

## The effect of acoustic quality on work productivity and psychosocial stress levels in the basement lobby area

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ARTICLE INFO	ABSTRACT
<p><i>Article history:</i> Received February 18, 2021 Received in revised form April 06, 2021 Accepted October 16, 2021 Available online April 01, 2022</p> <p><i>Keywords:</i> Basement Noise Productivity Psychosocial stress</p> <p><b>*Corresponding author:</b> Frengky Benediktus Ola Architecture Study Program, Faculty of Engineering, Universitas Atma Jaya Yogyakarta, Indonesia Email: <a href="mailto:frengky.ola@uajy.ac.id">frengky.ola@uajy.ac.id</a> ORCID: <a href="https://orcid.org/0000-0003-2049-6050">https://orcid.org/0000-0003-2049-6050</a></p>	<p><i>The basement lobby area in Campus II of Universitas Atma Jaya Yogyakarta was originally designed to function as a vehicle parking and laboratory space with noise-generating equipment, but it is currently being used as a place for students to do assignments. Meanwhile, it has been discovered that psychosocial stress can be caused by continuous exposure to noise, thereby, making it necessary to consider the quality factor of the indoor environment of this area for students use. Therefore, this study was conducted to determine the effect of the noise in the basement lobby area on student work productivity and psychosocial stress. This involved the use of a quantitative method by measuring the noise level using Phonic PAA3 per one point in the 4 segments of the corridor according to the provisions of SNI 7231:2009. Moreover, a qualitative approach was also applied by distributing online and offline questionnaires to determine the perception of noise, psychosocial stress, and its effect on work productivity. A total of 109 respondents consisting of 48 architecture, 40 civil engineering, and 21 techno-biology students using the lobby as a place to do assignments were used as the respondents. The data obtained were analyzed using a simple regression method in the SPSS25 program. It is important to note that the quantitative and qualitative measurements were not conducted simultaneously. The results showed that the study room does not fulfill the standard reference value of 45dB required for the noise level as indicated by the highest and lowest noise (Leq) values recorded to be 74.10dB and 64.34dB in segments B and A, respectively, as well as the overall average of 70.1dB. Furthermore, the combination of the qualitative and quantitative data showed that the noise affects students' psychosocial stress by 43% and productivity by 45%, hence, this means the noise reduced the student productivity. Therefore, the noise factor needs to be considered in planning a workspace or converting the function of space in order to ensure its purpose is achieved maximally.</i></p>

### Introduction

Room acoustics is related to the noise level and sound quality condition in a room. Poor acoustic performance has the ability to cause dissatisfaction with the work environment,

thereby affecting the performance of the workers (Frontczak et al. 2012). Meanwhile, it is possible to generate noise either from the outside or inside the room. According to Banbury and Berry (2005), external noise includes the sound from vehicles, crowds, and machines while the internal



ones are in the form of conversations between room users (Ola et al. 2020), public announcements, the sound of machines, and work equipment. Pellerin and Candas (2004) also discovered that a 3dB change in indoor sound level has the ability to reduce productivity by 2%.

Noise is a disturbing sound and a major source of severe stress (Fooladi 2012). People generally think the noise is related to the loudness of sound, while Satwiko (2019) discovered that the annoyance level does not always depend on the sound level but also the condition of the receiver. This means a low sound that is disturbing can be considered a noise. It is important to note that exposure to high levels of sound pressure has the ability to cause psychological health problems such as anxiety, depression, stress, and fatigue. Moreover, some of the activities mostly affected by noise generally include verbal communication, teaching and learning, mental activity, and sleep. However, most people are not aware of the impact of this noise, specifically those who exposed to low levels of noise for a long period. The existence of excessive noise in areas where educational activities are being conducted can reduce the performance of the teachers, students, and staff. According to de Souza, Alberto, and Barbosa (2020), some of the negative effects of noise include psychological and mental stress, irritation, inefficiency in work and studies, and even depression. Asmaningprojo (1995) also confirmed that it has the ability to influence a person's work effectiveness.

Selye stated that pathogens, causes of physical stress such as shock and noise, and causes of psychosocial stress have similar patterns of physiological response which is in three stages known as the generalized adaptation syndrome. The first is the warning stage which involves physiological changes from the initial reactions required to fulfill the needs created by stressors. The second is the resistance stage which is the full adaptation to the stressor with the consequent improvement or disappearance of stress symptoms. The third is the exhaustion stage which occurs when the stressor is severe and prolonged enough to deplete somatic defenses, thereby causing illness and even death (Selye 1978).

Stress is the response of the body and mind balance to change. This change can either be good or bad as well as a new situation which is different from previous ones experienced. According to Putri (2014), psychosocial stress is caused by

social environmental stressors which include all forms of phenomena in the work environment, place of residence, or society which have the ability to disrupt an individual's mental balance (Williams and Grossberg 2018; Kaplan, Sadock, and Grebb 2007) and require adaptation (Sumarni 1998). Moreover, psychosocial stressors can be in the form of problems being experienced by an individual (Putri 2014) or noise which can lead to stress and even depression (Selye 1978). This situation usually makes the body produce more adrenaline (Levi 1972). Meanwhile, an excessive, persistent, or repeated adrenaline activity over a period often causes a series of responses such as functional impairment in different organs and systems (Dunbar 1954). Cardiovascular disorders or high blood pressure can also be caused by prolonged psychosocial stress which is associated with chronic noise by (Cohen et al. 1986; Gary W. Evans 2001). Another study by Cohen et al. (1986) showed that the effects of noise on the teaching and learning process include communication disorders between teachers and students, among the students, and the need to change the teaching styles. People working in noisy environments for a long period have also been discovered to be susceptible to high blood pressure (Tomei et al. 2010). Noise has also been discovered to have a negative effect on the psychological level and behavior, work performance, concentration, (G. W. Evans and Hygge 2000), and memory impairment (Cohen et al. 1986). It also has the ability to reduce an individual's motivation (Glass 1972). However, a previous finding showed that the ability to control noise can lead to the reduction of its side effects (Gary W. Evans and Stecker 2004).

The interior of a room always has a strong influence on the sound condition, especially in terms of feasibility and quality (Sutanto 2015). One of the acoustic problems usually experienced is echo and it can be reduced through the use of absorbent materials. Meanwhile, most of the covering material normally used such as ceilings, concrete walls, wooden walls, tile floors, and wooden doors do not have good absorption capability to reduce echo (Zainudin et al. 2019). It has been discovered that the occurrence of this echo is associated with the repetition of sound based on the time difference between the direct and reflected sound. According to Sutanto (2015), it is usually heard very clearly when the reverberation time value is short and the sound diffusion is insufficient. Moreover, Tri Yuni

(2016) showed that the reverberation time can be used to determine the acoustic quality of the room and a good reverberation time for classrooms is set at 1 second.

Several studies discussed the effect of noise on employees' work stress levels as well as teaching and learning activities. An example of the effect of noise on work stress levels is a journal published in 2013 with a focus on the employees of PT. Semen Tonasa. The study applied a quantitative method by measuring noise using Phonic PAA3 and a qualitative method by distributing questionnaires to 23 workers in Shift I. The results showed there is a relationship between noise exposure of the workers in a factory and the stress levels they experienced (Ardiansyah, Salim, and Susihono 2013).

Another study conducted in 2019 at the State Elementary School 01 Buaran, South Tangerang also applied both methods. This involved measuring noise using SLM (Sound Pressure Level) and distributing questionnaires to 824 students and 37 teachers. The results showed that the State Elementary School 01 Buaran experienced noise that exceeds the standard level stipulated by the Minister of the Environment Decree No.48 of 1996 by 55 dB (Menteri Negara Lingkungan Hidup 1996). This caused 59% of the respondents to feel disturbed while 52% were unable to learn effectively (Cahyandari, Yulinawati, and Moerdjoko 2019).

The focus of this study is on the basement lobby area of Campus II, Universitas Atma Jaya Yogyakarta which was originally designed as a vehicle parking space and laboratory with noise-generating equipment. However, the space was converted to a place for students to do assignments without considering the acoustic quality required to use a room for learning. This was observed from the use of reflective materials such as concrete walls, ceramic floors, concrete slab ceilings, and fix glass windows as well as several air vents in the space. Therefore, the room is discovered to have a worse acoustic quality and is also prone to echoes. Meanwhile, Selye (1978) showed that noise can be one of the psychosocial stressors of stress and even depression. Previous studies were observed to be focused on the effect of noise on work stress and the level of acceptance in the learning process. Therefore, the novelty of this study is in the determination of the effect of noise level on psychosocial stress by reviewing the audial comfort of the students using the space and also to evaluate the student productivity in the

space when compared to other locations based on personal assessment.

## Method

This study was conducted in the basement lobby area of Campus II, Universitas Atma Jaya Yogyakarta which is usually used interchangeably by 2534 active students of the engineering and techno-biology faculties for assignments. The noise was measured based on the equivalent value using the Phonic PAA3 tool in accordance with the provisions of SNI 7231:2009 and this made it possible to use the values as a reference value throughout the time when the space was being used. Moreover, the quantitative and qualitative data were not collected simultaneously due to the ability of humans to recall events and sensations experienced (Lestari, Tjokro, and Putro 2013), thereby linking them to the actual measurement.

The effect of noise on psychosocial stress was determined based on student productivity level and the process was conducted by distributing questionnaires to students who used the basement for doing their assignments. The questionnaire was designed to have 22 questions and was distributed online to 72 and offline to 37 respondents, thereby having a total of 109 respondents. The offline ones were filled when the respondents were at the study room, while online ones were filled from different locations.

The questionnaire focused on evaluating the perception of the basement users regarding the noise level to determine its effect on their psychosocial stress and ultimately work productivity.



**Figure 1.** The atmosphere of study room usage

Quantitative method (noise level measurement)

The quantitative method was used to measure the noise level at a specified point in each zone. The study room was divided into 4 segments as indicated in figure 3 and the Phonic PAA3 was applied for this purpose to measure sound loudness from 30dB to 130dB and frequencies from 20Hz to 20,000Hz. The measurement was conducted on different days from 08:00 am – 08:00 pm based on the time the basement was being used. Each segment was measured 4 times and this means 16 measurements were made. It is important to note that each was conducted for 10 minutes and data was collected every 5 seconds. These data were subsequently used to determine the Equivalent Noise ( $L_{eq}$ ) and Noise Pollution Index ( $L_{NP}$ ) values through the use of the following formula:

$$L_{eq} = L_{50} + 0,43 (L_1 - L_{50}) \dots\dots\dots (1)$$

Description:

$L_1$ : Maximum noise

$L_{50}$ : Average noise

$$L_{NP} = L_{eq} + 2,56\delta \dots\dots\dots (2)$$

Description:

$L_{eq}$ : Equivalent index

$\delta$ : Standard deviation

The  $L_{eq}$  and  $L_{NP}$  values were compared with the applicable noise level standards. It is important to note that the value for a building used for learning purposes is not to exceed 45 dB according to Satwiko (2019).

Table 1. The permissible noise by type of room

Building	Room	dBA
Education	Lecture and classroom	30-40
	Private study room	20-35
	Library	35-45

Source: Building physics (Satwiko 2019)

Table 2.  $L_{NP}$  standard according to US Department of Housing and Urban Development

$L_{NP}$	Community acceptance criteria
< 58 dBA	Acceptable
58 – 74 dBA	Still acceptable
74 – 88 dBA	Generally unacceptable
>88 dBA	Totally unacceptable

Source: Building acoustics (Mediastika 2006)



Figure 2. Field measurement

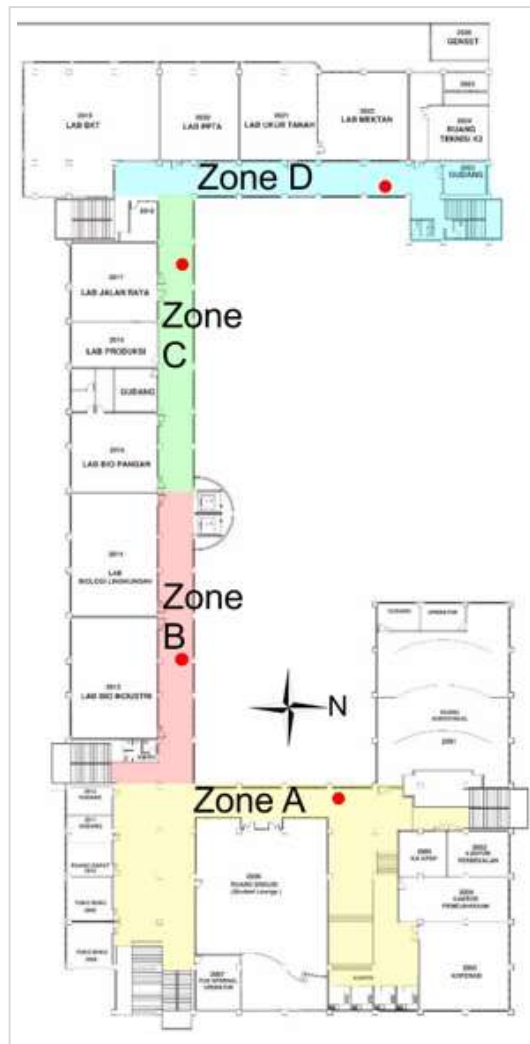


Figure 3. Zoning and measuring point (red dot)

Qualitative method (noise perception and productivity level)

The qualitative analysis was conducted by distributing online and offline questionnaires to 109 students consisting of 48 in architecture, 40 in civil engineering, and 21 in techno-biology who have previously done their assignments in the study room. The questions were divided into three groups as well as a complimentary question which are outlined as follows:

1. Those related to the noise level of the study room based on the user's perception. The questions are as follows:
  - a. Have you ever experienced a crowded situation at certain hours when using the basement lobby area of Campus II for doing your assignments?
  - b. In your opinion, can the basement lobby area be said to be noisy?
2. Those related to psychosocial stress. The questions are as follows:
  - a. Are you acoustically disturbed by the noises made by other basement lobby users such as chatting, listening to music, and others?
  - b. In your opinion, can the basement lobby area of Campus II be said to be noisy?
  - c. Can the noise in the basement lobby area reduce your productivity while working on your assignments?
3. Those related to productivity level in order to determine the effect of the psychosocial stress experienced by the users on the level of productivity. The questions are as follows:
  - a. Is your productivity in terms of the time required to work on your assignments in the basement lobby area of Campus II better than in other places? (The assignments are completed faster in the area when compared to other places)
  - b. Is your productivity in terms of achieving targets while working on assignments in the basement lobby area better than in other places? (The target is achieved faster when working on assignments in the area compared to other places)
  - c. Is your productivity in terms of the level of focus in working on assignments in the basement lobby area better than elsewhere? (There is more focus working on assignments in the basement hall than in other places)
  - d. Is your productivity in terms of grades obtained from working on assignments in

the basement lobby area better than in other places? (Better grades are obtained on assignments done in the basement hall when compared to other places).

4. The complementary question focused on the reasons the users feel comfortable or uncomfortable while working on their assignments at the study room.
  - a. Why do you feel comfortable or uncomfortable while working on your assignments in the basement lobby area of Campus II?

The responses were analyzed using SPSS25 software. Moreover, the sampling method used was selected based on the following Solvin formula:

$$n = \frac{N}{1 + N(e)^2} \dots\dots\dots(3)$$

Description:

- n: sample size or number of respondents;
- N: population size;
- e: the tolerable leniency in the accuracy of sampling error;
- Range of e-value: 10% – 15%.

The e-value used in this study was 0.15 or 15% for architecture and civil engineering students and 0.2 or 20% for techno-biology students.

The terms of the Solvin formula:

- e-value = 0.1 (10%) for a large population
- e-value = 0.2 (20%) for a small population.

The existing data were compared and the relationship between the noise measurement with several questions from the questionnaire was determined using 2 variables which are as follows:

- Variable X (Noise);
- Variable Y (Productivity).

The overall questionnaire was also analyzed using SPSS25 software through the following stages:

1. The validity test was used to determine each question item is easily understood by the respondents.
2. Reliability test was used to determine each question item in one variable is interrelated or constant.
3. A simple regression test was used to determine the effect of independent (noise) on dependent (productivity) variables. This is the conclusion

of the analysis conducted using the SPSS25 software.

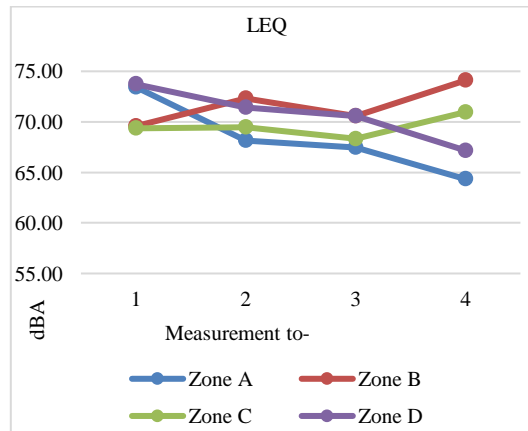
### Conclusion drawing method

The results from the quantitative and qualitative analysis were used to obtain one question each on noise, productivity, and psychosocial stress experienced by basement users. The question regarding noise was later compared with the values obtained from field measurements while the results of the questionnaire analysis regarding productivity and psychosocial stress were compared with the results of the simple regression test. Therefore, the correlation between the comparisons made was used to draw the conclusion for this study.

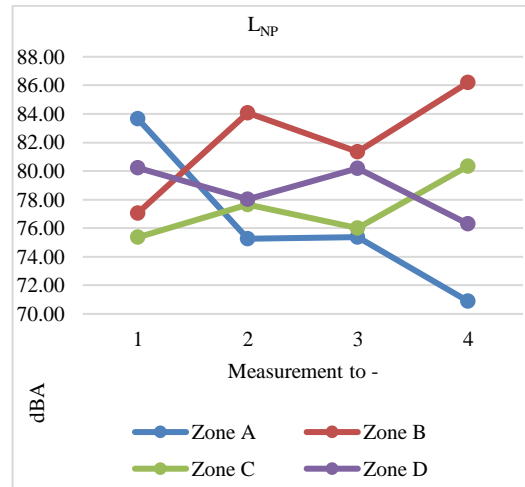
## Result and discussion

### 1. Noise measurement results

The noise at the study room was observed to have exceeded the applicable standard of 45dB required for a room designed as a learning facility. This means the basement lobby area is noisy as indicated by the threshold value of 45dB for LEQ in [graph 1](#) and 74dB for  $L_{NP}$  in [graph 2](#).



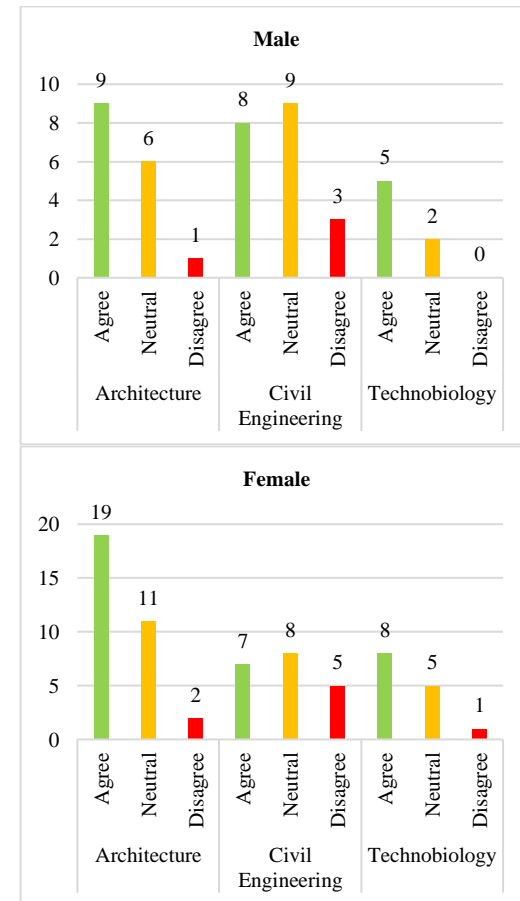
Graph 1. Compilation of equivalent noise values



Graph 2. Compilation of noise pollution index

### 2. Noise analysis according to respondents

The responses provided in the question showed that the users perceive the study room to be noisy.

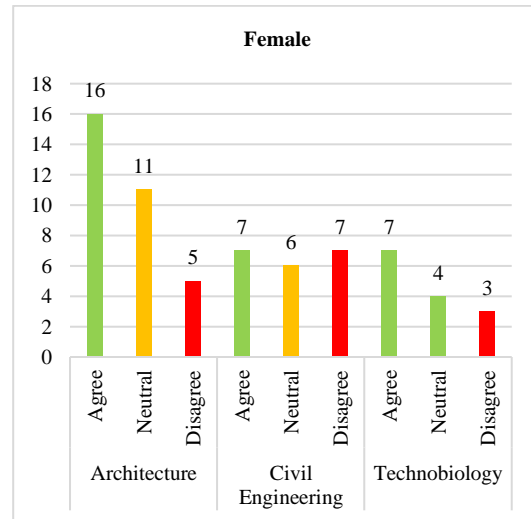
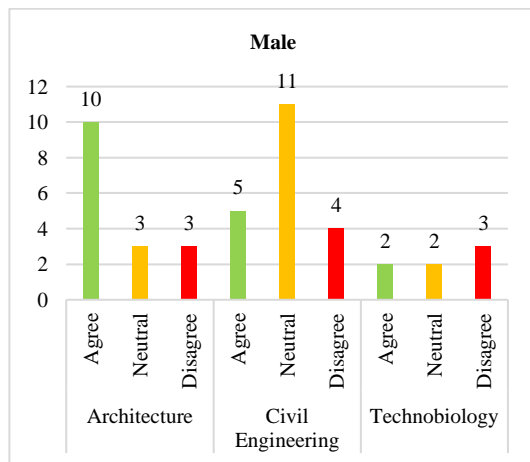


Graph 3. Path, circulation

This was indicated by 51% of the respondents which agreed that the area is noisy, 38% were neutral, and only 11% did not feel it is noisy. Their perception is also supported by the noise measurement results which showed the highest and lowest noise (Leq) values to be 74.10dB and 64.34dB in segments B and A, respectively, while the overall average was 70.1dB. Meanwhile, 49% of the respondents believed the area is not noisy due to the fact that they were engaged in group work activities which generally require discussion, ignore the surrounding noise, and even make noise that is unwanted by other users.

### 3. Analysis of respondents experiencing psychosocial stress due to noise

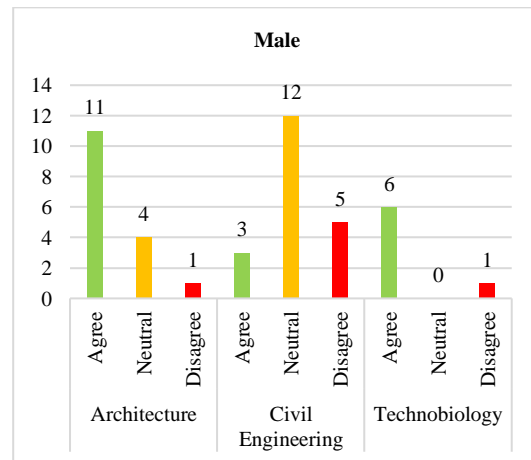
The findings from the responses provided in the questionnaires showed that most of the students are disturbed by the noise in the study room. This was indicated by a total of 43% that felt disturbed and experienced psychosocial stress because of the noise while 34% were neutral and only 23% were not disturbed. This means a total of 57% are not affected by the noise in the area. It is important to note that the results of the quantitative and qualitative measurements are not significantly relevant considering the fact that the group work activities being conducted by the students at the study room are the source of the noise. In some cases, some of the students listen to songs using earphones in order to block the noise out.

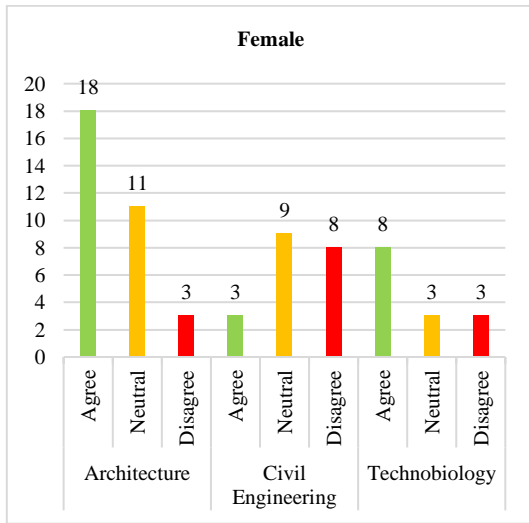


**Graph 4.** Students that experience psychosocial stress

### 4. Analysis of reduction in productivity due to psychosocial stress

The responses showed that 45% of the respondent experienced a reduction in productivity, 34% are neutral, and only 23% did not have such experience. This is in line with the findings of [Asmaningprojo \(1995\)](#) that noise affected human performance, especially the psychological aspect. It is also important to note that the 55% that did not experience a reduction in their effectiveness was due to the same reasons cited in sub-chapter 3.3. However, there is a correlation between the percentage of respondents observed to have audial disturbance in the qualitative analysis with those who experiencing psychosocial stress and decreased productivity.





Graph 5. Decrease in student productivity

##### 5. Conclusions drawn using SPSS25 software

The responses were analyzed using a simple regression test in SPSS25 software and the results showed the noise caused psychosocial stress for the students and also reduced their productivity. This is observed from the following simple regression test results:

Table 3. SPSS25 simple regression test results

Model	Unstandardized Coefficients		Sig.
	B	Std. Error	
(Constant)	15,276	1,840	0,000
Noise	-0,169	0,052	0,001

- i. The consistent value of Y (Productivity) was 15.276;
- ii. The regression coefficient of X (Noise) was -0.169 and this means every 1% addition of the noise value reduced productivity by 0.169. Moreover, the negative regression coefficient means the direction of the effect of X (noise) on Y (productivity) is negative.

## Conclusion

The results showed that, first, the intensity of the noise exceeds the standard threshold. Second, this continuously makes the students working on their assignments in the study room feel disturbed and experience psychosocial stress. Third, this psychosocial stress led to a reduction in the level of productivity such that a 1% addition of the noise value was discovered to be causing a 0.169 decrease in productivity. Fourth, some conditions

and actions of the respondents blurred the correlation between the noise level using the qualitative method. Fifth, noise perception was correlated with decreased productivity and increased psychosocial stress. Sixth, further study is needed to improve the acoustic quality of the basement lobby of Campus II, Universitas Atma Jaya Yogyakarta.

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#### **Author(s) contribution**

**Maria Christina Prasetya** contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

**Frengky Benediktus Ola** contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.