Int. J. Nonlinear Anal. Appl. 14 (2023) 4, 101–110
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2023.22992.4363

The impact of traffic noise on educational buildings (University of Technology, Department of Architecture Engineering as a case study)

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(Communicated by Seyed Hossein Siadati)

Abstract

This study addresses the impact of traffic noise on educational buildings. By selecting a sample, a classroom in the Department of Architectural Engineering at the University of Technology during the academic year 2021/2022 AD. The noise level was measured inside the given hall and outside it. The hall is located on the ground floor of the department, and measurements were taken using the Professional Environment Meter (P.E.M). The study covered 10 days to give actual and realistic readings after taking them at different times. The rate was calculated for the hall. The result of the calculation (average) showed that it exceeded the limit allowed for classrooms of (40db-db.30) for this educational institution. This study is the first of its kind because it discusses the impact of traffic noise on educational buildings and concludes that noise pollution is one of the most disturbing sounds for humans. Some movement activities can produce harmful noise as a result of continuous movement. This can cause some distractions in the learning process.

Keywords: noise, traffic noise, sound design, auditory pollution, frequency
2020 MSC: 60H99, 91B76

Introduction

Determining the location of private educational buildings on major streets where the noise source is direct has an impact on the educational institution in general and students in particular. Therefore, it is necessary to determine the level of noise caused by passing vehicles and their movement around the campus area during activities of teaching and learning. Hence, this research aims to discover the noise level that likely disturbs the learning process.

Consequently, this research aims to discover the amount of noise level that is likely to disturb the learning process, and the main purpose of this research is also to find the noise level on the campus and determine the problems of physical pollution resulting from human activity and the concept of noise and traffic pollution with its causes, types, effects, and prevention. In addition to seeking the best methods and means to reduce noise and traffic pollution and their impact on the educational environment, (University of Technology as a case study).

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Received: November 2022 *Accepted:* February 2023

As for the importance of the study, traffic noise is a type of environmental pollution affecting human health. The European Environment Agency issued a dangerous report titled "Environment" in which it stated that 451 million people are regularly exposed to noise. The negative effects of noise are not limited to complete or partial hearing loss or, rather, they go beyond that, causing fatal diseases and permanent disabilities in some cases, including heart attacks.

As for the methodology of the study, the researcher relied on modern devices to determine the severity of the impact of noise and traffic pollution on students, where readings of the devices were taken, and a field survey was conducted for a sample of civil society segments, at various ages and spatial levels. The researcher adopted the descriptive analytical method to study the research.

Literature review

Interfaces for immersive audio (2013) Intelligent Acoustic

This study addressed enhancing speech clarity and reducing noise levels in schools. At the same time, teachers frequently suffer from voice problems due to the high vocal load they are exposed to at work. Vocal support is related to vocal stress, and the decay time is derived from the response to the verbal-auricular impulses, which are related to vocal comfort. The speech clarity model was established based on the beneficial to harmful ratio and on the experimental signal-to-noise models in classrooms to deduce audio instructions for the classrooms, considering the physical size constraints associated with the number of students in each class.

The recommended values of reverence time in fully occupied classrooms for the flexible teaching process are between (0.45 seconds and 0.6 seconds) and between (0.6 and 0.7 seconds) for unoccupied ones for furnished classes that contain (40) students and of (210) square meters. This study adopted the condition for classrooms with a size of less than 210 cubic meters. This study adopted the analytical-descriptive approach of the acoustic space related to the speaker and its relationship to sound in order to obtain the practical design of pure acoustics.

Vocal comfort is a subjective feature in space that is directly related to the positive assessment of speech spaces, purposes, perceived support, and negativity associated with feeling the need to raise the voice and fatigue after talking for a long time in space.

Acoustic stress: It is a physiological amount that differs from the intensity of sound, which explains the changes in sound production required to communicate at different distances.

It is concluded, from the above, that the acoustic design of classrooms is based on acoustic comfort. It is suggested that the echo time in conditions of full occupancy depends on the cube root of classroom size. Classrooms are spaces for listening, speaking and learning, hence, the criteria for speech clarity have also been taken in considerations to have more precise recommendations. There are two concepts related to the voice of the teachers are identified in this context: vocal comfort and vocal stress.

The Effect of School Design on Student Performance (2015)

This study explored the impact of school design on students' performance. It was taken from 150 students who studied in two schools, public and private. The School Design and Planning Lab (SDPL) model was used as an assessment indicator for school design and some of its design characteristics, such as unrestricted functional landscapes, interior spaces, outdoor spaces, and natural life, all of which were explained to the students.

A study was conducted to compare the performance of students, which is determined by the average scores of their final achievements, with measures of school environmental characteristics. The design characteristics of these schools and the students' levels were also studied. The quantitative data that was subjected to a set of descriptive statistics showed that the design of schools represents a strong factor for students studying in private schools.

Learning spaces are considered powerful components that motivate students to study and progress. Learning spaces can stimulate feelings, create a sense of security and prepare students for learning. The study shows that design characteristics such as poor sound design, poor ventilation, inadequate lighting, and continuous exposure to noise undermine the learning process. Hence, school designers should create learning environments that motivate students.

These physical environments should not only be functional, rather they should provide quiet spaces, study and analyze the impact of physical learning and teaching spaces, and conduct research (acoustic design, noise, air quality, spatial density, students' performance and attendance, and study learning and teaching spaces).

We conclude from the above that the study focused on designing effective learning environments in order to support learning and improve students' performance due to the availability of a comfortable acoustic environment.

Study (Ludovico Ausiello study, November 2019 circulation)

Standards for acoustic design for higher education learning environments

This addresses the acoustic performance standards contained in BUILDING BULLETIN (BB93) Requirements, E4 of Building Regulations, School Building Regulations, and Independent School Standards: The acoustic performance standards in BB93: BUILDING BULLETIN BB93 meet E4 requirements in Building Regulations, School Building Regulations, and Independent School Standards.

School acoustics: BB93 (Design Guide 2015) It provides information and standards for acoustic design for schools, for use by acoustic consultants, architects, developers, and designers to aid in the designing and testing of new school buildings. Background noise measurements were studied, where they were performed in accordance with the standards. BB93 defines indoor ambient noise levels (IANL) values, which exclude noise from teaching activities, classroom equipment, and rain noise.

These values mainly take into account the noise generated by building services, including ventilation systems, air conditioning, and sound sources outside the learning environment, and they are measured through the use of a sound level meter. This study aims to investigate the acoustic requirements in the educational environment. The study was implemented by evaluating several acoustic parameters by testing three rooms in a period of two semesters, including background noise, echo time (RT), speech clarity, speech intelligibility (SI), and sound power.

We conclude from the above that there is a good correlation between subjective and objective results. This fact is reflected in the measured noise and sound levels. The highest and lowest measured background noise levels in a theater were (39.8 dB) and (33.9 dB) respectively.

(Alexandra Sotiropoulou, Ioannis Karagiannis, Maria Papaioannou 2019)

Sound Insulation Performance of Prefabricated Concrete Partitions in Hellenic School Buildings This study addressed the acoustic insulation performance of precast concrete partitions in Hellenic school buildings in Greece. The scope of this study is to investigate the transmission of surrounding noise through the connections between ready-made concrete elements in Greek school buildings where these connections are not present in the proper structure of ordinary concrete buildings. Sound insulation measurements were carried out in two precast-concrete buildings of the cell type; the latter involves demountable/reusable concrete elements (cells).

The transmission of ambient noise at the joints may be more obvious. A sample of seventeen sections of the façades and interior of the classrooms were tested. The sound insulation was predicted based on the classical theory and confirmed by the analysis of the measured data. The sound insulation performance of the tested sections was sufficient, except for the composite sections that include door and window openings. This section has been identified as a major source of sound insulation deterioration. The importance of careful plugging of joints has been addressed.

The lack of sound transmission and insulation in buildings is detected as a problem, so in the past few years there has been a growing interest in establishing acoustic measures at different frequencies. Then airborne sound insulation measurement is useful, especially for the construction field, taking into account noise sources, sound insulation, echo time, and source control according to the British standard (BS) 8233: 2014, which is part of a group designed for assessing the sound insulation properties of building elements. It is designed to measure the transmission of sound through a part or partitioning material in a building.

The International Standards Organization (ISO) published a calculation procedure, ISO 717-1 and ISO 16283-1, where a trend is established for school buildings of this type. However, unlike ordinary concrete buildings consisting of a good (homogenous) structure, the ready-made buildings are constructed of essential constriction elements. This can be a limiting factor for the sound insulation rates to be achieved, since joints are potential pathways for surrounding noise transmission. The aim of this study is to investigate the sound insulation performance of concrete partitions in Greek school buildings.

Individual control as a new way to improve classroom acoustics: simulation-based study 2020

This proposal addresses sound conditions in classrooms carefully, studying the current conditions of sound quality in classrooms as well as the effects of bad acoustics on students' health and performance. Previously, noise was the biggest internal environmental problem in classrooms:

(87%) of primary school students reported that they suffer from noise. A laboratory study that included a group of students showed that sounds are better in the acoustically treated classroom than in the untreated ones. Many recommendations and standards have been developed regarding acoustics in the classroom. Most countries have their own sound standards in schools.

The UK Building Bulletin provides comprehensive guidance and recommendations for the acoustic design of schools, including that the place of teaching and study should provide an appropriate frequency time (RT) for "clear teacher-student speech communication" and "clear student-to-student communication". A previous study found that the limits of (RT) are becoming more restrictive, where (RT) is shorter in these countries (2015). The Netherlands emphasized its primary school guidelines that rank three different quality levels (Very Good; Good; Fair) for sound types in the classroom.

The current study consists of several computer simulations conducted by a ray tracing-based acoustic space prediction program called Computer Aided Theater Technology (CATT-Acoustic). The classroom-level acoustic improvements, such as the use of ceiling panels, do not perform well to solve the noise and sound problems in the classroom.

The acoustic effects of five different classroom settings: for individual sound enhancement (one-sided and two-sided curtains), classroom sound enhancement (half ceiling and full ceiling), and a single "control" setting, were simulated using computer-aided theater technology (CATT-Acoustics).

Noise

Noise is the unwanted sounds caused by the vibrations of bodies and affects, in one way or another, the general health and the quality of daily life of humans. It is calculated by the difference between the logarithmic pressure between the sound pressure whose intensity is to be measured and the pressure of the least sound (P0) that the human ear can hear, which is (20) micro pascals. [9]

The intensity of the noise to which the human ear is exposed is measured with the unit of decibel known as "dB", as determined by the measuring device that conforms to international standards ISO-176. Noise is considered to have physiological and psychological effects that harm a number of people, which is increasing day by day. Rapid urban growth has helped to increase the intensity of noise and exacerbate this problem. Noise is a contemporary disease that exists in cities affected by noise pollution. (Al-Jawadi, 2013).

Noise pollution (noisiness)

Noisiness is one of the effects that accompany the existence of mankind and its attempts to change the pattern of nature in order to achieve more luxury and a comfortable life. Noisiness is as old as man, as the inscriptions on some clay tablets that were found in the Iraqi cities of (Sumer) and (Babylon) refer to the boredom and restless of the town, which is teeming with the noise emanating from human tools and machines. The Greek and Roman cities imposed strict orders to prevent disturbing noises from being issued at night, and even the streets in the neighborhoods of philosophers and scientists were covered with materials that absorbed the sounds of horses' hooves because they considered noise limited the ability of philosophers to think. [10]

Noise is nothing but an annoying sound of a high degree.

Sound: Sound is known to be the external influence on the ear, and it causes the sense of hearing through the propagation of sound waves in space. Not every sound is considered noise, as it is the interference of loud, sharp, and undesirable sounds. [1]

The most important characteristics of sound are sound intensity, pitch, and sound type.

Pitch: It is the characteristic that distinguishes between sharp and thick sounds and it is related to the frequency of the vibrating body.

The type of sound: It is a difference in the tone of the voice, even if its intensity and degree are equal, so the ear distinguishes the voice of the man and the voice of the woman.

1. Psychological effect: when the sound being louder than normal, it leads to a lack of vital activity, anxiety, internal uneasiness, confusion and dissonance. Where the exposure to noise for a period of one second reduces concentration for a period of (30) seconds.
2. Neurological effect: The noise reaches the central nerve cells in the brain via nerve fibers, irritating them and reflecting on the body's organs such as the heart.

3. Affecting hearing: The sense of hearing is entrusted with the direct impact of noise, and complaints about the sound's harshness begin when its intensity reaches 50 decibels.
4. Effect on production and performance: efficiency decreases during noise. [3]

Physical Pollution

Physical pollution is one of the most important factors with a harmful impact on the environment and on contemporary civilization. It is primarily a technical (human) product. It is related to the change of normal physical values in the environment, such as radio, light, electromagnetic, radiological, thermal, and noise changes, and it is linked to the increased concentrations of these physical values over their normal range, with which different organisms have adapted. [4]

People always suffer from some or all forms of physical pollution and places. Humans are forced to be exposed to this type of pollution. The risk of physical pollution to humans is no less than that of air, soil, or water pollution, because, according to the definition provided by the World Health Organization, good health means "compatibility between the human body and its environment so that all organs and systems perform their functions efficiently and in perfect harmony with this environment." [8]

Noise Pollution

Noise has become an attribute of the present era, as people encounter it wherever they are and around the clock. Noise can be defined as "a form of physical pollution; it is inconsistent and unwanted overlapping sounds that cause harm and inconvenience to those who are exposed to it". [7]

The American physicist Alexander Bell invented the unit of sound intensity, which was later known as the decibel. It starts with measuring noise from zero as a minimum point, which means that there is no trace of the sound at all, and ends at 140 decibels as a maximum point, where the sounds are harmful. Humans can hear sound intensities of 20 decibels. [6]

The maximum sound intensity that the human ear can hear without causing pain in the ears is 120 decibels. Studies have shown that sounds that exceed (60 decibels) fall within the circle of auditory pollution that is harmful to humans. [2]

Conclusion

Conclusion: Conclusion: Noise is not limited to humans only, rather it was found that loud noises affect some animals, causing them to become very nervous. However, there are two positive aspects in dealing with noise compared to other types of pollution, "temporality" meaning lack of permanence, in other words, the effect of noise ends as soon as the noise stops. This means that noises do not leave clear trace in the environment, and nothing remains around us.

As for the second aspect of noise, which makes it differs from other types of pollution, is that it is largely "local", where it can be felt only near the source. Its effects do not spread and are not transmitted from one place to another, as in the case of air pollution or water that moves from one region to another or from one country to another through Borders, prompting to describe them as "environmental problems."

The Study Sample

One of the sound effects is the diversity of noise between car engines and aircraft sounds. Accordingly, the tone of human voices has increased, and everyone is now complaining about screaming and noises. They are two sources of physical pollution, which not only damage the individual's comfort but also cause a lot of distorted vibrations to the hearing and the nervous system in particular, and consequent negative physiological effects on the body.

Where the noise leads to a lack of vital activity, irritation, tension, and confusion. Noises also reach through the nerve fibers to the central nerve cells in the brain and agitate them, which leads to psychological and health damage that may result in chronic anxiety, psychological stress, depression, and possibly chronic fatigue as well. The negative impact on the vitality of the nervous system is a direct cause of high blood pressure and some other diseases. Noisiness leads to a decrease in the ability of students' comprehension inside the educational institute.

Noise exhausts many city dwellers, but most of them do not attribute this to their exposure to noise and look for other reasons.

Sample / University of Technology / Department of Architectural Engineering - Hall No. (1) ground floor - lecture hall.

One of the halls of the Department of Architecture Engineering overlooks the sub-street:

First:

1. The floor (ground) of the hall is gradual. The gradient in the floor has a significant impact on the hearing process.
2. Lines of sight towards the stage.
3. The design feature of the floor is graded and plays a great role in the sound performance of the hall.
4. The loss of sound energy is reduced, resulting in repeated echo treatment. The seats are covered (with fabric). This is a type of absorbent material that helps balance the time of sound frequency.

Second: corridors

1. The hall has two corridors (parallel) for seating chairs.
2. It is not preferable to place the corridor in the center of the hall because it leads to the refraction of the wave reflected from the ceiling of the hall, which results in poor sound performance.
3. The middle part of the hall is the preferred part of the audience and the receiver in a visual term.

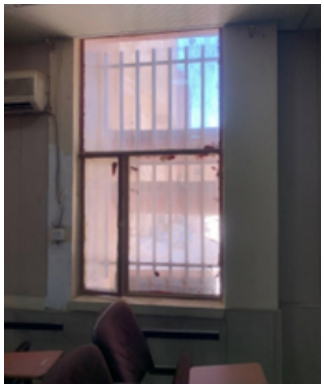
Third: Walls:

1. It is necessary to achieve sound insulation in the walls of the hall (internal and external) to reach acoustic privacy.
2. The aim of sound insulation is a complete sound balance in the classroom, by selecting processors and absorbents materials, and making the surface near the professor's platform of reflective materials. The materials used in the hall of the Department of Architectural Engineering are wood (in the form of panels) - the walls are to the right and left.

3. As for the back wall of the hall, it is covered with absorbent materials (wood), which helps in a cycle of scattering and spreading sound waves. The wooden panels are one of the most important reasons that help in improving the auditory condition of the hall.
4. The materials that are used in wall coverings are among the reflective acoustic and sound-absorbing treatments, according to the method of their formation, type and material from which they are made.

Fourth: the ceiling:

1. The ceiling should be soundproof because it is designed to direct sound to the rare parts of the space. The hall ceiling is a continuous surface. Reflective ceilings are divided into: - flat, concave, convex.
2. The ceiling in the hall of the Department of Architectural Engineering, according to the design, is flat.



3. The ceiling lighting in the hall is evenly distributed and confined horizontally on a parallel line with appropriate dimensions.
4. As for the color of the ceiling, it is white in order to give openness and wideness, unlike the function of other colors. The ceiling of the hall is a void ceiling (secondary ceiling) through which appliances pass.

Fifth: (Windows and doors)

1. They are basic and necessary elements in the interior space, as they are connected to the floor and ceiling, and their function is to provide lighting, air entry and exit, and define the attribute of the space.
2. The windows in the hall on one side overlook the outer space of the university.
3. One of the most important treatments for an environmental phenomenon is the presence of windows. Windows sizes, selection, design and openings are made according to the function of the space. Among the most important things to consider are (shape, measurement, fragmentation), how to open and close the window, glazed space, thermal insulation, sound insulation, rain insulation, ventilation insurance, noise insulation and insulation against fires.

Seven: Seats:

The seats are distributed in the hall in a staggered manner:

1. The seats are organized with two lanes to allow movement between them.
2. In terms of performance, aesthetics and student comfort, each seat has a backrest and is made of sponge and fabric material, to provide convenience for students.
3. Eight: sound design

1. The shape of the hall is rectangular.
2. The distribution and organization of seats in the study hall (seats are fixed to the floor) helps a better sound reception.

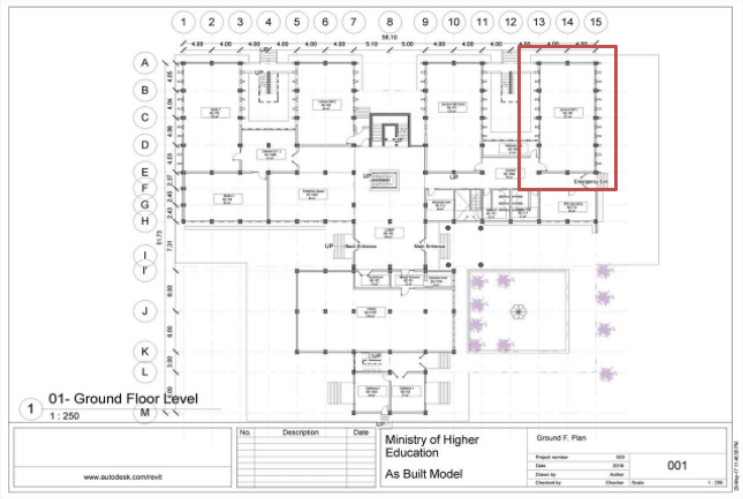
3. The seats are made of sponge, which leads to raising the acoustic performance because they are sound absorbent that helps to reduce noise.
4. Wood panels help absorb sound.
5. There are two types of noise in the hall
   (a) Interior noise: noise (speech, door sounds, windows, sound entry points, walking, appliances [including cooling, air conditioning, display... etc.]).
   (b) External noise is a number included (cars, students, workers, external traffic)

Conclusion: From the above, it is concluded that noise is treated using insulating materials, sound-absorbing materials, double-thickness windows, thick (double) insulated doors, insulation materials in floors, walls, and ceilings, and modern techniques are adopted for the sound insulation measures. And sound insulation in the hall's internal and external walls is critical to achieving good sound performance.

One of the main conclusions reached here is a flowchart that shows the noise level from the outside and its intensity inside the hall.

1. The rate of noise entry from outside the space to the internal space decreases for several reasons, most important of which is the presence of afforestation from the side of the classroom. From an environmental point of view, trees are considered a noise repellent, which reduces the entry of noise into internal spaces.
2. The presence of external breakers within the design on the windows of the hall helps to reduce noise entry.
3. Covering the interior walls in the study hall with wooden panels, which helps to absorb sound. Wood is one of the sound-absorbing materials in terms of sound design, but aesthetically it adds a special elegance to the space. Roof sheathing helps sound reflection. [5]

Time (hour)	The study hall with presence of students (8:30) a.m.	Study hall with the presence of students and turning off the cooling devices	Study hall with the presence of students and turning on the cooling devices	Study hall with the absence of students and turning on the cooling devices	The study hall when empty
08:00	50	41	50	48	42
09:00	53	50	53	42	48
10:00	53	52	53	52	48
11:00	54	44	51	51	41
12:00	58	48	53	52	47
01:00	54	53	61	63	46
02:00	50	43	42	41	43
Average	53.1	47.2	51.8	49.8	45



Conclusion: A survey of noise levels outside educational, health, and commercial buildings proved that most of them are subjected to noise from road traffic. It has been proven that the use of short measurement samples provides

reliable data on standard noise levels in buildings, especially educational ones. Through the readings taken from the device for the sample, it is concluded that the highest noise achieved is 77.1db the next day at 12:01, which indicates that the noise period increases after 10:00 AM.

Flowchart shows the noise and the highest range it reaches at 12:00 PM due to the increased car traffic and the movement of people.

Conclusions:

1. Taking the sample (a study hall in the architectural engineering department – university of technology), it is concluded that the sound and thermal isolation, especially in the spaces used for lectures, requires noise isolation where flat plates are used in the hall.
2. The use of wood boards in the hall since wood is a sound-absorbing material.
3. One of the most important sound qualities in the classroom is the sound quality heard by students, which affects the sound reflected back at them. Therefore, wooden boards have been used to cover the interior space, due to their most important propriety, sound absorption.
4. The nature of the material used inside space is based on the function of that space, especially if it is used for educational purposes, which takes into account the frequency of sound, which is in turn affected by two important factors: the nature of the material used in surface covering and the size of the space.
5. The purpose of this study is to improve acoustic performance and reduce noise in educational halls.
6. The increase in the number of students in the department to the double, which causes an increase in noise as well.
7. The location of architectural engineering close to the sub-street, which is crowded most of the time due to its commercial function associated with continuous cars noises.
8. The building is close to the sub-street and the secondary street with lack of plants and trees that are considered as noise repellents.
9. The lack of quietness behavior inside the departments and hold respect for the learning specificity.
10. The use of iron in doors and windows that allow the penetration of noise with no regards to the sound isolation factor.
11. Other reasons that are attributed to the lack of internal sings that recommend keeping low levels of voice or no-talking in the corridors, because they are sections of study halls.
12. The combined noise affects the sound comfort of occupants (students) and the safe noise level is from (45db) to (40db), and if it is more than 50db it will cause a problem in students' learning process.
13. Every (10db) increase in the classroom affects sound comfort in the first place, and the learning ability.
14. When the bounce time is more (0.6 seconds), students in the front lines will face a difficulty differentiating between letters.
15. The longer the reverberation time, the lower the students' comprehension ability because of the vocal cooperation.
16. Improving the acoustics in the classrooms by using sound-absorbing materials in the space designated for education in ceilings and walls, which leads to reducing noise inside the space.
17. The use of sound – scattering or absorbing materials in walls and the porous materials in internal surfaces (ceilings) leads to a reduction in sound echo, resulting in improved speech clarity.
18. One of the most important equations in sound distribution is the vibration time that helps reduce the sound level and insulation after turning on the sound source. Vibration time is one of the main physical properties of the surface areas of the spaces on which sound transmission depends. As for the speech transmission coefficient, it is important to determine the quality of speech transmission to the listeners.

Recommendations

1. Treating this problem starts from outside to inside and vice versa, in terms of planting trees outside of the hall to obstruct noise, and using aluminum instead of iron in doors and windows due to its sound and thermal isolation that manages the environment.
2. Maintaining the capacity of the department and not allowing huge numbers to increase because these are essential sources of high noise levels inside the building.
3. Placing guides and instruction signs inside the building to keep corridors quiet, especially those that lead to classrooms.

4. Prevent the use of vehicle horns in the sub-street by regulating a law by the state to respect the campus and its educational institutions.
5. Use sound-absorbing material for covering the halls as wood, while not allowing the use of reflective materials for this purpose.
6. Include sound design in educational buildings, particularly the educational institutions.
7. Undertaking studies to address the nature of materials and their impact in several aspects, mostly on sound absorption and reflection,
8. Keep abreast of recent technological developments in sound design in educational spaces.

Beneficiaries: Ministry of Higher Education and Scientific Research, University of Technology.

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