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Assessment of Noise Pollution Exposure to Elementary Students: A Case in Argao, Cebu, Philippines

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Abstract

A learning environment greatly influences students' learning outcomes. Children are strongly affected by noise because it negatively impacts learning at a critical developmental stage. The assessed schools are located near the national highway, exposing children to noise levels higher than the World Health Organization's recommended level of 35 decibels. Previous research evaluates the students' exposure to noise and its effects but cannot elaborate on their perception of this exposure. The instruments used were a questionnaire to determine student's perceptions and a Sound Level Meter (SL-4010) to measure noise levels in specific locations. Significant relationships and significant differences between variables were analyzed with the use of SPSS v16.0. The primary cause of possible noise-related effects on students' well-being and attentiveness in class was identified via Pareto Analysis as transportation and classmates and the noise level. The noise level is highest between 8 am and 12 pm. However, the students perceived that their noise level exposure is only **Somewha**t impactful even though the lowest Leq_{min}, 36.6 decibels (dB), surpasses recommended level by the WHO. Statistical methods were also used to determine that students' demographics do not significantly affect their perceptions. There is also no significant difference between noise level perception and noise level measurement.

Keywords: decibels (dB); noise level; noise pollution; elementary schools; students.

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1. Introduction

Noise is an unwelcomed artificial sound that pervades the surroundings. It is any sound that irritates one's ear and comes from an outside source. On the other hand, noise pollution consists of annoying or harmful noise [1]. According to the World Health Organization (WHO) Guidelines for Community Noise, background sound levels (BSL) during teaching sessions should not exceed 35 dB so that students can hear and interpret spoken words [4]. Noise levels above 75 dB are high enough to cause irritation, aggressive behavior, and sleep disruption.

School, like home, workplace, are essential microenvironments in our country. The proper physical learning environment of schools helps children's cognitive, creative, social, physical, and intellectual development. Due to its adverse impact on learning at a crucial developmental stage and lesser ability to predict, understand, and cope with stress than adults, children are heavily affected by noise. According to one comprehensive National Geographic entry, these loud or inescapable sounds can cause hearing loss, stress, and high blood pressure. According to the WHO's Community Noise Guidelines, noise pollution interferes with spoken communication, impairs performance such as reading attention and memory and causes concentration and communication problems. Noise has the most significant impact on reading attention, problem-solving, memory, and communication skills, resulting in misinterpretation of instructions, decreased motivation, and higher error rates [4]. Since 2011, the US Environmental Protection Agency has warned school districts about the dangers of traffic pollution and advises them to think twice before choosing locations near main roads or truck routes.

Unwanted loud noises, also known as noise pollution, plague the Philippines' learning environments available to students. Several sound monitoring sessions conducted recently in diverse learning environments in Northern Mindanao and Western Visayas found that continuous and individual BSLs exceeded the permitted range, reaching levels considered detrimental to the ear by audiologists. Scientific findings have established that noise pollution poses threats to human health and the learner's cognitive abilities [4]. There had been some studies into the detrimental impact of constant environmental noise on the environment. Despite this, there have been few reports on schoolchildren's academic performance and achievements [5].

The municipality of Argao has several schools built near the highway. The highway is one of the primary sources of noise pollution worldwide, and the fact that no noise concerns or issues have been raised in the vicinity is considerably more disturbing. Thus, with the aid of the facts and issues presented, the researchers conducted the study in four selected elementary schools as children are considered more vulnerable and have no control over their environment. This paper assesses the noise pollution in the area and identifies its potential impact on children.

2. Materials and Methods

2.1. Materials

Adapted questionnaires from the published paper of Felcyn and his colleagues [18] and Costa and his colleagues [19]. The Industrial Engineering Department provided a Sound Level Meter (SL-4010) to accurately record and

measure the noise level. The distance between the school's main gate and the roadway was measured using steel tape. Using the acquired data, SPSS v16.0 was utilized to examine the significant differences and relationships between variables. The questionnaires are subdivided into 4 different variables namely Profiling, Factors, Time-Frame Exposure, and Respondent's Perceived Noise Level. These variables are necessary for determining the difference between the actual and perceived levels of noise, as well as its potential impact on students.

2.2. Design

The entire study was carried out as descriptive-correlational research, which entailed describing the variables and the natural relationships between and among them. It provided a detailed analysis of the sources of noise pollution in a learning environment and the degree to which it was measured, how students experienced it, and its potential impacts on them. Data will also be interpreted using descriptive and inferential statistics. This will provide statistical, mathematical, and numerical analysis for the data acquired through computing.

2.3. Environment

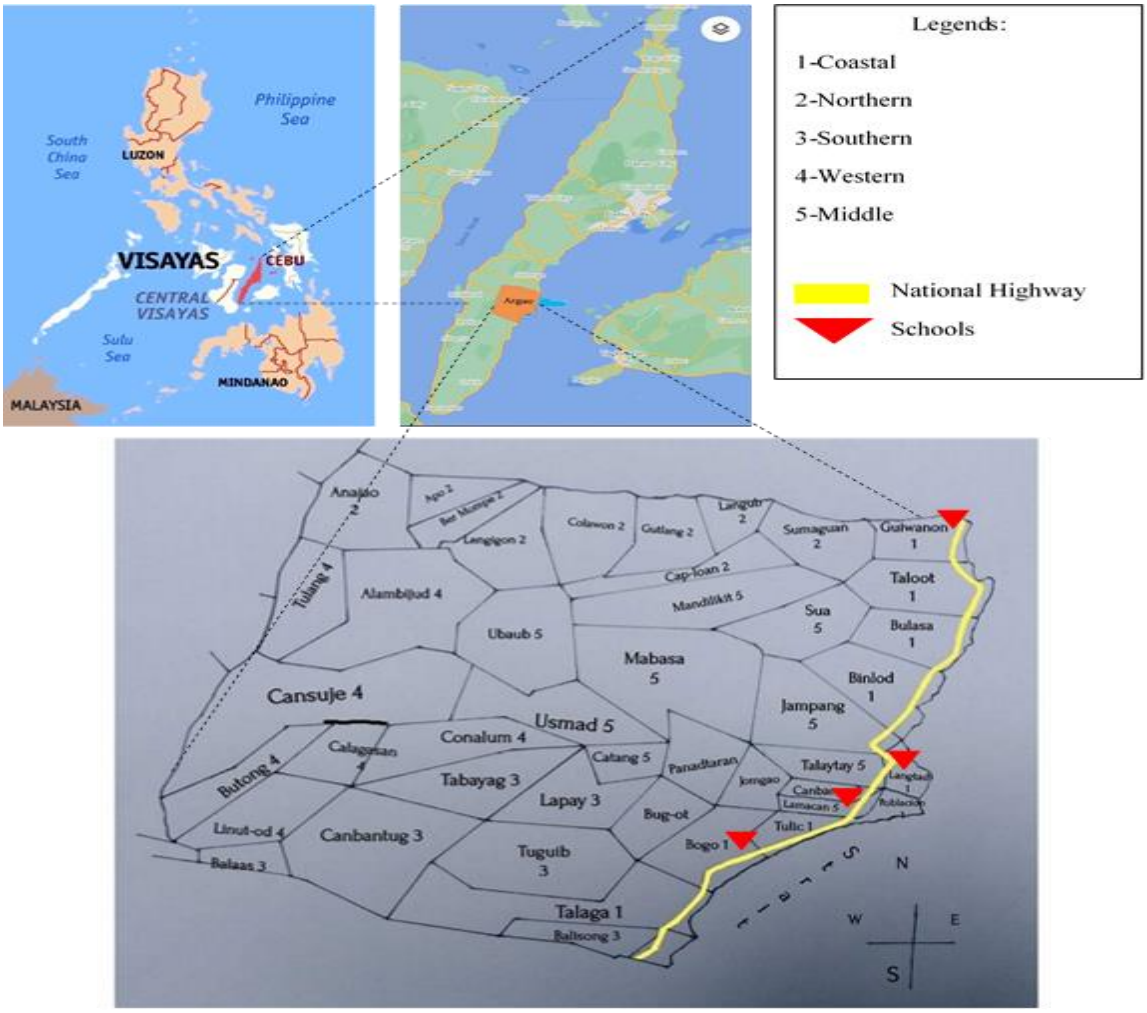

Figure 1: Locale of the Research Environment.

Shown in Figure 1 is the area of the study which is set in the Municipality of Argao, which is located in the southern part of Cebu and is approximately 68 km from Cebu City. It is a first-class municipality in the province of Cebu, Philippines [2]. Under the Philippines National Structure Code, the four schools were selected as it fails to meet the specific standards for the design and safety of elementary school students where it states that schools should be located at a notorious place above 200 m, such as but not limited to highway [11]. The selected elementary schools are less than 10 m away from the highway. This means that the students are exposed to one of the primary causes of ambient noise exposure in urban areas based on the World Health Organization (WHO). Among the schools along the highway in Argao, four elementary schools were selected: Guiwanon Elementary School, Langtad Elementary School, Argao Central Elementary School, and Bogo Elementary School.

2.4. Respondents

The respondents are students who have taken a class in the chosen grade levels' classes, representing students who have been exposed to noise pollution in the region during an actual class before the pandemic. Researchers used a conservative sampling with only thirty students in each school. It allows researchers to obtain a sample population that best represents the entire population being studied. Students in grade six levels are eliminated from the list of respondents as they are no longer belong to the population of the schools during the collection of data.

2.5. Data gathering procedure

Every primary school's principal received a transmittal letter. Due to the pandemic, students were given survey questionnaires and a letter of consent to parents by including them in their module. The researchers then use a Sound Level Meter (SL-4010) to measure noise levels for three days and a steel tape to measure the distance between the highway and the school. SPSS v16.0 was used to analyze the collected data.

2.6. Statistical treatment of data

The gathered data was analyzed using SPSS v16.0. Descriptive statistics were used to determine the sources of noise and the demographics of the students (mean, frequency, and percentage). The Pearson's R Correlation Coefficient was utilized to evaluate if there was a significant association between the distance between the noise source and the level of noise exposure experienced by the students. The students' perceptions of the impact of noise during class were determined using the Weighted Mean method. The relationship between the students' profile, measured noise level, and the perceived noise level was determined using the Chi-Square method. The researchers conducted a one-way ANOVA to see if there was a significant difference between the students' perceived level of noise and the actual noise level assessed by the researchers. The equivalent noise levels Leq_{max} and Leq_{min} for each classroom were determined using Equivalent Continuous Sound Level in time measurements of 4 h in the morning and 3 h in the afternoon for three consecutive days.

Leq_{min} = minimum average value of the noise level gathered in every classrooms of each school

$\mathbf{Leq_{max}}$ = maximum average value of the noise level gathered in every classrooms of each school

The calculation used the formula as follows:

$$\mathbf{Leq = 10\ log_{10}\ [\sum t_1 10^{Lj/10}]} \quad (1)$$

Where, **t1** = the fraction of time representing the hours 8 a.m. to 12 p.m. (that was = 1/4)

t2 = the fraction of time representing the hours 1 p.m. to 4 p.m. (that was = 1/3)

Where, **Lj** = represent the noise levels gathered in the hours of 8 a.m. to 12 p.m and 1 p.m. to 4 p.m.

2.7. Review on Related Literature

Constructivist and Human Cognition learning theories, which recognize the role of cognitive performances in the learning process, lend support to this study. According to cognitive psychologist Pascale Michelon, cognitive performances are "brain-based skills needed to perform any task from the simplest to the most complex; they are primarily concerned with the mechanics of human learning, pay attention, remember, and solve problems than with any actual knowledge" [4]. Dr. David Jonassen, a former professor of Instructional Systems at Pennsylvania State University, stated that in a constructivist learning environment, students use complex cognitive skills and active techniques to help them become expert learners, constantly reflecting on their experiences and honing their ability to integrate new information [4]. During a classroom learning situation, the student is exposed to two types of stimuli: the primary one, which is the teacher's voice, and to which the student must devote all of his attention; and the secondary one, which is the competitive noise, which the student must be able to ignore in order for the main message not to be distorted [13]. Noise-induced complications in young children obstruct teacher-student communication and, as a result, affect the learning process. Noise pollution in the classroom might make it difficult to learn. Children who are forced to learn in noisy situations score lower on standardized examinations on average. When we think about speech perception, another point of real interest is the teacher's voice, because it is responsible for the great task of knowledge transmission, and it must be clear, harmonious, intelligible, and free of all and any competing noise, or the students will not follow the teaching [14].Learning is the result of cognitive processing, according to the above-mentioned theories. Learning will be harmed by any negative impact on cognitive processing. If noise pollution in the learning environment harms cognitive performance, learning and competency will be impacted as well [4]. Research shows that reading concentration, problem-solving ability, and memory are most affected by noise, which will also affect communication capabilities, leading to misunderstandings of commands, decreased motivation and increasing error rates [4]. When students are engaged in tasks that require higher mental processes, such as learning new concepts or when teachers verbally introduce new or complex information, the ability to pay attention is most important found that the ability to recognize sentences in noisy environments improves systematically with age for children ages 7, 9, 11, 13, 15, and 17 years [21]. According to these theories, the process of acquiring information and cognitive learning may be interrupted by noise. Among the three pollution types of air, water, and noise, noise pollution has a higher potential for personal injury, but it has received less attention. The researchers were therefore driven to assess noise pollution in a children's learning

environment, specifically in four selected elementary schools along the highway in Argao, Cebu, and then identify its potential effects to these students.

3. Results and Discussion

3.1. Demographic data of the students and school distances

The respondents had 15 students each grade level from the 120 elementary students studied. In terms of the age of the students in question, 11% of the students were 6-year old, 23% students were 7-year old, 24% students were 8-year old, 23% students were 9-year old, 13% students were 10-year old, and 6% students were 11-year old. In gender, 46% of the students were male while 54% were female. For children and teenagers, grade school is the most important educational institution. Furthermore, listening practices account for about 75% of an average school day. However, during the educational process, students and teachers are subject to noise from both inside and outside the classroom and/or school. Furthermore, contemporary teaching approaches based on cooperative norms contribute to the noise in the educational process [15].

Table 1: Distances of schools and classrooms.

Variables	**Distance from the main gate (m)**	**Distance from the highway (m)**
Schools		
Guiwanon Elementary School (GES)		3.6
Langtad Elementary School (LES)		6.3
Argao Central Elementary School (ACES)		7.64
Bogo Elementary School (BES)		8.35
Educational Grade of Classrooms where actual noise level measurement was taken		
NEAREST		
Grade 1	2.1	
Grade 2	8.3	
Kindergarten A	7.7	
Grade 1 A	15.3	
SECOND NEAREST		
Grade 4	3.9	
Grade 3	8.4	
Kindergarten B	7.8	
Grade 1 B	15.4	

In Table 1, distances of the main gate of the schools from the highway were stated, which unable to meet the provided standards by the Philippine National Structure Code of 2001 for the design and safety of elementary school students. According to it, schools should be located at a notorious place above 200 meters from, but not

limited to the highway [11]. The national highway was roughly 3.6, 6.3, 7.64, and 8.35 meters distant from GES, LES, ACES, and BES, as shown in the table.

3.2. Factors that influence noise pollution

Table 2 shows the sources of noise pollution in the students' learning environments, together with the frequency and percentage of students' perceptions of what causes noise in each school. Transportation is the most frequently observed to cause noise at Guiwanon Elementary School (GES), Langtad Elementary School (LES), Argao Central Elementary School (ACES), and Bogo Elementary School (BES), with 57%, 40%, 50%, and 57%, respectively. Among the 120 students of the selected schools, transportation is 51%, followed by classmates (21%), people outside (10%), rain falling (9%), human activities (8%), and equipment (1%). A research from the National Bureau of Economic Research, as referenced by Webber, adds to understanding of the effects of attending school near major highways. Although land near highways may be less expensive, school districts and parents are typically unaware of the health problems associated with roadway pollution [17].

Table 2: Frequency and Percent of the sources of noise that bothers the students the most at school.

SOURCES	GES		LES		ACES		BES		OVERALL	
	F	%	F	%	f	%	f	%	f	%
Transportation	17	57	12	40	15	50	17	57	**61**	**51**
Rain falling	1	3	7	23	1	3	2	7	**11**	**9**
Human activities	2	7	1	3	4	13	3	10	**10**	**8**
Equipment	0	0	1	3	0	0	0	0	**1**	**1**
People outside	3	10	3	10	3	10	3	10	**12**	**10**
Animals	0	0	0	0	0	0	0	0	**0**	**0**
Plant noise	0	0	0	0	0	0	0	0	**0**	**0**
Classmates	7	23	6	20	7	23	5	17	**25**	**21**
TOTAL	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**120**	**100**

In Pareto Analysis (Figure 2), the sources of noise that fall above the 80% cut-off line are people outside, rain falling, human activities, and equipment. These sources may be less critical, but they must be addressed sooner rather than later. Transportation and classmates, on the other hand, come beneath the 80% cut-off line. Transportation noise is a common source of distraction for students. Exposure to transportation noise can impair students' ability to recover from short-term memory. These sources must be addressed promptly, as they have been recognized as the primary cause of possible noise-related effects on students' well-being and attentiveness in class [3]. According to the World Health Organization, noise pollution can be found both indoors and outdoors and is caused by road traffic, railways, aircraft, factories, construction, and public works. As a result, countries have been encouraged to measure and evaluate noise pollution in their territories by drawing noise

maps [20]. In general, noise pollution research shows that noise harms activities like communication and concentration, particularly in educational institutions, the campus is a place where many noise sources can be found, including noise produced by leisure activities as well as noise emissions from laboratories, electrical equipment, and other sources. Road traffic has been identified as the primary cause of noise by several researchers researching noise levels on various campuses [20].

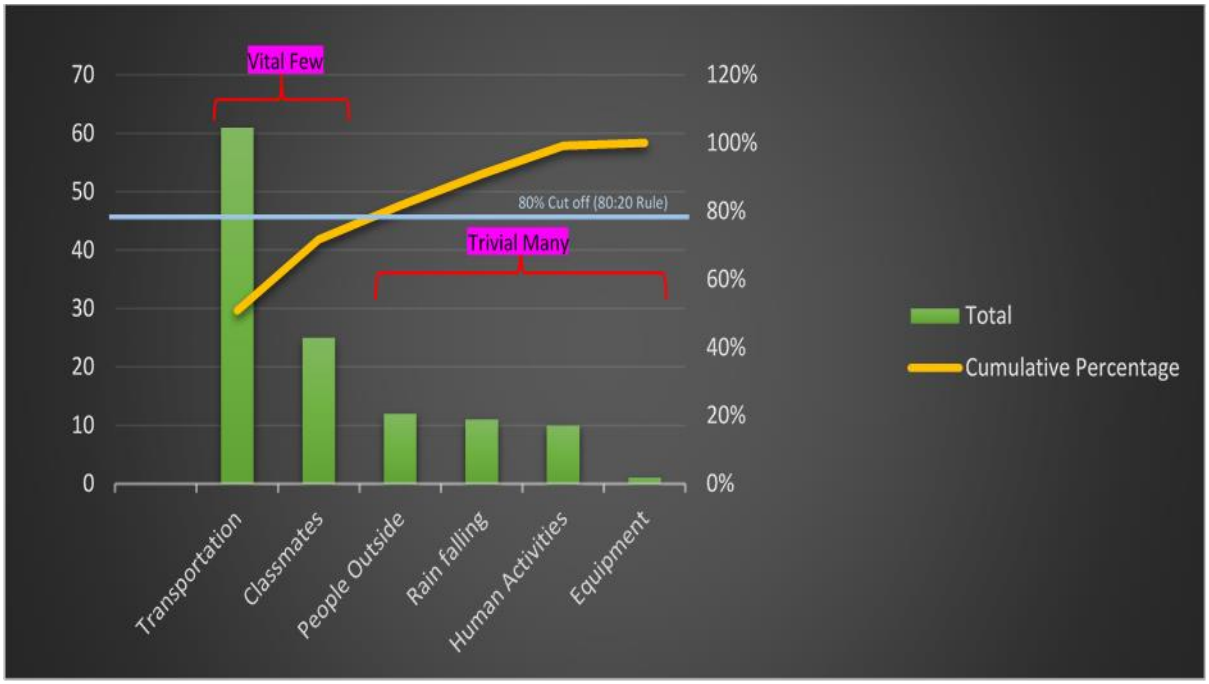

Figure 2: Pareto Chart – Analysis of the sources of noise.

3.3. Noise level measurement and perception to time-frame of noise exposure

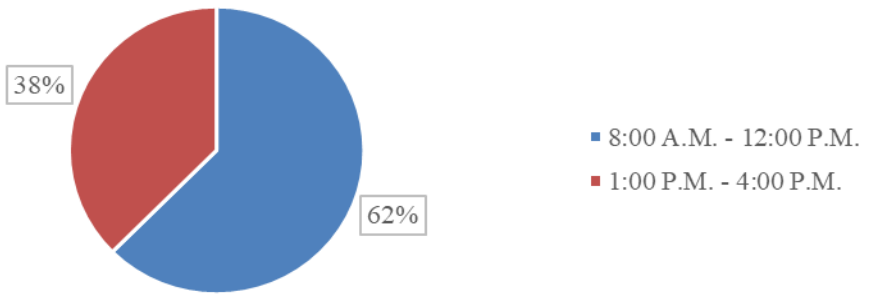

Figure 3: Percent of the respondents' perceived time-frame prone to exposure to noise**.**

The lowering of intelligibility, and thus the hearing and understanding of speech by children of various ages in varied noise and acoustic settings. The overall effects of chronic noise exposure on children are deficits in sustained attention and visual attention; poorer auditory discrimination and speech perception; poorer memory for tasks that need high processing demands of semantic material; and poorer reading ability and college

performance on national standardized tests. Additionally, it's important, both for learning and for social interaction, that children are ready to hear and understand their peers within the classroom [7]. Figure 3 shows that 62% of students believe they are more exposed to noise between 8 am and 12 pm, whereas 38% believe they are more distracted by noise between 1 pm and 4 pm. The student's perception of the noise level exposure, on the other hand, falls into the category of **Medium**. It signifies that the noise level is moderate and not excessive. Nevertheless, it interferes with students' ability to communicate and learn. In schools, the WHO recommends a maximum noise level of 35 dB. However, the highest Leq_{max} among the evaluated schools for three days is 80.3 dB, while the lowest Leq_{min} is 36.6 dB which exceeds that standard.

3.4. Significant relationship of respondents' demographics and perception to noise level exposure

Table 3: Demographics and Time-frame Chi-Square test.

	Age			**Grade Level**			**Gender**			**School**		
	Value	df	Asymp. Sig. (2-sided)	Value	Df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.629	5	0.987	1.671	7	0.976	0.056	1	0.813	0.391	3	0.942

Table 3 shows that the critical value of x2 with 5 degrees of freedom (df) is 11.0705. At a 5% level of significance, the null hypothesis fails to reject, suggesting that the student's perception of the time frame of their exposure is unaffected by their age and has little correlation with their grade levels. In addition, the necessary chi-squared value for 5% significance and 1 degree of freedom is 3.84. The null hypothesis fails to reject since the chi-square statistic from these data is $x^2 = 0.056 < 3.84$. Though the male and female frequencies differ slightly, there is not much difference to indicate that the students' gender and their perception of the exposure time frame are correlated.

3.5. Significant relationship between the distance from the source of pollution and actual measurement of noise exposure

Table 4: Correlation between distances and noise level measurement (8 am – 12 pm).

Correlation Matrix	**Day 1**		**Day 2**		**Day 3**	
	Leq_{max}	**Leq_{min}**	**Leq_{max}**	**Leq_{min}**	**Leq_{max}**	**Leq_{min}**
Distance	-0.895	-0.653	-0.843	-0.709	-0.813	-0.543

Table 5: Correlation between distances and noise level measurement (1 P.M. – 4 P.M.).

Correlation Matrix	**Day 1**		**Day 2**		**Day 3**	
	Leq_{max}	**Leq_{min}**	**Leq_{max}**	**Leq_{min}**	**Leq_{max}**	**Leq_{min}**
Distance	-0.664	-0.551	-0.783	-0.642	-0.955	-0.517

Shown in Table 1, the distance of the classrooms from the highway indicates the location of the researchers during the actual measurement of the noise level. For the nearest classrooms, the first grade in GES got the highest Leq_{max} of 79.6, 80.3, and 79.1 in the time-frame of 8 a.m. – 12 p.m. from day 1 to 3, respectively, while BES got the lowest Leq_{max} of 66.3, 67.6, and 68.5 in the time frame of 8 a.m. – 12 p.m. from day 1-3, respectively. At 1 p.m. – 4 p.m. from day 1 to 3, GES still got the highest Leq_{max} of 79.2, 76.4, and 79.1 while the schools that got the lowest Leq_{max} are ACES (60.6) on day 1, LES (60.9) on day 2, and BES (57.2) at day 3. On the other hand, in the second nearest classrooms, the highest Leq_{max} for three days at 8 a.m. – 12 p.m. is in GES with average noise levels of 77.2 on day 1, 75.6 on day 2, and 76 on day three while in BES got the lowest Leq_{max} of 65.1 and 65.4 in day 1 and 2, and ACES at day 3 with a Leq_{max} of 66. With Leq_{max} of 77.5, 74.4, and 7.6, GES got the highest among the four schools at 1 p.m. – 4 p.m. from day 1, 2, and 3, respectively. On the other hand, ACES got the lowest Leq_{max} of 60.6 on day 1 and 57.2 on day three, while LES got 60.9 on day 2.

The correlation between the distance of the school from the dominant source of noise and the level of noise measured were investigated. As shown in Tables 4 and 5, the Pearson Correlation matrix indicates a strong negative correlation among the variables where distance and noise level generally move in opposite directions. It means that if the distance decreases, the noise level increases. A research from the National Bureau of Economic Research, as referenced by Webber, adds to the understanding of the effects of attending school near major highways [12]. Over 6.4 million students attend public school within 250 meters of a major highway, and roughly one in every five schools were opened in the 2014-2015 school year were built near a busy road [8]. All experts in education and educational psychology of teaching and learning agree that effective education is dependent on having a goal, the appropriateness of the physical and social environment of sophistication, motivation of teachers and students for teaching and learning, the student's cognitive, emotional and motor preparation, sound management of sophistication by teachers, their mastery over the topic, and therefore their passion for his or her work and the students' progress [9]. The results indicate the importance of considering the location of schools in minimizing students' risk exposure.

3.6. Impacts of noise pollution exposure to students

Noise pollution has become a serious environmental concern, resulting in annoyances and health issues **[23]**. In comparison to ambient noise, there has been less study on the impact of noise on students in lecture rooms in the past. However, research in this field is growing, with many recent studies looking into the impact of internal noise on students' reading, numeracy, and overall performance.

As shown in Table 2, the student's perception of the effects of their noise level of exposure falls under the scale of 2.70 - 3.40, which indicates **Somewhat (Usahay)**. This means that the noise is sometimes observed and identified to disturb the students' attention and learning process. According to research, children who have a high resting force per unit area, are stressed, and have reading delays are those exposed to pollution during the learning process. Furthermore, pupils who are exposed to noise pollution learn not to focus on the professor, which can affect their reading and language skills [6].

Table 5: Perception of the students to their noise level exposure.

Questions	GES		LES		ACES		BES		Overall	
	WM	D	WM	D	WM	D	WM	D	WM	D
Do you think your school is noisy?	3.07	Some what	2.97	Some what	2.80	Some what	2.73	Some what	**2.89**	**Some what**
How annoying is the noise you usually hear when you're at school?	3.20	Some what	3.07	Some what	2.97	Some what	2.83	Some what	**3.02**	**Some what**
How often do you notice that there is noise?	3.20	Some what	2.87	Some what	3.00	Some what	3.17	Some what	**3.06**	**Some what**
Do you think noise interferes with your schoolwork?	3.17	Some what	2.93	Some what	2.90	Some what	2.87	Some what	**2.97**	**Some what**
Do you think noise distracts you?	3.37	Some what	2.90	Some what	3.10	Some what	2.57	A little	**2.98**	**Some what**
Because of noise pollution, do you find it difficult to concentrate or follow what the teacher is saying?	3.03	Some what	3.00	Some what	2.83	Some what	2.80	Some what	**2.92**	**Some what**
Grand Mean	**3.17**	**Some what**	**2.96**	**Some what**	**2.93**	**Some what**	**2.83**	**Some what**	**2.97**	**Some what**

When background noise interfered with speech, it was discovered that students' output dropped significantly, particularly when learning to read. In the acoustically treated halls, students performed better in word intelligibility tests. When other students were talking in the classrooms, the change was particularly noticeable. Research of pre-school children who were exposed to 75 dB (A) levels in the classroom yielded similar findings. The children's output in the letter, number, and word recognition improved after acoustic therapy to minimize noise. In a study of older students, ages 13 and 15, working in noise levels of 58 to 69 dB(A), there was a weak link between annoyance and the influence of noise on schoolwork; nevertheless, there was a strong link between annoyance and the impact of noise on schoolwork. The dangers of noise exposure to one's wellbeing cannot be overstated. As a result, the World Health Organization (WHO) and Nigeria's Federal Environment Protection Agency (FEPA) have developed noise standards and limits. When such norms are breached, it is referred to as noise pollution [23]. According to WHO Guidelines for Community Noise, background sound levels (BSL) during teaching sessions should not exceed 35 dB so that students can hear and understand spoken messages, as quoted by Diaco [4]. Noise levels above 75 decibels can irritate people, trigger offensive behavior, and disturb sleep. Noise levels above 75 dB can cause elevated levels of stress, heart rate, and potential hearing loss, and noise levels below 65 dB can cause hypertension. Hearing loss or distortion is the most common symptom of noise pollution. Hearing loss is often identified as an occupational hazard, particularly when the person works in an industry that produces loud sound or noise. Noise exposure also has a number of physiological and psychological consequences. In school children, the combination of noise and air pollution has been linked to respiratory problems, dizziness, and exhaustion [23].

4. Conclusions

The study's findings show that students' perceptions of their noise exposure do not correspond to noise exposure levels. The demographics of students, such as their school, grade level, age, or gender, have minimal influence on their views. According to measurements performed in classrooms, classroom noise levels may vary based on the location. When the students' perception of their noise level exposure is compared to the actual noise exposure level, they are confirmed to be at harm. The noise pollution has received little attention in a learning environment in the Municipality of Argao in Cebu, Philippines. Noise pollution has not been well taught to schoolchildren, and classroom acoustics are poor. This situation is not conducive to the well-being of schoolchildren or their learning environment. It is recommended that it be addressed by implementing an awareness program and modifying classroom design. This may include noise pollution awareness pamphlet for teachers and students and an acoustic classroom design. It aims to raise student awareness of noise pollution and minimize their exposure and its impacts while maximizing students' intelligibility.

5. Limitations

The pandemic made it harder to obtain data. The noise level was recorded for only three days with fewer vehicles on the highway, and there were no students in school. However, the researchers manage to acquire sufficient and valid data to support the assessment of noise pollution in a learning environment in the municipality of Argao.

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