A comparative study on indoor soundscape assessment via a mixed method: a case of the high school environment

Abstract

Environments for learning-teaching activities require optimum acoustical conditions since students` learning attitudes are directly related to verbal speaking. However, optimum acoustical conditions are not enough to provide acoustic comfort to students. To explore the acoustic requirements of educational spaces, there is a need to understand the role of sound and in which factors auditory perception of students changes. This study explores the relationship between auditory perception and the built environment in a high school. It aims to provide design guidelines for educational facilities using the systematic categorization that defines the comparison between classroom and computer laboratory spaces in İhsan Doğramacı Foundation Bilkent High School. To understand the existing acoustic conditions in a selected educational facility, Equivalent Continuous A-Weighted Sound Level (L_{Aeq}), Reverberation Time (T30), and Speech Transmission Index (STI) were measured. This mixed method study includes quantitative and qualitative research methods. Data was collected through multiple instruments, including a questionnaire survey (n=117) and semi-structured interviews (n=50). The data analyses were conducted using SPSS v.20 statistical software and applying the method of Grounded Theory (GT). The results show that the auditory perception of students does not only depend on sound levels since the responses towards sound sources and sound levels changed depending on the context of the space (such as the lecture content or the students' task). The conceptual framework presented the relations between the built environment, acoustic environment, and auditory perception of students. The results of this research were interpreted for possible improvement directions, providing a guideline for designers to shape the auditory quality of future educational spaces.

Keywords: Soundscape, High-School Environment, Auditory Perception, Grounded Theory

1. Introduction

The phenomena of perception depend on the five senses working collectively and individually. However, society generally focuses on the visual sense over other sensory modalities, and the auditory perception is ignored [1,2]. In relation to this subject, Schafer aimed to improve the acoustic environment and create a sonically improved place by conducting studies on listening [3]. This concern resulted in the emergence of the concept of 'soundscape.'

As soundscape studies have gained more importance, the International Organization for Standardization (ISO) published three standards to define soundscape research methods [4–6]. The ISO 12913-1 [4] proposed a comprehensive international definition and defined soundscape as the "acoustic environment as perceived or experienced and/or understood by a person or people, in context." The process of understanding or perceiving the acoustic environment includes the interrelations between person, activity, and place. A conceptual soundscape framework was demonstrated to explain their correlations in ISO [4]. Seven concepts and their relations were defined: context, sound sources, acoustic environment, auditory sensation, interpretation of auditory sensation, responses, and outcomes.

For data collection, ISO/TS 12913-2 proposed three methods that are used in several studies of soundscape: questionnaires, interviews, and soundwalk [5]. Accordingly, ISO/TS 12913-3 was published to establish data analysis methods for both qualitative and quantitative data [6]. As well as statistical analysis, Grounded Theory (GT) is also referred to as an accepted data analysis method, and researchers have lately utilized GT in soundscape studies [7,8]

Previous field surveys of soundscape have mainly handled relatively large rural or urban areas [9–14]. However, indoor soundscape studies have lately emerged in the literature, concentrating on the enclosed sound environment [15]. In indoor soundscape, case studies have been researched in structures such as residential buildings [16,17], hospitals [18], transport hubs [19,20], religious spaces [21,22], restaurants [23], shopping malls [24,25] and museums [26,27]. Within the scope of study-based spaces, there are a limited number of studies of libraries [28,29], open-plan offices [7,30], study rooms [31], and classrooms [32–38]. Considering the fact that children (mainly those below 17 years old) get their main educational base and form their characters in educational facilities [39], these spaces gain importance for soundscape research. The classroom soundscape influences students' efforts to receive and understand all audible messages related to learning [35].

Therefore, it is necessary to analyze the listening conditions of educational spaces and to understand the specific auditory perception of children.

To evaluate educational facilities' acoustic conditions, speech intelligibility (as the base of verbal communication), reverberation time, background sound levels, and ambient sound levels have been studied often [40–42]. In Turkey, many studies have analyzed the acoustical conditions of classrooms [43–45]. It is commonly found that the acoustic requirements of classrooms do not meet the recommended values for educational spaces. Though exposure to high levels of sound does not ensure optimum conditions for teaching and learning [28], acoustical parameters are not the only indicators for understanding the ideal acoustic environment for education. In order to improve the efficiency of learning in educational spaces, one must analyze students` auditory perception towards the built and acoustic environment.

Since background information about sounds can ease the control of understanding to create a more positive reaction towards the environment [28], understanding the perceived environment where sounds are produced is crucial, as is differentiating the primary sound sources, understanding background sound levels, and creating spaces according to these considerations. The relation between the context of sounds and the acoustic environment has been investigated in some studies [27,31,46]. The results show that context is an inseparable aspect of the perception of the acoustic environment; studies should be evaluated with a holistic approach to understand the background effects in sound perception.

Recently, educational methods have shifted from traditional didactic teaching towards group work activities [47]. Future educational spaces are expected to be more technological, interactive, participatory, and mobile [48]. In that context, new educational facilities are thought to have classroom designs with more advanced tools (such as projectors, computers, and projection screens), granting opportunities for group discussions and cooperative learning activities [49]. For such conditions, the definition of acoustic requirements and the evaluation of auditory perception will help constitute the acoustical base for educational facilities. When thinking the existing governmental approach to the acoustic requirements in Turkey, noise management policies such as [50,51] are still in use. One [50] covers the topics of sound level evaluation, noise management strategies, noise maps, and environmental noise strategies whilst the other [51] includes the information about noise evaluations and insulation applications in buildings, acoustical performance values of buildings, application of sound insulation process and rules regarding acoustical consultancy and acoustical reporting. In addition, though those noise management policies of the Turkey are compatible with ones of the EU, a governmental understanding of the soundscape approach has not been developed yet. [52] Similarly, the guidelines like Acoustic Comfort in Schools [53] includes about the physical acoustical considerations in schools as sound/noise sources, background noise levels, reverberation time, and classroom acoustics. Following these conditions, this study investigates the soundscape of educational spaces with an analysis of existing acoustical conditions. The goal is to provide outcomes for the base of soundscape understanding.

To achieve this, the study analyzes the effects of the acoustic environment on students' auditory perception in the high-school environment by conducting research on both a classroom and a computer laboratory. It evaluates the relations between auditory perception and the built and acoustic environments of the high schools. Two research questions have been formed, as follows: (i) How do built and acoustic environments affect students` auditory perception in the high school environment? (ii) How does the perceived acoustic environment affect students' preferences of the built environment in educational facilities? The main aim is to provide design guidelines for educational spaces with a systematic categorization that is defined by comparing classroom and computer laboratory environments. To achieve this goal in educational facilities, we used statistical analysis and GT to analyze both the general frame of auditory perception and the relationships between the elements of auditory perception.

2. Method

2.1. Case Study Setting

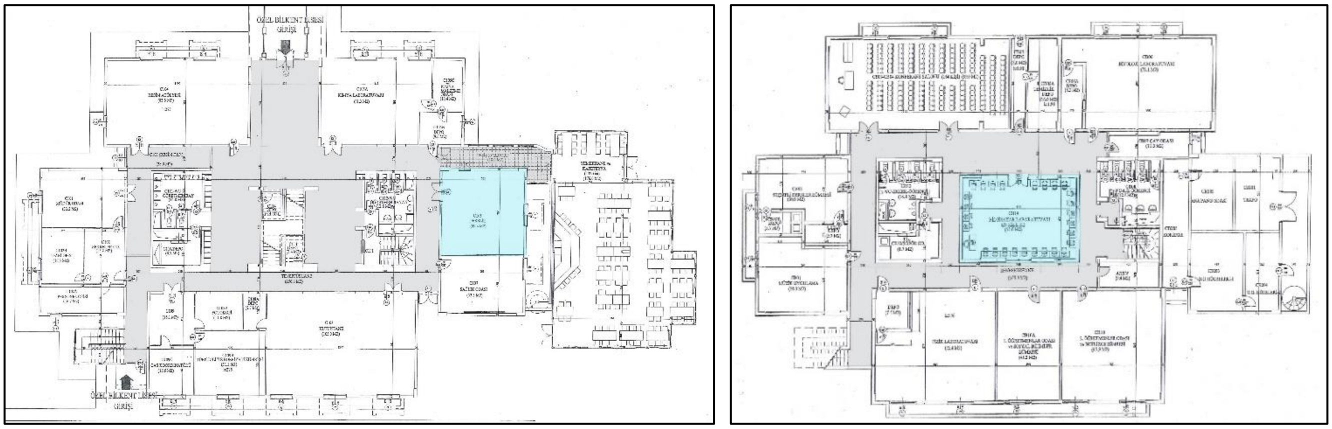
The building in the selected case study is located in the capital of Turkey, Ankara, which has a population of about 5,600,000 [54]. The majority of the population is comprised of young people due to the high number of universities in Ankara. The study was carried out in İhsan Doğramacı Foundation Bilkent High School, located in the east part of the Bilkent University campus (Figure 1); it is thought to satisfy the optimum conditions expected of an educational facility to conduct the research. Built in 1993, the structure of Bilkent High School is composed of a reinforced concrete frame combined with a gable roof, which is a common typology of high schools in

Turkey. The acoustic environment of the school includes a diversity of sound sources, not only ones that originate in the high school environment but also those associated with the university campus.

(a) **(b)**

Figure 1: The location of Bilkent High School (a) and an image of Bilkent High School (b)

Bilkent High School has multiple classrooms, laboratories, and art rooms as well as a library and a conference hall. To increase the data available for educational spaces and evaluate the difference of course conduction in theoretical and applied courses, a classroom and a computer laboratory were chosen as venues for the case study (Figure 2). As indicated in Mackrill et al.[28], comparing multiple soundscapes increases certainty of the positive soundscape environment rather than giving an absolute answer.

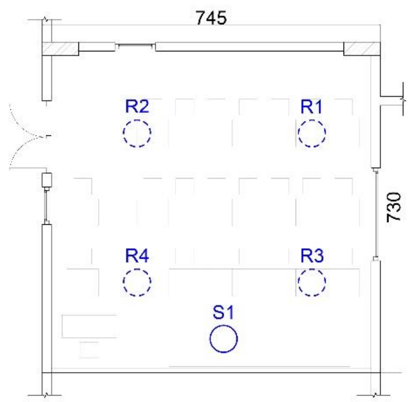
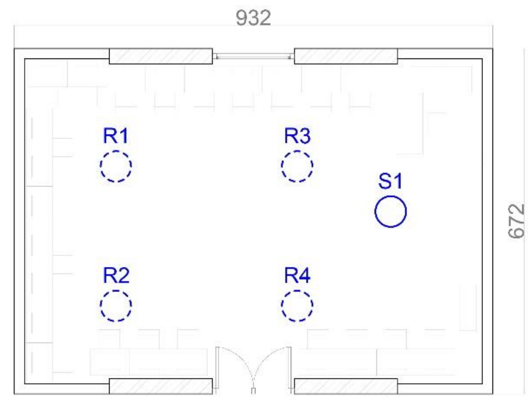


(a) (b)

Figure 2: Classroom (a) and computer laboratory (b) locations in high school
(blue indicates classrooms; gray indicates corridors)

The computer laboratory is a shared space used by students in different grades. It is in the center of the building on the basement floor, surrounded by corridors. The selected classroom is also used in other elective courses by students in different grades and is surrounded by corridors, a lateral façade of the building, and a health room (located in the ground floor plan). When considering the functions of spaces, the difference in terms of light – the need for daylight in the classroom and for artificial light in the computer laboratory – resulted in the selection of these spaces. To present the similarities and differences between the selected areas, the spatial properties of the classroom and computer laboratory are shown in Table 1.

Table 1: The spatial properties of classroom and computer laboratory

	Classroom (CLASS)	**Computer Laboratory (LAB)**
Plan Configuration (dimensions are given in centimeters)		
Area	Around 55 m^2	Around 57 m^2
Ceiling Height	2.8 m	2.8 m
Structural System	Reinforced Concrete	Reinforced Concrete
Walls	Brick with oil painting	Brick with oil painting
Ceiling	Plaster on reinforced concrete	Plaster on reinforced concrete
Floor	Carpet on reinforced concrete	Ceramic tile on reinforced concrete
Openings	Three windows and a door	A window and a door
Furniture	22 wooden desks and a whiteboard	27 wooden desks, 24 computers, two closets, and a whiteboard

2.2. Participants

Data was gathered through the questionnaire and interviews. Students voluntarily participated in the questionnaire for the classroom (n=59) and computer laboratory (n=58). The demographic distribution of students was recorded as 72 males (61.5%) and 45 females (38.5%), and as age 16 (47%) and age 15 (44.4%), since the selected spaces are used for elective courses (Table 2). The questionnaire participants were chosen with a cluster sampling method for the semi-structured interviews (n=50). Participants were asked to share their grade point averages (GPA) to understand whether there is a linkage between the acoustic environment and academic success. Most of the students (78.2%) GPAs were recorded as over 70.

Table 2: The students` frequency distribution of socio-demographic characteristics

Socio-demographic results		Frequency (n)	Percentage (%)
Gender			
	Male	72	61.5
	Female	45	38.5
Age			
	14	8	6.8
	15	52	44.4
	16	55	47.0
	17	1	0.9
	18	1	0.9
GPA			
	49–0	1	0.9
	59–50	7	6.1
	69–60	17	14.8
	84–70	45	39.1
	100–85	45	39.1
	Not Answered	2	1.7

2.3. Experimental Setup

This is a mixed-method study that consists of both quantitative and qualitative research methods. The aim of the quantitative survey is to understand the physical properties of the acoustic environment, while the qualitative survey evaluates the students` perception of these environments. In the study students participated in questionnaires and semi-structured interviews [5].

After the setup of the sound level meter, acoustic comfort and sound preference questionnaires were distributed to the students (to be completed in 10 to 15 minutes). With the start of the regular class, the sound level meter measured the acoustic environment during a one-class time of 40 minutes. Meanwhile, semi-structured interviews were conducted with three to five students in each class; these took between four and 14 minutes. At the end of the lecture, the value of the sound level meter was recorded. This process was repeated in both environments several times (Figure 3). Most of the semi-structured interviews were consisting of the number of students that we can interview during the class. However, while analyzing the data, we required to increase the number of interviews for a few more days until it is monitored that new data collection does not lead to any further changes to the theory, its categories and sub relationships.

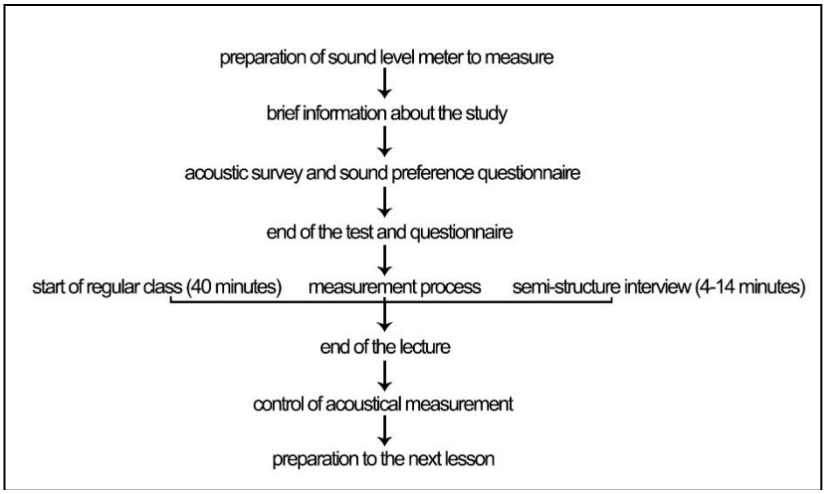


Figure 3: Process of the study

2.4. Acoustic Environment

To understand the existing acoustic conditions in the selected educational facilities, the Equivalent Continuous A-Weighted Sound Level (L_{Aeq}), Reverberation Time (T30), and Speech Transmission Index (STI) were measured. In real acoustic environment measurements, the Bruel & Kjaer 2230 Sound Level meter was used. The weather was sunny, and there was no wind or rain. For L_{Aeq}, the sound level meter was located in the center of both the classroom and computer laboratory at a height of 100 cm for 9th-grade students and 110 cm for 10th-grade students (in consideration of the sitting position of the receiver [5], as referred in the American National Standard [55]). Measurements were conducted in both occupied and unoccupied conditions to understand the effect of background sound level [55]. There was no significant difference in terms of sound levels between the classroom (occupied: 62.6 dB, unoccupied: 49.2 dB) and the computer laboratory (occupied: 64.9 dB, unoccupied: 49 dB), although their acoustic environments have different sound sources. In unoccupied conditions, the maximum noise level of classrooms in Turkey is accepted as 45 dB[50], and the measured values of unoccupied conditions do not meet standards. Moreover, sound level values of occupied conditions were recorded higher than 55 dB, which is the limit level of loss of listeners' attention [54].

The researchers observed the existing sound sources in both environments before presenting the questionnaire (Table 3). All current sound sources were present in the selected environments, apart from music sound. Music was observed as a sound source that does not exist in the environments during the class hour; however, during class practice times, teachers occasionally allow students to listen to music. Measurements of reverberation time (T30) and speech transmission index (STI) were conducted with the Bruel & Kjaer 2230 sound level meter, omnidirectional sound source, and building acoustics analyzer in an unoccupied condition (Figure 5). The sound level meter was arranged to a height of 110 cm (representing a sitting student) and the omnidirectional sound source was set to 150 cm (representing a standing teacher). The position of receiver points and sound source were defined as at least one meter distance from the walls, and the teacher's location was determined as near the whiteboard and teacher's desk (Table 1).

Table 3: Existing sound sources in classroom and computer laboratory

Classroom	Computer Laboratory
Speech	Computer Fan
Laughter	Projection Fan
Corridor Speech	Electrical Ventilation
Footsteps	Electrical Installation
Roadway Traffic	Mouse Click Sound
Air Traffic	Keyboard Sound
Birds Singing	Speech
Rain Sound	Laughter
Projection Fan	Corridor Speech
Electrical Installation	Sounds of Adjacent Spaces
Electrical Ventilation	Footsteps
Phone Ringing	Alarm Sound
Clock Sound	Phone Ringing
Siren-Ambulance Sound	Clock Sound
Alarm Sound	Music Sound
Music Sound	Chair Wheel Sound
Sounds of Adjacent Spaces	
Paper Turning/writing Sound	

The results of reverberation time (T30) measurements show that reverberation time between the frequencies of 500Hz to 2000Hz has values in the range of 1.08 to 2.23 in the classroom and 0.8 to 0.9 in the computer laboratory. According to the Acoustical Society of America, recommended reverberation time values for classrooms are between 0.4–0.6; this shows that none of the selected spaces meet the reverberation time requirements [56]. However, Mean STI values were found as 0.63 in the classroom and 0.61 in the computer laboratory. This shows that both spaces have values between 0.6 and 0.75, demonstrating good speech intelligibility [57].

Figure 4: In-situ measurements of T30 and STI in unoccupied condition

2.5. Data Collection

Qualitative and quantitative research methods were used for data collection. The questionnaire survey (Ethics Committee for Research Projects Involving Human Participants in International Review Board of Bilkent University, 2020_10_23_01) was used to collect quantitative data, analyzed with the SPSS v.20. statistical analysis program; the data from the semi-structured interviews were used in GT analysis [58,59]. We aimed to evaluate the auditory perception of students in a miscellaneous way with different scales achieved through multiple methods. Since "questionnaires offer an objective means of collecting information about the people`s knowledge, beliefs, attitudes and behavior"[60], we decided to develop a questionnaire to explore and explain relationships between concepts related with auditory perception and built environment. To comprehend the background reasons and relations in a more flexible way when compared to the questionnaire, we applied GT by composing a conceptual soundscape framework of educational spaces in response. to define the ideal acoustical conditions of the educational spaces considering the auditory perception of students. The questionnaire (prepared in Turkish) includes closed and open-ended questions (see Appendix) to evaluate the soundscape over several topics: expectation, preference, auditory environment, physical environment, context, interpretation of the sound environment, and response (as indicated in ISO 12913-1 [4]). The rationale behind including the open-ended questions section was to "reduce measurement error by eliminating random guessing" [61]. The close-ended questions were evaluated with a five-point scale ranking system. The questions, including the evaluation of sound sources, were formed with reference to Yang & Kang [14].

Semi-structured interviews make it possible for researchers to intimate relationships with participants, which enables them to access richer information and greater flexibility of topic coverage [28]. Semi-structured interview questions cover topics such as identification of recognized sound, indication of positive and negative sound sources, sound preferences, sound perception, comfort level, and sounds' effects on students' class performance. Twelve semi-structured questions were determined, which form the categories created in GT (Table 4).

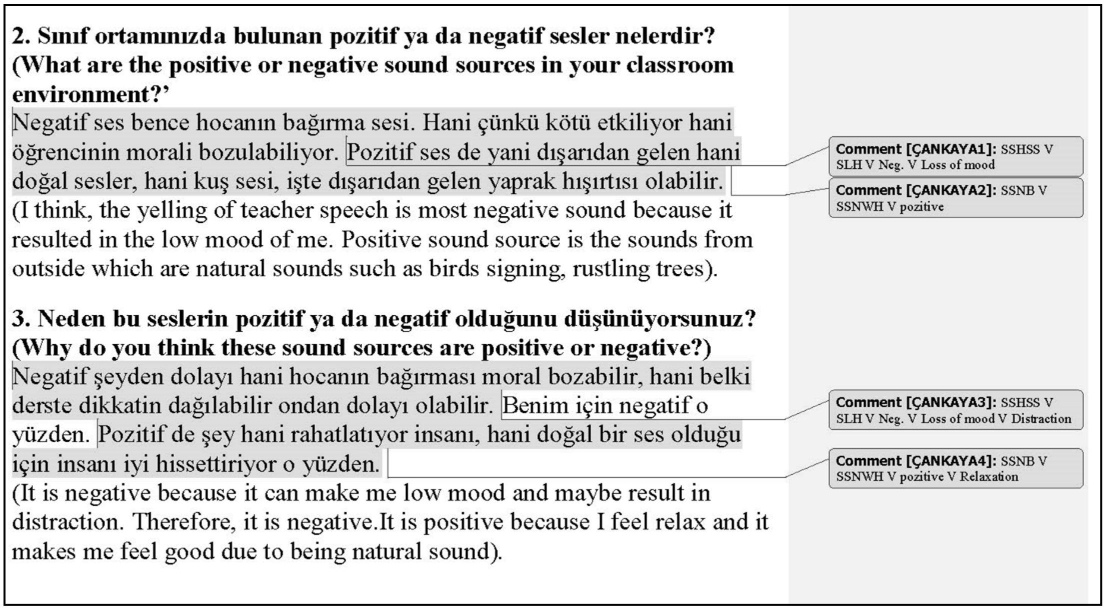
Table 4: Semi-structure interview questions

Semi-structure interview questions	Categories
1. What do you expect to hear in your classroom /computer laboratory environment?	Acoustic Environment
2. What are the positive or negative sound sources in your classroom/ computer laboratory environment?	Acoustic Environment
3. Why do you think these sound sources are positive or negative?	Perception Context
4. What do you prefer to hear in your classroom/ computer laboratory environment?	Context
5. What do you prefer not to hear in your classroom/ computer laboratory environment?	Acoustic Environment
6. Do you associate any sound with your current classroom/ computer laboratory environment?	Responses / Outcomes
7. How does the soundscape of the classroom/ computer laboratory environment affect your behavior and psychological response?	Context
8. How would you describe the future soundscape of the classroom/ computer laboratory environment?	Context
9. What would be the ideal classroom/ computer laboratory soundscape from your point of view?	Perception
10. Do you perceive background noise in your classroom/ computer laboratory environment? If so, how would you describe it?	
11. How do sound sources affect your class performance in your classroom/ computer laboratory environment?	Responses
12. How do the physical characteristics except sound affect your class performance in your classroom/ computer laboratory environment?	Built Environment

2.6. Data Analysis

We used questionnaires and semi-structured interviews to collect data for analysis. The data collected through the questionnaire was evaluated using the statistical software IBM SPSS Statistics v.20.[62]. First, we checked the survey's reliability with the value of Cronbach's alpha. Then, the data was analyzed to control whether it is normally distributed with Kolmogorov-Smirnov the test of normality, due to the number of participants exceeding 30. To understand the distribution, we conducted a frequency analysis. Results of Kolmogorov-Smirnov the test of normality showed that data is not normally distributed ($p < .05$). Due to the fact that data is found as not symmetrically distributed, we decided to run a non-parametric test named as Mann-Whitney U Test to evaluate the differences between two conditions in which different participants have been used. Lastly, since variables were measured in an ordinal level, we chose to use Spearman's rho (rs) Correlation to analyze the dependency between questions.

We conducted semi-structured interviews in Turkish, which were recorded with a Dictaphone application on a cellphone and later transcribed verbatim. We followed the coding process (open-coding, axial coding, and selective coding) as explained in the GT of Strauss and Corbin [63]. Once all recordings were transcribed, we broke down the initial data into the labels in the open coding phase to explore the relations. To illustrate, the sentence *'I think, the yelling of teacher speech is most negative sound'* was labeled as 'Sound Source Human Source Speech'(SSHSS). Moreover, *'the yelling of teacher speech'* also referred to 'Sound Level High'(SLH). The phrase continues with the sentence *'because it can decrease my mood'* that was coded as 'Loss of mood.' It was found that these three labels are related to each other. The whole sentence is summarized as 'SSHSS v SLH v Loss of Mood' (Figure 5). In axial coding, we evaluated the labels to create categories and subcategories based on the similarities and differences. Finally, we defined the categories and subcategories to generate a conceptual framework for educational facilities.



2. Sınıf ortamınızda bulunan pozitif ya da negatif sesler nelerdir? (What are the positive or negative sound sources in your classroom environment?'

Negatif ses bence hocanın bağırma sesi. Hani çünkü kötü etkiliyor hani öğrencinin morali bozulabiliyor. Pozitif ses de yani dışarıdan gelen hani doğal sesler, hani kuş sesi, işte dışarıdan gelen yaprak hışırtısı olabilir.

(I think, the yelling of teacher speech is most negative sound because it resulted in the low mood of me. Positive sound source is the sounds from outside which are natural sounds such as birds signing, rustling trees).

Comment [ÇANKAYA1]: SSHSS V SLH V Neg. V Loss of mood

Comment [ÇANKAYA2]: SSNB V SSNWH V pozitive

3. Neden bu seslerin pozitif ya da negatif olduğunu düşünüyorsunuz? (Why do you think these sound sources are positive or negative?)

Negatif şeyden dolayı hani hocanın bağırması moral bozabilir, hani belki derste dikkatin dağılabilir ondan dolayı olabilir. Benim için negatif o yüzden. Pozitif de şey hani rahatlatıyor insanı, hani doğal bir ses olduğu için insanı iyi hissettiriyor o yüzden.

(It is negative because it can make me low mood and maybe result in distraction. Therefore, it is negative.It is positive because I feel relax and it makes me feel good due to being natural sound).

Comment [ÇANKAYA3]: SSHSS V SLH V Neg. V Loss of mood V Distraction

Comment [ÇANKAYA4]: SSNB V SSNWH V pozitive V Relaxation

Figure 5: Open Coding: Labelling Process (in Turkish)

3. Results

3.1. Questionnaire Survey: Close-ended Questions

The results were evaluated through several statistical tests with IBM SPSS Statistics v.20. We found the survey's reliability regarding Cronbach`s alpha values as 78% in the classroom and 75% in the computer laboratory. Both values reflect a high strong consistency between the questions.

We evaluated the questionnaire to define the sound sources in both environments with frequency distribution. Prominent sound sources were music sound, bird song, traffic sound, alarm sound, the sound of adjacent classrooms, and siren-ambulance sound. Music was selected as the most relaxing sound source (80%) for both environments, while the most annoying sound source was referred to as traffic sound (74.1%) in the classroom and alarm sound (72.7%) in the computer laboratory. In both environments, human-based sound sources (such as speech, laughter, and footsteps) were generally evaluated as neither annoying nor relaxing, and electro-mechanical sound sources (such as ventilation sound, electrical installation sound, projector sound, and ringing phones) were reported as annoying.

According to the results of the Mann-Whitney U Test, the difference between common sound sources of both environments was found significant only in laughter ($p< 0.05$, $U = 1196$, $z =-2.46$). Apart from laughter, no significant difference in perception of sound sources was found.

Laughter was evaluated as a positive sound source in the computer laboratory environment and as a negative sound source in the classroom environment (Figure 6).

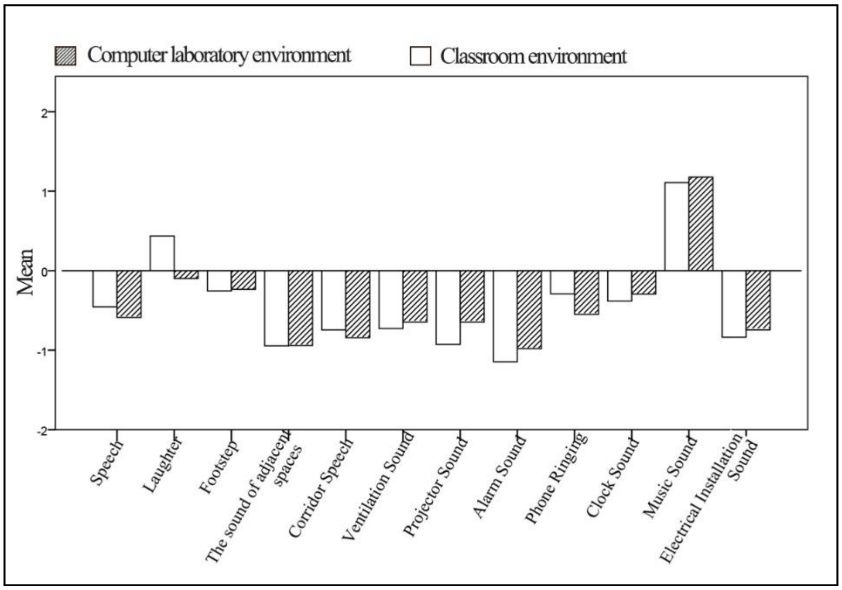


Figure 6: Mann-Whitney U Test for the evaluation of common sound sources

The fourth part of the questionnaire includes questions about the evaluation of acoustic comfort, sound level, and self-assessed class performance. The Mann-Whitney U test results show that sound level (p value = 0.001; $\alpha < 0.05$) was evaluated differently in both environments. The majority of the students reported sound levels as high in the classroom (55.17%) and as neither low nor high in the computer laboratory (72.41%).

We thought that it is vital to explore the correlations between acoustic comfort, sound level, and self-assessed class performance (Table 5). In the classroom environment, the sound level was found to have a significant negative correlation with comfort level (rs= -0.470, p=0.0005, n=58). We interpreted that if the environment has a high sound level, the students' comfort level decreases. Moreover, the sound level had a significant negative relationship with self-assessed class performance (rs= -0.404, p=0.002, n=58). We interpreted that self-assessed class performance of students decreases as sound level increases. A positive association was also observed between comfort level and self-assessed class performance (rs= 0.518, p=0.0005, n=58). We inferred that when comfort level increases, self-assessed class performance of students increases. In the computer laboratory environment, the only significant correlation was found between sound level and self-assessed class performance (rs= -0.514, p=0.0005, n=58). We evaluated that if the sound level is perceived as high, the self-assessed class performance of the students decreases. The other questions did not show any significant correlation with each other. In addition, we found no significant relationship between the socio-demographic characteristics of students and the acoustic evaluation of the spaces.

Table 5: Results of Spearman's rho (rs) Correlation test for the dependency between questions

Questions	Classroom			C.Laboratory		
	rs	p	n	rs	p	n
Sound Level (Q4.1.) & Comfort Level (Q4.2.)	**-0.470***	0.0005	58	-0.130	0.329	58
Sound Level (Q4.1.) & Class Performance (Q4.3.)	**-0.404***	0.002	58	**-0.514***	0.0005	58
Comfort Level (Q4.2.) & Class Performance (Q4.3.)	**0.518***	0.0005	58	0.190	0.152	58

3.2. Questionnaire Survey: Open-ended Questions

The second part of the questionnaire included open-ended questions that were aimed to understand the identification of recognized sound sources in educational facilities. As indicated in Table 6, human-based sound sources were referred to in the classroom environment, while electro-mechanical sound sources were mostly mentioned in the computer laboratory environment; this was a result of the difference in the acoustic environments of the spaces. Due to the different theoretical and practical courses in the selected educational facilities, the classroom students preferred to focus on the teacher`s speech while students in the computer laboratory indicated their desire for a quiet environment or an acoustic environment with low-level music.

Table 6: Open-ended questions and answers in educational facilities

Open-ended questions	Classroom	Computer Laboratory
(Q.2.1). Please write the first three sounds that come into your mind when thinking about the classroom environment/computer laboratory environment	Speech, laughter humming, and whispering Footsteps, scraping sound sources (table or chair moving sound) Corridor speech, the sound of adjacent spaces, the speech of university students	Computer fan sound, keyboard-mouse sound, ventilation Speech and chair moving sound Laughter, whispering, teacher`s speech Page-turning and writing sound
(Q.2.2). Which sounds do you prefer to hear in your classroom environment/computer laboratory environment?	Teacher`s speech Low sound level sound sources Music	A quiet environment Low-level Music Low-level speech Computer Fan Sound Keyboard-Mouse Sound
(Q.2.3). Which sounds do you prefer not to hear in your classroom environment/computer laboratory environment?	Speech of students, humming, and whispering High sound level sound sources Projector sound, lighting sound, ventilation sound, alarm sound	High-level Teacher`s speech Group conversation, laughter Ventilation sound, lighting sound, and projector sound

3.3. Semi-structured Interview: Grounded Theory

We generated a conceptual framework by using GT, showing the relations between themes for the acoustic environment of the educational facilities. To regulate the process between codes, we pursued a systematic approach, as indicated in Figure 7. To illustrate, in the labeling process, both sentences *'if the sound level high; human speech is negative'* and *'if the sound level high; traffic sound is negative'* phrases were coded as "a1" and "a2" to improve the study with an order. These codes "a1" and "a2" were evaluated to give key terms such as SSHS (Sound Source Human Speech), SLH (Sound Level High) and conceptualized into the title as "aa1," which means 'the relationships between sound levels and sound sources.' The concepts became more apparent after the open coding phase. Later, these concepts composed the categories depending on their similarities or differences in the axial coding phase. For example, "aa1" and "aa2" were gathered, and the A1 category was defined, which is about *'negative sound sources and sound levels.'* A2 was also a category that included labels about positive sound sources and sound levels. Lastly, A1 and A2 were found similar and created the category AA1 as *'acoustic environment.'* After creating the main categories, subcategories and their relationships were defined. The core category was selected in the selective coding phase. Therefore, categories and subcategories were revealed to develop a general conceptual framework that will give information about the auditory perception of students in the high-school environment.

The conceptual framework revealed six categories and thirteen subcategories (Figure 8). The categories are built environment, acoustic environment, perception, context, responses, and outcomes. Perception was selected as a core category that has a relation with all categories. The differences and similarities between classroom and computer laboratory environments were indicated in the framework. Each category of the framework was supported with classroom student (CS) and laboratory student (LS) comments.

Sorting Memos	Labeling	Conceptualizing Data	Categorizing Data	Categories	Subcategorised
(What are the positive or negative sound sources in your classroom/laboratory?) "For example there is speech. It is both negative and positive. It depends on the class lesson....." "Negative sound is the yell of teacher's sound because it affects badly and makes students upset. Positive sounds i think can be outside sounds such as nature sounds, bird sound, wind sound....." "Sometimes there are so many outside noises when cars or bikes are passing fast. If the class is also quiet, these noises are distracting my attention....." "Loud speech among students. It is really distracting. When i did not concentrate, i have to warn them....." "I think positive sound is no sound. I prefer quiet class....." "I actually like the outside noises. It gives me feeling that the life goes on outside, and we are not prisoners....." .... (Why do you think these sound sources are positive or negative?)	a1. Speech is both negative and positive and it depends on the class lesson. a2. Teacher's sound is negative if it is high level. It makes students upset. a3. Positive sounds are nature sounds, bird sound, wind sound. a4. If cars or bikes are passing fast, they are distracting the attention. a5. High sound speech is distracting and resulting the loss of concenration. a6. If i did not concentrate, i have to warn them. a7. Quiet class is positive. a8. Outside noises are positive because it shows the flow of life.	aa1. If the sound level high, traffic sound and speech are negative. (a1, a2, a5, a11) aa2. If the sound level high, speech is distracting, makes students upset, and results the loss of concentration. (a2, a4, a5) aa3. Positive sounds are nature sounds, birds song, wind sound. (a3) aa4. If i did not concentrate, i have to warn them. (a6) aa5. Quiet class is positive. (a7, a15, a16). aa6. Outside noises are positive because it shows the flow of life. (a8)	A1. Positive sound sources are some sounds of nature (wind sound, birds songs, bells, silence) and outside sources (aa3, aa5, aa6) A2. Negative sound sources are motorized transport sounds, voice, electro-mechanical sounds (aa1, aa2, aa9). A3. Coping methods are verbal intervention and habitutation. (aa4, aa6)	AA1. Acoustic Environment AA2. Built Environment AA3. Perception AA4. Context AA5. Responses AA6. Outcomes	AA1. Acoustic Environment (1) Physical Parameters (2) Sound Sources AA2. Built Environment (1) Spatial Relationships AA3. Perception (1) Foreground Sounds (2) Background Sounds AA4. Context (1) Soundscape Preference (2) Coping Methods (3) Ideal Environment AA5. Responses (1) Positive Responses (2) Negative Responses (3) Neutral Responses AA6. Outcomes (1) Physical Outcomes (2) Long-Term Outcomes
Initial Data Collection	Open Coding	Axial Coding	Selective Coding	Defining Categories	Generating the substantive theory

Figure 7: Grounded Theory Process

Acoustic Environment

To identify recognized sound, students were asked to define what they expect to hear when they think about their classroom or computer laboratory environment (Table 5). Among the expected sound sources, speech was the most frequently mentioned in the classroom environment, while computer fan sound was mostly referred to in the computer laboratory environment. In addition, sound levels were also crucial in terms of the auditory perception of students. The same sound sources could be perceived differently in different sound levels. Generally, students did not prefer to hear sounds at high levels because high-level sounds were perceived as noise, even if the students chose to hear them in the acoustic environment when they were at normal hearing levels.

LS: *If they are (referring to his friends) talking at low levels, I do not feel distracted. However, if they are talking at high levels, it affects my performance negatively.*

Built Environment

We found that spatial relationships change the auditory perception and the context in which soundscape is generated. These factors were space allocation, layout, and materials. They impacted the students' comfort and, consequently, sound perception during the class. To illustrate, classroom students indicated that they always sense the odor and sound of the cafeteria during class hours because of the location of their classroom. Therefore, the built environment results in changes in auditory perception towards the acoustic environment.

CS: *I always hear the sounds of knives and forks during class.*

LS: *There is the speech of the teacher and staff in the corridor. I do not perceive any sound other than this because our laboratory is on the ground floor.*

Perception

Students were also asked to define positive and negative sound sources in their environments. Results show that the selection of positive and negative sound sources depended on several things, such as the relation with the environment, the social preference of the student, the context of sound sources, and the mood of the students. Perceived sound sources were analyzed into two subcategories, foreground and background. For foreground sound sources, the most positive sources were the speech of the teacher, laughter in the classroom, and music in the computer laboratory. Moreover, the negative sound sources were found to be high-level speech in the classroom, ventilation, and the computer fan sound in the computer laboratory. We infer that sound levels affect the perception of sound sources; whenever a sound is described as having a high sound level, it is generally indicated as a disturbing sound source in an environment.

For background sound sources, the positive ones were compiled as natural sound sources like birds song, wind, and water sound in the classroom; there were no positively mentioned background sound sources in the computer laboratory. As negative background sound sources, roadway traffic in classrooms and corridor speech in the computer laboratory were frequently mentioned. Although the students generally perceived background sounds as negative, some did prefer to hear the background sound in their educational spaces.

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

According to the conceptual framework, participants developed positive, negative, and neutral responses towards the acoustic environment and its related sound sources (Figure 9). Some students accepted the speech of their friends as a part of the acoustic environment, but sounds – mostly speech – from adjacent spaces, which did not belong to the acoustic environment of the occupied areas, were perceived negatively. Moreover, the students first perceived the inner sound sources in the school while considering the background sound.

CS: *I am distracting from outside speech and sounds from adjacent spaces. For example, I am trying to read something. If I hear these sounds, I am struggling not to listen to them. It is just distracting.*

Context

We asked the students to define sound preferences regarding the selected educational spaces. Music sound was the most preferred sound source in both spaces. In addition, students generally did not want to hear human-based sound sources like high-level speech, group conversation, humming, laughter, corridor speech, or the sound of adjacent spaces in the classroom; in the laboratory, they did not want to hear high-level speech, group conversation, ventilation or chair moving sound.

To identify an ideal educational environment, the students in both spaces indicated that they preferred low or average sound levels during class time. Another crucial question was whether they chose to study in a quiet environment or not. A quiet environment receives both positive and negative approaches among students.

CS: *I prefer to hear the teacher's speech, my friends' speech, and laughter. I also want to hear outside noise because I wouldn't say I like the quiet class environment.*

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

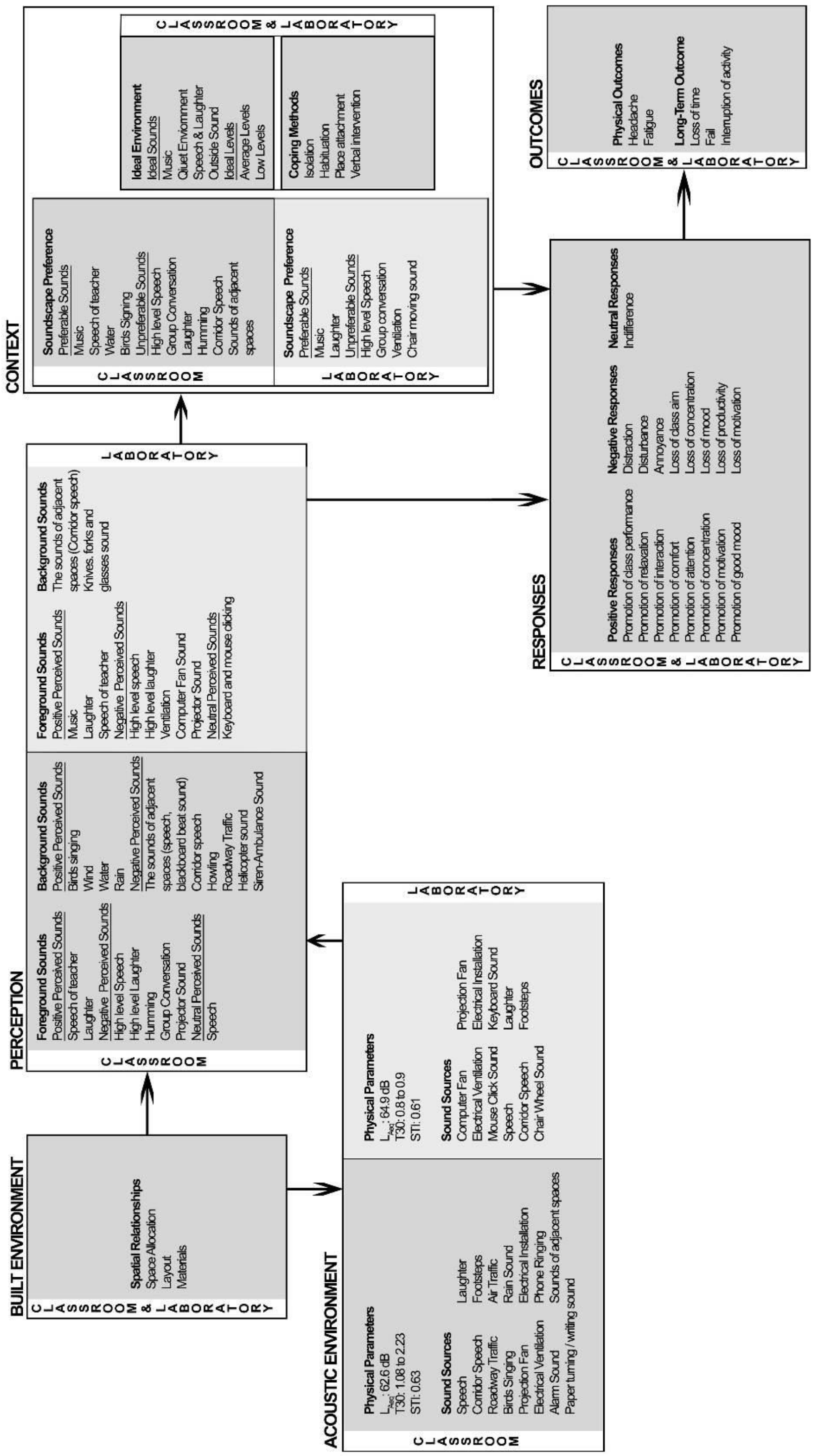


Figure 8: The conceptual framework for classroom and laboratory

Another essential part of the conceptual model is coping methods. Students improved some solutions to achieve their ideal acoustic conditions because coping methods helped them handle the existing situations. Coping methods such as isolation, habituation, place attachment, adaptation, and verbal intervention sometimes acted as bridges between responses and perception. One interesting result is in the approach to keyboard sound and computer fan sound. The students evaluated them as a part of the environment because they evoked the feeling that all students were working simultaneously.

LS: *I can evaluate all sounds in this laboratory as negative, but I think that in a computer laboratory, there should be these kinds of sounds. Therefore, I do not evaluate them as negative or positive. They are the parts of this environment.*

CS: *If there is so much sound in the environment, I put my head to the table and try to isolate myself. After then, I can focus on my lesson.*

CS: *I can give more attention to my lesson in a quiet environment. Libraries help students to learn the same thing; you must show respect to the people studying there, so you must be silent. However, if I am in a noisy environment, I am raising my voice to be heard.*

Responses

We found that students have positive, negative, and neutral responses towards educational facilities' acoustic environments. Positive responses were exemplified as promoting relaxation, interaction, comfort, attention, concentration, motivation, and mood. The negative responses were 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 how can I be productive in such a noisy environment? I do not know.*

LS: *In a quiet environment, I feel very relaxed and focus on the lesson. After that moment, I do not consider the environment, and I think my lesson.*

Additionally, students were prone to use emotional terms to define their feelings towards sound sources. When they were presenting their auditory perception, they also preferred to add some expressive phrases to them.

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

Outcomes

Outcomes emerged as the last part of the conceptual framework. They can be classified as physical outcomes and long-term outcomes. The students' answers indicated that sound sources in the acoustic environment resulted in physical outcomes such as headache and fatigue and long-term outcomes such as failure, loss of class performance, and interruption of activity.

CS: *If I cannot hear my teacher clearly, my desire to listen is decreasing. Maybe, I think that I understood the lesson. I did not. I realize this situation when I failed the exams.*

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

4. Discussion

The generated conceptual framework and results of the statistical analysis show that soundscape study needs to work with multiple methods to better reveal auditory perception. The relation between objective and subjective results points out that auditory perception is affected by not only the physical properties of sound but also the context in which the sounds are heard.

4.1. Acoustic Environment

Although findings of acoustical parameters mostly do not meet the ideal acoustic environment for the classroom and computer laboratory, auditory perception towards the acoustic environment in both spaces was independent of acoustical parameters. Auditory perception should not be assessed only by measuring the sound levels of spaces. Although reducing sound level is suggested for community sound control [64], it does not necessarily establish a positive environment [65].

When comparing the acoustical conditions of spaces, there was no sharp distinction in terms of energy of the sound waves (L_{Aeq}); however, the students` descriptions of sound sources were different due to the variety of sound sources in the acoustic environments. Apart from this, the rest of the categories show similarities in both environments.

We infer that auditory perception depends on the context in which sound is heard rather than the physical properties of soundwaves. A positive soundscape environment can be achieved by ensuring the appropriate contexts. Context is the core of auditory perception due to the definition of meaning attributed to sound. This finding is in line with the study of Acun & Yılmazer [7], who developed a framework indicating the correlation between soundscape interpretation and the context of sound. The results of this study are also parallel to those of Yılmazer & Acun [21], in which the influence of the context on the interpretation, response, and outcomes of the soundscape was demonstrated.

The results indicate that the perception of sound sources differs with different sound levels. A sound source can be accepted as a positive sound when it is heard at an acceptable sound level. However, when it is heard at high levels, it can create a loss of performance in and a distraction from listening. Although auditory perception depends on context more than the physical properties of sound, the physical attribute of sound is an undeniable factor in perception. The findings of Shield and Dockrell [66] (showing that chronic exposure to high sound levels has a detrimental effect on the academic performance of students) support this result. Sound exposure during learning is hazardous to students' mental development and the normal learning process for language and reading [67].

4.2. Context

Context is the primary element with a direct relation to auditory perception. Sound preferences, identification of sound sources, background sound, and the development of a coping method are all related to the context of the sound source. It is seen that auditory perception regarding sound sources differs according to the space in which the sounds are heard (such as laughter in this study). The reason may depend on the students' tasks. Students stated that classroom lecture requires a more interactive atmosphere, which includes more speech and laughter. On the other hand, the computer laboratory lecture depends more on a practical application, which demands concentration on the computer screen. Laughter was more acceptable in classroom lectures than in computer laboratory lectures.

Speech was a controversial sound source that students sometimes accepted as a part of the environment and sometimes did not want to hear during a lesson [59]. Human-based activities, such as people talking or children playing, are usually evaluated as more pleasant when compared to technological sounds or as neutral in terms of pleasantness [68] (also present in this study). The different evaluations regarding speech can be explained with the fact that the same sound source can be evaluated differently in different contexts. As Mackrill et al. have stated, soundscape could be perceived as positive, negative, or necessary given the contextual information or simulation [28].

CS: *For example, the speech of my friends. Sometimes it is positive, and sometimes it is negative. It changes according to the lecture. If we are in an important lecture, I do not expect to hear a speech at that moment. However, in a boring lecture, the speech of my friends helps me concentrate on the lecture again.*

Since the classroom has a connection with outside from a one lateral façade, it was unexpected that the prominent sound sources were mostly related with outdoor sound sources. When they asked to evaluate annoying and relaxing sound sources, they indicated outdoor sound sources which they are not a part of educational acoustic environment.   It can be a reason of that students were prone to habituate and accept the interior sound sources as a part of the educational spaces.

Background sound sources weren't accepted as a part of the positive soundscape in high schools because the origin of the sounds was not related to the physical space. However, speech was mostly referred to as neutral and a part of the acoustic environment. If the sounds are accepted, understood, and habituated, the perception of the soundscape shows a more positive approach [46]. If a person associates a sound with an environment, one can accept the sounds more easily and demonstrates a positive approach. The most highlighted background sound sources were the ones that were produced inside of the school. Zannin and Marcon [69] found a similar result, reporting that the primary background sounds in schools originated inside, like the speech of students or teacher of a neighboring classroom. It can be interpreted that the most mentioned sound sources were the ones that were mostly attached to the specific space.

Regarding coping methods, students are able to develop a positive soundscape towards the environment. Even if the sound sources were evaluated negatively, they accepted them as a part of the environment. Similarly, Acun [70] found that keyboard sound evokes a positive feeling on employees' sound perception in open-plan offices. Moreover, students sometimes developed coping methods such as habituation, adaptation, and isolation for acoustic comfort. Likewise, previous research conducted in study rooms shows that students accept and habituate sounds to continue working, although they are not satisfied with the acoustic environment [31].

Electro-mechanical sound sources were evaluated as annoying sounds. This is parallel with the findings of Axelsson et al. [68], who noted technological sounds as generally unpleasant. Music was indicated as a preferable sound source in both educational spaces. Results show that the students concentrate better if they study with music. Students defined their preferences in terms of the context of the lecture. For example, students generally preferred to work with music if the task required less effort or if the lesson was based on an applied method.

LS: *I think low-level music can be played because you do not need to talk or listen too much in the computer laboratory. You are just concentrating on your computer screen, so it will be good to cheer up the environment.*

Another interesting finding is that even if music was limitedly allowed to the classroom / computer laboratory in the practice phase of some courses, it was selected as most prominent relaxing sound source in both educational spaces. It can be a reason of that music may help to increase the concentration to the task of the students deal with by creating a masking effect towards the other sounds. The interpretation may be developed that students sometimes requires a disconnection with the acoustic environment to feel more concentrated in the learning phase.

Students assessed the need for a quiet environment depending on the context and the task at hand. This is parallel with the findings of Acun & Yılmazer [7], who report that employees in an open-plan office preferred neither a quiet environment nor a noisy environment.

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

4.3. Outcomes for Designers

In this section, we offer some suggestions for designers when shaping educational facilities, considering both the built and auditory environments. These considerations will lead to developing a governmental understanding of the soundscape approach as well as act as a guide for designers. First, the location of educational spaces and the relation of adjacent spaces are quite important in terms of the auditory environment. The design of educational facilities should include consideration of the function of adjacent areas. In this study, the classroom was located near the cafeteria, and students frequently mentioned that the dining environment's sounds were disturbing background sounds. The students mostly preferred to hear music and natural sound sources, and we suggest that the location of these learning environments should be arranged with reference to these preferable sound sources. If this situation cannot be ensured, speech-based environments (due to the fact that speech is evaluated as neutral in the study) can be considered in the adjacent space. Sound insulation could also be recommended as an essential physical barrier to avoid the disturbance of surrounding sound sources.

As future classrooms will likely be more technological and interactive, music could be integrated into classes for certain situations. Technology could also be used to find a solution for speech intelligibility problems in classrooms; it is expected that new educational spaces will be supported by additional screens and loudspeakers. Future classrooms may provide students with more adaptable sitting layouts than the classical lecture layout. In the study, the classroom had a classical lecture layout whilst the computer laboratory had a U-shape plan layout. Circular sitting layouts are recommended for certain situations and, in interactive lectures, can diminish the sound levels of the class, providing an opportunity for small group conversations.

Additionally, participants were asked, in semi-structured interviews, to imagine their future classrooms. They expected quieter, technological spaces, and their ideal class layout would provide students with some private educational space. In that sense, future interactive classrooms could have design adaptations to create quiet private spaces for students for necessary situations. In that context, it is important to consider not only the spatial relationship of spaces but also the aural associations. With this study, the positive soundscape can be used as a criterion to understand aural requirements based on the subjective interpretations of participants in educational facilities.

4.4. Limitations and Future Work

One limitation of the study is the age difference of the students was quite similar due to their elective courses. It would be better to consider the perception of students of different ages. Second, the integration of psychoacoustic parameters (loudness, sharpness, roughness) into the subjective evaluation could give more of an understanding of the perceptual construct of students. However, the psychoacoustic parameters were not taken into the scope of the study. In addition, although the use of open-ended questions resulted in variety in the data, comparing these results to those of the semi-structured interviews created difficulty in controlling the data sets in the process of the study.

In further studies, real-time measurements and evaluations might be limited by the COVID-19 pandemic. In that context, we recommend that possible research methods for and studies of digital educational environments could be investigated and developed as a contribution to the literature. Educational facilities to study could include kindergartens, primary schools, and university classrooms, which would increase data and aid in understanding the educational soundscape needs of different grades. Moreover, the research could be conducted in areas that offer different types of lectures (such as music rooms, auditoriums, and painting classes) to represent the overall understanding of soundscapes in educational spaces. In addition, the findings were limited to local conditions. It is recommended to conduct a cross-cultural study to globalize the findings.

5. Conclusion

The researchers of this study aim to provide a comprehensive soundscape analysis in the high school environment that can be used to develop outcomes for designers. This research took place in two educational spaces, a classroom and a computer laboratory. We found that the auditory perception of students towards the acoustic environment does not only depend on the sound levels; responses towards sound sources and sound levels change according to the context of the space, such as the content of the lecture and the students' tasks. However, the physical properties of a sound wave have quite an effect on students` perception when they consider the perception of sound at different levels. Human-based sound sources were perceived with a neutral approach, although background speech was evaluated negatively in both spaces. If a sound source did not belong to the environment, the students perceived it negatively due to the distraction it produced. Generally, natural sound sources and low-level music were accepted and evaluated positively within the educational environment, and electro-mechanical sound sources and motorized transport sound sources were found to be unpreferable. Based on the findings, it can be concluded that the insertion of natural sound sources and low-level music as well as the elimination of electro-mechanical and motorized transport sound sources can be used as guidelines for soundscape development in educational spaces. It is necessary to provide students with acoustic comfort physically and psychologically to reinforce learning in educational spaces. The conceptual framework shows that a positive perception of soundscape promoted concentration, attention, focus, motivation, and mood in both spaces, and that the negative perception of soundscape resulted in annoyance and distraction as well as loss of concentration, motivation, productivity, and attention. This relates to the fact that an increase in the positive perception of a soundscape will boost learning ability and class performance, which are the main aims of educational spaces. We found that students developed coping methods to handle the negative soundscape, including habituation, adaptation, and isolation. In addition, the students reached some long-term results such as failure, loss of class performance, and interruption of activity. Therefore, we found that soundscape depends on not only sound sources but also on the physical and social context in which they are heard. Moving forward, we suggest potential locations for educational spaces, the creation of silent private areas, and the integration of controlled sound sources.

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Appendix

Dear Participant,

This study will be used in ‘A comparative study on soundscape in the high school environment’ titled master thesis in Bilkent University, Department of Interior Architecture and Environmental Design. The answers will be used only for academic purposes.
Thank you for your interest.

ACOUSTIC COMFORT AND SOUND PREFERENCE SURVEY

1	**Please answer demographic information.**					
Gender	Male ○	Female ○				
Age	13 ○	14 ○	15 ○	16 ○	17 ○	18 ○
Grade Point Average (GPA)	100-85 ○	84-70 ○	69-60 ○	59-50 ○	49-0 ○	

2	**Please answer the questions below according to your opinions.**
2.1.	**Please write the first three sounds that come into your mind when thinking the classroom environment/computer laboratory environment.**
2.2.	**Which sounds do you prefer to hear in your classroom environment/computer laboratory environment?**
2.3.	**Which sounds do you prefer not to hear in your classroom environment/ computer laboratory environment?**

3	Please evaluate the sound sources that are present in this classroom during the class.				
	Annoying -2	-1	Neither annoying nor Relaxing 0	1	Relaxing 2
Speech					
Laughter					
Footstep					
Sounds of adjacent spaces					
Corridor speech					
Traffic sound					
Siren/ ambulance sound					
Birds signing					
Ventilation sound					
Projector sound					
Alarm sound					
Phone ringing					
Clock sound					
Music sound					
Electrical installation					

3	Please evaluate the sound sources that are present in this computer laboratory during the class.				
	Annoying -2	-1	Neither annoying nor Relaxing 0	1	Relaxing 2
Speech					
Laughter					
Footstep					
Sounds of adjacent spaces					
Corridor speech					
Ventilation sound					
Keyboard/mouse sound					
Projector sound					
Computer fan sound					
Alarm sound					
Phone ringing					
Clock sound					
Music sound					
Electrical installation					

4	**Please complete the sentences by choosing the most suitable statement for you.**
4.1.	**The sound level in this classroom environment/computer laboratory environment is ....**
Very High	
High	
Neither High nor Low	
Low	
Very Low	
4.2.	**I feel ……. in terms of sound environment in this computer laboratory/classroom during the class.**
Very comfortable	
Comfortable	
Neither Comfortable nor Uncomfortable	
Uncomfortable	
Very Uncomfortable	
4.3.	**The sound levels in this classroom environment/computer laboratory environment have a (n) ……. effect on my class performance.**
Extremely Positive	
Positive	
Neither Positive nor Negative	
Negative	
Extremely Negative	

References

[1] Porteous JD, Mastin JF. Soundscape. J Archit Plann Res 1985;2:169–85.

[2] Schafer. The Soundscape: our sonic environment and the turning of the world. Rochester: Destiny Books; 1977.

[3] Uimonen H. Soundscape. J Acoust Ecol 2008;8.

[4] ISO. ISO 12913-1:2014(E) Acoustics - Soundscape - Part 1: Definition and conceptual framework. Geneve: Switzerland: 2014.

[5] ISO. ISO/TS 12913-2 Acoustics- Soundscape Part 2: Data collection and reporting requirements. 2018.

[6] ISO. ISO/TS 12913-3: 2019 Acoustics- Soundscape Part 3: Data analysis. 2019.

[7] Acun V, Yilmazer S. A grounded theory approach to investigate the perceived soundscape of open-plan o ffi ces. Appl Acoust 2018;131:28–37. https://doi.org/10.1016/j.apacoust.2017.09.018.

[8] Milo A. Reflecting on sonic environments through a structured questionnaire : Grounded theory analysis of situated interviews with musicians 2020. https://doi.org/10.1177/1351010X20911066.

[9] Mediastika CE, Sudarsono AS, Kristanto L, Tanuwidjaja G, Sunaryo RG, Damayanti R. Appraising the sonic environment of urban parks using the soundscape dimension of visually impaired people. Int J Urban Sci 2020;24:216–41. https://doi.org/10.1080/12265934.2020.1713863.

[10] Zhang X, Ba M, Kang J, Meng Q. Effect of soundscape dimensions on acoustic comfort in urban open public spaces. Appl Acoust 2018;133:73–81. https://doi.org/10.1016/j.apacoust.2017.11.024.

[11] Jeon JY, Hong JY, Lavandier C, Lafon J, Axelsson Ö, Hurtig M. A cross-national comparison in assessment of urban park soundscapes in France, Korea, and Sweden through laboratory experiments. Appl Acoust 2018;133:107–17. https://doi.org/10.1016/j.apacoust.2017.12.016.

[12] Liu F, Kang J. A grounded theory approach to the subjective understanding of urban soundscape in Sheffield. Cities 2016;50:28–39. https://doi.org/10.1016/j.cities.2015.08.002.

[13] Nilsson ME, Berglund B. Soundscape quality in suburban green areas and city parks. Acta Acust United with Acust 2006;92:903–11.

[14] Yang W, Kang J. Soundscape and sound preferences in urban squares: A case study in Sheffield. J Urban Des 2005;10:61–80. https://doi.org/10.1080/13574800500062395.

[15] Dokmeci PN, Kang J. Objective parameters for acoustic comfort in enclosed spaces. 20th Int Congr Acoust 2010, ICA 2010 - Inc Proc 2010 Annu Conf Aust Acoust Soc 2010;5:3488–91.

[16] Mohamed MAE, Dokmeci Yorukoglu PN. Indoor soundscape perception in residential spaces: A cross-cultural analysis in Ankara, Turkey. Build Acoust 2020;27:35–46. https://doi.org/10.1177/1351010X19885030.

[17] Torresin S, Albatici R, Aletta F, Babich F, Oberman T, Siboni S, et al. Indoor soundscape assessment: A principal components model of acoustic perception in residential buildings. Build Environ 2020;182:107152. https://doi.org/10.1016/j.buildenv.2020.107152.

[18] Okcu S, Ryherd EE, Zimring C, Samuels O. Soundscape evaluations in two critical healthcare settings with different designs. J Acoust Soc Am 2011;130:1348–58. https://doi.org/10.1121/1.3607418.

[19] Wang B, Kang J, Zhao W. Noise acceptance of acoustic sequences for indoor soundscape in transport hubs. J Acoust Soc Am 2020;147:206–17. https://doi.org/10.1121/10.0000567.

[20] Yilmazer S, Bora Z. Understanding the indoor soundscape in public transport spaces: A case study in Akköprü metro station, Ankara. Build Acoust 2017;24:325–39. https://doi.org/10.1177/1351010X17741742.

[21] Yilmazer S, Acun V. A grounded theory approach to assess indoor soundscape in historic religious spaces of Anatolian culture: A case study on Hacı Bayram Mosque. Build Acoust 2018;25:137–50. https://doi.org/10.1177/1351010X18763915.

[22] Zhang D, Zhang M, Liu D, Kang J. Soundscape evaluation in Han Chinese Buddhist temples. Appl Acoust 2016;111:188–97. https://doi.org/10.1016/j.apacoust.2016.04.020.

[23] Zhang S, Kang J. The Influence of Crowd Density on Evaluation of Soundscape in Typical Chinese Restaurant. INTER-NOISE NOISE-CON Congr. Conf. Proc., Institute of Noise Control Engineering; 2016, p. 155–60.

[24] Mediastika CE, Sudarsono AS, Kristanto L, Mediastika CE, Sudarsono AS, Kristanto L. Indonesian shopping malls : a soundscape appraisal by sighted and visually impaired people and visually impaired people. Archit Eng Des Manag 2020;0:1–20. https://doi.org/10.1080/17452007.2020.1833829.

[25] Hellström B, Sjösten P, Hultqvist A, Dyrssen C, Mossenmark S. Modelling the Shopping Soundscape. J Sonic Stud 2018;1.

[26] Yang T, Kang J. Subjective evaluation of sequential spaces. Appl Acoust 2020;161:107139. https://doi.org/10.1016/j.apacoust.2019.107139.

[27] Orhan C, Yilmazer S. Harmony of context and the built environment: Soundscapes in museum environments via GT. Appl Acoust 2021;173:107709. https://doi.org/10.1016/j.apacoust.2020.107709.

[28] Mackrill J, Cain R, Jennings P. Experiencing the hospital ward soundscape: Towards a model. J Environ Psychol 2013;36:1–8. https://doi.org/10.1016/j.jenvp.2013.06.004.

[29] Dökmeci PN, Kang J. A comparative case study of indoor soundscape approach on objective analyses and subjective evaluations of libraries. Proc Acoust 2012 2012:2171–7.

[30] Ma H, Shu S. An experimental study: The restorative effect of soundscape elements in a simulated open-plan office. Acta Acust United with Acust 2018;104:106–15. https://doi.org/10.3813/AAA.919150.

[31] Acun V, Yilmazer S. Understanding the indoor soundscape of study areas in terms of users' satisfaction, coping methods and perceptual dimensions. Noise Control Eng J 2018;66:66–75. https://doi.org/10.3397/1/37667.

[32] Shu S, Ma H. Restorative effects of classroom soundscapes on children's cognitive performance. Int J Environ Res Public Health 2019;16. https://doi.org/10.3390/ijerph16020293.

[33] Akbari E. Soundscape Compositions for Art Classrooms. Concordia University, 2014.

[34] Shin SB. Acoustic measurements based on a soundscape analysis in an open-plan classroom in a primary school. J Acoust Soc Am 2014;135.

[35] Flagg-Williams JB, Rubin RL, Aquino-Russell CE. Classroom soundscape. Educ Child Psychol 2011;28:89–99.

[36] Anderson K. The problem of classroom acoustics: The typical classroom soundscape is a barrier to learning. Semin Hear 2004;25:117–29. https://doi.org/10.1055/s-2004-828663.

[37] Lubman D, Sutherland LC. The role of soundscape in children's learning. J Acoust Soc Am 2002;112:2412–3. https://doi.org/10.1121/1.4779858.

[38] Chan Y-N, Choy Y-S, To W-M, Lai T-M. Influence of Classroom Soundscape on Learning Attitude. Int J Instr 2021;14:341–58.

[39] Tang SK. Speech related acoustical parameters in classrooms and their relationships. Appl Acoust 2008;69:1318–31. https://doi.org/10.1016/j.apacoust.2007.08.008.

[40] John J, Thampuran AL, Premlet B. Objective and subjective evaluation of acoustic comfort in classrooms: A comparative investigation of vernacular and modern school classroom in Kerala. Appl Acoust 2016;104:33–41. https://doi.org/10.1016/j.apacoust.2015.09.017.

[41] Tang SK, Yeung MH. Reverberation times and speech transmission indices in classrooms. J Sound Vib 2006;294:596–607. https://doi.org/10.1016/j.jsv.2005.11.027.

[42] Zannin PHT, Zwirtes DPZ. Evaluation of the acoustic performance of classrooms in public schools. Appl Acoust 2009;70:626–35. https://doi.org/10.1016/j.apacoust.2008.06.007.

[43] Bulunuz M, Güner F. Assessment of Noise Levels of Elementary Schools in France and Fransa ve Türkiye ' deki İlkokullarda Gürültü Düzeylerinin Değerlendirilmesi. Elem Educ Online 2019;18:777–87. https://doi.org/10.17051/ilkonline.2019.562053.

[44] Bulunuz N. Noise Pollution in Turkish Elementary Schools : Evaluation of Noise Pollution Awareness and Sensitivity Training. Int J Environ Sci Educ 2014;9:215–34. https://doi.org/10.12973/ijese.2014.212a.

[45] Polat S, Bulut Kırıkkaya E. Gürültünün eğitim-öğretim ortamına etkileri. XIII. Ulus.

Eğitim Bilim. Kurult., 2004, p. 1–12.

[46] Mackrill JB. Understanding and improving the perception of a hospital ward soundscape. Underst Improv Percept a Hosp Ward Soundscape 2013:N.PAG p-N.PAG p.

[47] Mealings KT, Demuth K, Buchholz JM, Dillon H. An assessment of open plan and enclosed classroom listening environments for young children: Part 2 - Teachers' questionnaires. J Educ Pediatr (Re)Habilitative Audiol 2015;1:1–19.

[48] Pääkkönen R, Vehviläinen T, Jokitulppo J, Niemi O, Nenonen S, Vinha J. Acoustics and new learning environment - A case study. Appl Acoust 2015;100:74–8. https://doi.org/10.1016/j.apacoust.2015.07.001.

[49] Park EL, Choi BK. Transformation of classroom spaces: traditional versus active learning classroom in colleges. High Educ 2014;68:749–71. https://doi.org/10.1007/s10734-014-9742-0.

[50] Çevresel gürültünün değerlendirilmesi ve yönetimi yönetmeliği [Regulation on assessment and management of environmental noise]. 2010. https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=14012&MevzuatTur=7&MevzuatTertip=5.

[51] Binaların Gürültüye Karşı Korunması Hakkında Yönetmelik [Regulation on Protection of Buildings Against Noise] n.d. https://www.resmigazete.gov.tr/eskiler/2017/05/20170531-7.htm.

[52] Erçakmak UB, Dökmeci Yörükoğlu PN. Comparing Turkish and European Noise Management and Soundscape Policies: A Proposal of Indoor Soundscape Integration to Architectural Design and Application. Acoustics 2019;1:847–65. https://doi.org/10.3390/acoustics1040051.

[53] TMMOB Makine Mühendisleri Odası İzmir Şubesi. Okullarda Akustik Konfor [Acoustic Comfort in Schools] 2015. http://www.iccevrekalitesi.net/pdf/3.pdf.

[54] The Turkish Statistical Institute. Statistic Data Portal n.d. https://data.tuik.gov.tr/Kategori/GetKategori?p=nufus-ve-demografi-109&dil=1 (accessed December 27, 2020).

[55] ANSI. American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools. Acoust., 2010.

[56] Acoustical Society of America. Classroom Acoustics 1. 2000.

[57] Houtgast T, Steeneken HJM, Ahnert W, Braida LD, Drullman R, Festen JM, et al. Past, present and future of the speech transmission index. 2002.

[58] Çankaya S, Yilmazer S. a Comparative Study on Soundscape in High School Environment 2016:141.

[59] Çankaya S, Yilmazer S. The effect of soundscape on the students' perception in the high school environment. Proc INTER-NOISE 2016 - 45th Int Congr Expo Noise Control Eng Towar a Quieter Futur 2016:4809–16.

[60] Boynton PM, Greenhalgh T. Selecting, designing, and developing your questionnaire. BMJ 2004;328:1312–5. https://doi.org/https://doi.org/10.1136/bmj.328.7451.1312.

[61] Bridgeman B. A Comparison of Quantitative Questions in Open-Ended and Multiple-Choice Formats. J Educ Meas 1992;29:253–71.

[62] IBM Corp. IBM SPSS Statistics for Windows, Version 20.0 2011.

[63] Strauss A, Corbin JM. Basics of qualitative research: Grounded theory procedures and techniques. Sage Publications, Inc.; 1990.

[64] Bruce NS, Davies WJ. The effects of expectation on the perception of soundscapes. Appl Acoust 2014;85:1–11. https://doi.org/10.1016/j.apacoust.2014.03.016.

[65] Dubois D, Guastavino C, Raimbault M. A cognitive approach to urban soundscapes: Using verbal data to access everyday life auditory categories. Acta Acust United with Acust 2006;92:865–74.

[66] Bridget S, Julie D. The effects of environmental and classroom noise on the academic attainments of primary school children. J Acoust Soc Am 2008;123.

[67] Vallet M, Karabiber Z. Some European policies regarding acoustical comfort in educational buildings. Noise Control Eng J 2002;50:58–62. https://doi.org/10.3397/1.2839678.

[68] Axelsson Ö, Nilsson ME, Berglund B. A principal components model of soundscape perception. J Acoust Soc Am 2010;128:2836–46. https://doi.org/10.1121/1.3493436.

[69] Zannin PHT, Marcon CR. Objective and subjective evaluation of the acoustic comfort in classrooms. Appl Ergon 2007;38:675–80. https://doi.org/10.1016/j.apergo.2006.10.001.

[70] Acun V. Investigating the effect of indoor soundscaping towards employees' mood and perception in open plan offices 2015.