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TECHNICAL RESEARCH

THE EFFECT OF NOISE EXPOSURE IN RESIDENTIAL BUILDINGS ON STUDENT E-LEARNING DURING CORONA PANDEMIC

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Abstract: During the past decades, environmental noise and its negative effects on humans in its entire social, economic, and health aspects have been addressed. However, the study of the impact of noise in residential buildings on E-learning for university students during the lockdown period due to the Corona pandemic, specifically in Iraq, had not been sufficiently studied, which is the research problem. The research aims to explain the acoustic insulation and the negative impact of noise exposure in residential buildings on E-learning for university students during the quarantine period. A questionnaire was conducted for several Iraqi university students. The questionnaire has detected many indications (noise sources, use of headphones, duration of use, effects of noise exposure, and noise insulation control). The results showed the negative effects of noise that the students may feel, such as hearing difficulty, lack of concentration, raising the voice when speaking, discomfort, tinnitus, headache, and nausea; and determining the student's knowledge of noise and their opinions. The research recommends the adoption of acoustic insulation in residential buildings to reduce the negative effects of noise exposure on E-learning education.

Keywords: *E-learning education; noise; acoustic insulation; noise exposure; corona.*

1. Introduction

The Corona pandemic that started in 2020 and continues to be a threat is impacting all aspects of life worldwide, especially work and education, which are managed remotely via the Internet. E-learning has become a distinctive feature of this epidemic. Despite the decrease in the number of infected people and the start of attendance studies, most educational institutions, including universities and colleges in the world, have maintained e-learning and have not canceled it completely[1-5]. Around the world, researchers have studied the impact of noise annoyance and its effect on health, psychological aspects, work and education quality, and external influences such as noise and sound pressure levels in cities[6-9]. In contrast, recent studies focused on adolescents suggest that a higher level of noise exposure in residential buildings leads to higher rates of annoyance and may negatively affect learning for students of all ages, in addition to the social effects and the efficiency of learning[10].

Meanwhile, Dzhambov et al.[11] showed that education during the pandemic period led to a change in the perception of the internal acoustic environment through a questionnaire conducted

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on several university students at home for several basic acoustic indicators, including prior confounding factors and impact rates, social demographic planning, home-related characteristics, and general sensitivity to environmental influences, and mental health. Group perceived sounds into three distinct factors - mechanical, human, and natural. The results showed the importance of a positive, sound environment in promoting a sense of positive health during the lockdown.

This study aims to know the effect of noise exposure on students during e-learning and whether their houses have appropriate acoustic insulation by conducting a special questionnaire for a sample of Iraqi university students from different social strata

2. Noise Types in Cities

Noise is defined as every sound that is harmful and disturbing to daily activities such as work, rest, enjoyment, and study. Large cities suffer from this phenomenon, especially those resulting from the vehicles and the sounds of factories and workshops[12]. Contemporary cities are witnessing development and acceleration in growth and change in land use, which has contributed to the overlap of various activities and the increase of roads designated for transportation, including trains within cities, tunnels, and bridges, which contributed to an increase in public noise levels[12-14]. The main sources of external noise in contemporary cities can be summarized as follows:

- The sounds of various public and private means of transportation, including cars, medium and large vehicles, motorcycles, and other things, crowd city streets. As well as planes, especially jet planes, and many airports (and due to urban expansion) have become close to cities, and planes fly over cities.
- Construction sounds, such as the sound of different construction works, construction, and the establishment of services within cities. Other sounds of local industries such as blacksmithing, carpentry, and various technological devices, such as the sound of car radios or parties, electricity generators, and cooling.
- Industrial noise is a group of sounds of different strengths and frequencies that change without order or arrangement, leading to an undesirable feeling among workers and negatively affecting human health. This noise arises when mechanical vibrations come from solid objects, liquids, and gaseous media. These mechanical vibrations are transmitted to the air in the work area and cause a change in Hertz sound loudness.

3. Acoustic Insulation in Residential Buildings

Reducing noise levels in residential buildings is one of the basics of the architect’s work to reach acoustic comfort. Determining the amount of sound insulation (acoustic insulation) of materials used in walls, floors, and other building components enables the designer to determine the acceptable percentage of sound insulation that can be achieved by using certain materials and providing a comfortable acoustic space [15]. The decrease in sound transmission to walls and floors is measured in decibels. This indicator shows the sound intensity ratio through the building components to the sound intensity falling on the entire area. This decrease in sound transmission depends entirely on the weight of the building materials and their structural composition. It is a numerical value

that is not affected by the acoustic environment on both sides of the building's components.[16]

1. The acoustic insulation value of the wall depends on its materials (density, nature of the material, thickness of the material) and the way the materials are bonded together.
2. The value of sound insulation in single-layer walls depends on the mass, and doubling the thickness of the wall or doubling its mass will cause an increase in sound insulation of only 6 dB.
3. The sound insulation of the wall increases with the increase in frequency. It also increases by 6 dB whenever the frequency is doubled.
4. Using solid floors such as carpets or finishes made of sound-absorbing materials such as rubber and others attenuates the sound transmitted through the building. However, it weakens the noise transmitted in the air.
5. The suspended floor attenuates the noise transmitted through the building and the air. It can be reinforced with continuous layers of sound-absorbing insulators installed directly between the raised floor layers or on insulating chairs for sound transmission between the floor layers tightly. Concrete is used in the floor layers, noting the good overlap of the edges of the floor with the walls and ensuring that there is complete insulation between the two layers of construction and raised concrete.
6. Increasing the window glass's thickness improves the glass's mass and hardness, so its sound insulation increases.
7. The air cavity between the layers of window glass does not affect unless it is of appropriate thickness with a variety of thicknesses of glass layers and tight fixation to achieve appropriate sound insulation.
8. Some double-layered windows are filled with gases such as argon, xenon, and sulfur hexafluoride. This gas filling improves the sound insulation at high frequencies, but at frequencies less than 250 Hz, it will not achieve a significant effect. Since most traffic noise frequencies are within the low-frequency range, using multi-layer glass with interstitial gases does not have high acoustic insulation effectiveness for windows.
9. The tight fixation of the window frames with the walls of the building and with the window glass is required to achieve sound insulation and prevent rainwater from entering the building. The weakness in the tires is due to a lack of conformity in specifications, lack of tight installation, or building precipitation after a period of construction.

In addition to the above, the type of noise sources, acoustical characteristics, and background noise levels are very important estimates of a good sound insulation performance [17].

4. Buildings Regulation Codes of Acoustics

The approved building standards for residential buildings focused on reducing sound levels, especially at night, to prevent disturbing residents. In 1999, the World Health Organization (WHO) made international recommendations related to research on the harms of community noise, factory noise, and public transportation noise, such as vehicles and trains, on human health and how to make choices. The most prominent recommendations of the World Health Organization are.[12]

4.1. Noise Exposure at Night

The World Health Organization recommended that the noise levels that humans are exposed to at night should be 10 dB lower than during the day. The value of the noise that a person is exposed to is measured standardly based on the presence of one noise source during the period during which a person sleeps, which is the time between 10 pm to 6 am, provided that the amount of noise does not exceed 30 dB as a general average in the duration of sleep depending on the provision of insulation Appropriate acoustic in housing construction. This value can also be increased in street space, reaching a maximum of 45 dB.

4.2. Noise Exposure During the Day

Noise is more intense and varied during the day and evening, which reduces the ease of understanding conversations and focusing on the required daily work, so it set a noise exposure value of no more than 65 dB in crowded places such as commercial places and 55-50 dB in residential areas. The Iraqi Building Code has set limits for noise in residential areas to be between 25-35 decibels.[15]

5. Methodology

A questionnaire was conducted for several Iraqi university students. It was designed according to the noise sources that the student is expected to be exposed to in the house environment during e-learning, including noise emitted by diesel-electric generators, vehicles, motorcycles, loudspeakers, construction works, and other sources. The targeted age sample was 18 to 25 years old of both genders.

The goals of the questionnaire are detecting these noise sources; use of headphones, duration of use, the purpose of using, and showing the negative effects of noise that the students may feel, such as hearing difficulty, lack of concentration, raising the voice when speaking, feelings of discomfort, tinnitus, headache and nausea; and determining the student knowledge of noise and their opinions.

The questions in the questionnaire were divided into four groups. The first dealt with the sources of noise expected to be present within the house's surroundings, whether they are internal or external sources. The second included wearing headphones, how many hours does the user wear, and does the student use one or two headphones) and does the user abide by the warning message on the mobile phone screen when the headphone volume is raised. The third group asked the participants about the effects of exposure to noise (feeling of discomfort, nervous tension, irritability and loss of nerve, headache, insomnia, raising the voice when speaking, nausea, lack of concentration, hearing difficulty, and tinnitus). The last group was concerned with general questions about the participants' knowledge of noise, whether there is a need to use sound insulation in buildings and houses, are they prefer to spend their own time in a quiet place or not, and are they focused get distracted when they hear sounds from their room outside.

The sample of the research included 200 university students from different specializations. Likert scale was used to measure the frequencies with five categories, [1) never, 2) seldom, 3) sometimes, 4) often, and 5) almost always] for specific noise questions and two categories [1) yes and 2) no] for general noise questions.

6. Results and Discussion

The question about what are the external sources of noise (generators, horn vehicles,

traffic roads, parking lots, loading and unloading cargo vehicles at a nearby warehouse, loudspeakers from different sources) audible inside the house, the answers showed up to 30% of the participants complain most of the time about the noise emitted from external sources and those whose homes are close to diesel generators, or their houses are located on the main roads or close to car parks, in addition to the spread of vehicle owners (peddlers) who use loudspeakers to announce their goods (Food items such as fruits and vegetables, gas bottles used for cooking and heating, buying and selling used materials.etc.). While ranging between 33.5 to 60.5% of the participants were not affected by this type of noise. This was the cause of sound insulation treatments in the building. Fig.1 shows the answers for the exposures to external noise sources.

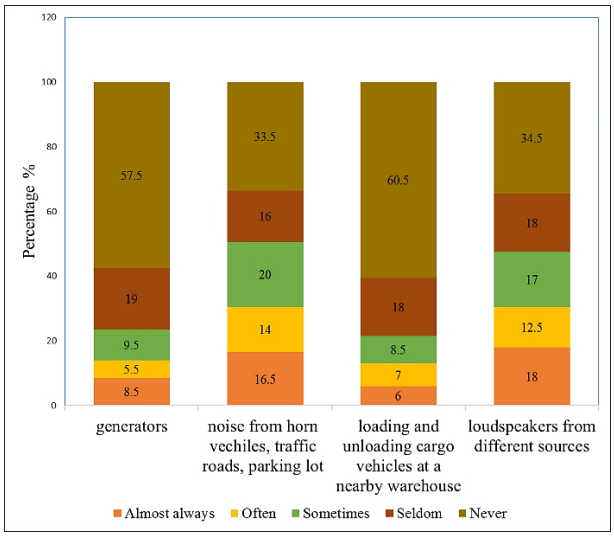

Figure 1. The answers for "What are the external sources of noise audible inside the houses."

The second question was a rephrasing of the first question. It includes the question, "*Are you affected by the noise sources mentioned in the first question when you are outside the house?*" The answers were the opposite of the answers to the first question. Up to 62% of the answers mostly complain about the noise of the external sources mentioned in point 1, as shown in Fig. 2. The rest of the participants are less affected and complain about the noise because they are accustomed to practicing their life activities within noise levels above 50 decibels [12]. Fig.2 shows the answers to "*What are the external sources of noise outside exposure.*"

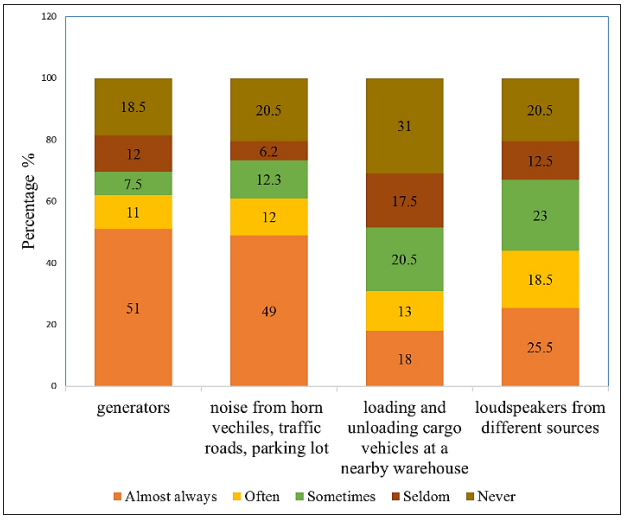

Figure 2. The answers for "What are the external sources of noise effect outside the houses."

During the corona pandemic, E-learning was essential to accomplish the study for all stages. Regarding the question of using a mobile phone and computer headphones during study time, about 92% of the participants used them due to their need for focus, privacy, and noise blocking off the surrounding area. In addition, 80% of headphone users ignore the warning message that appears to them that the sound volume level has risen above the permissible limits. Fig. 3 shows these percentages.

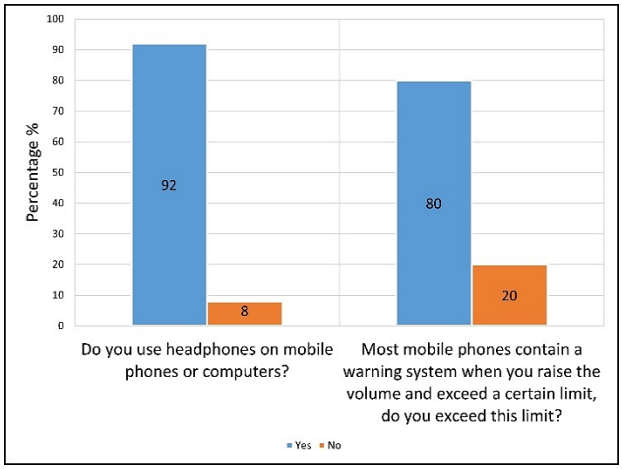

Figure 3. Participant percentage that uses headphones.

When checking and analyzing the participants' answers to the questionnaire, 68% wear the two headphones to create their own isolation area to help them focus on listening and understanding during online lectures. Fig. 4 shows these percentages.

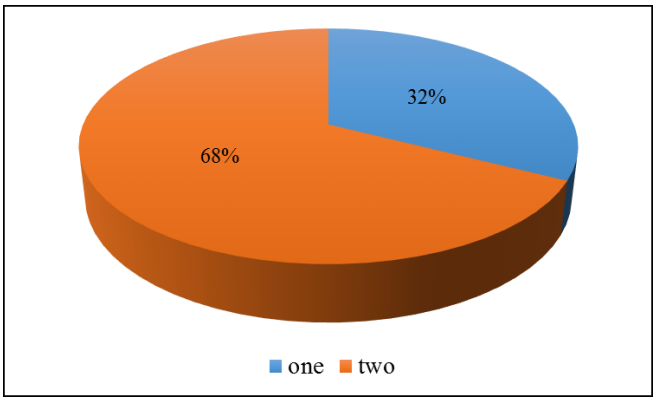

Figure 4. The headphones users' percentage.

In most undergraduate studies, the lecture schedule usually starts at 8:30 in the morning and lasts about 6 hours. Therefore, students' use of headphones is included in the lecture schedule, and this is what was shown by the questionnaire, where 81% of the participants used them for less than 6 hours. While 15% of the participants use their headphones for about 10 hours a day, the remaining 4% use headphones for more than 10 hours. These percentages showed in Fig. 5.

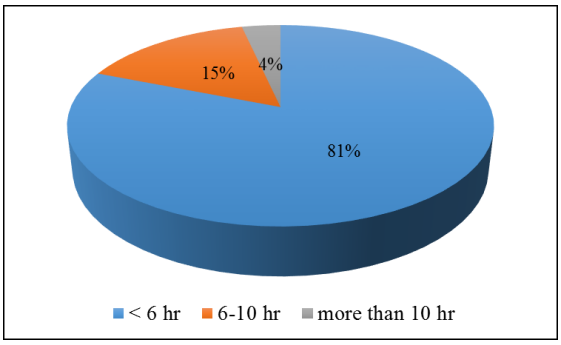

Figure 5. The number of hours that participants wear headphones.

Noise's health effects include many symptoms. It has been observed by researchers[17-22], including discomfort, nervous tension, irritability, loss of nerve, headache, insomnia, raising the voice when speaking, nausea, lack of concentration, hearing difficulty, and tinnitus. According to the questionnaire, up to 86% of participants feel discomfort when exposed to noise, whatever its sources, from inside or outside the house, or as a result of continuously wearing headphones for several hours during electronic education per day. 74% of participants suffer from nervous tension, irritability, and loss of nerve. The noise caused a headache, insomnia, raising the voice when speaking, nausea, lack of concentration, hearing difficulty, and tinnitus for 66.5%, 66%, 61%, 44%, 55.5%, 34%,48% of participants, respectively. All the percentages above show the participants feeling different sensations (almost always, often, sometimes, and seldom). Fig.6 shows the symptoms that participants can feel

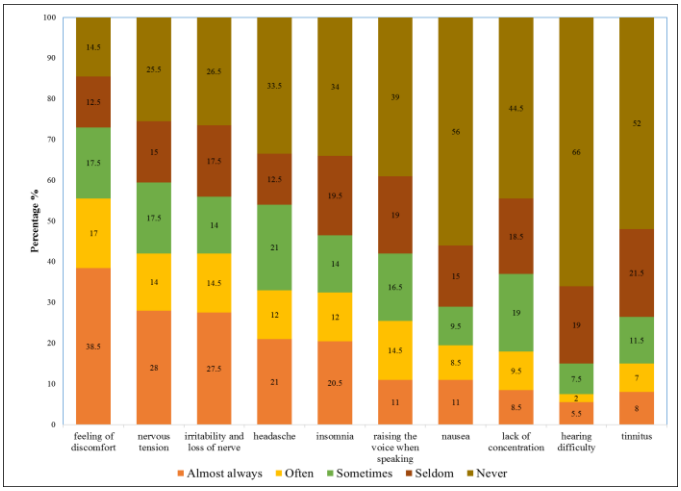

Figure 6. The symptoms participants may experience.

The target groups in this questionnaire are university students, and it is assumed that they possess a minimum level of information and knowledge of noise and its health effects; this was explained by 81.5% of the participants, while 18.5% of them did not have this information

The results of the general questions showed that 78.5% preferred using sound insulation in their houses, 96.5% preferred quiet places, and 82.5% suffered from distortion by sudden noises. Fig. 7 shows the percentage of the general questions.

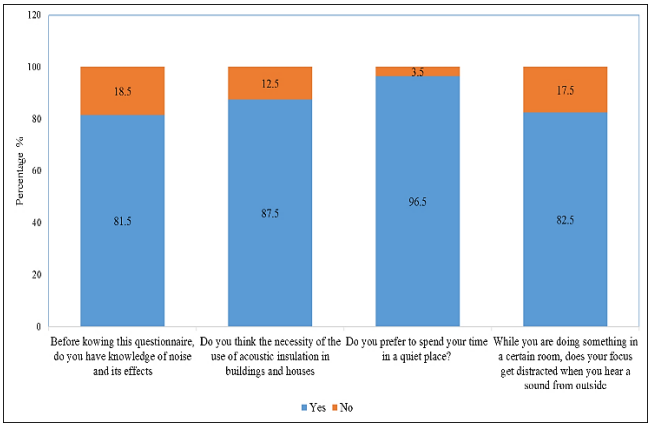

Figure 7. The percentage of the general questions.

7. Conclusions

It is necessary to provide sound insulation in existing and under residential construction buildings due to the high noise exposure they suffer from, especially near public streets and private generators besides the indoor noise sources.

The high noise level exposure from e-learning sources such as loudspeakers in the computers or headphones may harm the students' hearing.

Moreover, the high noise level exposure negatively affected students' health and education during the pandemic. Therefore, there is a need to reduce noise levels and rely on recommendations of the World Health Organization and local acoustics code for Permissible noise levels.

There is a need for public awareness about the negative effects of noise, which helps to implement standards for noise insulation, in addition to activating laws and legislations related to reducing external noise levels.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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