the effect of indoor soundscaping towards employees' mood and perception in open plan offices. Ankara: İhsan Doğramacı Bilkent University; 2015.

13. Egan MD. Architectural acoustics: McGraw-Hill Custom Publishing 1988.

14. Acousticator. Speech Transmission Index 2012 [cited 2015 13 August]. Available from: https://en.wikipedia.org/wiki/Speech_transmission_index#/media/File:STI_CIS_Scale.png.

15. Truax B. Acoustic Communication. Norwood, New Jersey, USA: Alex Publishing Corporation; 1984.

16. Mackrill J, Cain R, Jennings P. Experiencing the hospital ward soundscape: Towards a model. Journal of Environmental Psychology. 2013;36:1-8.