To my lovely parents,

Halime and Serdal Çankaya

A COMPARATIVE STUDY ON SOUNDSCAPE
IN HIGH SCHOOL ENVIRONMENT

The Graduate School of Economics and Social Sciences

of

İhsan Doğramacı Bilkent University

by
SILA ÇANKAYA

In Partial Fulfillment of the Requirements for the Degree of
MASTER OF FINE ARTS

in

THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN
İHSAN DOĞRAMACI BİLKENT UNIVERSITY
ANKARA

July 2016

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

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ABSTRACT

A COMPARATIVE STUDY ON SOUNDSCAPE IN HIGH SCHOOL ENVIRONMENT

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MFA in Interior Architecture and Environmental Design

Supervisor: Assist. Prof. Dr. SemihaYılmazer
July 2016

The various factors of school environments have been investigated to affect individuals psychologically and physiologically. As one of this, sound has been studied through acoustic measurements focusing on noise management approach. To create positive acoustic environment, it is vital to reveal positive and restorative effects of sounds upon the people. This approach leads to the emergence of concept of 'soundscape'. Aim of the study is to examine the effect of soundscape on the students' perception and mood in high-school environment. This study compares classroom and computer laboratory in Bilkent High School, Ankara. The study includes two methods as objective measurements and subjective surveys. To understand the acoustic conditions of spaces, sound levels (L_{Aeq}), Reverberation Time (T30), Speech Transmission Index (STI) and Definition (D50) were measured. Questionnaire (n=125), PANAS test (n=125) and semi-structure interview (n=50) were conducted simultaneously. SPSS and Grounded Theory were used to evaluate the subjective results. Results showed that music and natural sound sources mostly preferred to electro-mechanical sounds. Moreover, students do not believe that sound levels have an effect on their class performance or comfort level. Only socio-demographic difference was found between temperature level and gender. It is observed that soundscape creates no effect on the students' mood. The several differences were found in perceived environment between classroom and computer laboratory. Results showed that the soundscape of a space could not be examined by objective measurements alone such as sound levels. On the other hand, established conceptual framework revealed eight categories. Generated patterns showed that soundscape depends on not only sound sources, but also the physical and social context in which they are heard.

Keywords: Auditory Perception, Conceptual Framework, High-school Environment, Mood, Soundscape

ÖZET

LİSE ÇEVRESİNDE İŞİTSEL PEYZAJ ÜZERİNE KARŞILAŞTIRMALI BİR ÇALIŞMA

Çankaya, Sıla
Yüksek Lisans, İç Mimarlık ve Çevre Tasarımı

Tez Yöneticisi: Yrd. Doç. Dr. Semiha Yılmazer
Temmuz 2016

Bireyleri okul çevrelerinde fiziksel ve psikolojik olarak etkileyen çeşitli faktörler araştırılmaktadır. Bunlardan biri olarak ses, akustik ölçümler aracılığıyla gürültü denetimi yaklaşımını odaklayarak çalışılmıştır. Pozitif akustik çevre yaratmak için, seslerin insanlar üzerindeki pozitif ve canlandırıcı etkilerini göstermek önemlidir. Bu yaklaşım 'işitsel peyzaj' kavramının doğmasına yol açmıştır. Bu araştırmanın amacı, lise çevrelerinde ses peyzajının öğrencilerin algısı ve ruh hali üzerindeki etkisini araştırmaktır. Bu araştırmada, Özel Bilkent Lisesi'nde bulunan sınıf ve bilgisayar laboratuarı çevresi karşılaştırılmıştır. Araştırma, objektif ölçümler ve subjektif araştırmalar olarak iki yöntemi içermektedir. Mekanların akustik durumlarını anlamak için, ses seviyeleri (L_{Aeq}), çınlama süresi (T30), Konuşma İletim İndeksi (STI) ve Ayırt Edilebilirlik (D50) ölçülmüştür. Anket (n=125), PANAS test (n=125) ve görüşmeler (n=50) eş zamanlı olarak yürütülmüştür. SPSS ve Köklenmiş Teori subjektif sonuçların değerlendirilmesinde kullanılmıştır. Sonuçlar, müzik ve doğal ses kaynaklarının elektronik-mekanik ses kaynaklarına göre çoğunlukla tercih edildiğinig östermiştir. Ayrıca, öğrenciler ses seviyesinin onların ders performansına ya da rahatlık seviyesine etkisi olduğuna inanmamaktadırlar. Tek sosyodemografik farklılık sıcaklık seviyesi ve cinsiyet arasında bulunmuştur. İşitsel peyzajın öğrencilerin ruh hali üzerinde etkisi olmadığı gözlemlenmiştir. Sınıf ve bilgisayar laboratuarında algılanan çevrede bir kaç faklılık bulunmuştur. Sonuçlar, bir mekanın işitsel peyzajının yalnızca ses seviyesi gibi objektif ölçümlerle değerlendirelemeyeceğini göstermiştir. Bunun yanı sıra, oluşturulan kavramsal sistem sekiz kategori ortaya çıkarmıştır. Ortaya çıkan bağlantılar, işitsel peyzajın sadece ses kaynaklarına değil, onların duyulduğu fiziksel ve sosyal bağlama da dayandığını göstermiştir.

Anahtar Kelimeler: Duyumsal Algı, İşitsel Peyzaj, Kavramsal Sistem, Lise Çevresi, Ruh Hali

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LIST OF ABBREVIATIONS

AI	Articulation Index
ALC	Active Learning Classroom
CLASS	Classroom
CS	Classroom Student
D50	Definition
dB	Decibel
GPA	Grade Point Average
GT	Grounded Theory
Hi-Fi	High Fidelity
ICU	Intensive Care Units
LAB	Computer Laboratory
L_{Aeq}	Equivalent Continuous A-weighted Sound Level
Lo-fi	Low Fidelity
LS	Computer Laboratory Student
N	Loudness
NA	Negative Affect
PA	Positive Affect
PANAS	Positive and Negative Affect Schedule
SNR	Signal-to-Noise Ratio
SPL	Sound Pressure Level
STI	Speech Transmission Index
T30	Reverberation Time
WSP	World Soundscape Project

CHAPTER 1

INTRODUCTION

Educational spaces have been mostly analyzed in terms of examining acoustical parameters or subjective evaluation of educational spaces has been conducted with the noise management approach in existing literature (John, Thampuran, & Premlet, 2016; Peng *et al.*, 2015; Tang, 2008; Xie, Kang, & Tompsett, 2011; Zannin & Marcon, 2007). However, soundscape approach bases on the people's perceptions of the acoustic environment more than analysis of acoustic parameters (Zhang, Zhang, Liu, & Kang, 2016). It is seen that there is a lack of understanding regarding the various factors influencing educational spaces in terms of soundscape approach.

It is important to ensure good acoustic conditions in educational spaces because good acoustic conditions result in deeper, more sustained and less stressful listening (Lubman & Sutherland, 2001). As anticipated in literature, the selection of correct acoustic parameters is important to analyze acoustical conditions of educational spaces. First of all, "speech intelligibility" is a critical parameter in educational spaces because it is the base of verbal communication as acoustically (Hodgson, 1994). Speech intelligibility is evaluated with the speech transmission index (Yeung, 2004). Moreover, reverberation time, background noise levels, and ambient noise levels have been studied frequently to understand the acoustic conditions of educational spaces in many studies (Hodgson, 1994; John *et al.*, 2016; Tang & Yeung, 2006; Zannin & Zwirtes, 2009).

In perceptual construct of soundscape studies, the study includes the analysis of identified types of sounds that is a better predictor than the equivalent sound-pressure level (Axelsson, Nilsson, & Berglund, 2010). Zhang *et al.* (2016) cited Kang (2007) as to reveal, "When the sound is lower than a certain sound level, the degree of acoustic comfort does not significantly change with an increase in the sound level".

Therefore, soundscape mostly depends on subjective responses of people such as identification of types of sounds, acoustic comfort and sound level evaluation. In addition to that, context is an important part in soundscape perception because it directly affects auditory sensation, interpretation of auditory sensation, and responses and outcomes of people towards acoustic environment (ISO, 2014). Moreover, the perception of people can change in terms of different cultural and social factors, as well as their living experiences (Yu & Kang, 2014). Apart from these factors, noise (or sound) is an effective factor on the children's mood (Lundquist, Kjellberg, & Holmberg, 2002).

The relationship between environment and individual can be constructed with the help of senses and aesthetics (Uimonen, 2008). The phenomena of perception depends on the working of five senses collectively and individually (Wallace, 2012). However, society generally focuses on visual sense over other sensorial modalities and the aural perception is ignored (Porteous & Mastin, 1985; Schafer, 1977). Related to this subject, "Schafer was worried about 'the dominance of eye culture' and 'the loss of the sonological competence' in modern societies" (p.2817) (Schulte-Fortkamp & Lercher, 2003). He aimed to improve the environment and to create a sonically better place by enhancing listening studies (Uimonen, 2008). This concern resulted in the emergence of the concept of 'soundscape'.

The mistake in sound studies is to substitute sound concept with noise approach after industrial revolution (Wallace, 2012) because industrial revolution initiated a variety of new sounds which have different quality and intensity from those of the past and tends to obscure past sounds (Schafer, 1977). Therefore, the research studies start to focus changing acoustic environment and its new sounds. However, it is necessary to study all the sounds of the environment because it provides a base not only to create a more holistic approach in acoustic studies but also to reveal positive and restorative effects of sounds upon the people as well as detrimental effects.

Soundscape approach has been widely studied in large rural or urban areas (Kang & Yang, 2005) because it emerged as aural equivalent of 'landscape' (Schafer, 1977).

However, it is realized that soundscape is also an important phenomena to understand the way people respond towards the indoor acoustic environment. When considering indoor soundscape as a new research area, there are limited number of studies which are conducted in indoor research area such as hospitals (Mackrill, 2013; Okcu, Ryherd, Zimring, & Samuels, 2011), libraries (Dökmeci & Kang, 2012), metro-stations (Bora, 2014) and open-plan offices (Acun, 2015). In addition to that, educational spaces have not been investigated in terms of soundscape approach although they are important spaces in which children up to 18 years old spend most of their times and develop their characters.

To conclude, the presence of comfortable acoustic environment provides the students good listening; thus improvement of the efficiency of communication, concentration, and scholar achievement. It is important to understand the effect of soundscape on the students' perception and mood in educational spaces. To achieve that, the present study includes the measurement of objective parameters and the evaluation of subjective survey; and their correlations in two educational spaces as classroom and computer laboratory.

1.1 Aim and Scope

As indicated before, the sound research in educational spaces generally focus either acoustic analysis of school environments or environmental noise management approach. However, the current gap in knowledge indicates the need to evaluate educational spaces with soundscape approach integrating data sources and methods (Figure 1). The contribution of the study is to present the soundscape of educational spaces as a case study example and create a comprehensive understanding through soundscape of educational spaces. As shown in the proposed conceptual framework, it is intended to integrate data sources and show all relationships between revealed patterns and themes for educational spaces.

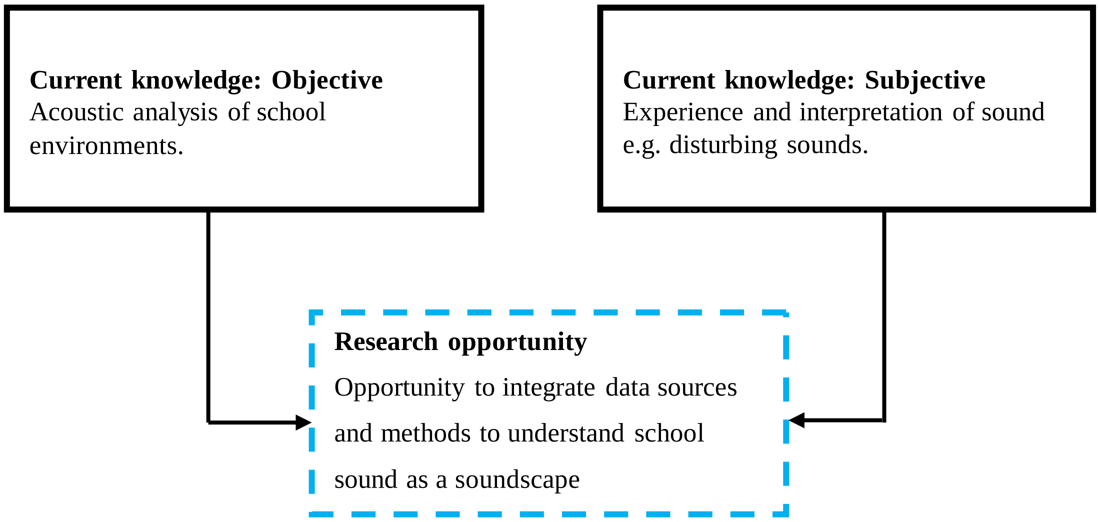


Figure 1: The current gap in knowledge regarding the school environment soundscape (Adapted from Mackrill (2013))

This study explores the effects of soundscape on students' perception and mood in high-school environment. Aims of the study are to understand the role of sound within the high school environment, to examine the acoustic comfort and sound preferences of students, and to explore what are the positive, negative feelings that soundscapes can evoke. It also intends to contribute literature as a case study example on soundscape approach. Moreover, this study purposes to create a conceptual soundscape framework in high school acoustic environment. Other objective of the study is to correlate the relation between acoustic environment (objective results) and interpretation of auditory sensation (subjective evaluation of students). In addition to that, this study aims to compare two educational spaces whether there is a different understanding in term of soundscape approach.

In order to achieve these aims; two methods were applied as objective measurements and subjective survey. Whilst objective measurements present the acoustical conditions of selected educational spaces, subjective survey aims to understand the perceptual construct of students towards soundscape. Continuous A-weighted sound levels (L_{Aeq}), reverberation time (T30) and Speech Transmission Index (STI) were selected and evaluated as objective parameters of high-school environment. On the other hand, semi-structure interviews, questionnaire and PANAS test constituted perceptual analysis of students towards high-school acoustic environment. Variety of subjective survey methods aims to understand the general approach of students with questionnaire and PANAS test; and to explore the background of their reasons; relations and patterns with the semi-structure interview. The comparisons between these methods as objective and subjective or between instruments as semi-structure interviews and statistical tests, or between spaces as classroom and computer laboratory create the detailed information about the soundscape of educational spaces.

1.2. Structure of the study

The thesis consists of six chapters. First chapter is Introduction, which gives the background information about the soundscape understanding, the importance and contribution of the study. Aims of the study is briefly explained and finalized with the structure of thesis.

Second chapter provides Literature Review on soundscape study. It includes the detailed information about the concept of soundscape as history and definition of soundscape, the differences of soundscape approach from previous methods, important elements in soundscape approach. Moreover, it gives information about soundscape assessment approaches that are the objective parameters of acoustic environment and subjective survey methods. Lastly, it informs about previous studies regarding soundscape to understand the literature findings. It is concluded with the information about educational spaces in terms of acoustical factors and psychological factors.

Third chapter is Method, which gives information about the methodological process of the study. Firstly, aims of the study, research questions and hypotheses are stated. It continues with the explanation of the study setting, sample, and methods. The methods include two steps, as objective measurement and subjective survey. This chapter gives the detailed information why and how selected research methods are applied.

Results part is the fourth chapter of the thesis. It consists of two titles as objective results and subjective results. Objective results give the results of measurement of acoustical parameters in selected educational spaces. Subjective results include the information about the statistical analysis from questionnaire and PANAS test results and conceptual framework from semi-structure interview results.

Following Results, Discussion chapter is given. This chapter compares the results of the study with the previous studies in literature and shows the important conclusions to understand the soundscape of educational spaces. The results are discussed in terms of objective and subjective differences in classroom and computer laboratory environment.

Last section is Conclusion, which gives the closing deductions depends on the results of the study and summarizes whole research. Limitations of the study and recommendations of future research are given; and the study is finalized.

CHAPTER 2

LITERATURE REVIEW

2.1. Educational Buildings

Dokmeci and Kang (2010) distinguished indoor acoustic environment as civil, public, private and commercial (Figure 2).Among these spaces, acoustical conditions in educational spaces have always been a worldwide issue because children spend most of their times in educational spaces. Children especially aged below 17 takes the main educational base and forms their characters in these spaces (Tang, 2008). It is vital to ensure good acoustical conditions, which provides the efficiency of learning environment and the efficiency of communication (Karabiber & Vallet, 2003; Lubman & Sutherland, 2001).

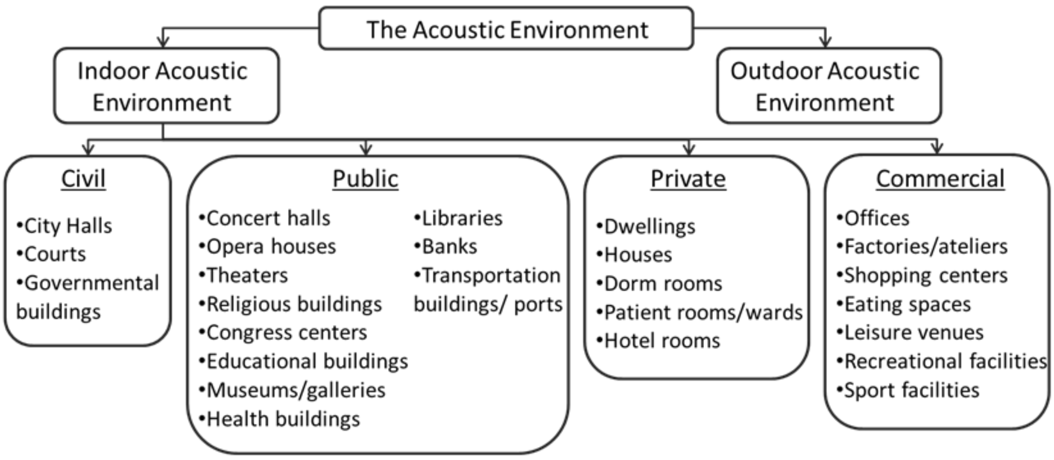


Figure 2: Classification of architectural spaces (Adapted from Dokmeci and Kang, 2010)

Listening is an ability which can be evaluated as a duty of student (Hagen, Huber, & Kahlert, 2002) because it is one of the psychological functions that defines the perception of people towards environment (Liu & Kang, 2016). 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.

However, schools have not been studied in terms of the soundscape approach. To explore the understanding of school environment and increase case study examples, it is necessary to analyze the school environment in the light of soundscape approach. Previous studies give broad explanation of understanding for environmental noise management approach. Nonetheless, it is important to understand the acoustical requirements to ensure good conditions in school environment and to benefit from the findings of earlier studies before analyzing the school environment from the soundscape approach.

2.1.1. Background Information of Educational Spaces

The design of educational spaces is accepted as one of the leading factors that affect students' learning. The environment defines the habits, beliefs and values of people; and encourages theirphysical, mental and social development (Shmis, Kotnik, & Ustinova, 2014). To create a better understanding between complexity of human psychology and the environmental factors; the cognitive science approach gave importance to the role of classroom design on students' teaching (Park & Choi, 2014).

Educational spaces give information about the educational history of teaching and learning. According to Park& Choi (2014), education shifted from elitism to massification after industrial period (Figure 3). In ancient Greece, education was rhetorical; and students were sitting around their teachers without any order. Later, students in cathedral schools arranged as two lines facing each other in one desk. However, when larger spaces were needed, desks were arranged as five linear rows and desks, and teacher was standing at the front of center, which is quite similar to today's classrooms. Lastly, classrooms expanded their space and reached much number of students after industrial period.

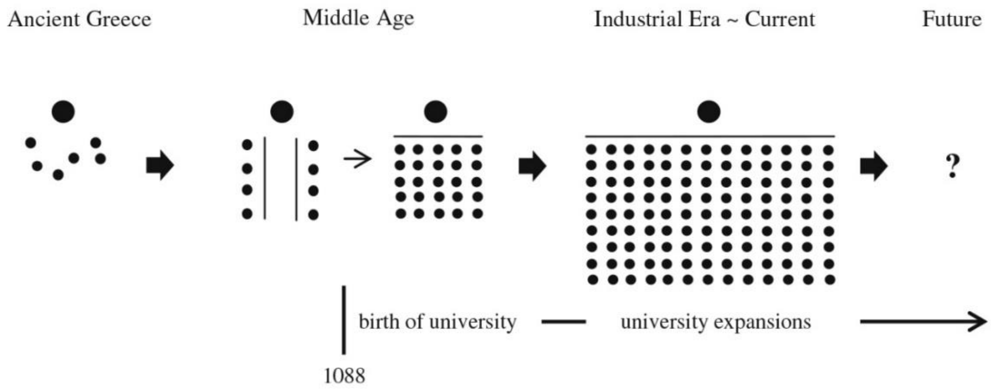


Figure 3: Transition of classroom layout (Park & Choi, 2014)

Future classrooms are expected to be more technological, interactive, participatory and mobile (Pääkkönen *et al.*, 2015). Related to that, new educational spaces are thought to have classroom designs with more technological development such as projectors, computers and projection screens, granting opportunities for group discussion, cooperative learning activities (Park & Choi, 2014). New forms of pedagogy and learning spaces results in the need to be more practical in designing educational spaces (Pääkkönen *et al.*, 2015). To achieve that kind of design, Active Learning Classrooms (ALC) were developed in the University of Minnesota and "The ALCs include large round tables that seat nine students each, laptop connections, multiple fixed flat-panel display, and an instructor station that allows for the selection and display of specific information" (p.752) (Park & Choi, 2014).

The proposed ALC layout as a futuristic offering is shown in Figure 4. There is limited number of applied examples of these type of classrooms. Moreover, the changes in educational spaces result in the changes in their acoustic evaluation. However, the following section will introduce the acoustical analysis over the regular classroom that is still the current teaching layout in Turkey.

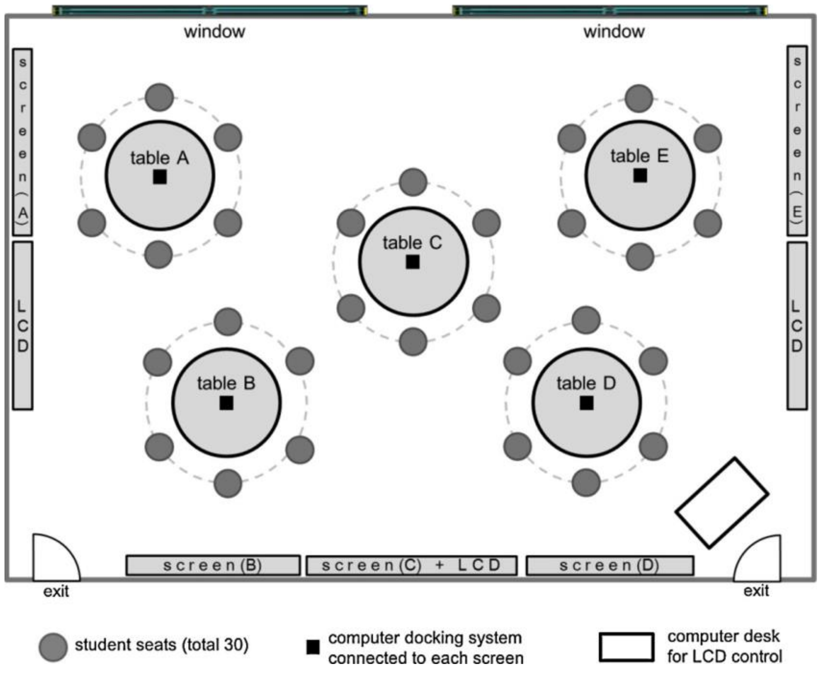


Figure 4: The example of ALC layout (Park & Choi, 2014)

2.1.2. Acoustical Factors

High sound levels make students exhausted and leads to waste their cognitive abilities, which results loss of attention and distraction from the content of the class (Hagen *et al.*, 2002). Acoustical parameters associated with sound levels are highly important to understand the presented acoustic environment because it is known that long-time noise exposure results in the loss of concentration and general cognitive functioning especially reading skills and affects performance of student (Xie *et al.*, 2011). Therefore, standards, regulations and national requirements were formed to handle with noise in different countries for school environment (Table 1).Ensuring appropriate noise level is highly important in school design because noise level above 55 dB brings about the loss of listeners’ attention (Zannin & Marcon, 2007).

Table 1: Background noise limit according to different countries for classroom environment (Vallet and Karabiber (2002))

Country	Year of definition	Background Noise Limit
Belgium	1987	35-45
France	1995	38
Germany	1983	35-40
Italy	1975	36
Portugal	2000	35
United Kingdom	1997	40
Sweden	2001	40
Brazil	1987	35-45
USA	2002	35-45
India	2007	40-45
Turkey	1986	45

To provide good acoustic quality in classrooms, it is important to ensure required reverberation time as well as background noise (John *et al.*, 2016). Reverberation time affects the children's verbal communication and learning skill(Peng *et al.*, 2015). Related to that, speech is an outstanding sound source for educational spaces because more than 60% of classroom activities is based on the speech between teachers and students or between students(John *et al.*, 2016). Human speech is an important sound source in classroom environment and speech interference is base of the noise policies due to its significant effect on the learning process(Vallet & Karabiber, 2002).First, speech intelligibility is affected by background noise (Tang, 2008)and also reverberation time because high reverberation time results in the increase of background noise and subsequently the decrease of speech intelligibility in classrooms(Peng *et al.*, 2015). Acoustic requirements for reverberation time and speech transmission index were standardized in different countries. Table 2 shows the reverberation time limits according to the national standards for different countries. Speech transmission index (STI) is accepted as universal descriptor to evaluate speech intelligibility level of classrooms. In addition to that, Values of Definition (D50) should be higher than 0.5 to provide good speech intelligibility in educational spaces.

Table 2: Reverberation time limits in different countries for classroom environment(Adapted from John *et al.* (2016))

Country	Reverberation Time (for 500- 1000 – 2000 Hz)	Volume (cubic meter)
Brazil	0.5 – 0.7	$270 \leq V \leq 600$
France	0.4 – 0.8	$V \leq 250$
	0.6 – 1.2	$V \geq 250$
Germany	0.6-1.0	$250 \leq V \leq 750$
USA	0.6	$V \leq 283$
	0.7	$283 \leq V \leq 566$
India	0.75 – 1.2	-

2.1.3. Psychological Factors

Psychologists defined three components to describe human learning as; cognition, motivation, and emotion (Meyer & Turner, 2002). The term cognition refers to "mental processes for gaining knowledge and understanding, which includes thinking, knowing, remembering, judging, problem solving, reasoning, comprehension and production of language and attention" (p.6) (Kocaoğlu, 2015). Therefore, cognition also includes the processes, which are needed to perceive the environment. Motivation refers to an internal condition that prompts the individual's emotional state, opinions and actions to act (Lahey, 2000). Emotion is "a complex set of interrelated sub-events concerned with a specific object" (Ekkekakis, 2012). Therefore, emotions includes actions, movements, and events such as facial expression, posture, gesture, specific behaviors, and conversation (Ekman, 1994).

Mood is also an important component for human learning due to the its effect on cognition(Russell & Snodgrass, 1987). In addition, mood has an effect on the person's memory, thinking and imagination (Izard, 1977). Mood refers to the person's core feelings in a subjective state at any given moment(Russell & Snodgrass, 1987). Mood and emotion are generally complicated. They are similar terms, but they do not refer same meaning. Mood and emotion differ each other into two key aspects. Firstly, duration time of mood lasts longer than emotion(Ekman, 1994). Secondly, mood is diffuse and continues to act in a lower intensity level when compared to the emotions (Frijda, 2009). Emotions are exemplified as surprise, fear, anger, and shame whilst moods are generally labelled as feeling ‘good’ and ‘bad’ (Ekkekakis, 2012).

Mood can be separated as positive or negative (Barone, 2000). Positive mood is seen in a state having optimistic and confident feelings, while negative mood evokes the feelings of anxiety, depression and fatigue (Febrilia & Warokka, 2011). Moreover, “in studies of the impact of mood, positive mood has shown a facilitating impact on memory, learning, and behavior, whereas negative affect has a depressing impact” (Febrilia & Warokka, 2011).

Sound evokes the emotions in the listener as negative and positive feelings(Hagman, 2010). Moreover, “the auditory system is not only a main channel for emotion induction, but is, more broadly, one of the main receptors for information about our surrounding” (p.10) (Hagman, 2010). Therefore, the effect of sound can be interrepted as an important element to construct cognitional perception. Studies focused the perception of acoustic environment with an environmental noise management approach. Therefore, questionnaires were generally including the subjective evaluation of acoustical parameters (level of sound i.e. L_{Aeq}, SPL or RT), acoustic comfort (level of satisfaction) and the effects of noise (annoyance, distraction, loss of concentration, anxiety, loss of school performance etc.). The effects of soundscape on students’ perception towards acoustic environment should be explored and correlated in terms of human learning elements (cognition, motivation, emotion) and mood in educational spaces.

2.2. History and Definition of Soundscape

A Canadian musician R. Murray Schafer firstly introduced soundscape as a term after working several years on sound studies. He was interested in relationships between the ear, human beings and acoustic environment (Schafer, 1977).In the late 1960s; Schafer was living in Vancouver, Canada and he was in a public movement to protest the noise pollution in city (Uimonen, 2008). To create the awareness, he informed students and citizens about noise pollution by giving several lectures(Hiramatsu, 2004). In addition, he established a project as World Soundscape Project (WSP) in Simon Fraser University (Truax, 2014) and the project was covering many disciplines as art, music, acoustics, social sciences, psychology, environmental health and city design(Westerkamp, Woog, Kallmann, & Truax, 2006) to combine artistic and scientific perspectives(Porteous, 1982). Schafer (1977) explained the contribution of integrating different disciplines into the sound studies as,

> The home territory of soundscape studies will be the middle ground between science, society and the arts. From acoustics and psychoacoustics, we will learn about the physical properties of sound and the way sound is interpreted by the human brain. From society, we will learn how man behaves with sounds and how sounds affect and change his behavior. From the arts, particularly music, we will learn how man creates ideal soundscapes for that other life, the life of the imagination and psychic reflection. From these studies, we will begin to lay the foundations of a new interdiscipline - acoustic design (p: 4).

Related to that, the aim of WSP was to improve the acoustic environment or soundscape in social, psychological and aesthetic ways (Truax, 1984) and to establish soundscape research area as an alternative to noise pollution(Westerkamp, 1991). The research group of WSP also conducted and published many studies as *The Vancouver Soundscape* and *Soundscapes of Canada* to understand national sonic environment of Canada, *Five Villages Soundscapes* to examine international sonic environment. As one of the important researchers in WSP group, Truax (1984) published *the Handbook for Acoustic Ecology* to give a detailed terminological dictionary for acoustic and soundscape research (Truax, 2014).

Soundscape approach firstly existed with the attempts to evaluate ‘noise’ and its effects (Schulte-Fortkamp, 2010). Following to that, soundscape approach was expanded something broader. It explores sound and noise in a holistic approach and includes how sound or noise behaves. They are perceived within its context, meaning and complexity (Brooks, Schulte-Fortkamp, Voigt, & Case, 2014) and it is accepted as the sonic part of quality of life with positive and negative sides (Liu & Kang, 2016; Schulte-Fortkamp & Fiebig, 2006). After gaining great importance in the field of acoustics, ISO (2014) proposed a broad international definition: “acoustic environment as perceived or experienced and/or understood by a person or people, in context”. Therefore, it means that soundscape examines how the individual or society perceive and understand acoustic environment through listening (Truax, 1984).

- **Typology of Soundscape**

Schafer (1977) examined features of soundscape into the three subtitles; keynote sounds, signals and soundmarks. He categorized the sounds to show each one’s individuality or domination. Keynote is a term that comes from the music term key or tonality of the particular composition. It enables the fundamental tone that maintains and promotes each piece of composition. Considering the figure-ground relationship in architecture, keynote sounds refer to the ground to the ambient sounds, hence it can be accepted as a background sound. They are heard and perceived continuously without needing any consciousness (Porteous & Mastin, 1985; Schafer, 1977; Truax, 1984). For example, keynote sounds of a landscape can be exemplified as sounds of water, wind, forest and birds (Schafer, 1977). Whilst keynote sounds are defined as background sounds, two other terms refers to the foreground sounds as being accepted as figure. Signals are the sounds, which comprise the acoustic warning devices as bells, whistles, horns and sirens. Signals are listened consciously and distinctive from the other sounds around. Lastly, soundmarks refers to the community sounds that can be understood or described by the people in related community. Soundmarks makes the acoustic environment of community unique (Schafer, 1977).

- **Soundmarks**

Sound sources are “the sounds generated by nature or human activity” (ISO, 2014). Sound source identification is an important step to initiate the soundscape study and many soundscape studies include the information about presence and nature of sound sources and its relation with human values in particular spaces. Brown, Kang, and Gjestland (2011) classified all sound sources in any acoustic environment and they created a common framework to provide sound source identification to the researchers. This provides to compare sound sources across places, and to diminish the different labels, value judgments and definitions across different studies. Figure 5 shows the possible sound sources in terms of the taxonomy of the acoustic environment. It includes two parts as indoor and outdoor environment and within the outdoor environment: urban, rural, wilderness and underwater. The categorization was designed to be universal in application although it got data mostly from studies of urban soundscapes. However, there were some overlaps, recordings and replays between categories. For example, domesticated animal sounds can be originated from animals related with a human activity.

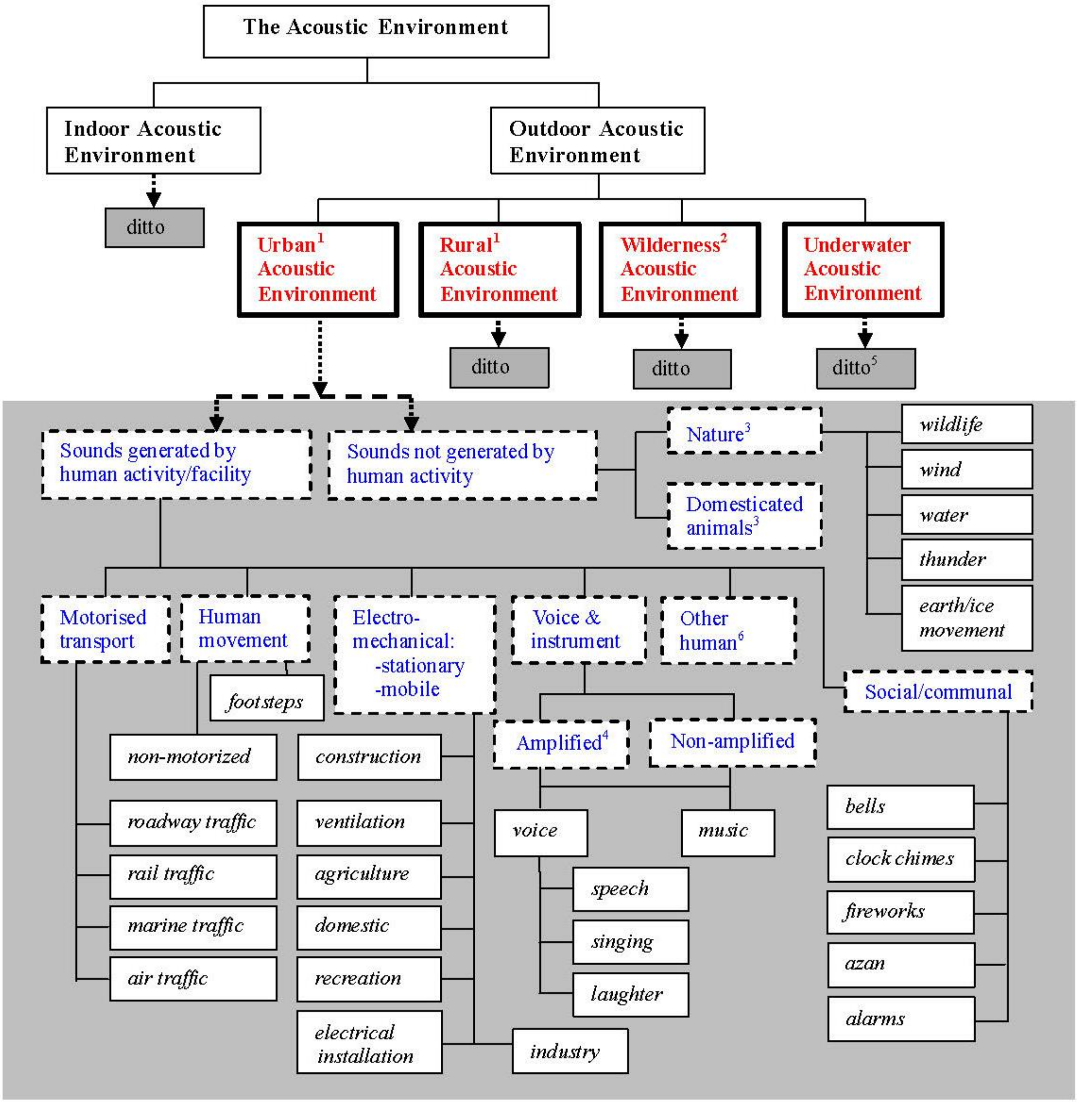


Figure 5: Taxonomy of sound sources according to different places (Brown *et al.*, 2011)

- **Differences between Environmental Noise Management Approach and Soundscape Approach**

Whilst Schafer (1977) explored the relationship between human and sonic environment, Truax (1984) extended this study to give the importance on the relationships between soundscape and noise research in his book, *Acoustic Communication*. According to the Truax (1984), acoustic environment is analyzed with integration of two approaches as the traditional, objective energy-based model of the acoustic environment (environmental noise management approach) and the subjective listener-centered model (soundscape approach). Brown (2010) explained the difference between these approaches (Table 3). First, sound is perceived as a waste in environmental noise management and as a resource in soundscape approach. Moreover, environmental noise management deals with the sounds of discomfort whilst soundscape approach takes sounds of preference. However, major difference between these two approaches is the way in which they deal with sound. Whilst environmental noise management approach concerns sound as a transfer of energy, soundscape approach takes it as a way of acoustical communication of individual (Truax, 1984). Differences between these approaches are not about sound sources or sound levels, but about the human outcomes through the sound sources (Brown *et al.*, 2011).

Table 3: Comparison of Environmental noise management and Soundscape approaches (Brown, 2010)

Environmental Noise Management Approach	**Soundscape Approach**
Sound managed as a waste	Sound perceived as a resource
Focus is on sounds of discomfort	Focus is on the sounds of the preference

Moreover, environmental noise management and soundscape have different approaches to evaluate the sonic data. Brown (2011) indicated the differences of these approaches by explaining the factors; sound level, wanted and unwanted sounds and their sound management methods (Table 4).

Table 4: Differences between Environmental noise management approach and Soundscape approaches (Brown, 2011)

Environmental Noise Management Approach	**Soundscape Approach**
Human response related to level of sound	Preference often unrelated to level
Measures by integrating across all sound sources	Requires differentiation between sound sources: *wanted sound* from *unwanted sound*
Manages by reducing level	Manages by *wanted sounds* masking *unwanted sounds*

2.3. Important elements in soundscape evaluation

- **Sound Level Evaluation**

According to Brown (2011), environmental noise management exists through physical descriptions of acoustics as level, frequency etc. Therefore, level of sound is generally related with human responses in environmental noise management approach. On the other hand; in soundscape approach, it is believed that sound quality of an environment cannot be evaluated by physical descriptions only (Brown, 2011). Sound levels are still measured to understand and evaluate the objective component of the sound, but it should be noted that two different sounds with same level could result in the different perceptions in the listener (Rey Gozalo, Trujillo Carmona, Barrigón Morillas, Vílchez-Gómez, & Gómez Escobar, 2015). Hence, sound quality of the environment was not evaluated by only sound level without thinking other factors like physical space (Hignett & Lu, 2010). “Matters such as context, the information in the sound, and individual attitudes and expectations, all play an important role in judgments of outdoor sound quality, either more important than level of sound, or even to the exclusion of level” (Brown, 2011). Davies (2009) explained that understanding the soundscape depends on the identification of the sounds, importance of the sounds and conceivably the proportion of certain sound sorts to other sound sorts inside the soundscape.

- **Wanted and unwanted sounds**

The sounds of preference or wanted sounds rely on the contexts of place, time, activity and person (Herranz-Pascual, Aspuru, & García, 2010). It can vary between person to person in terms of their ages, social status, and religion. In spite of these differences, sounds are discriminated as wanted and unwanted sounds in many contexts (Brown, 2011). Recently, the studies into 'what noise annoys you' shifted their perspectives into to the studies 'what sounds do you enjoy' or 'what sounds do you prefer' (Brown, 2011). Although the area is accepted as a new research field, it started to give some preference results. Natural sounds, especially of water, evoke positive feelings on people (Carles, Barrio, & Lucio, 1999; Nilsson & Berglund, 2006). Other natural sounds such as birds singing, sounds of animals and the sounds of wind in trees are also highly preferred as indicated in literature (Brown, 2011; Yang & Kang, 2005). Moreover, people prefer to hear the sounds made by humans such as voices, laughter, footsteps over the sounds generated by humans such as vehicles, machinery, ventilators (Brown, 2011). Therefore, soundscape studies can be assessed in terms of distinguishing between different sound sources; mechanical sounds from natural sources, human voices and footsteps from the sounds of transport, hence the unwanted sounds from wanted sound sources. However, environmental noise management approach evaluates the sounds holistically, generally independent of source (Brown, 2011). To achieve high acoustic quality in the environment, the differentiation of wanted or unwanted sounds in particular context is important as well as the levels of sounds (Brown, 2006).

- **Masking**

The differentiation of wanted or unwanted sounds is the results of the people's preferences towards an environment (Brown, 2011). To achieve better acoustical conditions in an environment, unwanted sounds should mask wanted sounds in soundscape planning. Masking is gained either wanted sounds are not masked by unwanted sounds or wanted sounds masking unwanted sounds (Brown, 2011). In soundscape approach, it is necessary to understand the identification of sounds and their related information with content. Measurement and management process of sounds in environmental noise management approach depend on the control of acoustical parameters such as decreasing the sound levels; but soundscape approach attempts to reach the masking unwanted sounds by wanted sounds (Brown, 2011).

- **The context of sound**

Soundscape study is composed of a system of relationships between behavior of sound, the listener and the environment. The listener can be the receiver as well as the sound maker (Truax, 1984). The context is an important part of sound studies to change the perception of individual or society because 'a sound means something partly because of what produces it, but mainly because of the circumstances under which it is heard' (Truax, 1984). Context in soundscape assessment includes as following (Brown *et al.*, 2011);

> -Place/location including the landscape, built form, and other aspects of the setting.
> -Dimensions of the physical environment including factors such as wind, temperature, lighting, traffic.
> -Personal activity in the place and the activities of others in the place.
> -Dimensions of the social environment including neighborhood/area characteristics and societal norms with respect to place, activity and behavior.
> -Personal dimensions as chronic exposure to sound at home or work and expectations of a place (p.389).

Schafer (1978) indicated that the general acoustic environment of a place can give clues about the social conditions of society because the sound perception of listener depends on both socio-cultural background and the psychological dimension (Schulte-Fortkamp, 2010).

- **Outcomes in terms of preferences of sound**

According to the Brown *et al.* (2011), soundscape studies revealed important specifications as the outcomes of assessment and the role of context. Although the soundscape studies assess the relationship between humans and the acoustic environment, researches have generally focused on the subjects which are soundscape quality, human preference or human acoustic comfort (Kang, 2007). The outcomes related to these subjects differed in terms of the different acoustic environment and its related context (Brown *et al.*, 2011). Table 5 shows potential direct outcomes according to the space. For example, whilst a place can be preferred due to its sense of relaxation; i.e. urban parks; another place can be preferred due to its sense of happiness. Moreover, “preference may be for a soundscape that provides information, clarity, and conveys safety. In yet another place or context, preference for a soundscape may relate to its unique cultural or natural characteristics” (p.388) (Brown *et al.*, 2011).

Table 5: Different outcomes that determines soundscape preference in different places (Brown et al., 2011)

Acceptability	Identification of place	Relaxation
Appropriateness	Importance	Safety
Clarity	Information	Satisfaction
Comfort	Liveliness	Sense of control
Communication	Naturalness	Solitude
Enjoyment	Nature appreciation	Tranquility
Excitement	Nostalgic attachment	Uniqueness
Happiness	Peacefulness	Variety
Harmony	Place attachment	Well-being

- **Lo-fi & Hi-fi**

With the Industrial and Electric revolutions, transition from rural to urban life brought about the changes of acoustic environment. Schafer (1977) explained this transition in acoustic environment with two terms as hi-fi (high fidelity) and lo-fi (low fidelity). He defined the pre-industrial period as having the hi-fi soundscape in which one can hear easily discrete sounds due to the low ambient noise level because hi-fi system provides a favorable signal-to-noise ratio, so the sounds can be differentiated easily. On the other hand, lo-fi soundscape refers to the post-industrial period which individual acoustic signals were masked with the density of different sounds. The lo-fi soundscape is a kind of sound congestion. Whilst there is a perspective between foreground and background sounds in hi-fi soundscape, there is a loss of perspective in lo-fi soundscape. Today, one of the world's biggest problems is the suffering from the overpopulation of sounds and the loss of acoustic information due to the lack of clarity. To sum up, hi-fi soundscape exists in the country more than the city, in the night more than the day, and in the ancient times more than the modern (Schafer, 1977).

- **Conceptual Framework**

The process of understanding or perceiving the acoustic environment includes the interrelationships between person, activity and place. In ISO standards established in 2014, a conceptual soundscape framework was demonstrated to explain their correlations within each other. Seven concepts and their relationships were defined: context, sound sources, acoustic environment, auditory sensation, interpretation of auditory sensation, responses and outcomes. Figure 6 shows the conceptual framework in soundscape studies. Sound sources distribute space and time, and the perceived sound differs with the acoustic environment conditions. After detecting and understanding the sound in auditory sensation phase, the brain starts to create useful information towards the acoustic environment in interpretation of auditory sensation phase. Lastly, short-term and long-term responses (outcomes) are created. For example, a bazaar can be a good example to explain this process. In district bazaar, there are some specific sound sources such as speech, roadway traffic, laughter. Some sound sources are dominant among others, i.e. someone who yells to sell his staff. The brain starts to understand the area and create information. As a result, person feels annoyance because of the high sound levels or feels energetic due to the interactive atmosphere of the bazaar. Maybe, next week he/she wants to go there again as a long-term consequence.

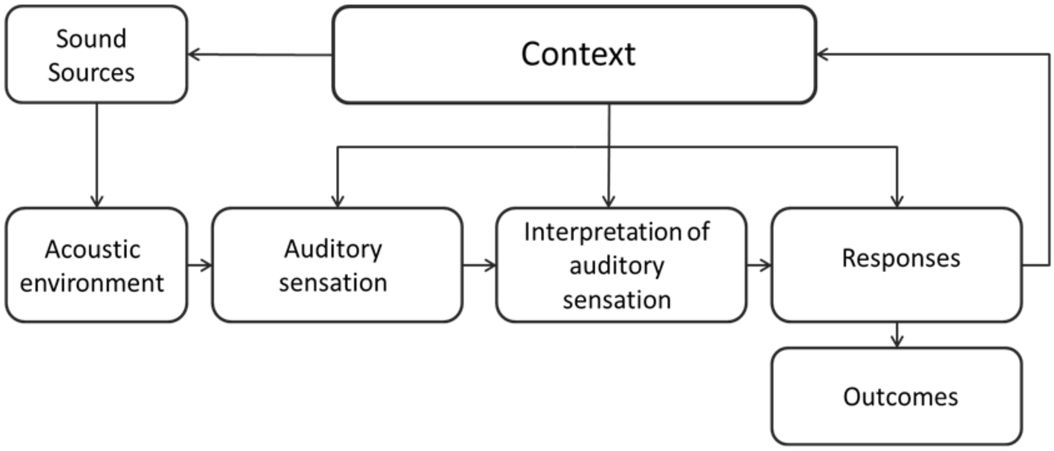


Figure 6: Elements in the perceptual establishment of soundscape (ISO, 2014)

2.4. Acoustic environment assessment approaches

According to theRey Gozalo *et al.* (2015), the acoustic environment is assessed with three approaches as physical, psychophysical and perceptual. The physical approach includes the objective evaluation of the acoustic environment. For example, measuring with the reference values such as sound levels (Rey Gozalo *et al.*, 2015). Noise maps, guidelines, international regulations are formed due to the objective evaluation of sound studies. The psychophysical approach analyzes the relationship between the acoustic environment and sound perception of people. It generally focuses on the physical magnitudes related with sound and people's responses. For example, people can get annoyed with high sound level in a place. Psycho-acoustic parameters such as loudness, sharpness, roughness, fluctuation strength and modulation (Waye & Öhrström, 2002)are evaluated under this title. The perceptual approach is used to define and understand the bases of psychological process of people when they evaluate the sound.

To examine the impacts of sounds on people, it is important to know that the process is based on more a subjective evaluation of people's perception rather than an objective evaluation of sound parameters(Kang, 2002, 2007; Kang & Zhang, 2009; Liu & Kang, 2016; Yang & Kang, 2005). However, to examine the soundscape of an acoustic environment, it is generally recommended to use both approaches together.

This following section will describe the objective parameters and subjective evaluation methods for soundscape study to give a general information. The psychophysical approach; or more specifically psychoacoustic parameters; will not be explained due to the out of scope of this thesis. As objective parameters, Sound Pressure Level (SPL), Equivalently Continuous Sound Level (L_{Aeq}), Reverberation Time and Speech Transmission Index (STI) will be defined. In the subjective evaluation method section, sound preference test, semantic differential scales, noise annoyance surveys, soundwalk method, and Grounded Theory will be explained.

2.4.1. Quantitative Evaluation of Acoustic Environment

- **Sound Pressure Level (SPL) and Equivalent Continuous A-weighted Sound Level (L_{Aeq})**

According to American National Standard (2010), sound level is “the strength of a sound in a manner related to how the ear perceives it” (p. 3). Sound Pressure Level is “a logarithmic measure of the root mean square sound pressure of a sound relative to a reference value, the threshold of hearing” ("Acoustic Glossary," 2016). The sound pressure level is expressed in decibels and abbreviated as dB. Equivalent Continuous Sound Level (L_{eq}) is defined as the total sound energy within a period ("Acoustic Glossary," 2016).

“Sound pressure level measured with a conventional frequency weighting that roughly approximates how the human ear hears different frequency components of sounds at typical listening levels for speech” (p.3) (ANSI, 2010). A young healthy person can detect sound energy from 20 Hz to 20000 Hz frequency ranges (Egan, 1988).

Human speech refers to the range between 125 Hz to 8000 Hz(Egan, 1988). Frequency weighting method is created to reflect the subjective response of humans towards objective sound levels (Acun, 2015). A-weighted sound levels mostly ignore low-frequency sound energy just as our ears do(Egan, 1988; Marie, 2009). Due to that, studies generally are conducted with the measurement of the A- weighted sound pressure level (L_{Aeq}) which is abbreviated as dB (A).

- **Reverberation Time**

Reverberation is the continuity of the sound from first source to the last repeated reflection from surfaces(Dudley, 1998). Reverberation Time was developed by Sabine in the late 19th century(Kendrick, 2009). In Sabine theorem, organ pipes were used to estimate the required time for the sound decay totally; and it was also discovered that the rate of sound decay is correlated with the size of space and the amount of absorption within it (Kendrick, 2009). Therefore, reverberation time is defined as "the time that is required for the sound pressure level in a room to decay 60dB" (Betancourt, 2011; Kendrick, 2009; Vilkamo, 2008). The reverberation time depends on three parameters as room volume, the sound frequency in the room and the total sound absorption in the room(Harris & Shade, 1994). With these parameters, Sabine formulated an equation to calculate the reverberation time as follows(Egan, 1988; Vilkamo, 2008);

$$T= 0.05 (V/A)$$

Where
T = reverberation time in seconds
V = room volume (ft^3)
A = total ft^2 of room absorption in Sabin

After the discovery of the relation between room volume and reverberation time, the preferred ranges of reverberation time at mid-frequency (average between 500 Hz and 1000 Hz) are formed for the different functional spaces by the study of Egan (1988). Figure 7 shows that as the room gets larger, reverberation time gets longer. Dashed lines around ranges indicate the extreme limits of acceptability. Long reverberation times are generally seen in spaces with hard surfaces due to the less number of absorption of reflections (Vilkamo, 2008).

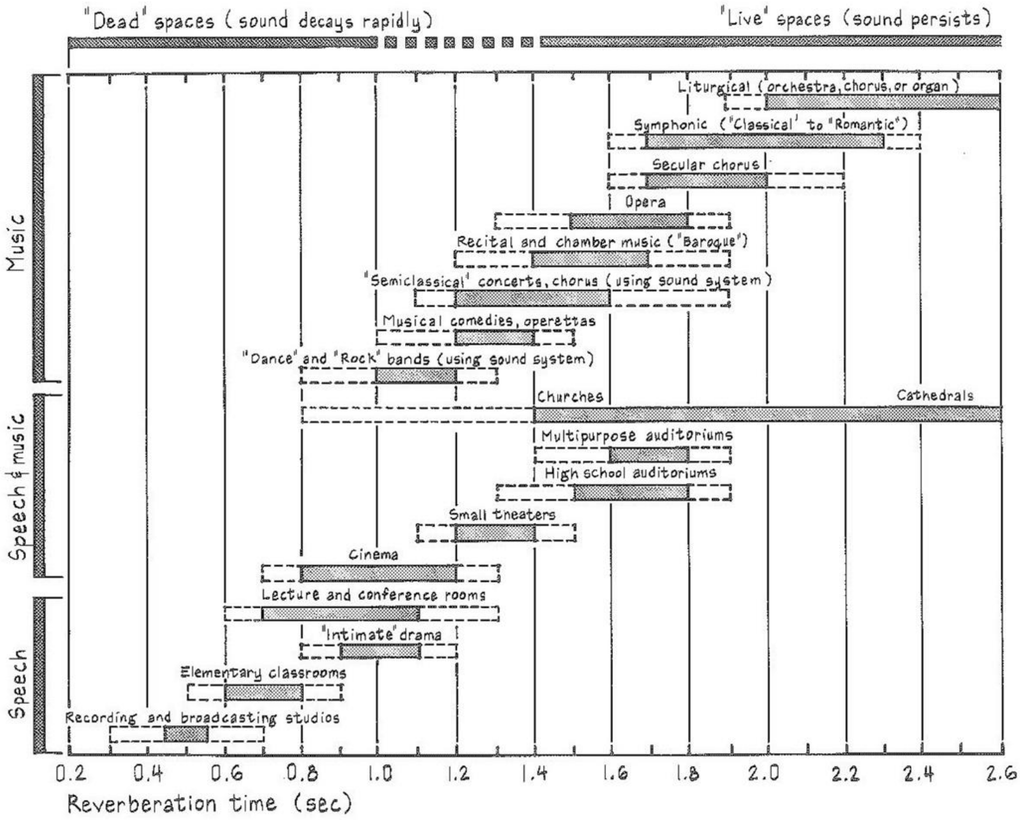


Figure 7: Reverberation time according to the different functional spaces(Egan, 1988)

- **Speech Transmission Index (STI)**

Providing good speech intelligibility in the spaces is an important issue to get suitable conditions for humans. Speech intelligibility can be defined as "a measure of effectiveness of understanding speech" (ISO, 2003). The effect of a transmission path on the intelligibility was studied by several researchers. Among them, Kryter's work in 1962 was the inspiring study for Houtgast and Steenekento establish the speech transmission index (STI) because Kryster developed the Articulation Index (AI) concept to quantify the effect of noise on speech intelligibility(Steeneken, 2001). Houtgast and Steeneken (1973) established STI concept to quantify the effect of noise on speech-like test signal(Steeneken, 2001). The transmission quality was improved from an analysis of the received test signal, and was formed as an index, Speech Transmission Index (STI) (Table 6).

Table 6: Speech Transmission Index (STI) (Adapted from Houtgast and Steeneken, 1971)

Intelligibility Rating	STI
Excellent	> 0.75
Good	0.6 to 0.75
Fair	0.45 to 0.6
Poor	0.3 to 0.45
Bad	< 0.3

STI was accepted as a prediction of speech intelligibility for Western languages in room and standardized. Speech intelligibility depends on the signal-to-noise ratio (SNR), background noise and reverberation characteristics of room(Hodgson & Nosal, 2002; Peng, Bei, & Sun, 2011). Background noise is the "sound in a furnished, unoccupied learning space, including sounds from outdoor sources, building services and utilities" (ANSI, 2010).

- **Definition (D50)**

Definition (D50) was proposed as a measure of definition or clarity. Definition (D50) is "an energy ratio of the energy in the early-arriving reflections (in the first 50 ms after the direct sound) to the total energy in an impulse response" (p.1) (Bradley, 2010). It is the earliest attempt to define the distinctness of sound (Kuttruff, 2009) . It is one of the important parameters, which describes speech intelligibility and influences the quality of sound (Karaman & Üçkaya, 2015). If values of D50 are higher than 50%, values of speech intelligibility are observed as above 90% (Karaman & Üçkaya, 2015) (Figure 8).

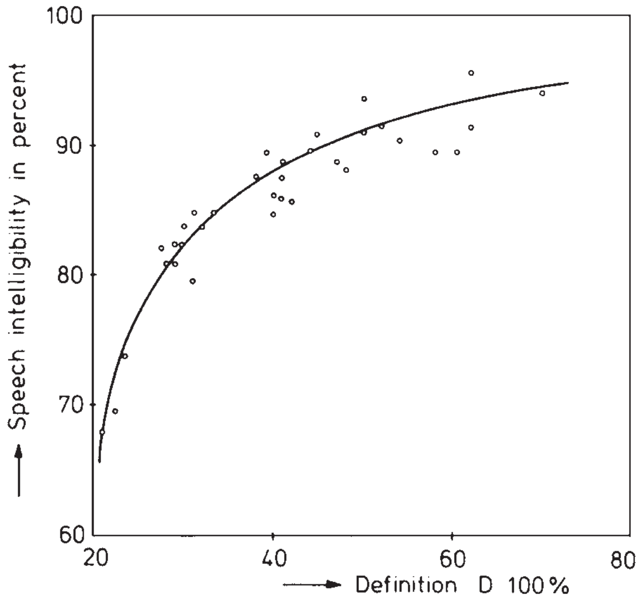


Figure 8: The relation of Definition and Speech Intelligibility (Kuttruff, 2009)

2.4.2. Qualitative Evaluation of Acoustic Environment

Studies regarding the soundscape include different survey methods to evaluate the perceptual approach of people towards acoustic environment. The mostly preferred methods and instruments in soundscape studies are sorted as questionnaires and interviews; semantic differential scales, soundwalk method, and Grounded Theory.

Firstly, questionnaires and interviews are commonly used instruments to understand the perception of people towards acoustic environment. These questionnaires are constructed as open-ended and closed-ended questions which in the form of multiple choice format or Likert-scale format. On the other hand, interviews are generally conducted with open-ended questions. Questionnaires and interviews are mostly used to understand the noise annoyance perception, the sound preferences of people, and acoustic comfort evaluation in soundscape studies. The effect of noise on people after industrial revolution results in the increase in the number of the studies focusing the noise annoyance and noise effects on health (Yu & Kang, 2010). Related to that, noise annoyance questionnaires were developed (Nilsson & Berglund, 2006). Sound preference evaluation is one of the important subjects, which reveal the discrimination of wanted and unwanted sound sources. Sound preferences are affected by many factors such as social, demographical, physical, behavioral and psychological (Yu & Kang, 2010). To understand the effect of these factors, sound preference evaluation is widely studied (Dubois, 2006; Gaver, 1993; Kang & Yang, 2005). Moreover, acoustic comfort evaluation is also widely studied in the field (Kang & Yang, 2005). Acoustic comfort evaluation generally includes the questions about the satisfaction level of users, evaluation of sound level and other factors affecting the sound perception. Although noise annoyance, sound preference and acoustic comfort evaluation were explained separately to give a detail understanding, these titles are not different from each other. Indeed, these titles should be studied together in questionnaires and interviews.

Secondly, semantic differential analysis is another method to understand the effect of sound on people. Semantic differential analysis was developed by Osgood, Suci and Tannenbaum in 1957 to explore emotional meaning of words (Kang & Zhang, 2010). It includes the adjective pairs such as comfort-discomfort, quiet–noisy, pleasant–unpleasant, interesting–boring, like–dislike. The participants are asked to fill the semantic differential test according to their perception towards sounds and the results of semantic differential analysis are evaluated with statistical analysis software. There are also some studies using semantic differential analysis in soundscape research (Bora, 2014; Kang & Zhang, 2010).

Thirdly, soundwalk method is one of the leading methods in soundscape study because it was firstly initiated by Schafer (1977). “The soundwalk is an exploration of the soundscape of a given area using a score as a guide. The score consists of a map, drawing the listener’s attention to unusual sounds and ambiances to be heard along the way” (p. 213) (Schafer, 1977). In soundwalk method, participants attend a walk through a space or defined spaces and are asked to answer questions about their experience (Bruce & Davies, 2014). The general aim is to create awareness to listen carefully and make judgments about the acoustic environment and its surrounding sounds (Kang & Zhang, 2010). The Schaferian sound walk was including an-hour-walk and following with discussion. However, soundwalk was developed with involving regular stops for discussion immediately to increase the effectiveness of method (Bruce & Davies, 2014; Davies, 2009). As a result, some studies used this method in urban environment (Bruce & Davies, 2014; Kang & Zhang, 2010), but it is not quite suitable for indoor acoustic environment.

Lastly, grounded theory is widely preferred to study the social sciences and natural sciences such as psychology (Strauss & Corbin, 1998). It is also a suitable method to explore the relation between the acoustical stimulus and perceptions of people for soundscape study (Liu & Kang, 2016). The following section will give detailed information about Grounded Theory due to being one of the subjective survey methods in this thesis.

- **Grounded Theory**

Grounded Theory was firstly introduced to the literature by Barney Glaser and Anselm Strauss in 1967. The urge that motivated Strauss and Glaser in 1967 to formulate Grounded Theory was the lack of subjective systematic qualitative research method (Mavaddat, 2014). Strauss and Glaser started to differ with each other; and each one developed different Grounded Theory methods. Glaser defended the classical Grounded Theory method whilst Strauss and Corbin developed a reformulation for the original Grounded Theory method (Heath & Cowley, 2004) (Table 7). This thesis takes the Strauss and Corbin (1990) Grounded Theory method.

Among qualitative methods, Grounded Theory became most effective and preferred method when generating theory is the main aim of the study (Mavaddat, 2014). Grounded Theory is a method to discover or establish a theory which is grounded into the data(Strauss & Corbin, 1998). It means that researcher is interested in developing a new ‘theory’ grounded in data rather than testing hypotheses (Dunne, 2011). Aim of Grounded Theory is to analyze the collected data systematically to create a general frame and to analysis the phenomena under investigation (Mavaddat, 2014).

To analyze data with Grounded Theory method, the data is gathered from different instruments such as interviews, recordings, videos. Later, data are transcribed verbatim and coded. Strauss and Corbin (1990) explained the process of coding into three main steps as; open-coding, axial coding and selective coding. Open coding includes the process that data are broken down analytically. The main aim of this process is to give different perspectives to the researcher to think and understand the present data. Similar events, actions and interactions in broken data are evaluated to form categories and sub-categories. In axial coding, categories and sub-categories are evaluated and related to each other to find out different correlations. Lastly, selective coding includes “the process by which allcategories are unified around a "core" category and categories that need furtherexplication are filled-in with descriptive detail (p.14) (Strauss & Corbin, 1990).

Table 7: Data analysis method of Strauss and Corbin(Adapted from Heath and Cowley (2004)

Process	**Strauss and Corbin**
Initial coding	Open coding Use of analytic technique
Intermediate phase	Axial coding Reduction and clustering of categories (paradigm model)
Final development	Selective coding Detailed development of categories, selection of core, integration of categories
Theory	Detailed and dense processfully described

- **Previous studies regarding qualitative and quantitative evaluations of acoustic environment**

To explore the soundscape research, it is vital to understand the previous studies of soundscape in different environments. In this section, important studies have been compiled to create an overall frame and to reveal important soundscape aspects from urban to indoor environments.

It is seen that previous field surveys of soundscape have mainly handled with relatively large rural or urban areas (Nilsson & Berglund, 2006; Porteous & Mastin, 1985; Tsai & Lai, 2001). One of the important studies in the area was conducted by Yang and Kang (2003) in several urban open public spaces of five European countries as Greece, United Kingdom, Italy, Germany and Switzerland. Sound preferences of people with different cultural background were explored. Subjects from different countries showed a similar tendency to prefer nature and culture-related sounds and to reject vehicle and construction sounds. However, their sound preferences were found highly different in the perception of some sounds as speech sounds. While some countries rated it as annoying (Greece &Germany), some of them rated it as relaxing (Italy). This study showed that the differences in cultural background and long-term environmental experience had an effect on the sound preferences.

Related to that, Yang and Kang (2005) in two urban squares in Sheffield, United Kingdom. Aim of the study was to understand the importance of soundscape design in urban squares and to get an overall understanding in people's general perceptions of urban soundscape and sound preferences. A questionnaire included the questions about an evaluation of the sound level, acoustic comfort, the identification of recognized sounds, the classification of sound preference and an indication of wanted and unwanted sounds. Semi-structured questions were related to the preferred sound environment. Results showed that natural sounds are generally preferred to urban sounds. There were also sound preference differences between different ages. As age increases, people became more tolerant towards natural, cultural and human-based sounds. In contrast, younger people were more favorable to music and mechanical sounds. Therefore, the perceived soundmarks defined the selection of urban squares of people.

Liu and Kang (2016) conducted a research with 53 participants in Sheffield. Aim of the study was to explore the factors, which identify the individual's preferences and understanding of urban soundscape. Data was gathered with in-depth interviews and evaluated with the Grounded Theory (Brooks *et al.*) method. The questionnaire was including questions about demographic information, the evaluation of the acoustic perception, soundscape feeling of people, and soundscape history of people. Results showed that five categories were generated as soundscape definition, soundscape memory, soundscape sentiment, soundscape expectation, and soundscape aesthetics. The evaluation of sounds of people did not only depend on the sound itself, or its physical parameters, but its relation with positive and negative behaviors. The meanings behind sounds composed of not only today's understanding but also the past information of people's mind. Moreover, people generally preferred to classify sounds as annoying sound and favorite sound with adding some emotional responses such as joyful, angry and sad. People expected different sonic environment such as more electronic and technical sounds in the future. Soundscape aesthetics supposed to find future-oriented aesthetic judgment.

On the other hand, the indoor soundscape studies have emerged into the literature lately concentrating on the enclosed sound environment (Dökmeci & Kang, 2012). Related to that; there are limited number of studies in indoor research areas such as hospitals (Okcu *et al.*, 2011); libraries (Dökmeci & Kang, 2012); metro-stations (Bora, 2014), and open-plan offices (Acun, 2015).

Okcu *et al.* (2011) investigated soundscape evaluations in two clinical healthcare settings in terms of nurse wellbeing and performance to analyze the sound environment and to understand whether results of objective measurement and subjective perception survey differs. Researchers selected two 20-bed intensive care units (ICU) with similar patient profile and treatment models, named as a neurological ICU (new treatment model) and medical-surgical ICU (old treatment model). The questionnaire was including the questions about noise annoyance, perceived loudness and work performance. The results showed that medical-surgical ICU was perceived louder and more annoying than the neurological ICU. Hence, medical surgical ICU created a greater negative impact on work performance, health outcomes and anxiety when compared to the neurological ICU. However, sound levels were measured similar between two ICU sound environments. Although results of objective measurement showed similar sound levels, they were inadequate to reveal the differences between perceived annoyance, loudness and performance. To conclude, researchers gave some design considerations to decrease the negative impact of noise on nurses such as reducing impulsive noise sources, using sound absorptive finishes, and creating noise control strategies for HVAC and other system.

Dökmeci and Kang (2012) conducted a research in three different libraries in Sheffield, United Kingdom. The aim of the study was to analyze the recorded objective results through the acoustic and psychoacoustic parameters and to relate objective results with the subjective evaluation. In objective measurements, sound pressure level, frequency spectrum, loudness, roughness, and sharpness were obtained from the recorded noise measurement. For the subjective analysis, socio-acoustic questionnaire was including intended purpose of the user, time spent in libraries, evaluation of physical conditions, demographics information, sound perception, noise annoyance, and sound preferences questions. Results indicated that the architectural and functional differences had an impact on the subjective evaluation. The mechanical sound sources such as mobile phones, personal music player and construction noise were found as most annoying sounds in libraries. Moreover, sound pressure level (SPL) and loudness (N) were found as significantly related with subjective evaluations of the students.

Bora (2014) aimed to find the negative and positive aspects which soundscape evokes on users in different types of spaces as open; semi-open and enclosed in Akköprü Metro Station and its immediate surrounding; Ankara. Objective and psychoacoustics parameters for soundscape quality were measured in three spaces and they were compared with the subjective responses. Ninety participants were asked to evaluate the selected environment with the seventeen adjective pairs in noise annoyance survey while listening sound recordings. Results showed that enclosed spaces was found as having highest noise annoyance rating; and subjects preferred to choose adjectives such as pleasant, calming, natural, joyful in open spaces whilst unpleasant, stressing, artificial, empty in enclosed spaces.

Another important study was conducted by Mackrill, Cain, and Jennings (2013) in a cardiothoracic ward in a UK hospital. The aim of the study was to understand individual’s subjective responses towards the surrounding sounds and to find the elements affecting the soundscape perception. Twenty-seven semi-structure interviews were conducted with the nurses and patients. A conceptual model describing perception of participants was established after reaching the themes and categories with the Grounded Theory method. The results showed that the perception of soundscape included information about not only the specific sound sources but also their context in which they heard. Research also had the objective measurement to understand acoustic environment of hospitals. Therefore, soundscape evoked positive and negative feelings on participants. They also developed the coping methods such as acceptation and habituation towards the negative sounds after understanding the background information and context of the sounds. In the conceptual model, physical and cognitive interventions were highlighted to create a positive soundscape perception on individuals.

Acun (2015) examined the effect of indoor soundscape quality on employees’ performance and mood. The study aimed to understand how employees’ perceive the acoustic environment of the open office spaces. Objective measurements were conducted to present acoustical conditions of open plan offices and semi-structure interviews were conducted with forty-seven participants. While objective measurements gave the information about acoustic environment of open plan offices, semi-structure interviews established a conceptual framework with Grounded Theory method. PANAS (Positive and Negative Affect Schedule) test was also conducted to understand the effect of soundscape on the mood of employees. Generated conceptual framework revealed different patterns and relationships between employees' perception of sound sources, sound preference and type of work they are performing. Moreover, correlations between satisfaction, sound levels and PANAS scores showed that if employees were satisfied with the sound levels, they had a positive mood.

CHAPTER 3

METHODOLOGY

This study explores the effects of soundscape on students' perception and mood in high-school environment. It also aims to contribute literature as a case study example on soundscape approach. In addition to that, this study compares two educational spaces to create a general soundscape frame for high-school acoustic environment.

The two research questions were formed to evaluate soundscape understanding. Hypotheses were proposed in terms of literature based on statistical tests because Grounded Theory, which was used in evaluation of semi-structure interviews, creates a theory rather than tests a hypothesis. Research questions were defined as,

R1. What is the effect of perceived sound environment on class performance and mood in classroom and computer laboratory environment?

R2. Based on a grounded theory, what would be categories and sub-categories in classroom and computer laboratory environment?

Hypotheses were defined as,

H1: When the sound level increases, acoustic comfort decreases in classroom and computer laboratory environment.

H2: Acoustic comfort affects class performance of the students in classroom and computer laboratory environment.

H3: Acoustic comfort has a positive effect on mood of the students in classroom and computer laboratory environment.

3.1 Selection of the site

As a case study area, İhsan Doğramacı Foundation Bilkent High School was selected that is located in the east campus of Bilkent University; Ankara (Figure 9). Therefore, location of school can be accepted in quiet zone. However, its location is in the air zone of military. Therefore, it includes variety of different sound sources apart from sound of university students.

Figure 9: The location of Bilkent High School (Google Earth, 2016)

Bilkent High School was constructed in 1993 that is accepted as a new building in terms of acoustical conditions (See Figure 10). It is a medium-size school including four floors with 309 students in total. The proportion of number of male and female students (164 male and 145 female students) is quite appropriate to understand the different genders' sound evaluation.

Figure 10: Bilkent High School (Photo taken by the author, 2016)

To compare the educational spaces in detail, two school environments were defined in terms of their different functions as classroom and computer laboratory. Mackrill *et al.* (2013) also states that achieving the positive soundscape environment can be easier with comparing soundscapes rather than givingan absolute answer. Number of sound sources and the content of lesson were main criteria to define these educational spaces. First, computer laboratory 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 were selected similarly in terms of area sizes and location of spaces (Figure 11, Figure 12) (For all floor plans, see Appendix B).

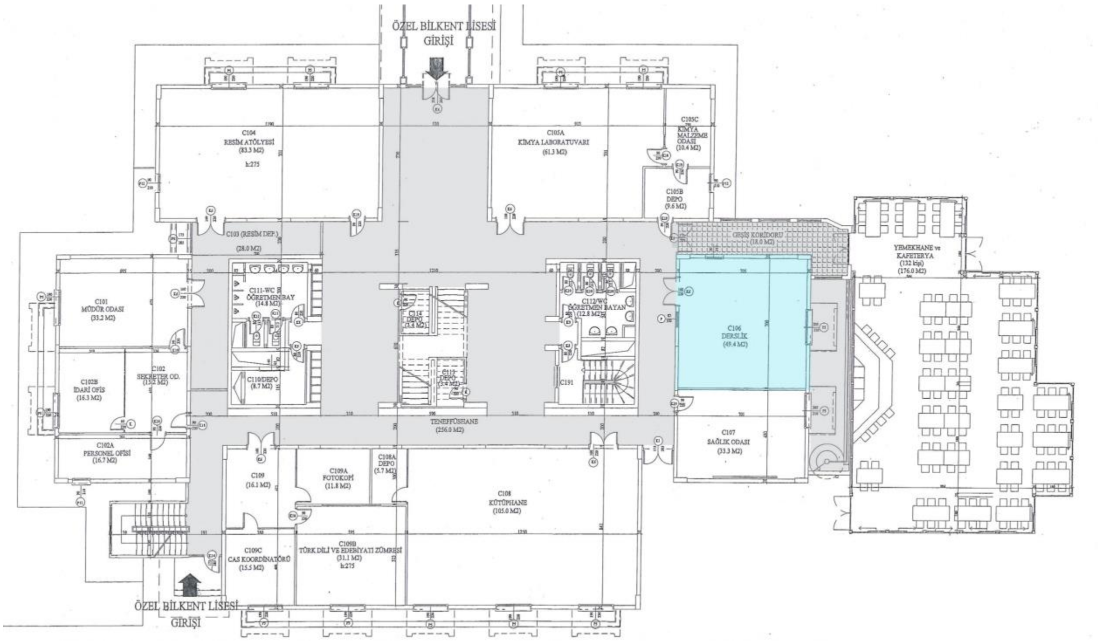


Figure 11: Classroom location in the ground floor plan (not to scale; blue indicating classroom; gray indicating corridors)

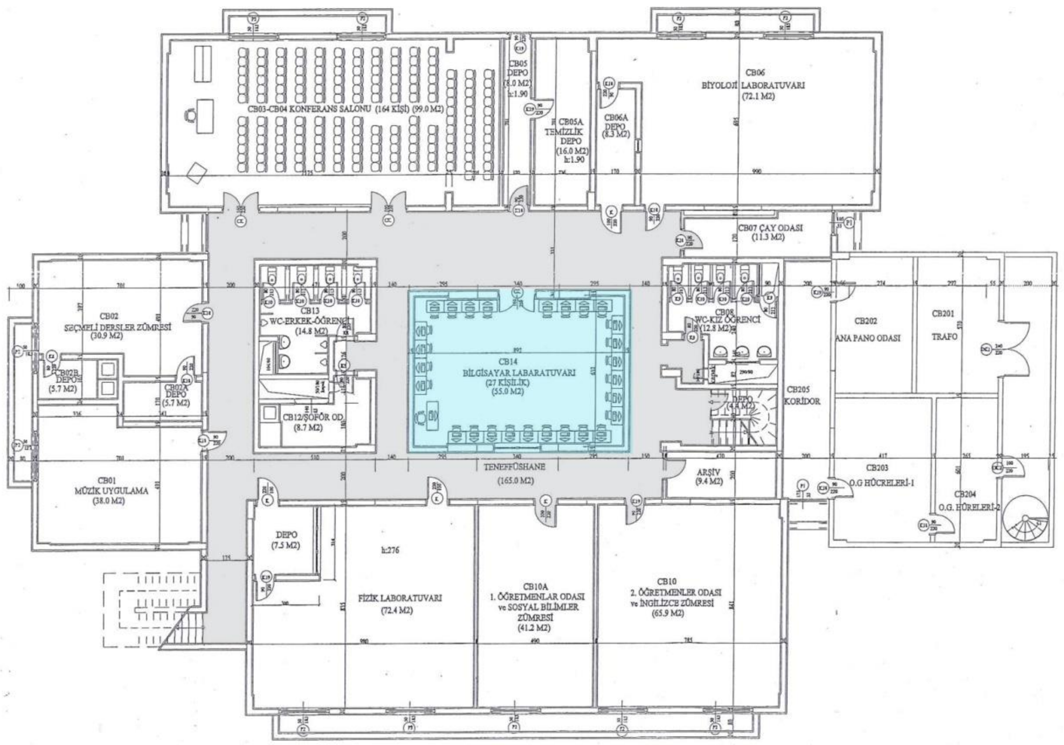


Figure 12: Computer laboratory location in the basement floor plan (not to scale; blue indicating classroom; gray indicating corridors)

Classroom is located among three corridors and lateral façade in the ground floor. Many students from different grade levels are using the selected classroom for elective courses. The classroom has around 55 m^2 area (7.45 cm & 7.30 cm) which takes ranging from 5 to 20 students for each elective course. The ceiling height was measured as 2.80 cm. Building's structural system is made with reinforced concrete and brick partitions. In classroom, ceiling is remained as plaster on reinforced concrete. Walls have plaster and oil paint on brick wall. Floor is covered with carpet on reinforced concrete. Classroom has three windows; covering 6 m^2 in total and one door; which is 4.3 $m^{2.}$ Layout of classroom consists of 22 wooden desks and a whiteboard.

Computer laboratory is located between corridors. It has no connection with outside. Many students are using the computer laboratory for their practical elective courses. Computer laboratory has around 57 m^2 area (8.92 m x 6.32 m) having from 5 to 20 students for each course. The ceiling height was measured as 2.80 meters. Computer laboratory was added to the building later for the need. Walls have plaster and oil paint on brick wall. The floor is covered with ceramic tile on reinforced concrete structure. Computer laboratory has a window and a glass door. Computer laboratory includes 27 wooden desks, 24 computer, 2 closet and a white board. The materials of classroom and computer laboratory are suitable to be reflective and non-diffusive except the usage of carpet in classrooms. In order to ease the understanding, classroom was abbreviated as CLASS and computer laboratory was abbreviated as LAB in this thesis.

3.2 Procedure of the study

Method of study includes two steps as objective and subjective surveys. Objective survey includes measurement of Equivalent Continuous A-Weighted Sound Level (L_{Aeq}), measurement of reverberation time (T30) and calculation of speech transmission index (STI). Subjective survey consists of two steps; statistical tests as questionnaire, and PANAS test; and semi-structure interviews. Table 8 shows the instruments and assessment methods of the research.

Survey was conducted in three different weekdays. Sound level measurements and survey were conducted in classroom in March 1, 2016and in computer laboratory in March 2, 2016. In April 4, 2016, reverberation time and speech transmission index were measured in both spaces. Bruel &Kjaer 2230 sound level meter was prepared to measure before the start of regular class. Later, brief information about the study was given to the students to create awareness towards the acoustic environment. Acoustic comfort and sound preference questionnaire and PANAS test were distributed to the students. Semi-structure interview was conducted with 3 to 5 students after regular lecture started. At the end of the lecture, acoustical value of sound level meter was recorded. This process was also applied for the computer laboratory environment (Figure 13).

Table 8: Method of the study

Method of the study	**Survey Aim**	**Instruments**	**Assessment**
Objective Survey	Measurement of Sound Level (L_{Aeq})	Bruel & Kjaer 2230 sound level meter	IBM SPSS Statistics 20
	Measurement of Reverberation Time (T30) Speech Transmission Index (STI)	Bruel & Kjaer 2230 sound level meter Omni-directional sound source Building acoustics analyzer	DIRAC
	Simulation of Reverberation Time (T30) Speech Transmission Index (STI)	Odeon Room Acoustics Software 13.01	Odeon Room Acoustics Software 13.01
Subjective Survey	Evaluation of students' perception of soundscape	Semi-structure interviews	Grounded Theory
		Questionnarie PANAS test	IBM SPSS Statistics 20

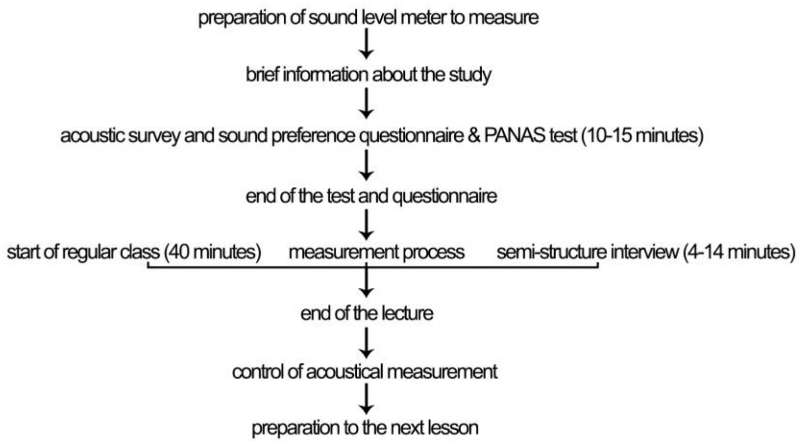


Figure 13: Survey Process

3.2.1 Objective Survey

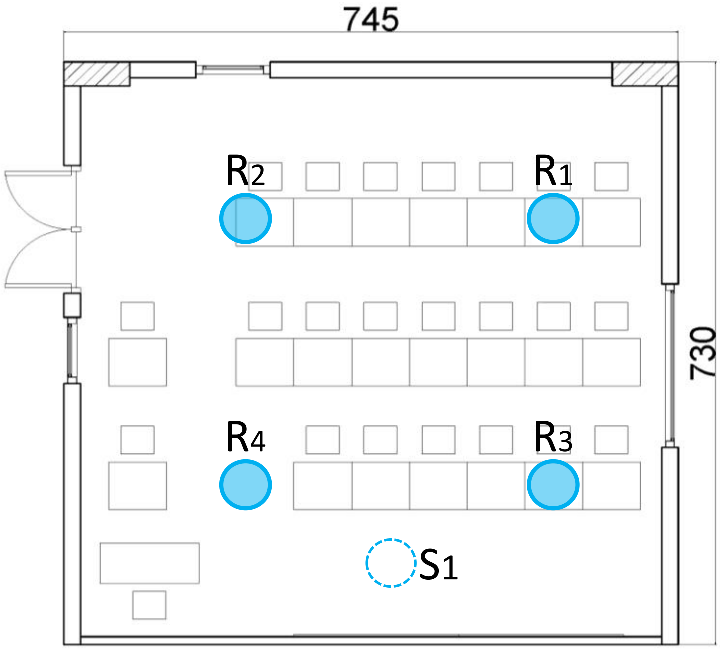
- Measurement of Equivalent Continuous A-Weighted Sound Level (L_{Aeq})

Firstly, Equivalent Continuous A-Weighted Sound Level (L_{Aeq}) was measured to reach the value of sound level in educational spaces. The weather was sunny (23 C^{o}) and the conditions were suitable to measure. There was no rain, no storm or any other extreme noise source. Before measurements (L_{Aeq} and T30), the calibration of the instruments was verified. Bruel &Kjaer2230 sound level meter was placed center point for each space with the height of 100 cm for 9th grade students and 110 cm for 10th grade students according to the American National Standard (ANSI, 2010). Measurements were conducted during occupied hours in school time with one-class hour time intervals (40 minutes). To understand the effect of background noise level, the measurements were conducted as occupied and unoccupied conditions of spaces(ANSI, 2010). In unoccupied condition measurements, windows were kept open and door was closed (Zannin & Marcon, 2007); lights were open and HVAC system was working (ANSI, 2010). During occupied condition measurements, windows were open and door was closed; lights were open and HVAC system was working to reflect the actual class environment (Figure 14).

Figure 14: Measurement of L_{Aeq} in classroom and computer laboratory environment.

- Measurement of Reverberation Time (T30) and Calculation of Speech Transmission Index (STI)

Reverberation time (T30) and speech transmission index (STI) measurements were conducted after school hours. The weather was sunny (20C°). Four receiver and one-source points were defined as to represent the teacher and students (Figure 15 and Figure 16). It was measured in an unoccupied condition, using Bruel &Kjaer Sound Level Meter type 2230 (110 cm height, representing a sitting student), omni-directional sound source (150 cm height, representing a standing teacher) and building acoustics analyzer. The measurements and calculations of the acoustical parameters were conducted with using DIRAC system. Each DIRAC measurement took approximately 2-5 seconds for each receiver location. Receiver points were defined as at least 1 meter far from the walls and there were not more than two people during in-situ measurements. Sound sources were also located 1 meter far from the walls; and the teacher's location was defined near whiteboard and teacher's desk. Simultaneously, temperature measurement was also conducted because thermal comfort also has a significant impact on the students' performance, in terms of attention, comprehension and learning levels(Corgnati, Filippi, & Viazzo, 2007). However, the temperature analysis is out of scope of this thesis. Prevailing humidity level and air temperature were checked in order to understand whether the necessary conditions provided or not.



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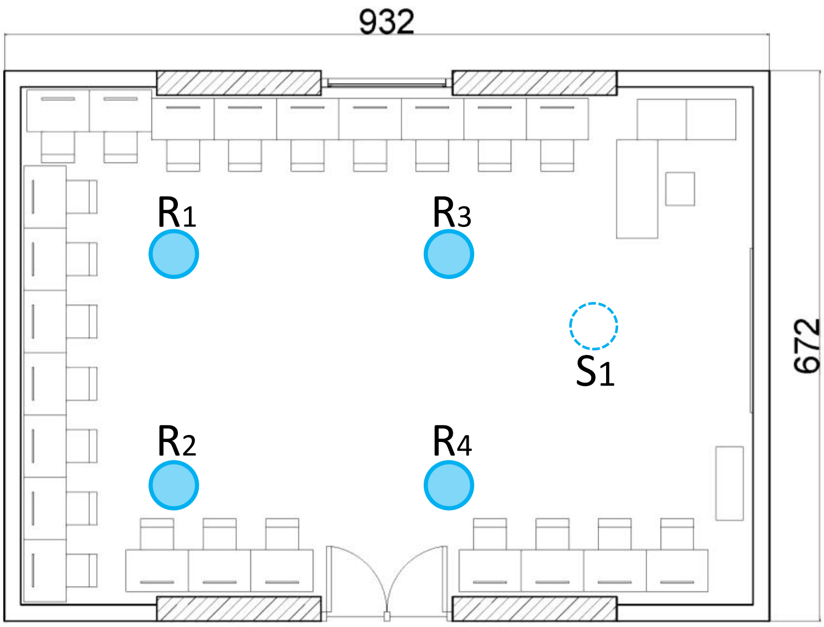


(b)

Figure 15: Source and receiver points in classroom (a) and computer laboratory (b) environment (not to scale, R1, R2, R3, R4 refers the receiver points; S1 refers to the source point)

Figure 16: Measurement of reverberation time (T30) in classroom and computer laboratory environment

Reverberation Time (T30) and Speech Transmission Index (STI) were measured in unoccupied conditions of spaces. To understand the acoustical parameters in occupied conditions, Odeon Room Acoustics Software 13.01 was used for simulation. To achieve this, unoccupied conditions of spaces were modeled with Sketch-Up 15. These models were transferred to the Odeon 13. Receiver and sound points were placed as reference to the measurement locations in both spaces. Noise Criteria for educational spaces was defined as NC 40 depending on results of background noise level measurements. Air absorption of spaces was defined according to in-situ measurements for temperature and humidity. Materials of spaces were selected from the proposed material list of Odeon 13. When unoccupied conditions were provided in simulation, occupied conditions of furniture (chairs) were defined from Bies and Hansen (2005) and "Absorption Coefficients α of Building Materials and Finishes" (2016).

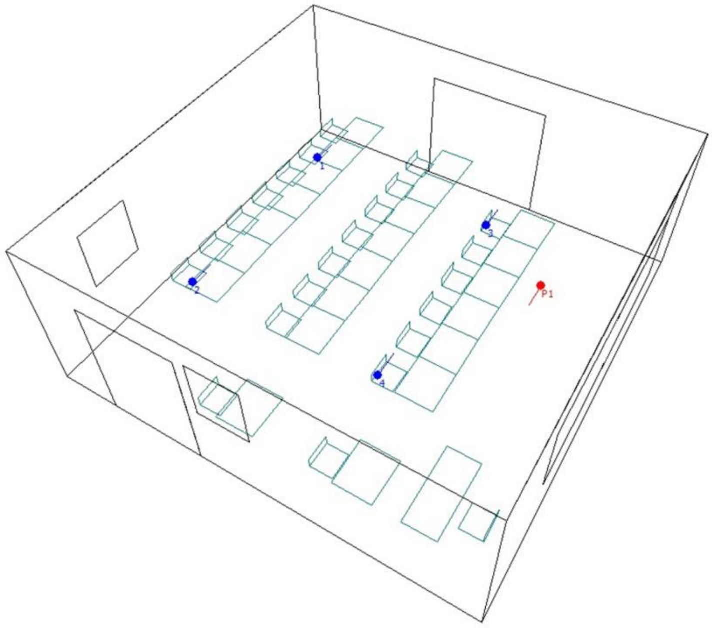


Figure 17: Simulation of classroom environment in Odeon 13 (blue points refers to the receiver points and red point refers to the sound source)

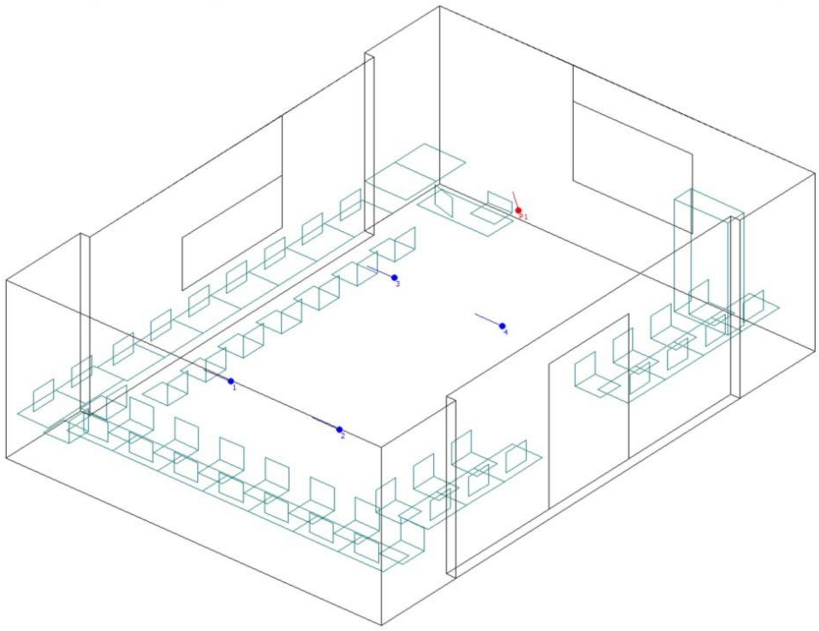


Figure 18: Simulation of computer laboratory environment in Odeon 13 (blue points refers to the receiver points and red point refers to the sound source)

3.2.2 Subjective Survey

- Acoustic Comfort and Auditory Perception Questionnaire

Subjective survey includes two methods as statistical tests; questionnaire, and PANAS test; and semi-structure interviews. Statistical tests consist of a questionnaire evaluating acoustic comfort and auditory perception of the students and PANAS test evaluating the mood of the students in educational spaces (See Appendix A). The questionnaire was prepared in Turkish for the easy conduct of the survey. 65 classroom and 60 computer laboratory students attended to the survey from 9^{th} to 10^{th} grade level. The students were selected with cluster sampling method. Self-administrated questionnaire consists of four sections. First section includes demographic questions based on the age, gender and grade point average (GPA).

Second section focus on the identification of recognized sound and an indication of wanted and unwanted sounds with open-ended questions. Open-ended questions give researcher an advantage to "reduce measurement error by eliminating random guessing" (p.253)(Bridgeman, 1992). This section was intentionally selected as the first section in acoustic evaluation questions in order not to manipulate the students' perception with the given sound sources.

The open-ended questions are as following,

- 'Please write the first sound sources that come into your mind when thinking the classroom environment / computer laboratory environment'
- 'Which sounds do you prefer to hear in your classroom environment / computer laboratory environment?'
- 'Which sounds do you prefer not to hear in your classroom environment / computer laboratory environment?'

Third section includes ranking question for the classification of sound preference of students. The sound sources that are present in educational spaces were compiled. The five-scale questions are often used to evaluate aesthetics preference research(Yang & Kang, 2005). In reference to Yang&Kang's (2005) paper, student were asked to rate the selected sound sources in the scale from -2 (annoying) to the +2 (relaxing).

Last section demonstrates the five-point-scale ranking questions about the evaluation of comfort level, sound level, temperature level, and the effects of sound level on the class performance. The answers towards to the question 'The sound level in this classroom environment / computer laboratory environment is …' were prepared as -2 (very low) to the +2 (very high). Likewise, the answers towards to the question 'The sound levels in this classroom environment / computer laboratory environment have a (n)…' effect on my class performance' were prepared as -2 (extremely negative) to the +2 (extremely positive).

- PANAS test

To measure the mood of people, PANAS (Positive and Negative Affect Schedule), which was developed by Watson, Clark, and Tellegen (1988), is widely preferred (See Appendix A). PANAS test is conducted to evaluate two fundamental elements of mood; positive affect (PA) and negative affect (NA). Participants were asked to rate "20 emotion words (10 positive, 10 negative) on a scale of 1 to 5 (1 being very slightly or not at all, 5 extremely) to indicate the extent to which they felt that emotion at the moment" (p.216) (Pretz, Totz, & Kaufman, 2010).Turkish version of PANAS test is adapted from the study of (Gençöz, 2000)(Figure 19).

Çok az veya Hiç -1-	Biraz -2-	Kısmen -3-	Sık Sık -4-	Çok Fazla -5-

	(1-5)		(1-5)
-İlgili	....	-Tedirgin	....
-Sıkıntılı	....	-Uyanık	....
-Heyecanlı	....	-Utanmış	....
-Mutsuz	....	-İlhamlı	....
-Güçlü	....	-Sinirli	....
-Suçlu	....	-Kararlı	....
-Ürkmüş	....	-Dikkatli	....
-Düşmanca	....	-Asabi	....
-Hevesli	....	-Aktif	....
Gururlu	....	-Korkmuş	....

Figure 19: Turkish version of PANAS test (Gençöz, 2000)

Before conducting the survey, the aim of the study was explained to the students to create awareness towards acoustic environment. After that, acoustic comfort and auditory perception questionnaire and PANAS test were distributed simultaneously. Total duration time to complete questionnaire and test was recorded as 10-15 minutes. The context of elective courses was also considered in classroom environment. Accordingly, survey was conducted in linguistic elective lessons as Turkish, French and German, instead of lessons like drama and music. Results of questionnaire and PANAS test were evaluated by software IBM SPSS Statistics 20, and they are presented in results and discussion sections.

- Semi-structure interview

Semi-structure interview was used to explore the perception of students towards the educational spaces. With the semi-structure interview, researcher creates an intimacy relationship with participant, and this situation allows researcher to reach wealthier information and greater flexibility of topic coverage(Mackrill *et al.*, 2013). The results of semi-structure interview were used to create a conceptual framework throughout filtering the necessary points from a wide range of data. The semi-structure interviews were conducted till the collected data was reached to the theoretical saturation point(Strauss & Corbin, 1998).

26 classroom and 24 computer laboratory students were interviewed during class hours in two days.The students were selected with cluster sampling method from each class that takes questionnaire and PANAS test. From the beginning of interview, each student was informed without giving the acoustic clues about learning environment not to create any bias on students' perception. Duration time of interviews ranged from 4 to 14 minutes. The language of interview was Turkish. 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, comfort level and the effects of sounds on students' lesson performance. The questions were prepared and adapted from the studies of Davies *et al.* (2013)and Ismail (2014)with additional adjustmens according to the indoor spaces.

The twelve semi-structure questions are as following;

- What do you except to hear in your classroom /computer laboratory environment?
- What are the positive or negative sound sources in your classroom/ computer laboratory environment?
- Why do you think these sound sources are positive or negative?
- What do you prefer to hear in your classroom/ computer

laboratory environment?

- What do you prefer not to hear in your classroom/ computer laboratory environment?
- Do you associate any sound with your current classroom/ computer laboratory environment?
- How does the soundscape of classroom/ computer laboratory environment affect your behavior and psychological response?
- How would you describe the futuresoundscape of classroom/ computer laboratory environment?
- What would be the ideal classroom/ computer laboratory soundscape from your point of view?
- Do you perceive background noise in your classroom/ computer laboratory environment? If so, how would you describe it?
- How do sound sources affect your class performance in your classroom/ computer laboratory environment?
- How do the physical characteristics expect from sound affect your class performance in your classroom/ computer laboratory environment?

The interviews were recorded on a cellphone with the help of Dictaphone application and the recordings were transcribed verbatim. Transcriptions were later coded to derive themes and categories related to each space via the grounded theory method.

CHAPTER 4

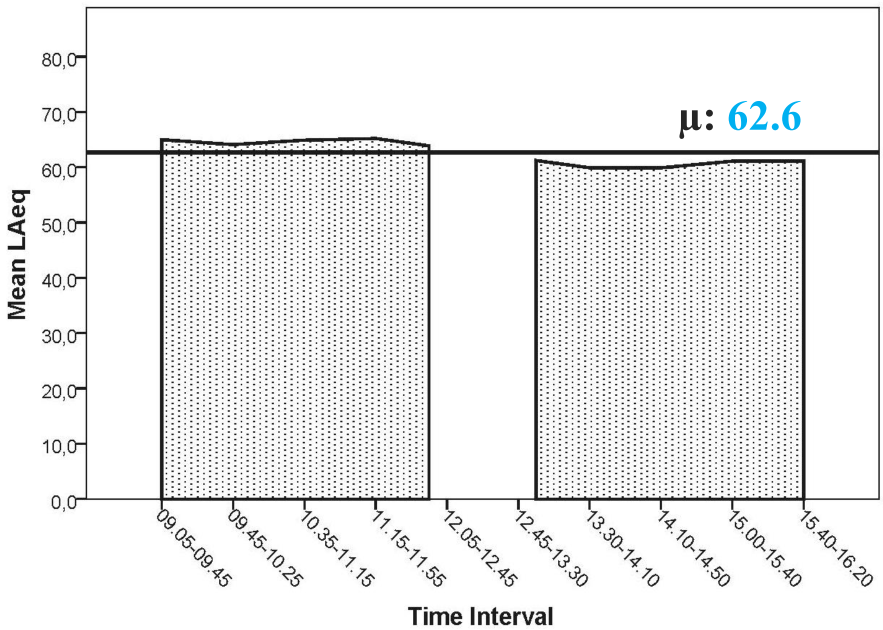
RESULTS

4.1 Objective Results

4.1.1 Equivalent Continuous A-Weighted Sound Level (L_{Aeq})

Sound level is considered one of the important acoustical parameters to reveal the acoustical conditions of environments. The results of sound level in both spaces were slightly different although both spaces have different acoustic environment. Measurement results showed that Equivalent Continuous A-Weighted Sound Level (L_{Aeq}) was recorded 62.6 db in classroom and 64.9 db in computer laboratory (Figure 20). Finding similar results in terms of L_{Aeq} was expected because the dominant sound source was observed as a human speech among different kind of sound sources in both educational spaces.

The background noise level was also measured during one-hour and it was found as 49.2 db (t: 20.8 ^{o}C; h: 32%) in classroom and 49 db (t: 25.4 ^{o}C; h: 23%) in computer laboratory. It was shown that the maximum limit for background noise level in educational spaces is 45 db in Turkey (Karabiber&Vallet, 2003). It was unpredictable because the selected classroom and computer laboratory were located with almost no connection with outside sound sources. It means that the indoor sounds such as ventilation, electrical installation were composing the majority of overall background noise levels



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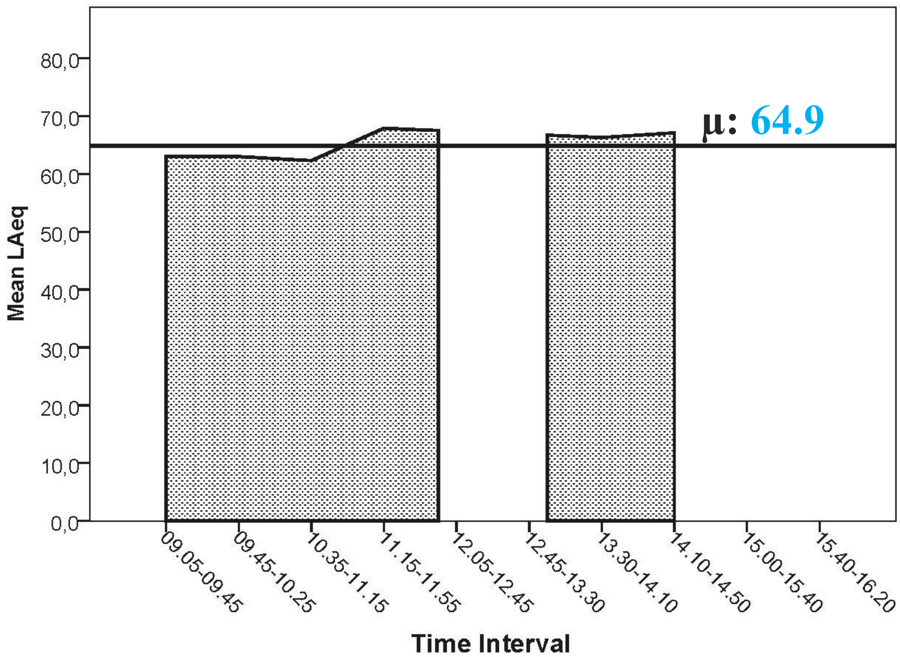
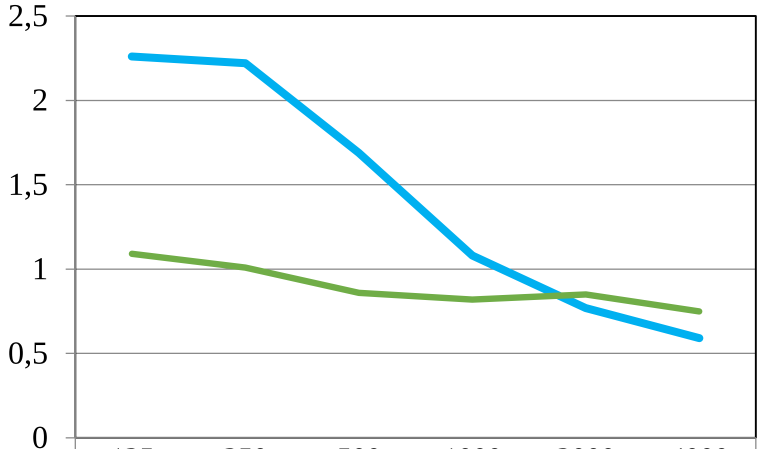


(b)

Figure 20: Results of L_{Aeq} measurements in educational spaces; (a) showing the classroom results and (b) showing the computer laboratory results; line showing the mean value (µ) for each space.

4.1.2 Reverberation Time (T30) and Speech Transmission Index (STI)

Reverberation Time (T30) was measured in furnished unoccupied conditions of the classroom and computer laboratory. Results of four receiver points were averaged. Required reverberation time should be between 0.6 and 0.8 in frequencies that relates with speech (Egan, 1988). The results of reverberation time (T30) showed that reverberation time between the frequencies of 500Hz to 2000Hz has values from 1.08 to 2.23 in classroom, and from 0.8 to 0.9 in computer laboratory (Figure 21). Therefore, both spaces did not have appropriate conditions for reverberation time. This situation indicates the lack of absorbing materials that results in the high reverberation time in classrooms (John *et al.*, 2016). It seems that although carpet was used as an absorbing material in classroom, it was not enough to create an appropriate atmosphere for better reverberation time. On the other hand, reverberation time in computer laboratory recorded slightly higher than recommended value according to the study of Egan (1988). However, reverberation time have wide range options (0.4≤T30≤1.2) in terms of different countries' standards (Table 7). Unlike classroom, computer laboratory can be accepted as having appropriate reverberation time.

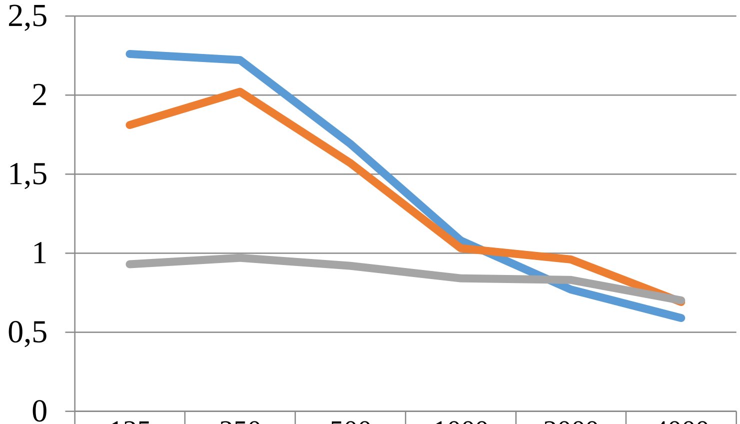


	125	250	500	1000	2000	4000
Classroom	2,26	2,22	1,69	1,08	0,77	0,59
Laboratory	1,09	1,01	0,86	0,82	0,85	0,75

Figure 21: Reverberation Times (T30) in classroom and computer laboratory

Speech Transmission Index (STI) was measured with DIRAC. Mean STI values were found as 0.63 in classroom and 0.61 in computer laboratory. It showed that both educational spaces have values between 0.6 and 0.75, which refers to the good speech intelligibility (Houtgast *et al.*, 2002). It should be noted that the values of both spaces are on the limit of good speech intelligibility.

Acoustical parameters for occupied conditions of spaces were evaluated with the simulation prepared in Odeon 13. The aim of the simulation program was to find the occupied values for reverberation time and speech transmission index. First, measurement and simulation results of the spaces were compared for unoccupied conditions to understand whether the simulation of spaces reflects the real conditions or not. Simulation of both spaces in unoccupied conditions showed similarity with the in-situ measurements in terms of values in the speech frequencies as 500Hz to 2000 Hz. After achieving similar unoccupied conditions, the acoustical parameters of occupied conditions were evaluated.

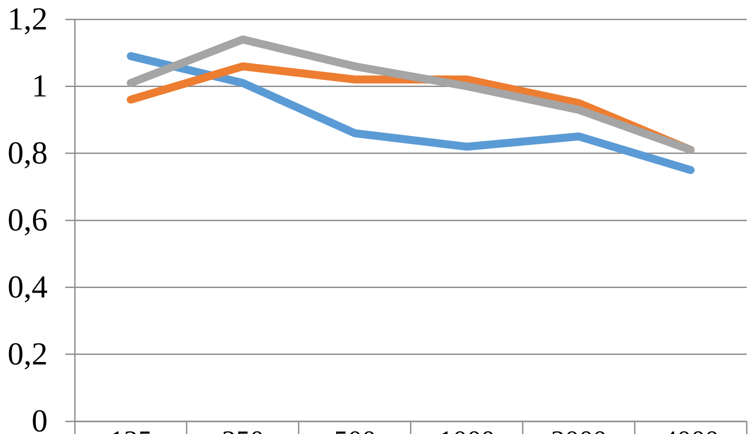


	125	250	500	1000	2000	4000
Measurement	2,26	2,22	1,69	1,08	0,77	0,59
Simulation (Unoccupied)	1,81	2,02	1,57	1,03	0,96	0,69
Simulation (Occupied)	0,93	0,97	0,92	0,84	0,83	0,7

Figure 22: Comparison of reverberation times (T30) in classroom

Results showed that classroom environment had better reverberation times in occupied condition when compared to the recommended values (Figure 22). In simulations, STI value of the classroom was found as 0.59 in an unoccupied condition and 0.68 in an occupied condition. Therefore, occupied classroom is accepted as having good speech intelligibility. Moreover, STI values for each receiver point showed differences. The closest receiver point to the source (R3) had best STI value among them (Appendix C). However, receiver points (R1, R2, and R4) showed similar STI values regardless of distance

Computer laboratory did not show a significant difference between unoccupied and occupied conditions. Both conditions can be accepted as to have appropriate reverberation times for educational purposes (Figure 23). In addition to that, STI values of computer laboratory were found as 0.62 in unoccupied condition and 0.61 in occupied condition in simulations. Therefore, reverberation time and STI values did not change with full capacity of students. Both values are on the limit of good speech intelligibility. It was also found that if the distance between source and receiver increases, STI values also increases (Appendix C). The closest receiver points (R3 and R4) were found as having better STI values than furthest receiver points (R1 and R2).



	125	250	500	1000	2000	4000
Measurement	1,09	1,01	0,86	0,82	0,85	0,75
Simulation (Unoccupied)	0,96	1,06	1,02	1,02	0,95	0,81
Simulation (Occupied)	1,01	1,14	1,06	1	0,93	0,81

Figure 23: Comparison of reverberation times (T30) in computer laboratory

Although the acoustical conditions of spaces did not meet the standards totally, the psychological responses of people can be different towards the related acoustic environment. Moreover, analyzing the acoustical parameters does not give necessary information to achieve the ideal conditions and to create a positive soundscape environment because integration of objective measures with subjective perception should be provided to construct a richer picture of the individuals' response to the space (Mackrill, 2013). Therefore, the following chapter will analyze the subjective responses of students towards the educational spaces.

Moreover, Definition (D50) was also evaluated to understand the clarity of speech. Results showed that computer laboratory environment has better D50 values than classroom. In low frequencies, classroom environment did not provide recommended percentage. In speech frequencies (500 Hz-2000Hz), Definition (D50) provided recommendations (D50>0.5). In computer laboratory environment, all frequencies have recommended values for D50 (Table 8).

Table 8: A table showing D50 values in classroom and computer laboratory

	125	250	500	1000	2000	4000
Classroom	0,26	0,32	0,46	0,41	0,52	0,63
Computer Laboratory	0,56	0,59	0,58	0,60	0,56	0,61

4.2. Subjective Results

This section analyzes subjective results of the survey. It consists of two different methods as statistical analysis and Grounded Theory. Firstly, results of statistical analysis were given to explain the general understanding of soundscape. Later, results of grounded theory were presented to create a greater insight to the soundscape approach in high-school environment. The results of two different subjective methods were compared with the objective survey results.

4.2.1 Statistical Analysis

Statistical analysis includes the results of questionnaire and PANAS test. IBM SPSS Statistical 20.0 software was used to evaluate the data. Reliability analysis, frequency tables, Spearman's Rho correlation coefficient and Independent Samples t-test were conducted.

Questionnaire of classroom (n=59) and computer laboratory (n=58) students were evaluated with the statistical analysis. Some questionnaires were eliminated due to unreliable context of their data. Firstly, it is vital to explore the demographic results of the sample group (Table 9). Results showed that 61.5% of the students were recorded as male while 38.5% of the students were recorded as female. Moreover, the survey was conducted with 9th and 10th grade level students due to their usage of selected spaces. Therefore, age of the students was generally ranging from 15 to 16, with the mean value of 15.44 years old. Grade point average (GPA) of the students was showed that 39.1% of the students have 100-85 average and 39.1% of the students have 84-70 average.

Table 9: A table showing the students' 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
	84-80	45	39.1
	100-85	45	39.1
	Not Answered	2	1.7

Second part of questionnaire was including open-ended questions that are about identification of recognized sound sources, wanted and unwanted sound sources. The evaluation of this part does not depend on statistical analysis. To preserve the unity of statistical results, this part was examined after SPSS results (See Page 69).
The reliability of the survey was checked and the value of Cronbach's alpha was found as 0.778 in classroom and 0.754 in computer laboratory. Both values referred that the questions have high strong consistency between each other.

Table 10: A table showing Cronbach's alpha of the survey

Spaces	**Cronbach's alpha**
Classroom (n= 59)	0.778
Computer Laboratory (n= 58)	0.754

Third of part questionnaire evaluates the perception of students towards related sound sources on a five-point-scale from 'annoying' to 'relaxing'. In order to ease the understanding for the distribution of sound source preferences, questions were recoded into a three-point-scale. Most annoying (-2) and annoying (-1) were clustered as annoying (-1) while relaxing (+1) and most relaxing (+2) were clustered as relaxing (+1). Neither annoying nor relaxing (0) was remained the same.

Students were asked to evaluate selected sound sources for classroom environment. Music sound (80.4%) and birds signing (72.4%) were selected as most relaxing sound sources whilst traffic sound (74.1%), alarm sound (71.7%); the sound of adjacent classrooms (70.5%) and siren-ambulance sound (66.7%) were rated as most annoying sound sources in classroom environment (Figure 24). Moreover, human-based sound sources such as speech, laughter, and footsteps were generally evaluated as neither annoying nor relaxing sound sources. Electro-mechanical sound sources such as ventilation sound, electrical installation sound, projector sound, phone ringing were generally evaluated as annoying sound sources.

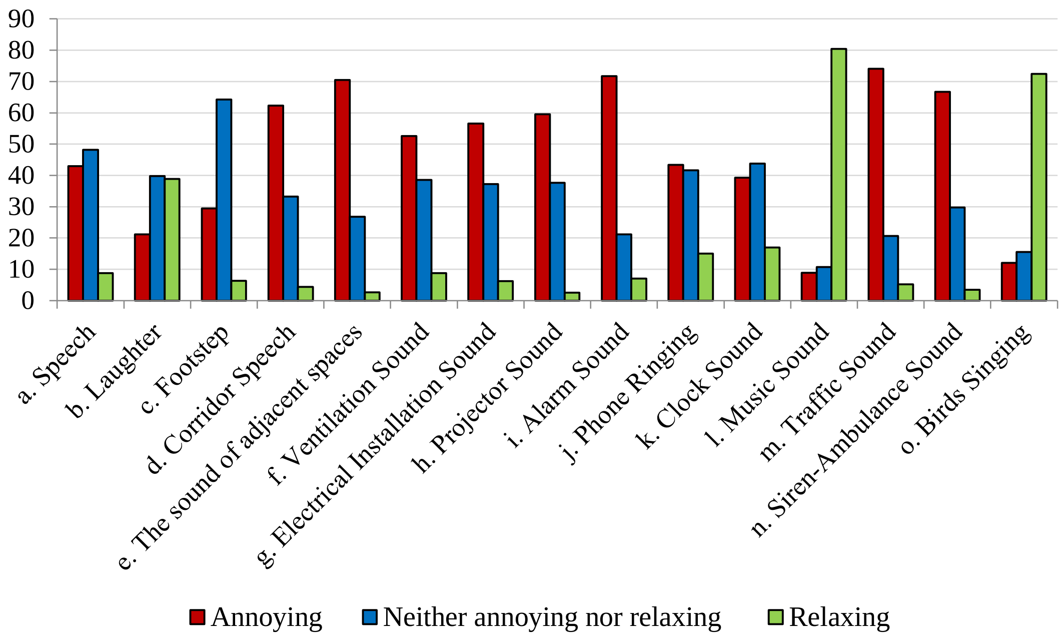


Figure 24: Frequency distribution for sound source preferences in classroom environment

In computer laboratory environment, selected sound sources were compiled to be evaluated by students. Results showed that most relaxing sound source was selected as music sound (80%); and the most annoying sound sources were defined as alarm sound (72.7%), the sound of adjacent spaces (69.1%) and corridor speech (62.5%). Similar to the classroom environment, human-based sound sources as speech, laughter and footsteps were evaluated as neither annoying nor relaxing sound sources. Electro-mechanical sound sources were generally perceived as negative sound sources (Figure 25).

It is inferred that music sound was indicated as most positive sound source and negative sound sources as alarm sound and the sound of adjacent spaces were evaluated as negative sound sources in both spaces. However, traffic sound was evaluated as most annoying sound source in classroom whilst corridor speech was recorded as negative sound source in computer laboratory. The location of spaces may result in these differences in perceived sound sources because classroom has connection with exterior; but computer laboratory is located among corridors.

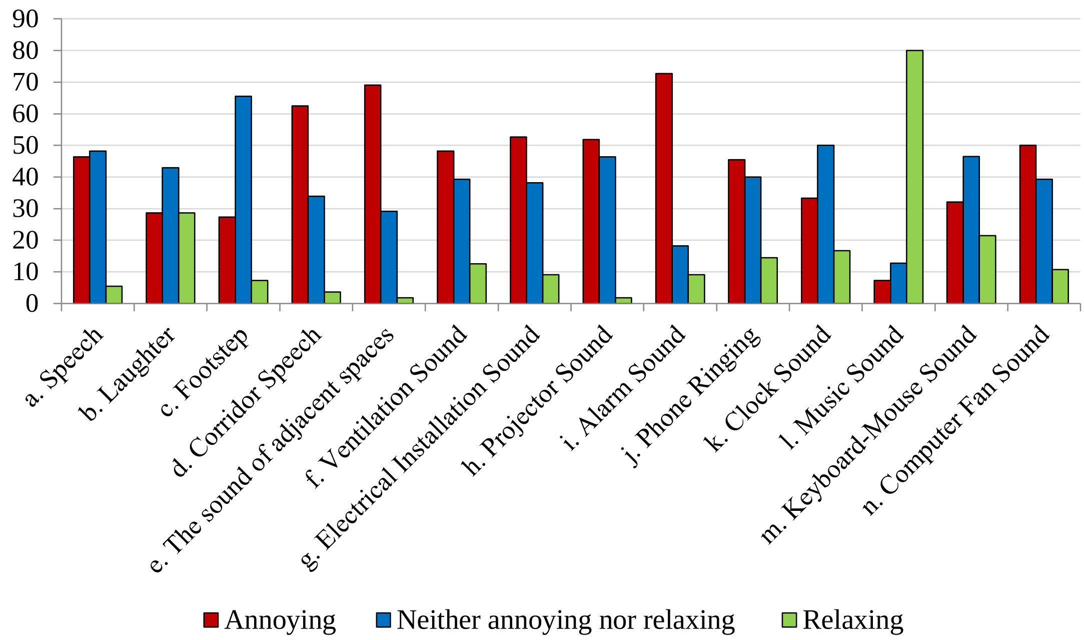


Figure 25: Frequency distribution for sound source preferences in computer laboratory environment

Moreover, the independent samples t-test was run at 95% significance level whether there are significant differences in perceived sound sources in high-school environments or not. Independent samples t-test is interpreted with the value of Sigmund (α) which should be smaller than 0.05 to indicate the significant difference between spaces. Common sound sources were evaluated and results showed that differences in mean values were found significant only in laughter (p value = 0.012, $\alpha < 0.05$, $t = 2.569$, $df = 111$) Apart from laughter, there are not significant differences in terms of perceived sound sources between classroom and computer laboratory students (Figure 26).

Forth part of the questionnaire is including the questions about evaluation of acoustic comfort, sound level, temperature level and class performance. These questions were also prepared on a five-point scale; and recoded on a three-point scale. First, independent samples t-test was run to understand whether there are differences in evaluation of these questions between classroom and computer laboratory environment. Results showed that sound level (p value = 0.03; $\alpha < 0.05$) and temperature level (p value = 0.034; $\alpha < 0.05$) were evaluated differently at 95%

significance level (2-tailed). The differences in comfort level and class performance questions were not found significant according to the independent samples t-test.

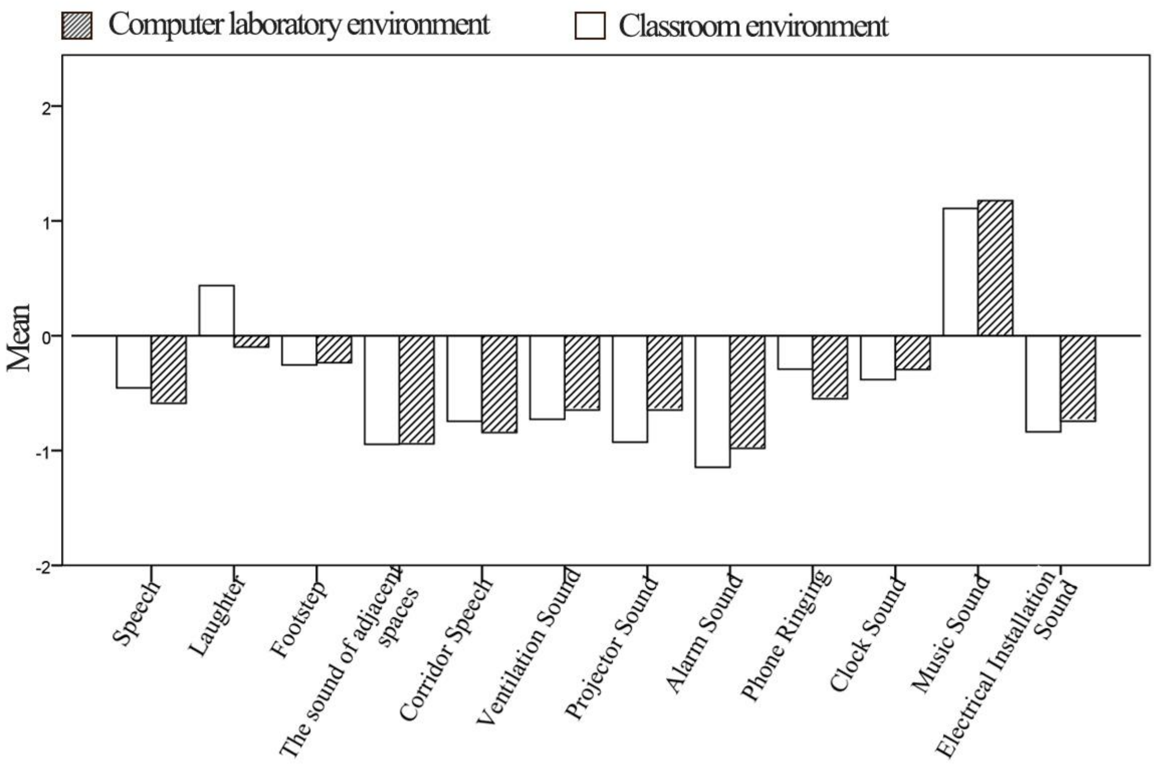


Figure 26: Independent samples t-test at 95% significance level for the evaluation of sound sources

To understand these differences, frequency distribution of sound level and temperature level were investigated. Results showed that 55.17% of the students were evaluated the sound level as high, 41.38% of the students were evaluated as neither low nor high and 3.45% of the students evaluated as low in classroom environment. In computer laboratory environment, 72.41% of the students evaluated sound level as neither low nor high, 22.41% of the students evaluated it as high and 5.17% of the students perceived sound level low (Figure 27).

Although the aim of the study was to evaluate the relationship between sound level and temperature level, temperature level found important more than expected. It shows the importance and role of other environmental factors in human perception.

Results of temperature level evaluation showed that 50% of the students evaluated the temperature level as high, 39.66% of the students evaluated as neither low nor high and 10.34% of the students rated as low in classroom environment. In computer laboratory environment, 50% of the students evaluated temperature level as neither low nor high; and 31.03% of the students perceived it as high; and 18.97% of the students rated temperature level low (Figure 28). Therefore, the evaluation of sound level and temperature level showed similar values according to the students' answers.

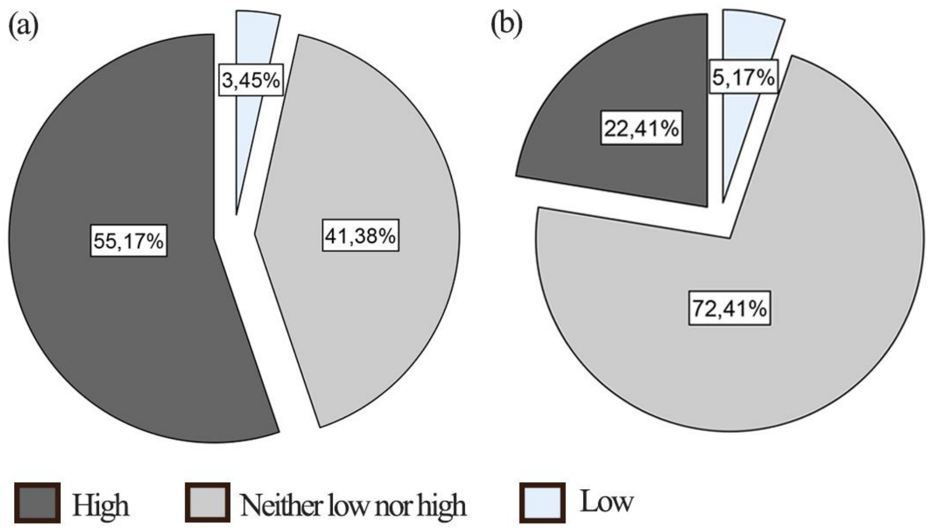


Figure 27: A pie chart showing the percentages of sound level evaluation
(a) classroom (b) computer laboratory

The evaluations of comfort level and class performance were assessed similar in both environments. Comfort level was evaluated as neither uncomfortable nor comfortable (39.66% of the students) in classroom environment and (44.83% of the students) in computer laboratory environment. Moreover, the class performance was rated as neither positive nor negative (44.83% of the students) in classroom and (53.45% of the students) in computer laboratory environment. Even if the students evaluated the sound level and temperature level as high, they do not believe that these factors have an effect on the acoustic comfort and class performance.

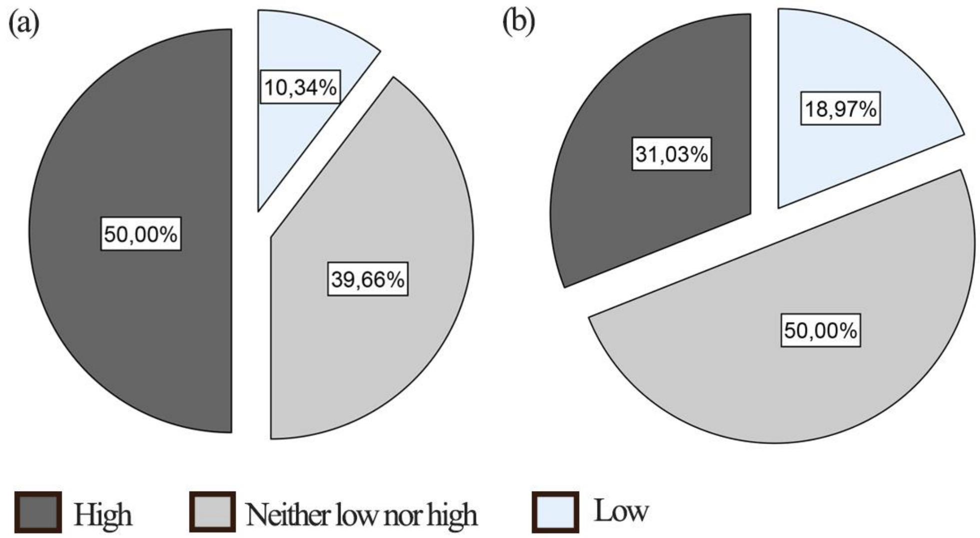


Figure 28: A pie chart showing the percentages of temperature level evaluation (a) classroom (b) computer laboratory

It is vital to explore the correlations between these factors. Questions in forth part were measured in an ordinal level. Spearman's rho (rs) is used to evaluate the correlation between ordinal variables and to analyze the dependency between questions (Argyrous, 2011). Spearman's rho value ranges from "-1" to "+1" and the value higher than 0.3 creates a significant correlation. The negativity or positivity of value indicates the direction of correlation (Argyrous, 2011).Therefore, Spearman's rho was selected to correlate these questions within each other.

In classroom environment, sound level was found as having a negative significant correlation with comfort level (rs= -0.470, p=0.0005, n=58). It is interpreted that if the environment has a high sound level, comfort level of the students decreases. Moreover, sound level had a negative significant relationship with class performance (rs= -0.404, p=0.002, n=58). It refers that when sound level increases, class performance of students decreases. Positive association was also observed between comfort level and class performance (rs= 0.518, p=0.0005, n=58). When comfort level increases, class performance of students increase, too. Temperature level was not found as having a significant correlation with any other questions at 99% significance level (2- tailed).

In computer laboratory environment, the only significant correlation was found between sound level and class performance (*rs*= -0.514, *p*=0.0005, n=58). If sound level is perceived as high, class performance of the students decreases. The other questions did not show any significant correlation within each other.

In addition to that, socio-demographic characteristics were analyzed related to the answers of forth part questions in both spaces. It was found that there is a negative significant correlation between gender and temperature level (*rs*= -0.441, *p*=0.001, n=58) in classroom environment at 99% significance level. Therefore, temperature perception differs according to the gender. Independent samples t- test was also run to evaluate whether there is significant differences between socio-demographic characteristics and questions in forth part, or not. Results supported that temperature level was evaluated differently in terms of gender in classroom environment (*p* value = 0.001, $\alpha < 0.05$, *t*=3.637, *df*=56). The frequency distribution of temperature level showed that male tends to perceive the environment warmer than females in classroom environment (Figure 29).

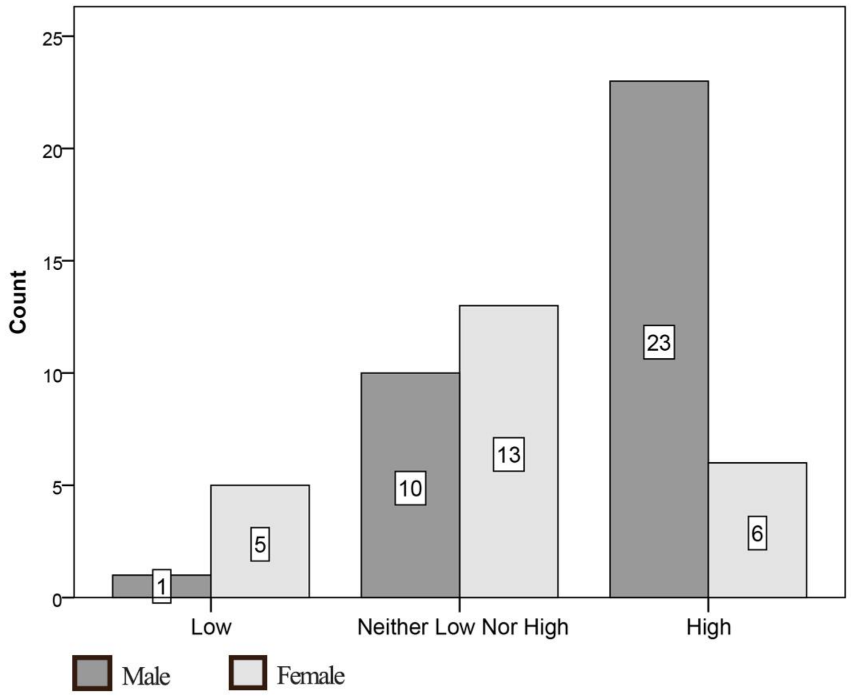


Figure 29: A clustered bar chart showing the frequency distribution of temperature level evaluation in classroom environment

In computer laboratory environment, it was found that there is a negative significant association between gender and temperature level (r_s= -0.337, p=0.01, n=58) at 95% significance level. Results of independent samples t-test showed that temperature level in computer laboratory environment was also evaluated differently according to the gender (p value = 0.009, α< 0.05, t=2.696, df=56). Figure 30 shows the frequency distribution of temperature level in computer laboratory environment according to the gender. It is interpreted that male students in both spaces perceived the environment warmer than females. The in-situ measurements of spaces showed that temperature were recorded around 23-25 ^oC which is the ideal room temperature.

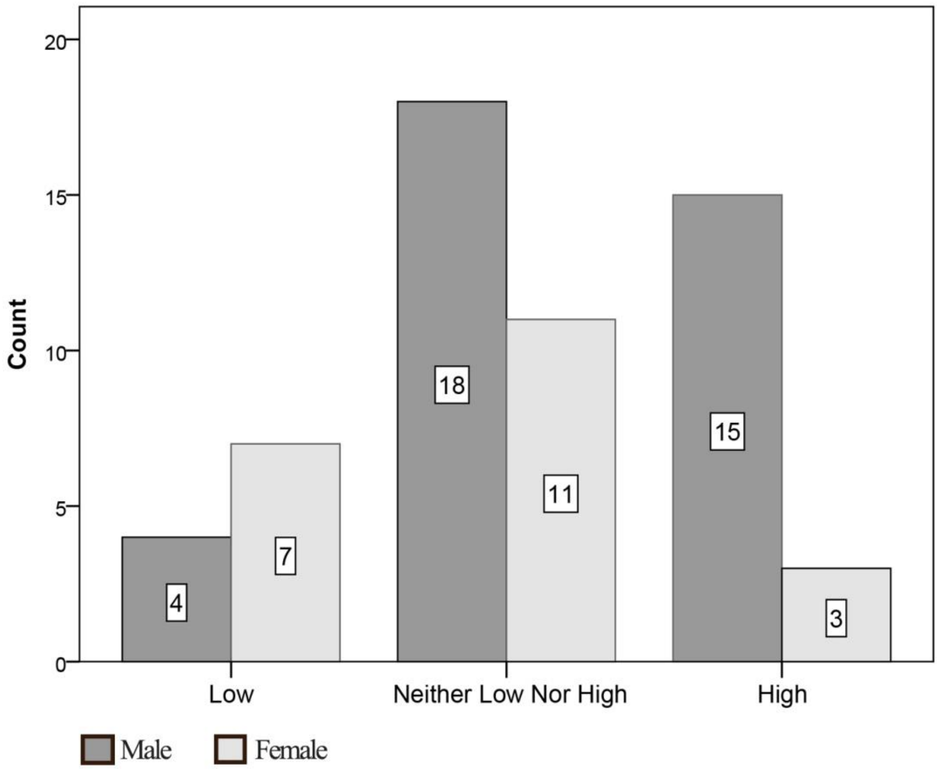


Figure 30: A clustered bar chart showing the frequency distribution of temperature level evaluation in computer laboratory environment.

The aim of temperature level question was to find the effect of temperature level on the sound level perception. It is seen that temperature level was perceived independently regardless of sound level. Results of temperature level evaluation were given to show the other relations, which may give inspiration to other researchers.

PANAS test was evaluated whether comfort level has an effect on mood of the students or not. Positive and negative scores of spaces were figured up separately. The data was measured in an interval/scale level in SPSS. Spearman's rho was used to evaluate the correlation between comfort level and PANAS scores. Results showed that there is no strong association between comfort level and PANAS scores in both spaces (Table 11).

Table 11: A table showing correlation between positive affect, negative affect and comfort level

Correlation between positive affect, negative affect and comfort level			**Positive Affect (PA)**	**Negative Affect (NA)**
Spearman's rho	Comfort Level (Classroom)	Correlation Coefficient	,104	-,061
		Sig. (2-tailed)	,457	,656
		N	53	55
	Comfort Level (Computer Laboratory)	Correlation Coefficient	,201	-,240
		Sig. (2-tailed)	,134	,070
		N	57	58

Objective results of the survey showed that L_{Aeq} and STI measurements were recorded similarly in both spaces. Sound level evaluation of the students presented that sound level was perceived high in classroom and neither high nor low in computer laboratory although sound level measurements showed the similar values for L_{Aeq}. Moreover, the reverberation time was measured differently in both spaces. The difference between measured reverberation times is around 0.8 seconds in frequency bands from 500 Hz to 2000 Hz. As indicated before, the students' comfort level evaluation did not differ in each other although computer laboratory enhanced the conditions for reverberation time and classroom could not. To understand the mood changes in terms of differences in reverberation times; Positive Affect (PA) and Negative Affect (NA) for both spaces were compared by using independent samples t-test at 95% significance level. Results showed that there is not a significant difference in the evaluation of positive affect (t=0.361, df= 109, p>0.05) and negative affect (t=-0.087, df= 112, p>0.05). Therefore, it can be interpreted that the difference between reverberation times in educational spaces did not have any effect on mood of the students.

4.2.2 Open-ended questions

Second part of the questionnaire was including the open-ended questions for both spaces. The questions aimed to understand the identification of recognized sound sources, indication of wanted and unwanted sound sources in educational spaces.

In classroom environment, most frequently recognized sound sources was composing of human-based sound sources such as speech, laughter, humming and whispering. Teacher's speech was also written separately because it perceived as an important sound source except for speech of students. Secondly, human movement sound sources as footsteps or scraping sounds as table or chair moving sound, blackboard and notebook writing sound, page turning sound were also mentioned frequently. Moreover, background sound sources such as corridor speech, speech of university students and the sound of adjacent spaces were indicated.

Wanted sound sources in classroom environment were generally based on the learning of lesson as teacher's speech. Some of them preferred quiet class environment. They generally added some phrases to indicate the level of sound as low. Secondly, they wanted to hear music mostly and natural sound sources such as water, wind, rain. Unwanted sound sources generally varied for each student. However, they generally indicated not to hear high level of teacher's speech, speech of the students, humming and whispering. Scraping sounds as table or chair moving sound, blackboard and notebook writing sound and page turning sound were frequently written as unwanted sound sources. In addition to that, electro-mechanical sound sources such as projector sound, lighting sound, ventilation sound, alarm sound were evaluated as unwanted sound sources. Lastly, outside sound sources such as traffic sound, construction sound and background sound sources as speech of university students and the sound of adjacent spaces were highly mentioned. While unwanted sound sources were firstly thought from the inside of classroom such as speech; wanted sound sources except for the teacher’s speech were generally selected from outside of classroom as natural sound sources or music.

In computer laboratory environment, recognized sound sources were mostly composing of electro-mechanical and technological sound sources as computer fan sound, keyboard-mouse sound, ventilation. Moreover, speech and chair moving sound were most frequently said sound sources. Except for speech, human-based sound sources as teacher’s speech, laughter, whispering were mentioned secondly. Lastly, page turning sound and writing sound were recognized easily by students. Students generally became more precise when asking wanted sounds. They generally indicated that a quiet environment with low-level music background and sometimes low-level speech. They secondly wanted to hear natural sound sources such as birds signing, water and wind sound. Computer fan sound, keyboard-mouse sound and teacher’s speech were defined as wanted sounds. As unwanted sounds, students preferred mostly not to hear human-based sounds as high level speech of teacher or students, group conversation, laughter; electro-mechanical sounds as ventilation sound, lighting sound, computer fan sound, keyboard-mouse sound, and projector sound; scraping sounds as chair moving sound and blackboard and notebook writing sound. Therefore, human-based sound sources were gained importance in classroom environment whilst electro-mechanical sound sources were mentioned mostly in computer laboratory environment due to the different acoustic environment of spaces and the context of lesson.

4.2.3 Conceptual Framework

- Data Analysis

Semi-structure interviews were evaluated with the Grounded Theory method. After transcribing all recordings, initial data were broken down into the labels in open coding phase. Figure 31 shows these coding labels for the classroom environment. For example, *'I think, the yelling of teacher speech is most negative sound'* phrase was labeled as 'Sound Source Human Source Speech' that was abbreviated as 'SSHSS'. Moreover, *'the yelling of teacher speech'* also referred to 'Sound Level High' with an abbreviation of 'SLH'. The phrase continues with the sentence *'because it can decrease my mood'* that was coded as 'Loss of mood'. These three labels were related with each other. The whole sentence was summarized as 'SSHSS v SLH v Loss of Mood'. Therefore, it means that these phrases were defined a relationship between codes.

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 31: Open Coding – Labeling Process

In axial coding phase, some labels related to the sentences were brought together to create categories and sub-categories. These created labels were questioned by making some comparisons and linkages with the each other. For example, a bird signing was labeled as ‘SSNB (Sound Source Nature Bird)’, traffic sound as ‘SSMTRT (Sound Source Motorized Transport Roadway Traffic)’ and footsteps as ‘SSHMF (Sound Source Human Movement Footstep). In that phase, the relationships were searched to create a category such as *‘Sound Sources’.* Merging terms generated categories and consequently sub-categories. Therefore, sound sources category was composed of sub-categories as motorized transport, human movement, electro-mechanical with reference to the classification of Brown, Kang, and Gjestland (2009). After defining categories, it was needed to select the core category, which has an extensive relationship with other categories.

Figure 32 shows the coding process of high-school environment to explain the order of the method in study, which was prepared with reference to the study of Liu and Kang (2016). In 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 is about ‘the relationships between sound levels and sound sources’. The concepts became clearer after open coding phase. Later, these concepts composed the categories depended on their similarities or differences in axial coding phase. For example, “aa1” and “aa2” were gathered and A1 category was defined which is about *‘negative sound sources and sound levels’.* A2 was also category that includes the labels about positive sound sources and sound levels. Lastly, A1 and A2 were found similar and created the category AA1 as *‘sound sources and sound levels’.* After creating main categories, sub-categories and their relationships were defined. Core category was selected in selective coding phase. Therefore, categories and sub-categories were revealed to create a general conceptual framework that will give information about the soundscape perception of students in high-school environment.

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. Sound sources & Sound levels AA2. Acoustic Environment AA3. Soundscape Perception AA4. Soundscape Preference AA5. Responses AA6. Coping Methods AA7. Intervening Factors AA8. Outcomes	AA1. Sound sources & Sound levels (1) Motorised Transport (2) Voice & Instrument .... AA2. Acoustic Environment (1) LAeq (2) RT .... AA3. Soundscape Perception (1) Positive Sounds (2) Negative Sounds .... AA4. Soundscape Preference (1) Wanted Sounds (2) Unwanted Sounds .... AA5. Responses (1) Positive Responses (2) Negative Responses .... AA6. Coping Methods (1) Habitutation (2) Intervention .... AA7. Intervening Factors (1) Lighting (2) Heating .... AA8. Outcomes (1) Physical Outcomes (2) Long-Term Outcomes ....
Initial Data Collection	Open Coding	Axial Coding	Selective Coding	Defining Categories	Generating the substantive theory

Figure 32: Grounded Theory Process (Adapted from Liu & Kang, 2016).

This study aimed to generate one conceptual framework for both spaces to reveal the connections and relations. Figure 33 shows the basic of conceptual framework that is composed of eight main categories. The detailed conceptual framework will be presented later. The categories are sound sources &sound levels; acoustic environment, soundscape perception, soundscape preference, coping methods, responses, outcomes, and intervening factors. Soundscape perception was selected as a core category that has relation with all categories. Each category of the framework was supported with CS (classroom student) and LS (laboratory student) comments to show the differences and similarities between categories. The comments of students were also used in Çankaya and Yılmazer (2016).

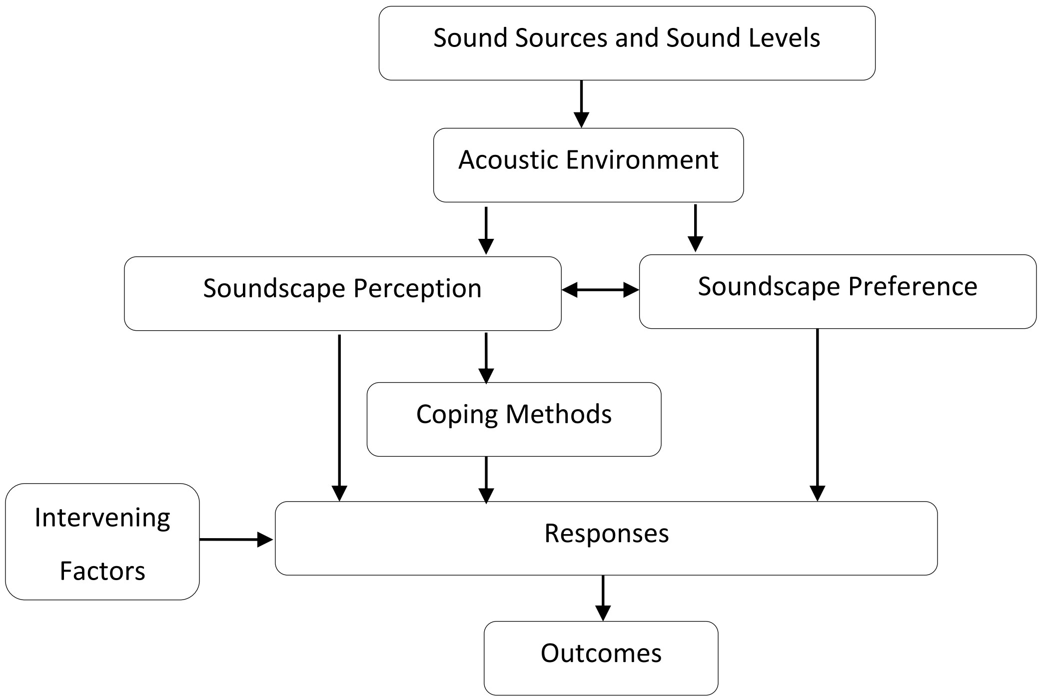


Figure 33: The basic of conceptual framework for high-school environment

Conceptual framework revealed 8 categories and 21 sub-categories (Figure 34). The soundscape flowchart started with the sound sources category. Sound sources category includes the identification of recognized sound sources, characteristics of sound sources and background noises; which can be accepted as present sound sources and its characteristics in the environment. The sound sources distribute the environment and comprise the acoustic environment. In acoustic environment with sound sources, soundscape perception and soundscape preferences are shaped. The students may evaluate the sound sources as positive, negative or neutral, and they may prefer or not prefer some sound sources. To handle with sound sources within the environment, they may improve some coping methods or they may directly respond to the environment. Moreover, the intervening factors may lead to the differences in students' responses towards the environment. At the end, they may constitute some outcomes. Therefore, the basic conceptual framework comprises of these categories; but it is necessary to examine each category as a separate heading.

-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 were listed in Table 12.

Table 12: Excepted 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	Footsteps
Electrical Ventilation	Chair Wheel Sound
Phone Ringing	

The answers of students in classroom and computer laboratory were compared and found different from each other. Speech was most frequently mentioned sound source in classroom environment whilst computer fan sound was mostly said in computer laboratory environment. This situation was expected because each space has different acoustical conditions. The other outstanding sound sources were exemplified as roadway traffic, laughter and birds singing in classroom and keyboard sound, ventilation sound, speech in computer laboratory environment.

In addition to that, sound levels were also important in terms of the perception of sound sources. Same sound sources can be perceived differently in different sound levels. Generally, students did not prefer to hear sounds in high levels because high-level sounds were generally perceived as noise even if the students preferred to hear them in their educational spaces.

Students were asked to list their sound sources, which do not belong to their environment as background sounds. Roadway traffic in classrooms and corridor speech in computer laboratory were frequently mentioned as background sounds. Moreover, some students preferred to hear background noise 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 connection with outside.*

-Acoustic Environment

Individual soundscape response towards the environment can be explored with firstly understanding the acoustical conditions of spaces. Acoustical conditions of spaces were given at the beginning of results part, but it is better to indicate them again to show missing piece of conceptual framework. The acoustical measurement of both spaces showed that although values of sound level and reverberation time were measured above standards, speech transmission index was recorded between recommended ranges (Table 13).

- Soundscape Preference

Students were asked to define their preferences for educational spaces. Students mostly preferred to hear music as a wanted sound in both spaces. In addition to that, students generally not to hear human-based sound sources as high level speech, group conversation, humming, laughter, corridor speech and sound of adjacent spaces in classroom and not to hear high level speech, group conversation, ventilation, chair moving sound in computer laboratory.

The students were also asked to define their ideal environment. The students of both spaces indicated that they preferred low or average sound levels during class time. Some students preferred to study with music whilst some of them wanted a quiet environment. Quiet environment was also controversial issue among students' preferences because some wanted to have a lesson in a quiet environment; and others found it as a distracting situation. Quiet environment have both positive and negative approaches as,
CS: *I prefer to hear the teacher's speech, my friends' speech and laughter. I also want to hear outside noise because I do not like quiet environment.*

LS: *Actually, I prefer the quiet environment but I am not trying to say that everybody is 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.*

- Soundscape Perception

Students were also asked to classify positive and negative sound sources in their environments. Results showed that the selection of positive and negative sound sources depended on several reasons such as the relation with environment, social and cultural preference of the student, the context of sound sources and the mood of the students. The most positive sound sources were birds singing and laughter in classroom, and music in computer laboratory. Moreover, the negative sound sources were found as speech in classroom, ventilation, and computer fan sound in computer laboratory (Table 13).

The positive sound sources were compiled as human-based sound sources as laughter, speech of teacher and natural sound sources as birds singing, wind and water sound. Negative sound sources were found as human-based sound sources as high level speech, high level laughter, humming, group conversation, transport sounds as roadway traffic, helicopter sound, siren-ambulance sound, electro-mechanical sounds as projector sound, ventilation, computer fan, keyboard and mouse clicking.

Table 13: Results of classroom and computer laboratory in selected categories

Categories	**Classroom**	**Computer Laboratory**
Sound Sources & Sound Levels	Speech	Computer fan sound
Acoustic Environment		
L_{Aeq}	62.6 db	64.9 db
RT	RT > 0.6	RT > 0.6
STI	0.63	0.61
Soundscape Preference		
wanted sound	Music	Music
unwanted sound	Speech	Speech
Soundscape Perception		
positive sound	Birds singing	Laughter
negative sound	Speech	Computer fan

- Responses & Coping Methods & Outcomes

The students of classroom and computer laboratory environment did not respond differently towards the acoustic environment. The answers of students were classified as positive, negative and neutral responses. 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 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 consider my lesson.*

Students also preferred to use some emotional terms to define their feelings towards sound sources. When they were expressing their perception towards the sound sources, they explained their responses by adding some emotional phrases to them.

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

Another important part of the conceptual model is coping methods. Students improved some solutions to achieve their ideal conditions because coping methods helped the students handle with acoustical conditions. It sometimes acted as a bridge between responses and soundscape perception. The examples of coping methods were isolation, habituation, place attachment, adaptation, and verbal intervention.

LS: *There are always some talks and laughter in lesson, but I do not feel bad about it. I think that they are part of this environment.*
CS: *If there is so much noise, I put my head to the table and try to isolate myself from environment. After then, I can focus on my lesson.*

Outcomes were emerged as the last part of conceptual framework. They are long-term consequences of soundscape perception. They were classified as physical outcomes and long-term outcomes. The answers of the students indicated that sound sources in the acoustic environment resulted in physical outcomes as headache, fatigue and long-term outcomes such as lesson 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 am thinking that I understood the lesson. Actually, I did not. I understand this situation after I failed the exams.*

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

- Intervening factors

Intervening factors are the factors that have an effect on the soundscape perception indirectly. It was found that environmental factors, spatial relationships, formal organizations and user profile may change the soundscape perception and the context in which soundscape was generated. These factors were environmental factors such as lighting, heating, odor, spatial factors such as location, and formal factors such as insulation. These factors had an impact on the students' comfort and consequently the sound perception during the lesson. For example, classroom students indicated that they always feel the odor and sound of cafeteria during class hours because their classroom was located near the cafeteria part. Therefore, intervening factors may result in positive and negative responses towards acoustic environment.

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, and this makes me very encompassed.*

Moreover, user profile is an also important factor because it directly affects the soundscape perception. Behavioral tendency, background information and mood were given as examples of user profiles.

CS: *Actually, it does not matter for me because I am playing basketball; and I got used to hear high-level cheering sound during the game. Therefore, high sound levels do not distract me during class hour; I can concentrate whenever I want.*

Conceptual framework was generated as 8 main categories, and 21 sub-categories. The detailed conceptual framework was prepared to summarize all context of each category (Figure 34).

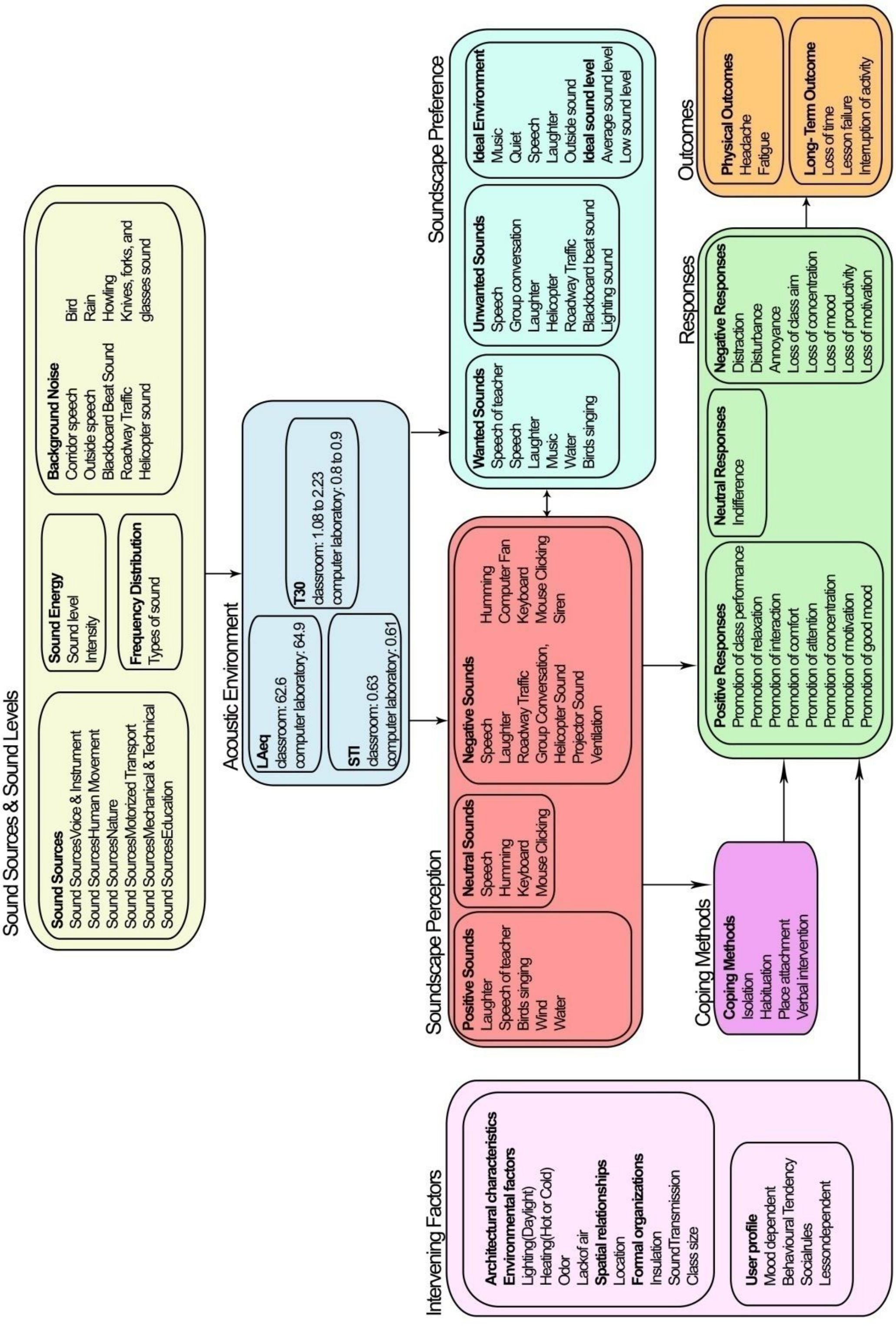


Figure 34: The detailed conceptual framework for high-school environment

CHAPTER 5

DISCUSSION

- **The evaluation of sound sources**

- Positive and Negative Sound Sources

First, sound preferences of the students were explored to understand the effect of soundscape on their perception. Within common sound sources, music sound was selected as most positive sound source and sound sources as alarm sound and the sound of adjacent spaces were evaluated as negative sound sources in both spaces. It is interesting that laughter was evaluated positive in classroom and negative in computer laboratory. The reason of it may depend on the task that the students deal with. It is said that classroom lecture needs more interactive atmosphere that includes more speech and laughter. However, the computer laboratory lecture depends more on practical application that needs concentration to the computer screen. It can be said that laughter was accepted as a part of classroom lecture when compared to the computer laboratory lecture. Moreover, speech is a controversial sound source to classify as positive or negative because some students accepted speech as a part of the environment, and some students did not want to hear speech in lesson. Human-based activities as people talking or children at play are usually evaluated as more pleasant when compared to the technological sounds, or as neutral in terms of pleasantness (Axelsson *et al.*, 2010), which is also present in this study. Moreover, same sound source can be evaluated differently in different contexts because soundscape could be perceived as positive, negative, or necessary with giving the information or simulation (Mackrill *et al.*, 2013).

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

Music was indicated as a relaxing sound source in both educational spaces. Results showed that the students feel more concentrated if they study with music. Although music was selected as most positive (also one of the most wanted sound sources) sound source in statistical analysis, music preference depended on the situation in terms of semi-structure interview results. Students defined their preferences in terms of the context of lesson. For example, students generally preferred to work with music if task requires less effort or the lesson is based on applied method.

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

-Background Noise

Background noise is an important factor that students generally refer. The sounds from adjacent spaces were evaluated negatively in both spaces as the second negative sound source. It means that the speech was accepted within the environment, but the sounds (mostly speech) from adjacent spaces were evaluated as a negative sound that does not belong to the classroom or computer laboratory environment. Moreover, the students firstly perceived the inner sound sources in school when thinking the background noise. This result is also similar with the findings of Zannin and Marcon (2007). They also found that the main noise sources originated inside the school as the speech of students and the teacher of the neighboring classroom.

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 hear. It is just distracting.*

Within the specific sound sources, traffic sound and siren-ambulance sound were evaluated as annoying sound sources in classroom whilst corridor speech was recorded as negative sound source in computer laboratory, all of which refers to the background noise. It may be result of the location of spaces because it also shapes the acoustic environment of spaces. Classroom was locating near the cafeteria area, and computer laboratory was locating among corridors.

CS: *I always hear sounds of knives and forks during class.*
LS: *There is speech of teacher and staff in corridor. I do not perceive any sound other than this because our laboratory was located in ground floor.*

In addition to that, electro-mechanical sound sources such as projector sound, ventilation sound, lighting sound were evaluated as annoying sounds. It was expected because technological sounds were generally evaluated as unpleasant sound sources according to the literature findings (Axelsson *et al.*, 2010).

-Sound Preferences

Semi-structure interview and open-ended questions were presented to understand the wanted sound sources. According to the semi-structure interview results, music was indicated as most wanted sound source in both spaces. In open-ended questions, they firstly preferred to hear teacher's speech or want a quiet environment in classroom. In computer laboratory, they wanted an environment with low-level background speech and music. Therefore, they firstly wanted to hear the sound sources that belong to the context of lesson such as teacher's speech. As indicated in results part, quiet environment was evaluated both negatively and positively because it does not mean that lack of negative sound results in the positive environment (Truax, 1984). It generally depends on the people's preferences in different contexts. Quiet environment is not evaluated as a wanted situation or as having high acoustic quality. For example a forest with wind in the trees, waves on a beach, birds singing have also high-acoustic quality although they do not have quiet environment (Brown, 2006). Secondly, students wanted to hear natural sound sources such as water, wind, rain in both spaces. It is also similar with the study of Yang and Kang (2005), who found that people prefer to hear natural sounds as a group when choosing the urban square.

Unwanted sound sources were mostly composing of human-based sound sources as high-level speech, group conversation, humming, corridor speech and sound of adjacent spaces in classroom. In computer laboratory, they were high-level speech, group conversation, ventilation sound, chair-moving sound. It is interesting that the students evaluated human-based sounds as neither annoying nor favorite in statistical results. In semi-structure interviews, they firstly indicated not to hear human-based sound sources instead of more annoying ones according to their statistical evaluation. This situation may depend on that they accepted background sound sources as they are; but they believed that they could change human-based sound sources. Moreover, speech was evaluated as both wanted and unwanted sound source in both spaces; but the students also indicated the level of sound while defining these sound sources. It means that the same sound source is perceived differently in different sound levels.

Results of open-ended questions showed that the students proposed different sound sources from given sound sources in questionnaire. For example, they mostly mentioned about scraping sound as writing sound, page turning sound in classroom and chair moving sound in computer laboratory. It actually proves that additional qualitative method is needed to give the participants free thinking.

In addition to that, computer fan sound and keyboard-mouse sound were also evaluated as wanted sound sources. They indicated that the keyboard sound and computer fan sound were evoking a feeling that all of the students are working at that moment. Acun (2015) also found that keyboard sound evokes the positive feeling on the employees' sound perception in open-plan offices.

- **The comparison of the methods**

-Comparison between objective measurements and subjective evaluation of sound level and temperature level

Acoustic comfort part includes the evaluation of acoustic comfort, sound level, temperature level and class performance. Results showed that students in both spaces felt neither comfortable nor uncomfortable although the spaces have different acoustical conditions. This situation cannot be explained with the sound level measurements (L_{Aeq}) which shows almost similar values in both spaces because students evaluated sound levels as high in classroom environment; neither high nor low in computer laboratory environment. The differences in the evaluation of sound levels showed that the sound perception is not evaluated by only measuring the sound levels of spaces. Although reducing noise level is suggested for community noise control (Bruce & Davies, 2014), it does not necessarily establish a positive environment (Dubois, 2006) .

The correlation of sound level and comfort level results showed that when sound level increases, comfort level of students decreases for classroom environment. No significant relationship between them was found for computer laboratory. It shows that the comfort level and sound level somehow related into each other, but this situation does not have any effect on the evaluation of comfort level of the students. Moreover, the students indicated that they are distracting on the high levels of sound.

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

Moreover, sound level was found as to relate with class performance negatively in both spaces. Results showed that when sound level increases, class performance of students decreases. Although the effect of sound on class performance question was mostly answered as neither negative nor positive, sound level and class performance had a negative association. The students may think that there are other reasons which affecting class performance more than sound level, but their association was also undeniable in terms of their answers. It can be supported with the study of Shield and Dockrell (2008) which showed that chronic exposure of high sound levels has a detrimental effect on the academic performance of students. It is important because noise exposure during learning is hazardous for students' mental development and normal learning process for language and reading (Vallet & Karabiber, 2002).

Furthermore, students evaluated the temperature level as high in classroom environment, and as neither high nor low in computer laboratory environment although the temperature level measurements showed similar values. It was found that temperature level did not have any significant relationship with acoustic comfort, and class performance. Although temperature level was perceived differently in both spaces, the evaluation of comfort level and class performance of students did not depend on this situation. However, there are some additional conditions which point out that temperature has an effect on some students.

CS: *The temperature level affects me so much, I generally feel cold. When nobody feels cold, I do. When I feel cold, I have really difficulty in listening because I need to make an effort to get warmer rather than to listen.*

All objective measurement results showed that soundscape is not evaluated only ensuring the acoustical standard. A positive soundscape environment can be achieved by ensuring the right contexts. Bruce and Davies (2014) cited Dubois (2006) that in soundscape studies, context as the type of noise, type of source and the meaning attributed to sound were found more important when compared to the value of noise level. It is inferred that the peoples' perception generally depends on the context of which sound is heard rather than the physical properties of soundwaves.

-Comparison of subjective results

The correlation between comfort level and class performance showed a positive association in classroom environment. When comfort level increases, class performance of the students also increases. If a student is satisfied with the environment, he/she can concentrate more on his/her lesson.

Moreover, the correlation between socio-demographic results and the answers of acoustic comfort part showed that gender and temperature level were related in both spaces. The frequency distribution of classroom environment showed that male students perceived the environment warmer than female students did, although the temperature measurements recorded around 23-25ºC in both spaces. It is interpreted as the result of male and female anatomic differences.

It is found that mood and comfort level of the students had no significant relationship. Therefore, the students' mood should be evaluated independently from the fact that whether the students are satisfied with the environment, or not. In addition, the scores of students' mood in both environments were compared. The scores of PA and NA were found similar in both spaces although the spaces had different reverberation times. It showed that the reverberation time did not have any effect on the students' mood.

-Responses & Coping Methods & Outcomes

The conceptual framework showed that students developed responses towards the acoustic environment and its related sound sources. Several positive, negative and neutral responses were formed for different sound sources. The conditions in which these responses developed were also important because background information about the sounds can ease the control of understanding to create a more positive reaction (Mackrill *et al.*, 2013). For example, some students accepted speech of their friends as a part of the environment. If the sounds are accepted, understood and habituated; the perception of soundscape shows more positive approach (Mackrill, 2013). It is interpreted as the soundscape association. If a person associates a sound with an environment, one can accept the sounds more easily, and shows a positive approach. Moreover, students sometimes develop the coping methods towards these sounds.

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. This is why I do not evaluate them as negative or positive. They are parts of this environment.*
CS: *I can give more attention to my lesson in quiet environment. Libraries help students learn same thing; you have to be respective to the people studying in there, so you have to be quiet. However, if I am in a noisy environment, I am raising my voice to be heard.*

In addition to that, students sometimes develop more general and long-term responses that are outcomes. Although they may accept or habituate the sound within the environment, they reach some outcomes for the environment. Soundscape may create some outcomes such as lesson failure, loss of time.

-Intervening factors

Intervening factors were also found important in changing soundscape perception of students indirectly because they changed the context in which sounds heard. These are physical factors as lighting, heating or user-dependent factors as behavior, mood. People can perceive the soundscape as positive, negative or neutral in terms of the effects of different intervening factors. Mackrill *et al.* (2013) cited Muzet (2007) that disturbance due to noise depends on many factors including age, sex and experience.

CS: *Lighting is so effective. For example, white light makes me annoyed during the class because I feel as if I am in the hospital.*

LS: *I am a person who likes to know what goes around. Therefore, I prefer to hear some background noise. It makes me feel good.*

- **Recommendations for future classrooms**

This thesis will be a base as the acoustic design guidance of future classrooms. First, wanted and unwanted sound sources are important to shape them. The students indicated that they mostly wanted to hear music in their educational spaces. For that reason, systems for music may be added to the new technological classrooms. Moreover, natural sound sources were also evaluated as positive sound sources. They may be added to the new technological systems to be used in necessary situations such as practical lectures. As unwanted sound sources, technological-mechanical sound sources and motorized transport sound sources were defined. The location of educational spaces may be defined not to take any negative sound sources or to mask the negative sound sources with positive sound sources.

Moreover, students were asked to define their future classrooms in semi-structure interviews. They expected more silent, technological spaces and they defined their ideal class layout as to give students some private educational spaces in necessity. In that sense, interactive future classrooms may have some design adaptations to give silent private spaces for necessary situations.

The selected classroom and computer laboratory had different plan layouts. Classroom was ordered as classical lecture layout whilst computer laboratory had a U-shape plan layout. However, future classrooms are expected to have circular sitting layout. This type of plan also will bring different acoustical issues. However, new educational spaces are supported with the additional screens, and loudspeakers. This situation will increase the speech intelligibility levels in classrooms.

CHAPTER 6

CONCLUSION

- **Summary of the research**

Sound studies started to focus on the environmental noise management approach after industrial revolution. It is seen that there is a lack of understanding, which evaluates acoustic environment with all negative and positive sounds. Related to that, the concept of soundscape was coined by M. Schafer in 1977. Later, soundscape was studied in many spaces, generally in urban or rural areas and indoor soundscape studies were initiated recently. Within indoor spaces, educational buildings were seen as an important research area because people up to 17 years old spend many of their time and develop their characters in their educational spaces.

Previous studies on school acoustic environment were exploring the acoustical parameters of related spaces. The subjective responses of students were generally ignored or were embraced as a general approach. Therefore, both approaches as objective measurements and subjective survey were combined in this study. The aim of the study is to explore the effect of soundscape on the students' perception in high-school environment. Two educational spaces as classroom and computer laboratory were selected to see whether there is a significant difference in soundscape understanding or not. Questionnaire and PANAS test were conducted with 125 students and semi-structure interview was conducted with 50 students. Results of questionnaire and PANAS test were evaluated with statistical software program SPSS; semi-structure interviews were evaluated with Grounded Theory approach. Existing data were evaluated and compared with each other to be presented as an overall frame of soundscape in high-school environment.

- **Main Results and Discussion**

This research revealed important results for the soundscape of high-school environment. Conducting two approaches as objective measurements and subjective surveys resulted in the variety of information about the soundscape of high-school environment in detail.

Firstly, acoustic measurements were conducted in classroom and computer laboratory environment. Measurement of Equivalent Continuous A-Weighted Sound Level (L_{Aeq}), Reverberation Time (T30) and Speech Transmission Index (STI) were conducted to understand the acoustic conditions of the spaces. Results showed that ambient sound levels were measured as 62.6 db in classroom and 64.9 db in computer laboratory. Although they have different acoustic environment and sound sources, sound levels in both environment were found similar. Moreover, values of reverberation time (T30) showed that computer laboratory is accepted as having appropriate reverberation time whilst classroom not. Although both environments had different reverberation times, their results of speech transmission index (STI) showed that both spaces had good speech intelligibility. In addition to that, simulation of the spaces in Odeon 13 showed that reverberation times had similar values in both environments in occupied conditions. STI values in occupied spaces were also found as having good speech intelligibility.

After defining acoustical conditions of both spaces, subjective responses of students were evaluated. Two subjective surveys were including two parts as statistical analysis and Grounded Theory. Statistical analysis gave the researcher to explore and understand the general approach of the students towards the soundscape in high-school environment. Results of grounded theory enabled to understand background reasons, relations and patterns between generated themes. Summary of the subjective results is explored in four parts, as sound sources, acoustic comfort evaluation, mood evaluation, and conceptual framework. Sound source recognition, positive and negative sound sources and identification of wanted and unwanted sound sources were defined in both spaces. Results showed that students in classroom environment firstly recognized human-based sound sources, and students in computer laboratory firstly recognized the electro-mechanical sound sources.

Moreover, positive and negative sound sources were defined according to the results of subjective survey methods. Positive sound sources were found as music, laughter, natural sound sources in classroom. Music was selected as a positive sound source in computer laboratory. Negative sound sources were found as electro-mechanical sound sources and motorized transport sound sources in classroom. Students of computer laboratory environment evaluated electro-mechanical sound sources negatively. Speech of the students was generally evaluated eventful as having both positive and negative comments. In general, human-based sound sources were examined with a neutral approach although background speech was evaluated negatively in both spaces. It shows that students accepted the inner speech as a part of their environment. However, if a sound source did not belong to the environment, they perceived it negatively.

The differentiation of wanted and unwanted sound sources is an important part of study to create a positive environment for students in future. Students in classroom environment indicated that they wanted to hear teacher's speech, music or natural sound sources whilst students in computer laboratory environment wanted to hear low-level background speech, music and natural sound sources. Unwanted sound sources in both spaces were generally composing of human-based sound sources, electro-mechanical sound sources and scraping sounds.

In addition to that, it was important to understand the evaluation of acoustic comfort in both spaces. Sound levels were evaluated as high in classroom environment and neither high nor low in computer laboratory environment although the objective measurements of both spaces showed similar values. Results of comfort level question showed that the students in both spaces felt neither comfortable nor uncomfortable. Therefore, the soundscape quality of a certain space is not examined by objective measurements alone such as sound levels. Moreover, the evaluation of the class performance was rated as neither positive nor negative in both spaces. It is interpreted that students did not believe that sound levels had an effect on their class performance or comfort level.

The negative significant correlation between sound level and comfort level showed that if sound level increases, comfort level decreases in classroom environment. However, this relation was not found in computer laboratory environment. In addition, it is seen that if sound level increases, class performance decreases. Even if the students do not believe that sound level has an effect on class performance, it was found in terms of the correlation results. Comfort level was found as to relate with class performance positively in classroom environment. When comfort level increases, class performance of the students also increases. Results of the evaluation of computer laboratory students showed that acoustic environment did not have an impact on their comfort level or class performance. The differentiation between these spaces can be the result of context of lesson because in classroom environment, students need to understand the teacher to be successful whilst students in computer laboratory have to practice their works on computer. Moreover, no relation was observed between mood and subjective responses as comfort level or between mood and objective measurements as reverberation time. Therefore, soundscape has no effect on mood of students in both spaces.

Temperature level was evaluated as high in classroom and neither high nor low in computer laboratory environment although the temperature level measurements showed similar values. However, temperature level was found as having no relationship with comfort level or class performance. Temperature level was related with the perception of different genders. Male students tend to perceive the environment warmer than female ones. This differentiation can be the result of their anatomical differences. It was found that there was no relationship between other socio-demographic results as age, gpa and acoustic comfort.
On the other hand, conceptual framework was established for both spaces to get a better understanding of soundscape in educational spaces. It revealed 8 categories, 21 sub-categories. The categories are sound sources &sound levels; acoustic environment, soundscape perception, soundscape preference, coping methods,

responses, outcomes, and intervening factors. The positive perception of soundscape promoted concentration, attention, focus, motivation and mood in both spaces, and negative perception of soundscape resulted in loss of concentration, motivation, productivity and attention, annoyance, distraction. It was found that students developed some coping methods to handle with the negative soundscape such as habituation, adaptation, isolation because if a person accepts the sound as a part of environment, he/she has more positive sound perception towards the environment. In addition, the students reached some long-term results as failure of lesson. Intervening factors such as location of spaces, insulation, lighting or some user characteristics were also found as effective in soundscape perception. With addition of intervening factors, people can perceive the soundscape as positive, negative or neutral in terms of his /her preferences.

Therefore, the evaluation of subjective responses of students was found important as well as the evaluation of objective parameters. It shows that researcher needs to evaluate both approaches together to understand the soundscape of space holistically.

- **Limitations of the Study**

This research has a few of limitations on the objective measurements and subjective evaluations. First, the age distribution of students can be accepted as a limitation because survey was conducted with 14 or 15 years old students due to their elective courses in classroom. It would be better to see the perception of all students from different ages. Secondly, integration of psychoacoustic parameters (loudness, sharpness, roughness) to the subjective evaluation could give more data to understand the perceptual construct of students. Due to the lack of measurement devices, this study cannot be conducted.

- **Recommendations for Further Research**

This thesis will be a base to create better understanding for further soundscape studies; and it contributes to the literature as a case study example in soundscape approach. As school environment, the perception of students from different ages can offer different findings. Therefore, this study can be conducted in kindergartens, primary schools or university classrooms. Moreover, the research can be conducted with different types of educational spaces such as music rooms, auditoriums, painting classes to represent the overall understanding of soundscape in learning spaces. Different building types also can be evaluated by using the methodology of this thesis. Therefore, it is also recommended that different methodologies such as listening tests, soundwalk method can be studied to outline possible additions for soundscape approach in high-school environment. In addition to that, further researchers can use this thesis as a base to create design recommendations in high-school environment depending on the sound preferences of students for classrooms in future.

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APPENDICES

APPENDIX A

Dear Participant;

This study will be used in ‘A comparative study on soundscape in high-school environment’ titled master thesis in Bilkent University, Department of Interior Architecture and Environmental Design. The answers will be used only as 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 which 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 which 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 chosing 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.	**The temperature level in this classroom environment / computer laboratory environment is ....**	
Very High		
High		
Neither High Nor Low		
Low		
Very Low		
4.3.	**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		
4.4.	**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		

Figure A. 1: Acoustic Comfort and Sound Preference Questionnaire (including third section for both spaces)

Değerli Katılımcı;

TBu anket, Bilkent Üniversitesi, İç Mimarlık ve Çevre Tasarımı Bölümü'nde ' Lise çevresinde işitsel peyzaj üzerine karşılaştırmalı bir çalışma' başlıklı yüksek lisans tezinde kullanılacaktır. Ankete vereceğiniz cevaplar, sadece akademik amaçlarla kullanılacaktır.

Gösterdiğiniz ilgiye teşekkür ederiz.

AKUSTİK KONFOR VE SES TERCİHİ ANKETİ						
1	**Lütfen demografik bilgilerinizi yanıtlandırınız.**					
Cinsiyetiniz	Erkek ◯	Kadın ◯				
Yaşınız	13 ◯	14 ◯	15 ◯	16 ◯	17 ◯	18 ◯
Not Ortalamanız	100-85 ◯	84-70 ◯	69-60 ◯	59-50 ◯	49-0 ◯	

2	**Lütfen aşağıdaki boşlukları size uygun olarak yanıtlayınız.**
2.1.	**Laboratuvarda/sınıfta bulunan seslerden aklınıza gelen ilk üç sesi yazınız.**
2.2.	**Sınıf/ Laboratuvar ortamında hangi sesleri duymayı tercih edersiniz?**
2.3.	**Sınıf/ Laboratuvar ortamında hangi sesleri duymamayı tercih edersiniz?**

3	**Bu sınıfta ders esnasında bulunan sesleri değerlendiriniz.**				
	Rahatsız edici -2	-1	Ne Rahatlatıcı Ne Rahatsız Edici 0	1	Rahatlatıcı 2
Konuşma sesi					
Gülme sesi					
Ayak sesi					
Bitişik mekanlardan gelen sesler					
Koridordan gelen sesler					
Trafik sesi					
Siren/ambulans sesi					
Kuş sesi					
Havalandırma sesi					
Projektör sesi					
Alarm sesi					
Telefon sesi					
Saat sesi					
Müzik sesi					
Lamba sesi					

3	**Bu laboratuvarda ders esnasında bulunan sesleri değerlendiriniz.**				
	Rahatsız edici -2	-1	Ne Rahatlatıcı Ne Rahatsız Edici 0	1	Rahatlatıcı 2
Konuşma sesi					
Gülme sesi					
Ayak sesi					
Bitişik sınıftan gelen sesler					
Koridordan gelen sesler					
Havalandırma sesi					
Klavye/mouse sesi					
Projektör sesi					
Bilgisayar fanı sesi					
Alarm sesi					
Telefon sesi					
Saat sesi					
Müzik sesi					
Lamba sesi					

4	**Lütfen aşağıdaki yargıları size uygun gelen seçeneği işaretleyerek tamamlayınız.**	
4.1.	**Bu laboratuvardaki/ sınıftaki ses seviyesini ……………………… buluyorum.**	
Çok Yüksek		
Yüksek		
Ne Yüksek Ne Düşük		
Düşük		
Çok Düşük		
4.2.	**Bu laboratuvardaki/ sınıftaki sıcaklık seviyesini ……………………… buluyorum.**	
Çok Yüksek		
Yüksek		
Ne Yüksek Ne Düşük		
Düşük		
Çok Düşük		
4.3.	**Bu laboratuvarda/ sınıfta ders esnasında ses çevresi açısından kendimi ……………… hissediyorum.**	
Çok Rahat		
Rahat		
Ne Rahat Ne Rahatsız		
Rahatsız		
Çok Rahatsız		
4.4.	**Bu laboratuvarda/ sınıfta ses seviyesi dersteki performansımı ……………………… etkiliyor.**	
Son derece olumlu		
Olumlu		
Ne olumlu Ne olumsuz		
Olumsuz		
Son derece olumsuz		

Figure A. 2: Acoustic Comfort and Sound Preference Questionnaire (Turkish version)

The PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent [INSERT APPROPRIATE TIME INSTRUCTIONS HERE]. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

_____ interested	_____ irritable
_____ distressed	_____ alert
_____ excited	_____ ashamed
_____ upset	_____ inspired
_____ strong	_____ nervous
_____ guilty	_____ determined
_____ scared	_____ attentive
_____ hostile	_____ jittery
_____ enthusiastic	_____ active
_____ proud	_____ afraid

We have used PANAS with the following time instructions:

Moment	(you feel this way right now, that is, at the present moment)
Today	(you have felt this way today)
Past few days	(you have felt this way during the past few days)
Week	(you have felt this way during the past week)
Past few weeks	(you have felt this way during the past few weeks)
Year	(you have felt this way during the past year)
General	(you generally feel this way, that is, how you feel on the average)

Figure A. 3: PANAS test (Watson *et al.*, 1988)

PANAS (Pozitifve Negatif Duygu Ölçeği)

Aşağıdaki maddelerde çeşitli duygu ve hisleri tanımlayan sözcükler yer almaktadır. Her bir maddeyi okuyunuz ve her bir sözcük için 1'den 5'e kadar numaralandırma yapınız. İçinde bulunduğunuz şu an için bu hisleri hangi sıklıkla yaşadığınızı belirtiniz.

Çok az veya Hiç -1-	Biraz -2-	Kısmen -3-	Sık Sık -4-	Çok Fazla -5-

	(1-5)		(1-5)
-İlgili	……………………	-Tedirgin	……………………
-Sıkıntılı	……………………	-Uyanık	……………………
-Heyecanlı	……………………	-Utanmış	……………………
-Mutsuz	……………………	-İlhamlı	……………………
-Güçlü	……………………	-Sinirli	……………………
-Suçlu	……………………	-Kararlı	……………………
-Ürkmüş	……………………	-Dikkatli	……………………
-Düşmanca	……………………	-Asabi	……………………
-Hevesli	……………………	-Aktif	……………………
Gururlu	……………………	-Korkmuş	……………………

Figure A. 4: PANAS test, adapted from (Gençöz, 2000) (Turkish version)

SEMI-STRUCTURE INTERVIEW QUESTIONS

1. What do you except to hear in your classroom /computer laboratory environment?

(Sınıf / Laboratuvar ortamında ne duymayı beklersiniz?)

2. What are the positive or negative sound sources in your classroom/ computer laboratory environment?

(Sınıf/ Laboratuvar ortamınızda bulunan pozitif yada negatif sesler nelerdir?)

3. Why do you think these sound sources are positive or negative?

(Neden bu seslerin pozitif ya da negatif olduğunu düşünüyorsunuz?)

4. What do you prefer to hear in your classroom/ computer laboratory environment?

(Sınıf/ Laboratuvar ortamınızda ne duymayı tercih edersiniz?)

5. What do you prefer not to hear in your classroom/ computer laboratory environment?

(Sınıf/ Laboratuvar ortamınızda ne duymamayı tercih edersiniz?)

6. Do you associate any sound with your current classroom/ computer laboratory environment?

(Sınıf/ Laboratuvar ortamıyla bağdaştırdığınız herhangi bir ses varmı?)

7. How does the soundscape of classroom/ computer laboratory environment affect your behavior and psychology?

(Sizce ses çevresi sınıf / laboratuvar ortamındaki insanların davranışlarını ve psikolojisini nasıl etkiler?)

8. How would you describe the future soundscape of classroom/ computer laboratory environment?

(Size göre gelecekteki sınıf ortamının ses çevresi nasıl olabilir?)

9. What would be the ideal classroom/ computer laboratory soundscape from your point of view?

(Size göre sınıflardaki ideal ses ortamı nasıl olmalıdır?)

10. Do you perceive background noise in your classroom/ computer laboratory environment? If so , how would you describe it?

(Sınıf ortamında ders esnasında her hangi bir arka plan sesi algılıyormusunuz? Algılıyorsanız, nasıl açıklayabilirsiniz?)

11. How do sound sources affect your class performance in your classroom / computer laboratory environment?

(Sınıf ortamınızdaki seslerin ders performansınızı nasıl etkilediğini düşünüyorsunuz?

12. How do the physical characteristics expect from sound affect your class performance in your classroom/ computer laboratory environment?

(Sınıf ortamınızın ses dışındaki fiziksel özelliklerinin ders performansınızı nasıl etkilediğini düşünüyorsunuz?)

APPENDIX B

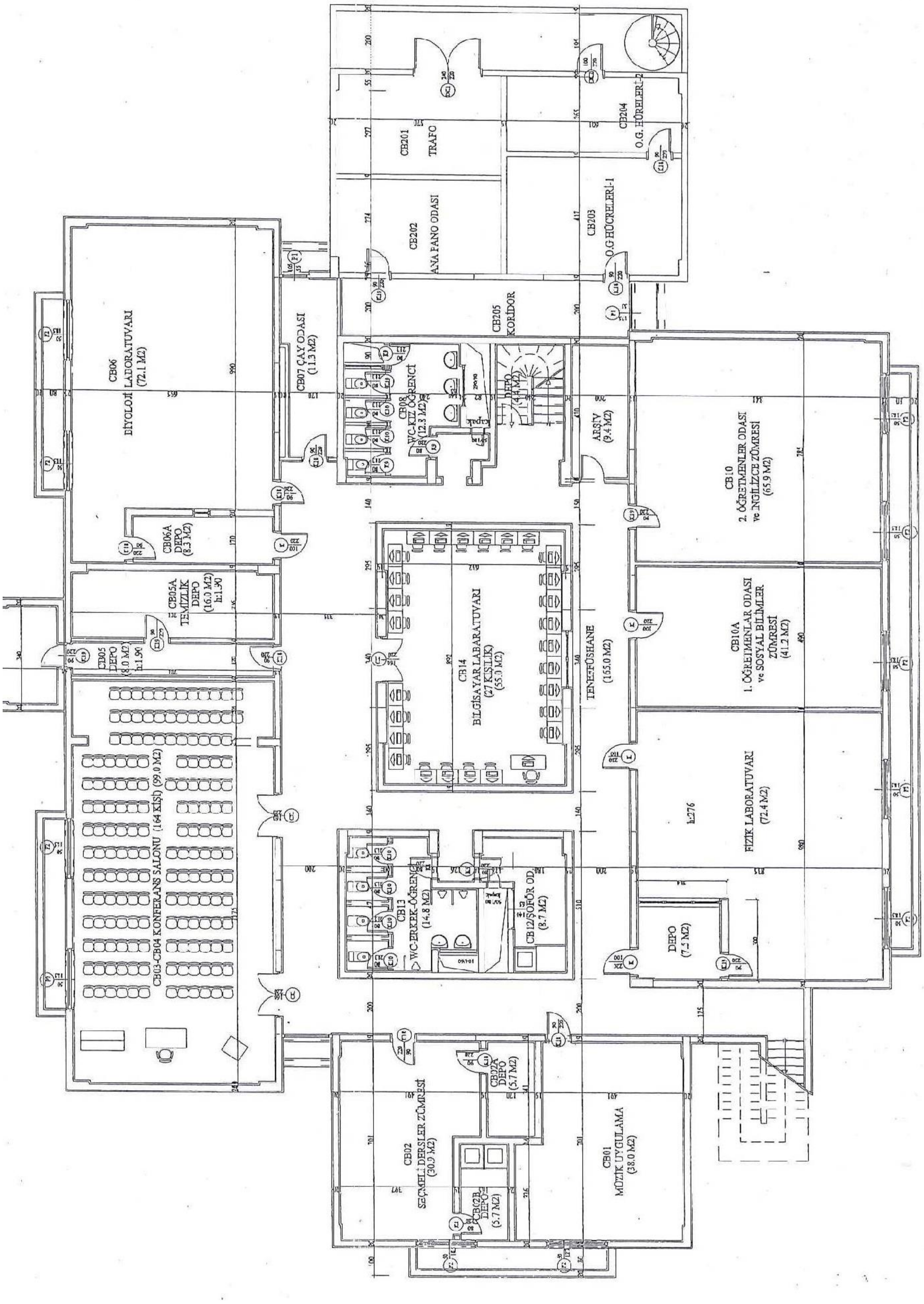

Figure B. 1: Basement floor plan of Bilkent High School (not to scale)

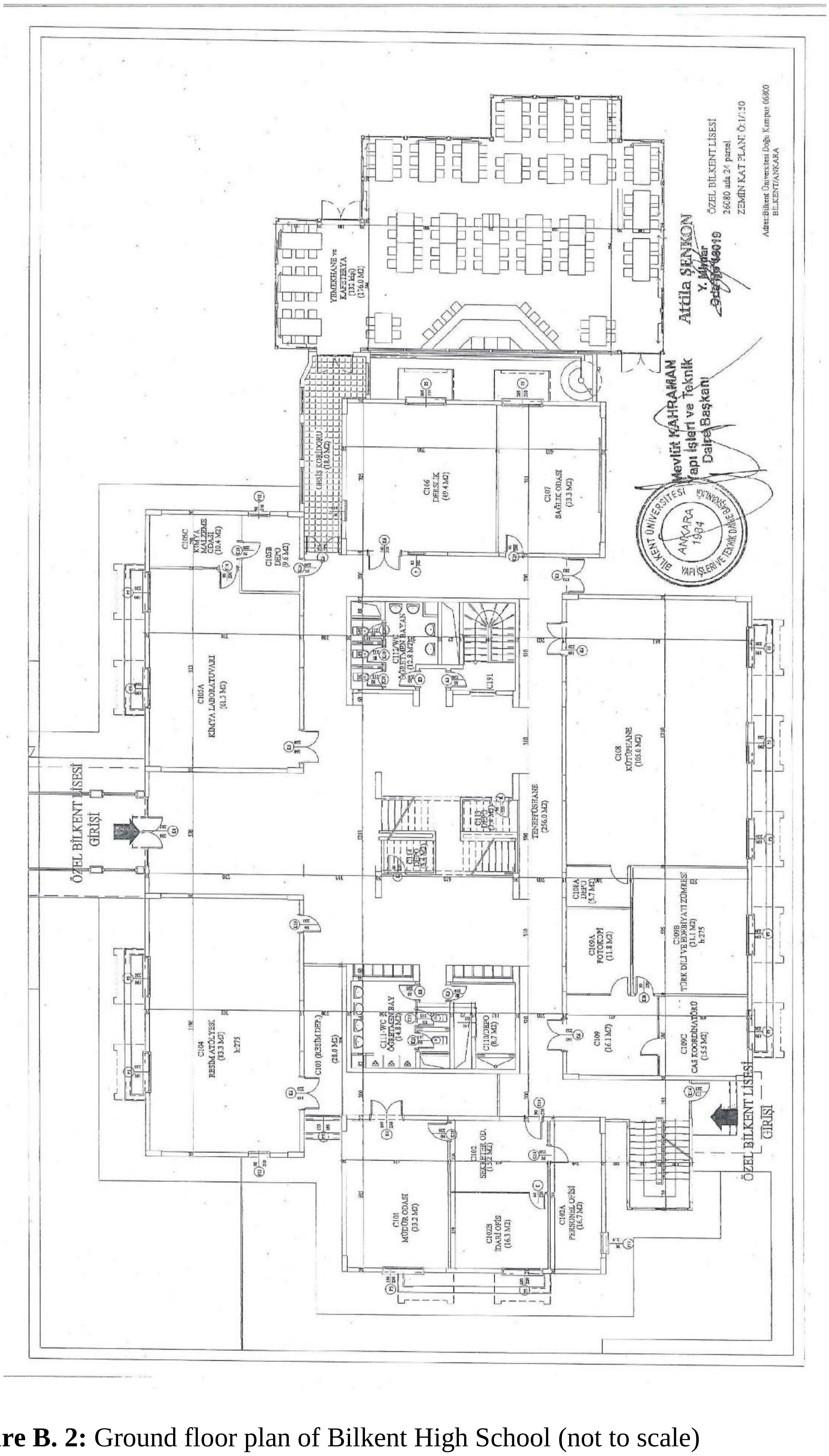

Figure B. 2: Ground floor plan of Bilkent High School (not to scale)

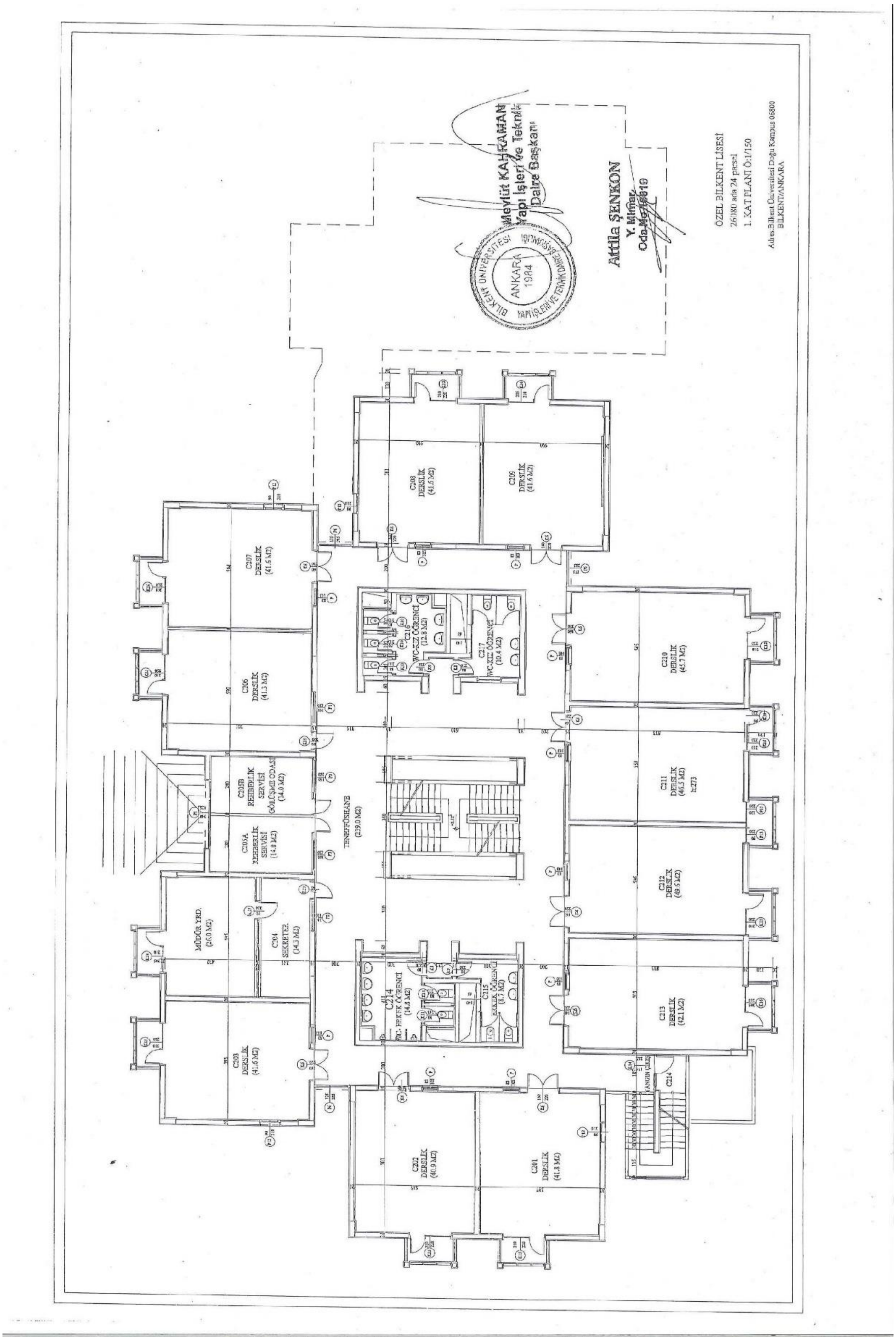

Figure B. 3: First floor plan of Bilkent High School (not to scale)

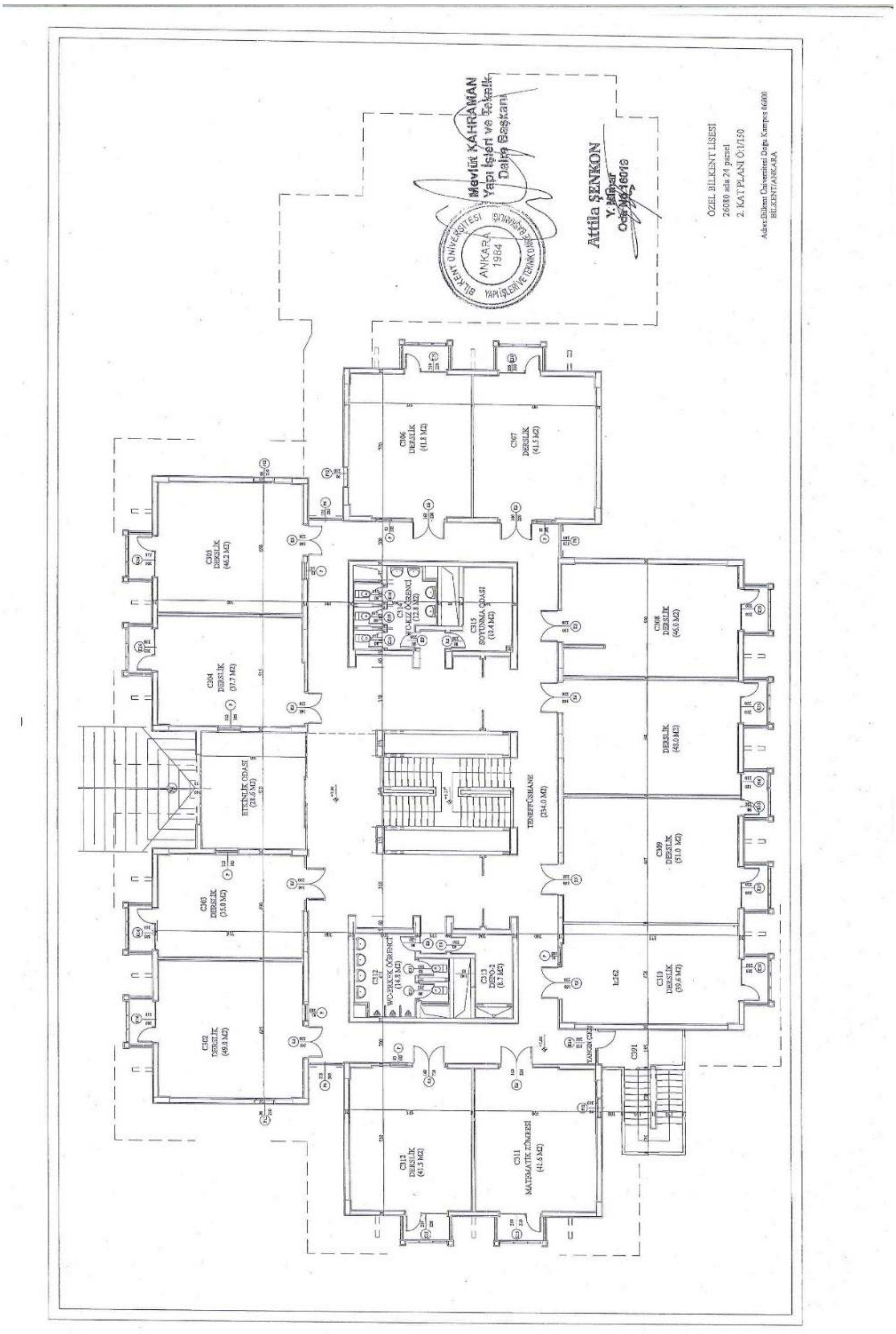

Figure B. 4: Second floor plan of Bilkent High School (not to scale)

APPENDIX C

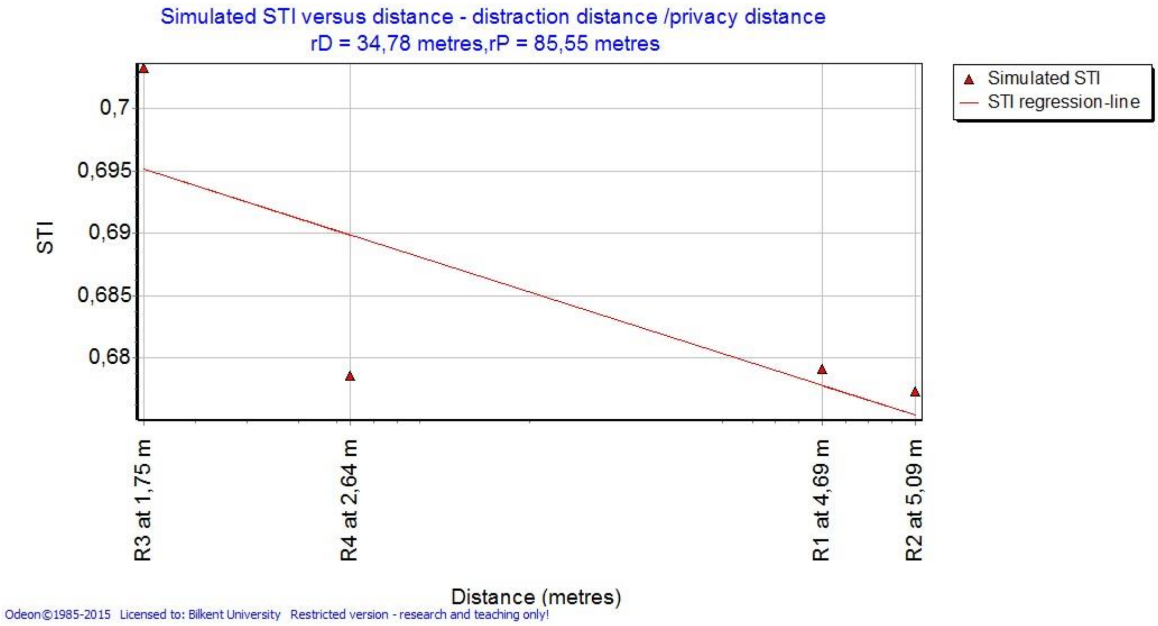

Figure C. 1: Relationship between STI values and distance of receiver points in classroom

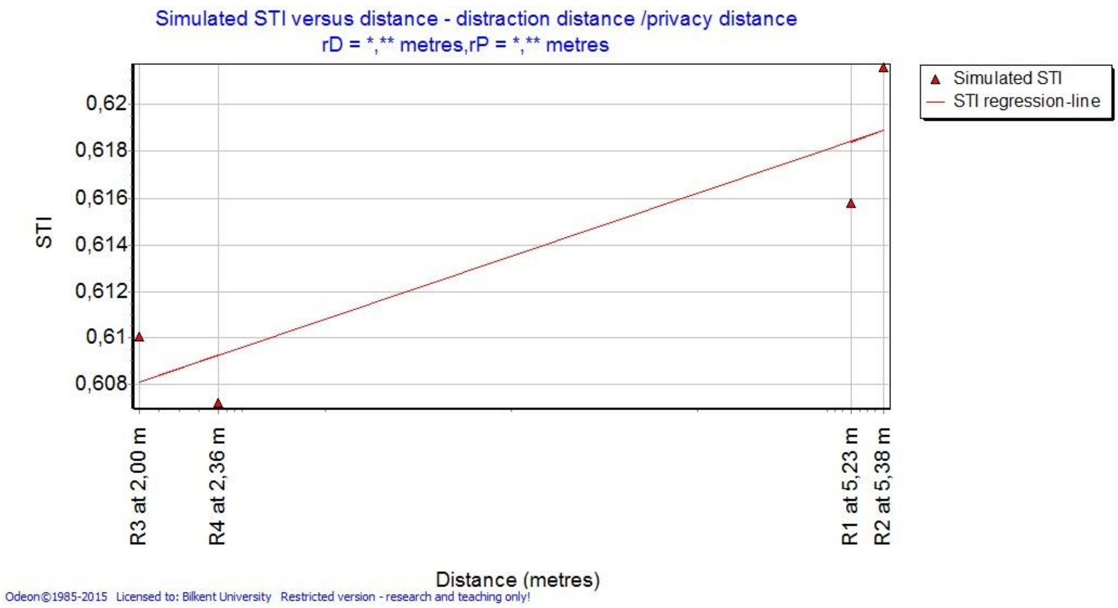

Figure C. 2: Relationship between STI values and distance of receiver points in computer laboratory