

Analysis of Environmental Noise Distribution in an Electrical Workshop Using Boxplot Statistical Method

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Article History : Received 011025; Revised 231025; Accepted 281125;

ABSTRACT – This study analyses the distribution of environmental noise levels in a technical workshop using a boxplot statistical approach. Noise data were collected from three monitoring stations over five working days, with measurements recorded at 15-minute intervals between 08:00 and 16:00. The dataset was processed using MATLAB R2019b to obtain key statistical parameters, including minimum, quartiles, median, maximum, and interquartile range (IQR). The results show that noise levels vary significantly across different days and monitoring locations. STA2 consistently recorded higher noise exposure and greater variability compared to STA1 and STA3, indicating that areas located near active working zones are more susceptible to fluctuating and elevated noise levels. In addition, certain days such as Tuesday and Friday exhibited higher variability, while other days showed more stable but consistently elevated noise conditions. The application of boxplot analysis provides a clearer understanding of noise distribution patterns beyond conventional average-based methods. This approach enables better identification of noise variability and potential high-risk zones within the workshop environment. The findings of this study can be used to support noise monitoring practices and contribute to improving safety and learning conditions in technical and vocational education settings.

KEYWORDS : Noise Analysis, Boxplot Method, Environmental Noise, Workshop Monitoring, MATLAB

1.0 INTRODUCTION

Excessive environmental noise has become a growing concern in technical and vocational education environments, particularly in workshops where practical activities are continuously conducted. Noise exposure not only affects occupational safety but also influences students' concentration, communication, and overall learning effectiveness. According to the World Health Organization, environmental noise levels exceeding 55 dB in educational settings may significantly reduce cognitive performance and learning efficiency [1].

From an occupational health perspective, prolonged exposure to high noise levels may lead to hearing impairment and physiological stress. The National Institute for Occupational Safety and Health recommends a maximum exposure limit of 85 dB for an 8-hour time-weighted average (TWA), while the Occupational Safety and Health Administration allows exposure up to 90 dB under controlled industrial conditions [2], [3]. These standards highlight the importance of continuous monitoring and assessment of noise exposure, especially in environments involving repetitive mechanical operations.

In technical workshop environments, noise levels are typically dynamic and non-uniform due to variations in equipment usage, student activities, and external disturbances. Previous studies have reported that noise levels in vocational workshops may range between 60 dB and 90 dB during active sessions, indicating potential exposure to moderate and high-risk acoustic conditions [4]–[6]. Additionally, noise variability has been shown to negatively affect task performance, communication clarity, and safety awareness among users [7], [8].

Conventional noise analysis methods often rely on average values such as LAeq or peak measurements. However, these approaches are limited in representing the full distribution and variability of noise data. Statistical techniques such as boxplot analysis provide a more comprehensive description of data distribution, including median, quartiles, and extreme values, enabling better identification of noise patterns and potential risk zones [9], [10].

Recent studies have increasingly applied statistical and data-driven approaches to environmental noise analysis, including distribution-based analysis, variability assessment, and

pattern recognition [11]–[13]. However, studies focusing on multi-day, multi-point noise distribution analysis in Malaysian technical workshop environments remain limited.

Therefore, this study aims to analyse the distribution of environmental noise levels in an electrical workshop using boxplot statistical methods. The analysis is based on multi-point measurements collected over five working days, allowing both temporal and spatial variations to be evaluated. The findings of this study provide a clearer understanding of noise behaviour and support the development of effective noise management strategies in technical and vocational education environments.

2.0 METHODOLOGY

This study adopts a quantitative approach to analyse the distribution of environmental noise levels within a technical workshop environment. Noise data were collected from three monitoring stations, namely STA1, STA2, and STA3, over five working days (Monday to Friday). The measurements were recorded at 15-minute intervals from 08:00 to 16:00, allowing sufficient data points to capture variations in noise levels throughout the daily workshop activities. The selection of monitoring locations was based on the workshop layout, where STA1 and STA2 were positioned near active working areas, while STA3 was located in a relatively less active zone to represent background conditions. Similar multi-point measurement approaches have been widely applied in environmental noise monitoring to capture spatial variations in acoustic conditions [11], [12].

All collected data were processed using MATLAB R2019b to ensure systematic organisation and accurate statistical analysis. The dataset was arranged according to the respective monitoring stations and days, followed by sorting and verification to ensure consistency before further analysis was carried out. The use of computational tools such as MATLAB has been widely reported in environmental studies for efficient data processing and statistical evaluation [13]. To represent the overall noise level within each time interval, the equivalent continuous sound level (LAeq) was considered. The LAeq value represents the steady sound level that contains the same acoustic energy as fluctuating noise over a given period. In this study, hourly noise values were obtained by averaging four consecutive 15-minute measurements. This simplified approach is commonly adopted in environmental noise studies to observe general temporal patterns when detailed spectral analysis is not required [14].

To evaluate the distribution characteristics of the collected data, boxplot statistical analysis was applied. This method provides a clear representation of data distribution through key statistical parameters, including minimum value, first quartile (Q1), median, third quartile (Q3), and maximum value. The interquartile range (IQR), which describes the spread of the middle 50% of the data, was calculated using the following expression (1):

$$\text{IQR} = \text{Q3} - \text{Q1} \quad (1)$$

In addition to describing data distribution, the IQR was also used to identify potential extreme values or outliers within the dataset. Values falling outside the defined range were considered outliers, based on the following equation (2) and (3):

$$\text{Lower Bound} = \text{Q1} - 1.5(\text{IQR}) \quad (2)$$

$$\text{Upper Bound} = \text{Q3} + 1.5(\text{IQR}) \quad (3)$$

The use of boxplot analysis for identifying variability and extreme values has been widely discussed in statistical and engineering applications, particularly for exploratory data analysis and environmental datasets [9], [15]. The analysis was carried out separately for each day and

monitoring station to enable both temporal and spatial comparisons. This approach allows the identification of daily noise patterns, differences between monitoring locations, and potential high-risk zones within the workshop environment. Similar analytical frameworks have been used in recent studies to support data-driven interpretation of environmental noise behaviour [10], [11].

3.0 RESULTS AND DISCUSSION

This section presents the analysis of noise level distribution across the three monitoring stations (STA1, STA2, and STA3) over five working days. The results are discussed based on the boxplot statistical summaries presented in Table 1, as well as the corresponding daily distribution patterns illustrated in Figures 1 to 5. Overall, the measured noise levels show noticeable variation throughout the week, reflecting the influence of workshop activities, student movement, and operational conditions. The distribution-based analysis provides a clearer understanding of how noise levels fluctuate rather than relying solely on average values.

Table 1. Boxplot Statistical Summary of Noise Levels for All Monitoring Stations (Monday–Friday)

	Station	Min	Q1	Median	Q3	Max	IQR
Monday	STA1	35	44	49	70	80	26
	STA2	33	43	47	75	95	32
	STA3	40	44	49	77	85	33
Tuesday	STA1	45	47	56	77	89	30
	STA2	43	47	60	82	90	35
	STA3	44	48	50	68	82	20
Wednesday	STA1	43	47	69	78	80	31
	STA2	45	49	73	80	85	31
	STA3	43	49	72	79	80	30
Thursday	STA1	45	49	70	77	85	28
	STA2	43	49	71	80	89	31
	STA3	43	49	67	72	86	23
Friday	STA1	35	45	69	78	83	33
	STA2	38	47	70	80	88	33
	STA3	50	52	68	78	85	26

3.1 Overall Noise Distribution

Based on Table 1, the boxplot statistical analysis shows that noise levels in the workshop vary significantly across different days and monitoring stations. The variation is clearly observed through the interquartile range (IQR), which reflects the spread of noise levels throughout the measurement period. Among the three stations, STA2 consistently recorded higher maximum values and wider IQR, indicating that this location experiences more fluctuating and intense noise conditions compared to STA1 and STA3. This pattern suggests that STA2 is more exposed to active working processes within the workshop environment. This finding is consistent with previous environmental noise studies, where higher variability is typically observed in active operational zones [11].

3.2 Noise Distribution on Monday

Referring to Figure 1, the noise distribution on Monday shows moderate median values (around 49 dB) across all stations. However, STA2 recorded the highest maximum value of 95 dB, indicating the occurrence of peak noise events. The IQR values for STA2 (32 dB) and STA3 (33 dB) are relatively high, suggesting that noise levels fluctuate significantly throughout the day. This variation is likely influenced by intermittent workshop activities such as tool usage and student movement.

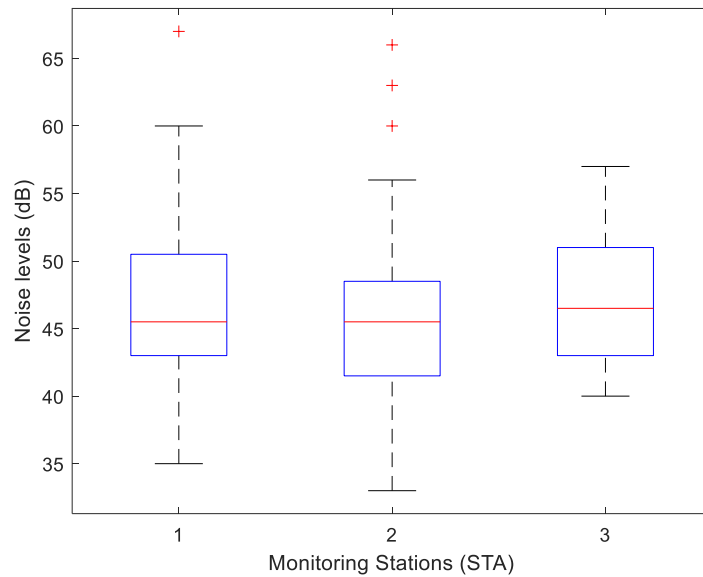


Figure 1. Boxplot Distribution of Noise Levels on Monday

3.3 Noise Distribution on Tuesday

As shown in Figure 2, Tuesday exhibits a clear increase in both noise intensity and variability. STA2 recorded the highest IQR value (35 dB), indicating a wide spread of data and inconsistent noise conditions. The median value at STA2 (60 dB) is also higher compared to other days, reflecting increased activity levels in the workshop. In contrast, STA3 shows a lower IQR (20 dB), indicating a more stable noise environment in less active areas.

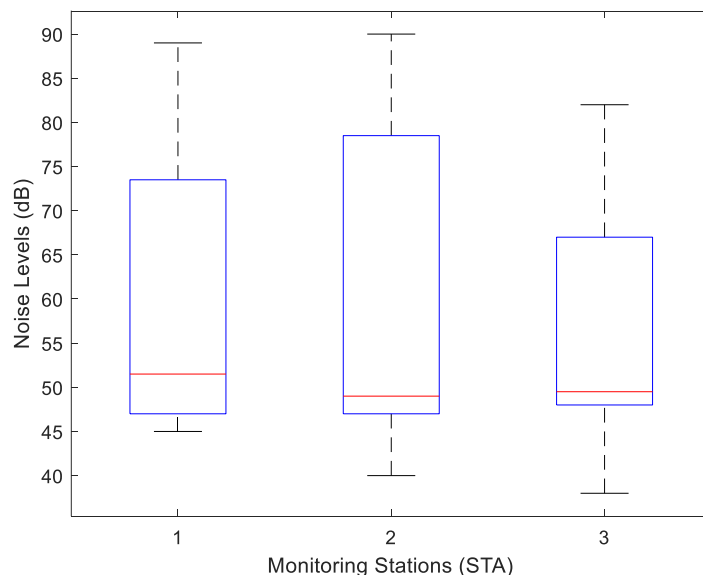


Figure 2. Boxplot Distribution of Noise Levels on Tuesday

3.4 Noise Distribution on Wednesday

Based on Figure 3, Wednesday shows consistently higher median values across all stations, particularly at STA2 (73 dB). Unlike Tuesday, the IQR values are similar across all stations (approximately 30 dB), indicating a more uniform distribution of noise levels. This suggests that the noise generated during this day is more continuous rather than intermittent, likely due to sustained practical activities throughout the workshop. Similar patterns of continuous noise exposure have been reported in workshop environments with sustained practical activities [14].

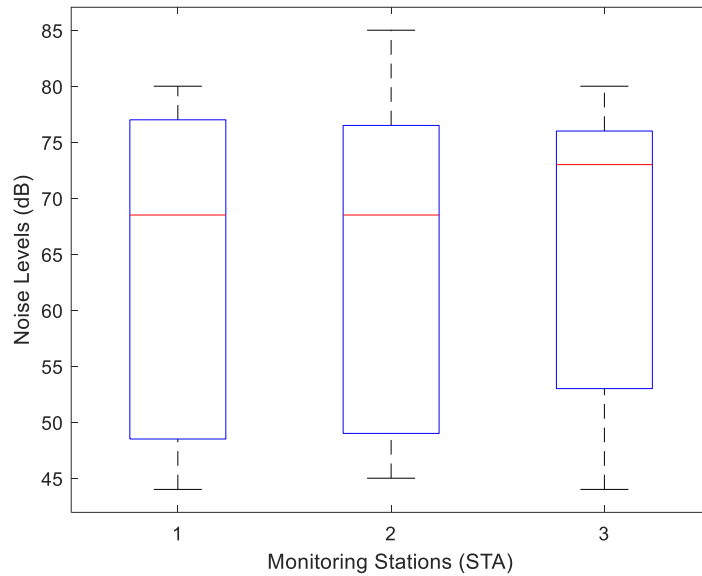


Figure 3. Boxplot Distribution of Noise Levels on Wednesday

3.5 Noise Distribution on Thursday

Referring to Figure 4, Thursday demonstrates a relatively stable noise pattern with moderately high median values (around 70–71 dB). The IQR values indicate moderate variability, particularly at STA2 (31 dB). Although the variation is not as high as Tuesday, the consistently elevated noise levels suggest prolonged exposure to moderate-to-high noise conditions, which may contribute to acoustic discomfort.

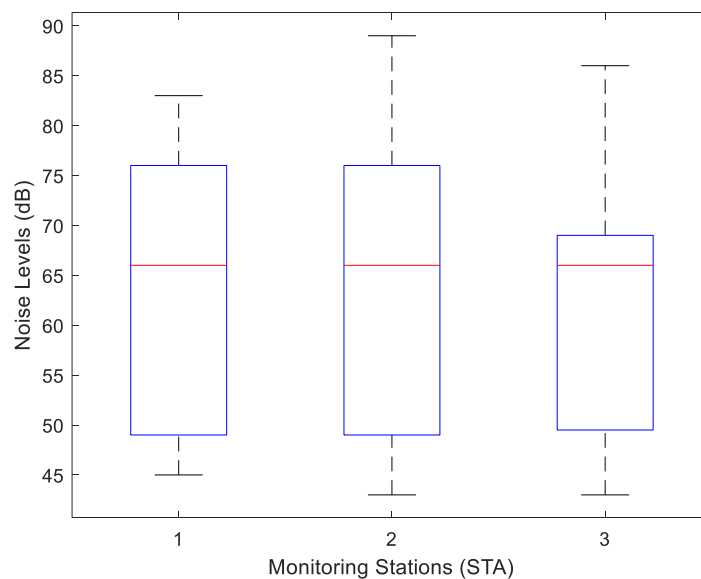


Figure 4. Boxplot Distribution of Noise Levels on Thursday

3.6 Noise Distribution on Friday

As illustrated in Figure 5, Friday shows a mixed pattern of noise distribution. STA1 and STA2 recorded relatively high IQR values (33 dB), indicating significant fluctuations in noise levels. At the same time, the presence of lower minimum values suggests periods of reduced activity. This indicates that the workshop environment on Friday experiences alternating phases of high and low noise exposure.

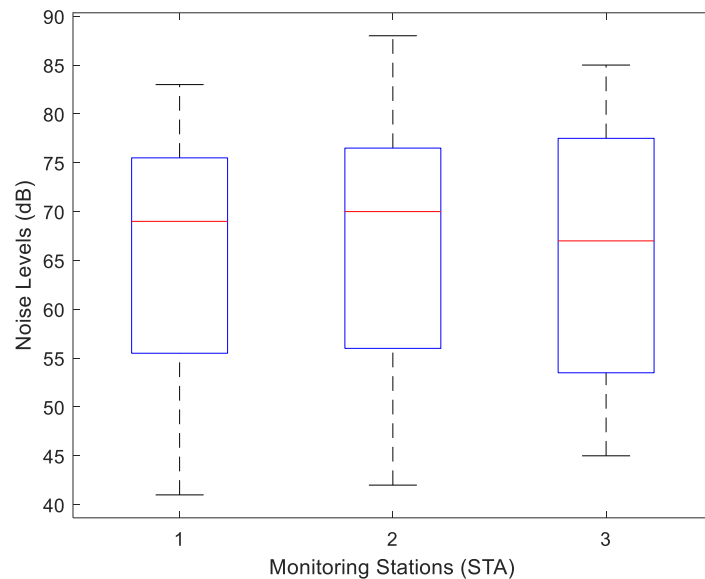


Figure 5. Boxplot Distribution of Noise Levels on Friday

Based on the overall analysis, several important observations regarding the impact of noise in the electrical wiring workshop can be identified. Firstly, the presence of high maximum noise levels (up to 95 dB) indicates that certain activities within the workshop may approach or exceed recommended exposure limits. This condition has the potential to affect communication between students and instructors, especially during practical sessions that require clear instructions.

Secondly, the large IQR values observed on several days, particularly at STA2, indicate that noise levels are highly inconsistent. Such fluctuations may lead to reduced concentration and increased fatigue among students, as the human response to changing noise levels is generally more disruptive compared to constant noise exposure. In addition, consistently elevated median values (above 70 dB) observed on certain days suggest prolonged exposure to moderate noise levels. This may contribute to discomfort and reduced learning efficiency, particularly during long practical sessions.

Furthermore, the spatial variation between monitoring stations shows that areas closer to active working zones experience higher noise exposure. This highlights the importance of workspace layout in influencing acoustic conditions within the workshop. Overall, the findings indicate that noise in the electrical wiring workshop is influenced by both temporal and spatial factors, and may have implications on student performance, safety, and overall learning environment. Therefore, appropriate noise management strategies should be considered to minimise exposure and improve workshop conditions. Fluctuating noise conditions have been shown to negatively affect concentration and communication, particularly in learning environments [7]. The recorded maximum noise level of 95 dB exceeds the recommended exposure limit suggested by NIOSH, indicating a potential safety concern in the workshop environment.

4.0 CONCLUSION

This study presents an analysis of environmental noise distribution in a technical workshop using boxplot statistical methods. Based on the data collected over five working days, it is evident that noise levels vary significantly depending on both time and location within the workshop. The use of distribution-based analysis has provided a clearer understanding of noise behaviour compared to conventional average-based approaches. From the results, STA2 was consistently identified as the most critical monitoring station, recording higher maximum values and greater variability across multiple days. This indicates that areas located near active working zones are more exposed to fluctuating and elevated noise levels. In contrast, STA3 generally exhibited more stable noise conditions, although occasional variations were still observed due to environmental and external factors.

The findings also show that certain days, particularly Tuesday and Friday, experienced higher variability in noise levels, while Wednesday and Thursday demonstrated more consistent but elevated noise exposure. These patterns suggest that both activity intensity and operational scheduling play an important role in influencing acoustic conditions within the workshop. Overall, the application of boxplot analysis has proven to be effective in identifying noise distribution patterns and variability. The results obtained from this study can serve as a useful reference for improving noise monitoring practices and supporting decision-making related to occupational safety and learning environments.

For future work, it is recommended to extend the analysis by incorporating longer monitoring periods and additional statistical or machine learning approaches to further enhance the understanding of noise behaviour. The integration of mitigation strategies, such as workspace reconfiguration or acoustic treatment, can also be explored to reduce noise exposure and improve overall environmental quality. The recorded maximum noise level of 95 dB exceeds the recommended exposure limit suggested by NIOSH, indicating a potential safety concern in the workshop environment.

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