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## The Influence of Lighting, Noise, and Temperature on the Academic Performance of Students amid Covid-19 Pandemic


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**Abstract.** The Coronavirus outbreak disrupted the global economy and human social activities, including schooling. Because of the worldwide school closure, face-to-face lessons have been stopped. Students desire to participate in real-time online learning was not well understood when the Coronavirus outbreak occurred. Despite this, there has been a progressive return to face-to-face education accompanied by online learning after more than two years of the COVID-19 pandemic. This international survey assessed students' readiness for live online learning using technology rather than the more traditional online/internet self-efficacy scale. This study is needed because of the COVID-19 outbreak (dependent variable). Three hypotheses were substantiated with the partial least square method to develop a structural equation model containing all four variables. Students' grades were shown to be directly influenced by

factors such as temperature, lighting, and noise. Three distinct elements influence university students' long-term viability (human resources). Males and females were found to have no statistically significant differences. We contend that during the Coronavirus pandemic, the gender disparity in learning was minimized because students were pushed to take greater responsibility for their education. Educators utilizing live online learning, particularly those educating students at various educational levels, can benefit greatly from this research. Students pursuing lower-level degrees should be encouraged to engage in more virtual activities and student-to-student relationships.

**Keywords:** Covid-19 pandemic; academic performance; online class; factors; students

## 1. Introduction

It is essential to ensure that the socioeconomic component of human well-being (i.e., security, health, and education) is spread equally across all socioeconomic classes and demographic groups. To put it another way, a good working environment is vital for maximizing productivity. In addition, an efficient design helps individuals preserve their physical and psychological components (knowledge, motivation, creativity, and social skills). As a result, human capital may be continuously developed. Using ergonomics theories, concepts, information, and methods may improve human well-being and system performance. Ergonomics aims to keep people healthy, comfortable, and safe at work and home. Employees are more productive while working in a healthy and safe environment. Workplaces poorly designed, both ergonomically and environmentally, put workers at risk by creating conditions that make it difficult for them to do their jobs well. Inadequate workstation design may lead to musculoskeletal disorders (MSDs). As a result of promoting human performance via ergonomic workstation design, workplace sustainability is improved. An ergonomic workstation design is crucial to increasing workplace sustainability and physical health, according to Mohezar and colleagues (2021). Workstations that are ergonomically designed may last longer, which improves sustainability. To maximize the efficiency of human resources, ergonomic design is essential.

For the most part, ergonomics studies are geared toward the workplace. Other occupations, on the other hand, may be jeopardized if the ergonomic design is not used. There is a comparable issue in education, where some conditions put people and students (teaching staff, administrators, directors) at risk. People with poor posture and sitting for a long time are more likely to develop musculoskeletal disorders (MSDs). Taifa (2022) examined the consequences of not considering ergonomics when designing student-friendly furniture and environments. Around 69% of students reported physical ailments, including 23% with hand and elbow discomfort and 19% with headaches. Another group of studies revealed that environmental factors might put students in harm's way in terms of ergonomics. In addition, studies found a connection between academic success, student health, and school climate (Cabacang, 2021, Vakalies et al, 2021, Magulod, Jr, 2018, Magulod Jr, Capili & Pinon, 2019, Obispo Magulod Jr, & Tindowen, 2021). Student's academic performance and attendance in online classrooms may be

adversely affected if they are subjected to poor ventilation, extreme heat, or excessive noise (even in a quiet room). On top of the already-mentioned negative effects on academic achievement, students in online classes may be subjected to uncomfortable and unsafe circumstances.

According to the World Health Organization (WHO, 2020), this outbreak has officially been declared a pandemic (Cucinotta & Vanelli, 2020). So many individuals are obliged to work from home for various reasons. Several industries need workers to work remotely. The US has 149,000 educational institutions, 34 million students, and 2 million instructors (Cucinotta & Vanelli, 2020). All students will be obliged to take online courses before the end of the school year in March 2020. And as the post-pandemic era has approached, many universities and colleges have embraced hybrid or blended modes of education (Singh et al., 2021). This kind of training combines on-campus sessions with flexible online learning. Students can enjoy face-to-face and online learning, as well as planned and self-paced classwork with hybrid and blended training (Singh, 2017, Magulod Jr, 2019). This type of instruction can become the new standard because it allows instructors to reinvent and revise content, particularly in disciplines where instructors have struggled to provide engaging learning experiences for students through an online medium of instruction (Rodriguez, 2020). Students have adjusted their habits to deal with the new realities of online education. Environmental, technological, and psychological factors are all evaluated. New circumstances may impact student health, safety, and academic progress. Noise, temperature, and illumination may distract them. If students want to get the most out of their new study area, they must interact with it. First, these uncomfortable positions may cause physical discomfort and suffering in the back, neck, and limbs, which may develop into MSDs.

Regarding psychological issues, online education might increase mental effort and tiredness. Online learning's speed may now be utilized. Exemplifying this includes learning and utilizing new technological tools (such as Classroom) to complete classwork or chores provided by teachers. Online class environmental elements, including noise, temperature, and light, are little researched. We would want to know how lighting and noise impact online students' results. It consists of six parts: Second, the study assesses COVID-19 and environmental variables (lighting, noise, temperature). Section 3 examines how the environment affects online students' academic progress. Section 6 summarizes the research results.

Since the pandemic breakout forced schools to adopt a new learning modality, many studies have already investigated the effects of online learning on students' academic performance (Arcinas, 2022, Han & Ellis, 2021; Mandasari, 2020; Oducado & Estoque, 2021, Rad et al., 2022). However, few studies consider the environmental factors behind students' virtual learning, such as light, noise, and temperature, as significant contributors to students' intellectual development. Additionally, most ergonomics research focuses on the workplace (Bailey et al., 2021; López-García et al., 2019; Marmaras & Nathanael, 2021). A productive environment is essential for students' boosting output. Additionally, an effective environment aids people in maintaining their psychological and physical

components. Therefore, there is a need to conduct studies on the effect of the mentioned variables on students' school performance, especially since many schools still prefer using online modalities as a part of learners' experience even after the pandemic.

### *Paradigm of the Study*

This study assumes that temperature, light, and noise directly impact how well students perform academically when studying online. As a result, it is anticipated that environmental factors will cause a change in a student's performance. The study's independent variables are the light, noise, and temperature in the learners' homes, while the independent variable is their academic performance. Thus, this study has established a causal relationship.

## **2. Literature Review**

### *COVID-19's Effect on University Students' Academic Achievement*

Researchers have studied COVID-19's impact on college student's grades. The implications of COVID-19 limitation on pupils' capacity to study freely, according to Kim et al. (2020). These investigators used an experiment in which 458 students were split into two groups for control and experimentation purposes. Students who were confined to their homes were included in the study. Students learning processes and productivity were both enhanced by confinement, as found by Subirats et al. (2021). Gonzalez and colleagues studied college students' views on online education during the COVID-19 outbreak (2020). These researchers conducted a survey of undergraduate and postgraduate students for their study. According to students, online courses are ineffective in developing nations such as Pakistan since the majority of students lack an Internet connection. As a result of the COVID-19 outbreak, children must deal with several difficulties, including a lack of normal classroom interaction and a lack of direct instructor involvement. As part of their research, Shahzad et al. (2020) surveyed COVID-19 students on their overall happiness. Students' satisfaction with online learning and their adaptation to the new environment was assessed using an online poll conducted by the authors. The findings showed that most students favor online education, even though they had to pay large fees for slow Internet connection.

Accordingly, Demuyakor (2020) studied students' mental health during the COVID-19 epidemic in an online classroom technology research. For this study, researchers devised a two-part survey. Academic accomplishment was one of the five key components in Section 2. A total of 775 students were surveyed via snowball sampling. Facing their peers in person, 59.5 percent of students stated that -it is essential to their academic success, while 55.5 percent claimed that the sheer volume of e-learning tasks causes stress and hinders their learning. Haider and Al-Salman (2020) investigated students' impressions of the impact of the COVID-19 pandemic on a variety of global issues affecting their lives in their dissertation. Students in this study favored public relations and instructional staff support at the respective universities. The pupils' inadequate computer abilities and inaccurate picture of their workload made it hard for them to perceive their increased academic achievement in the new classroom. Afro-Asian pupils were

also dissatisfied with their academic achievement compared to other socioeconomic groups.

The outbreak of COVID-19 was also examined by Tang et al. (2021) in terms of its impact on student academic performance. The authors conducted semi-structured phone interviews with three academics throughout his inquiry (Heads of the departments of mathematics and natural sciences). They also studied college students' performance (2021). The author used semi-structured phone interviews with three academics for his investigation (Heads of the departments of mathematics and natural sciences). His analysis shows that if COVID-19 is not fixed quickly, fewer pupils will pass math tests. If the COVID-19 pandemic is not handled immediately, his results show that the percentage of students who pass math exams may decrease.

### *Lighting's Effect on Academic Performance Among University Students*

Test scores or marks from instructors are used to determine whether a student has mastered a certain subject. Students' academic success is closely linked to their school's lighting level. According to Mudenda et al. (2021), a lack of light induces discomfort and worse academic performance. Pupils' grades may be affected by the illumination in their classrooms. Abbasi et al. (2021) investigated this to see whether lighting and ventilation in the home influenced children's grades. Ninety-two 10- to 12-year-olds participated. Researchers collected data on children's processing speed, focus, reasoning, and problem-solving abilities over four weeks. However, another study compared the effect of light on academic achievement. Warm 2900 K-450 lux increased students' learning speed, focus, and math abilities. Still, dynamic cool 4900 K-750 lux was found to improve all three of these factors simultaneously, resulting in a 6.6% improvement in student performance at  $p < 0.001$ . (11.8 percent,  $p < 0.006$ ).

Bluyssen et al. (2021), for example, looked at how solar-powered school supplies affected student achievement. According to the findings, solar illumination initially boosted student attendance, but that trend quickly faded. Academic results did not improve despite more time spent studying and attending class more often. Lighting color temperature was discovered to influence the academic performance of first-graders in comparable research as well. In order to examine the hypothesis that academic achievement is linked to cognitive and behavioral responses, they performed three physiological tests. In studies on easy, normal, and severe workouts, the ideal heart rates were found to be 3500 kHz, 5000 kHz, and 6500 kHz. In another study, ORIBO (2021) looked at the effects of classroom illumination on 738 students in the same classroom. The Testo-545 lux meter was used to assess classroom illumination, and the d2 Test of Attention was used to gauge students' academic performance in terms of speed and accuracy while writing and reading. The authors administered a questionnaire to measure students' impressions of classroom illumination. According to the results, students' attention and academic performance increased considerably ( $p < 0.05$ ) when exposed to illumination settings ranging from 250 to 500 lux. Study results showed that classroom illumination significantly influenced primary school pupils' intellectual growth, which was confirmed by Singh et al. (2020). This

research was built on a sample of 210 students chosen at random. Other than student interviews, researchers used accomplishment, motivation, and a self-created questionnaire to gather information (an observation checklist to assess physical components of the learning environment lighting level). Classroom illumination in this study significantly affected elementary school pupils' academic performance ( $p < 0.05$ ). According to Hypothesis H1, this is how it works: Hypothesis 1 (H1). While taking online courses during the COVID-19 epidemic, illumination significantly influences academic achievement.

### ***University Students' Academic Performance and Noise Exposure***

Several scholars have undertaken studies on the effect of noise on academic achievement. Acoustic questionnaires, such as He et al. (2022)'s, were utilized to examine the correlations between academic work and noise disturbance. Around 38% of students were distracted by background noise and discussion when doing cognitively demanding tasks like studying, reading, or writing. Sibley et al. (2021) investigated the influence of voice and effects of background noise on ADHD students' academic performance and ability to score tasks. (The number of participants is 52). An oral count technique was utilized to track how much time was spent reading. Writing correctness and essay word counts were also used to assess students' writing abilities in the classroom. Writing accuracy does not seem to be improved by white noise in the classroom. Pupils at two elementary schools were polled by Braat-Eggen et al. (2020) on noise levels, their effects, and their ability to manage it (a public and a private school). A 20-item questionnaire was sent to over 400 pupils, and classroom noise levels were measured. At recess, students complained of excessive noise, yet measurements showed that noise levels at private schools were on average 74.56 decibels (dBA) and in public schools were on average 82.18 dBA.

Students' well-being and achievement were studied by Wood (2020). A survey of 327 college students was utilized to determine current noise exposure. The Student Well-Being Process Questionnaire is used to calculate GPA, course assignments, and assessments to gauge students' well-being. The author's conclusion was that student noise levels had nothing to correlate with academic success. High-pitched noise has been shown to impair pupils' cognitive capacities, which are linked to academic success (Ruiz Alvarado, 2020). Students from three primary schools were studied: 135 males and 133 girls. In addition, students were divided into two groups and tested psychologically (background noise versus additional noise). A lot of noise affected the Stroop and Color Trace results. Finally, it was discovered by Caviola et al. (2021) that pupils who attended schools near a busy city street fared worse. For further information, see Thompson et al. (2022) and Nazneen et al. (2022; as a result, H2 is presented as a hypothesis.

Hypothesis 2 (H2). The noise level negatively impacts on-campus students' academic performance during the COVID-19 epidemic.

### ***The Impact of Temperature on University Students' Academic Performance***

Noise, light, and temperature all impact student performance. Baafi (2020) claims that classroom temperature influences student performance. So, according to López-Chao et al. (2019), cold temperatures confuse and agitate pupils, priming them to respond. They operate better in cool environments but not as well in

hotter ones. On average, Realyvásquez-Vargas et al. (2020) found that pupils' grades improved as the temperature rose. The seasons also mirrored student performance. To measure students' achievement in both seasons after the third year, Ko et al. (2020). It was shown that the first and third years significantly impacted student performance, but not the second.

Kumar and Singh (2021) also looked at the influence of gender on heat perception and academic performance. As the temperature increased, women's academic performance would rise, while men's academic performance would fall. Gender and 24 SAT-style questions were used to evaluate previous assumptions on the Google form. An association between heat perception and academic achievement was seen for three days in the same classroom ( $p = 0.049$ ). There was no gender difference in how well men and women performed academically, whether it was hot or cold. Two experiments were done this summer by Browning and Rigolon (2019). The air temperature varied significantly for a week depending on whether the split cooling units were running or idle. Students' views of their surroundings and symptoms were then gathered using visual analog scales that depict various components of schooling. According to the findings of two arithmetic and two language-based evaluations, students' performance increased significantly when the temperature was lowered from 25 to 20 degrees Celsius. Students' grades rose significantly when the outdoor airflow was increased from 5.2 to 9.6 L/s per square foot. Barker et al. (2019) evaluated a district of 70 elementary schools and 140 fifth-grade classes for their study. In the previous study, academic achievement was correlated with temperature. The researchers found that when temperatures dropped from 25°C to 20°C, students' average arithmetic scores climbed by 12-13 points. Finally, students' academic performance benefits considerably when they are comfortable in the classroom. According to Earthman's research, optimal temperature ranges exist in the literature connected to thermal quality and educational results. This source suggests keeping classroom temperatures between 20°C and 24°C to enhance student learning and comfort (68F and 74F, respectively). As a result, here's Hypothesis H3. Figure 1 shows the hypothetical causal model from the present study. Hypothesis 3 (H3). The temperature at home impacts college students' academic performance during the COVID-19 outbreak.

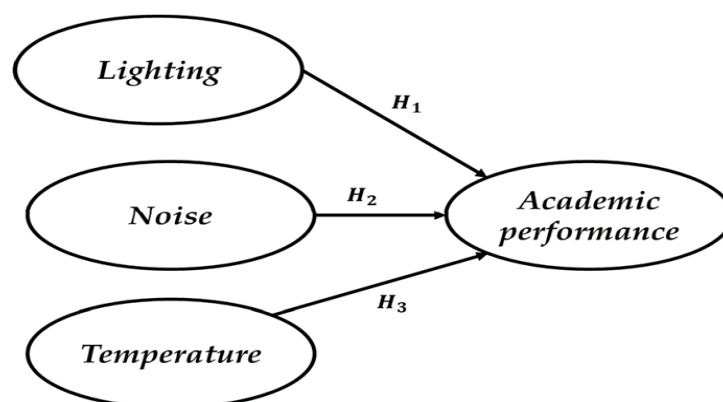


Figure 1. Hypothetical causal model

## 2. Research Method

A cross-sectional survey was used in this study. The three aspects of the method are questionnaire development, questionnaire delivery, and statistical analysis of the results.

### *Questionnaire Development*

Student's classroom performance has been affected by various environmental factors (lighting, noise, and temperature). There have been several studies that have relied on questionnaires to gather data. Researchers in Newman et al. (2022) used a questionnaire with three components. The emotional and physical well-being of students was the subject of Section 1. On classroom design, there were eight questions in the second portion (temperature, air sensation, air quality, noise, lighting). Headaches and attention troubles were among the topics covered in the third episode. An eight-part questionnaire, three of which focused on classroom temperatures, noise levels, and light levels. This technique was also used to analyze the design of learning spaces in various university courses. Using surveys, (Müezzinoğlu et al. 2021) studied the impact of illumination, noise, and temperature on academic performance. As a result of the widespread outbreak of COVID-19, environmental variables for these surveys were unable to be collected (lighting, noise, and temperature). The QEOC is created, as previously indicated. Here are the parts of the QEOC: Our first topic of discussion will be the effects of online education on students' mental and physical health. Research in this area aims to determine how environmental factors affect student academic achievement. A comprehensive literature review was conducted to discover research that examined the relationship between the dependent variable (lighting, noise, and temperature) and student performance. Several words spring to mind while thinking about these elements, including academic success, school, and students. The initial survey's findings were double-checked for accuracy using a literature review. After that, items are built for use in online classrooms where students study from the comfort of their own homes. Table 1 lists the altered elements and references.

**Table 1. Reference for questions on the Questionnaire of the Effects of Online Classes on Students' Health and Academic Performance (QEOC).**

Variable	Item	Reference
Lightning	My study area's lighting helps me to see well and focus while taking online courses.	[63]
	Changing the lighting in my study environment is one of the perks of taking college courses online (for example, opening and shutting shades, and curtains, having a table lamp, and having dimmers within reach).	[64]
	Visual comfort is aided by the quantity of illumination in my study area, including lights and computer screens.	[65]
Noise	When I take courses online, my study space is completely private.	[66]



	I can concentrate, take notes, and hear my lecturers and students because of my study space's background noise (from devices, discussions, and other sources). [67]	
	I can regulate the temperature in my studies, for example, by opening and closing doors and windows. [64]	
Temperature	My study room's temperature helps me focus and relax when completing online courses. [67]	
	It's simple to adjust the temperature in my online study space, for example, by opening and shutting windows and turning ventilators on and off. [64]	
	My study area's air quality is suitable for taking online programs. [66]	
Academic Performance	I can complete all my activities effectively by attending online courses. [68]	
	By attending courses online, I can plan my schedule so that I can complete all the tasks assigned to me by the professors. [68]	
	My grades have improved because of taking online programs. [68]	
	I've gained more information through attending online courses. [69]	
	I enhanced my communication abilities by attending online programs. [69]	
	By attending online programs, I've increased my teamwork abilities. [69]	
	My activity improves because of taking online courses. [70]	
	I am pleased with the results I achieved from attending online programs. [70]	

On a Likert scale of 1 to 5, responses to the QEOC must be given on the following five-point scale: never; rarely; occasionally; sometimes; often; constantly. This scale has been selected because of recent and similar research. Drafted questions were submitted into Google Forms when they had been completed.

### ***Respondents and sampling technique***

In order to attain the objectives of the study, the researchers made use of a total of 222 university students from 12 universities. Convenience sampling was used to select the respondents. It is the process of choosing a sample's participants based on their easy accessibility (Bhardwaj, 2019). In the study's case, only the students who took online courses and fulfilled the requirements for the application of the QEOC online were selected as respondents. For the profile characteristics of the respondents, the majority were aged 20-30 (72.37%), males (58.85%), and 185 (90%).

### ***Procedures***

First, the researcher asked permission from the university administrators, IRB, and other authorities to conduct this investigation. Second, after receiving permission from the authorities, students from 12 different institutions who took online courses during the COVID-19 epidemic were required to complete the QEOC. The students might be either undergraduates or graduates. To apply for the QEOC online, the following actions were required: Finding university instructors: A teacher might be contacted through email if their name and email address were published in publications such as conference proceedings, periodicals, and book chapters, or other sources. Following the acquisition of a list of academics with institutional email, an email detailing the project's purpose was sent. Also included was a link to the QEOC, which they may share with students and teachers within the university or even across the country. Some people were contacted through Classroom, while others were contacted through Facebook. The data gathered from the questionnaires were subjected to tabulation, organization, data cleaning, and appropriate statistical analysis with a statistician's aid. The researcher rigorously followed the ethical research considerations. Finally, the result from analysis, interpretation, and report writing was done.

### ***Ethical considerations***

The following ethical consideration was applied to perform this study: First, the study included obtaining permission using informed consent forms and letters of authorization from the school administrators of the respondent schools and other authorities. Second, before the respondents answered the questionnaires, the researchers ensured that they had enough information regarding the study's goals and agreed that the information they would share would be used as data for this study. And lastly, to abide by the data privacy act, the privacy of the respondents was observed by not mentioning names. And lastly, the Covid-19 health protocols were observed throughout the conduct of this study.

### ***Data Statistical Analysis***

Statistics are used to validate QEOC results and determine whether certain variables are related. There is strong evidence to support the three hypotheses made in Section 2.

### ***Statistical Validation of the QEOC Questionnaire***

Since the data were gathered on an ordinal scale, the median was replaced by outliers or missing values in the SPSS 24® program (Likert scale). Each QEOC variable is statistically verified using an appropriate Cronbach's alpha value of 0.7 as a minimum threshold. For this reason, only variables having correlations greater than or equal to 0.70 should be included in the analysis. Discriminant and convergent validity may both be assessed using the extracted average variance (AVE). A substantial p-value is required for each variable's AVE, which must be more than 0.5. The VIF index is used for each variable to determine if they have collinearity. This value must be less than 3.3. A non-parametric measure of predictive validity ( $Q2 > 0.2$ ) is computed using an ordinal sort of data and a measurement of the Q2 coefficient. The Q2 coefficient can be found only in

endogenous latent variables. A student's latent performance on a test is the explanatory latent variable.

**Table 2. Socio-demographic characteristics of the surveyed students.**

<b>Socio-Demographic Characteristics of Surveyed</b>	
<b>Students Age</b>	<b>Number (%)</b>
>18-20	45 (22.35%)
>20-30	148 (72.37%)
>30-40	14 (7.89%)
>40-50	5 (3.45%)
<b>Gender</b>	
Male	119 (58.85%)
Female	92 (47.30%)
<b>Marital Status</b>	
Single	185 (90%)
Married	15 (8.35%)
Free Union	12 (7.45%)
Other	4 (5.43%)

**Table 3. Surveyed students per university.**

		<b>University</b>											
Students Involved in the Survey		A1	B2	C3	D4	E5	F6	G7	H8	I9	J10	K11	L12
			95	90	13	10	4	3	2	1	1	1	1

### *Analysis of the Structural Equation Modeling*

Figure 1 may be examined using WarpPLS 6.0® software to determine the relationships between the variables (SEM). This program's partial least squares option comes in handy when data are ordinal and represent a small sample that does not match normalcy requirements (PLS). It is possible to get a deeper understanding of this model by using accuracy measures such as the average path coefficient (APC), average R-squared, and adjusted R-squared (ARS) (AARS). All collinearity and average block VIFs must be less than 5 to meet the criterion (AFVIF). The Tenenhaus index (GoF) must also be greater than 0.25. Additionally, an SEM must examine the factors' direct, indirect, and total impacts. Figure 1 shows that direct effects (arrows) may verify the model predictions. Another way to think about it is that indirect effects look at the relationship between two variables by examining the segments of a latent variable that connect the two. Overall impacts include both direct and indirect effects. Due to the short number of segments between independent and dependent variables, indirect effects are

not apparent in Figure 1. Using a p-value to determine if a variable-to-p-value relationship is statistically significant, one of the most known instances of direct effects is represented by the symbol S, which represents standard deviations. Finally, the size of each influence's impact is computed. The SE recognizes this capacity to classify an independent variable's influence on each dependent variable.

### 3. Results

#### *Descriptive Analysis of the Data*

Table 4 lists the variables that are both dependent and independent, as well as the components that make up each. Most students responded 3 = Occasionally, 4 = Usually, or 5 = Always for the three independent variables. However, the most common response for the dependent variable academic achievement was 3 = Sometimes. This finding implies that home settings are not optimum and that other factors influence academic achievement.

**Table 4. Descriptive Analysis**

Variable	Item	Answer	Frequency (0%)	Mean	Median	Standard Deviation
	A good amount of light in my study environment helps me see well and focus when taking online courses.	1 2 3 4 5	2(1%) 5(2.4%) 49(23.8%) 91(44.2%) 59(28.6%)	3.97	4	0.843
Lightning	Changing the lighting in my study environment is one of the perks of taking college courses online, for example, opening and shutting blinds and curtains, having a table lamp, and having dimmers within reach.	1 2 3 4 5	10(4.9%) 10(4.9%) 34(16.5%) 60(29.1%) 92(44.7%)	4.04	4	1.117
	When taking online classes, the quantity of illumination in my study environment (lights and the computer screen) provides me with visual comfort.	1 2 3 4 5	2(1%) 16(7.8%) 49(23.8%) 78(37.9%) 61(29.6%)	3.87	4	0.959

	I have complete privacy in my study space when taking an online class.	1 2 3 4 5	20(9.7%) 34(16.5%) 50(24.3%) 46(22.3%) 56(27.2%)	3.41	3	1.306
Noise	I can concentrate, take notes, and hear my teacher and other students because of the low noise level in my study environment (caused by electronic devices, discussions, and other outside influences).	1 2 3 4 5	13(6.3%) 34(16.5%) 74(35.9%) 66(32%) 19(9.2%)	3.21	3	1.038
	I can manage the amount of noise in my study environment, for example, by opening and shutting doors and windows.	1 2 3 4 5	18(8.7%) 36(17.5%) 53(25.7%) 57(20.4%) 42(20.4%)	3.33	3	1.229
Temperature	I can adjust the temperature in my study space while taking online classes by opening and shutting windows and turning on and off ventilators	1 2 3 4 5	12(5.8%) 17(8.3%) 36(17.5%) 73(35.4%) 68(33%)	3.82	4	1.154
	My study space has enough air quality for taking the class online.	1 2 3 4 5	4(1.9%) 12(5.8%) 51(24.8%) 67(32.5%) 72(35%)	3.93	4	1.002
	I can do all my tasks by attending online programs.	1 2 3	12(5.8%) 23(11.2%) 67(32.5%)	3.47	4	1.103

		4	64(31.1%)			
		5	40(19.4%)			
	I can plan my time by taking classes online and ensure I do all the work my instructors provide.	1	11(5.3%)	3.50	3.50	1.129
		2	25(12.1%)			
		3	67(32.5%)			
		4	56(27.2%)			
		5	47(22.8%)			
	My grades have improved because of taking online programs.	1	13(6.3%)	3.50	3	2.395
		2	27(13.1%)			
		3	72(35%)			
		4	62(30.1%)			
		5	32(15.5%)			
Academic Performance	By attending online courses, I have increased my knowledge.	1	27(13.1%)	2.84	3	1.143
		2	54(26.2%)			
		3	68(33%)			
		4	39(18.9%)			
		5	18(8.7%)			
	By attending online courses, I was able to strengthen my communication abilities.	1	27(13.1%)	3.05	3	2.167
		2	48(23.3%)			
		3	65(31.6%)			
		4	23(20.9%)			
		5	23(11.2%)			
	My creativity grows thanks to online courses.	1	29(14.1%)	3.03	3	2.177
		2	49(23.8%)			
		3	62(30.1%)			
		4	43(20.9%)			
		5	23(11.2%)			
	I'm pleased with the outcomes I've gotten from attending courses online.	1	28(13.6%)	3.24	3	2.370
		2	33(16%)			
		3	68(33%)			
		4	42(20.4%)			
		5	35(17%)			

### *Validation of Variables*

The QEOC questionnaire was well tested internally and content-wise (Table 5). In the QEOC, removing a variable lowers the Cronbach's alpha. As a result, everything was transferred to the QEOC. Figure 2 shows the indexes' results that support the conclusions of this investigation's dependent and independent variables. The revised R2 and R2 were more than 0.2, demonstrating predictive validity. Following validation results, an SEM might be used to analyze these factors.

**Table 5. Validation of variables and items**

<b>Variables and their Items</b>	<b>Cronbach's</b>	<b>Cronbach's Alpha if the item is removed from QEOC</b>
Lightning	0.776	
My study space's illumination makes it easy to see what's happening around me and helps me concentrate when taking online classes.		0.698
By opening and closing curtains and drapes, using a table lamp, and having dimmers within reach, I can control the amount of light in my study environment when taking online courses.		0.726
A good amount of illumination (from lamps and computer screens) helps me to focus when taking online classes.		0.643
Noise	0.816	
I can concentrate in peace since I am taking lessons online.		0.743
It's easier for me to concentrate, engage in class, and hear my lecturer and other students because of the noise level in my study environment (from devices, discussions, and other sources).		0.766
I can regulate the volume of noise in my study space (for instance, by opening and closing doors and windows).		0.712
Temperature	0.871	
		0.787

Being able to regulate my body temperature while taking online classes is essential for my concentration and well-being.		0.843
I can regulate the temperature in my study space while taking courses online (for example, by opening and shutting windows and turning ventilators on and off).		0.816
My study space has adequate air quality for taking online courses.		
Academic Performance	0.831	
Attending online classes allows me to finish all my tasks efficiently.		0.759
I'm able to manage my time better since I'm taking classes online and not in a traditional classroom setting.		0.760
The online classes I've taken have helped me improve my grades.		0.751
The classes I've taken online have helped me learn more.		0.751
I've improved my communication skills by taking online classes.		0.776
My ability to work with others has improved because of taking online classes.		0.756
My creativity is enhanced by taking online courses.		
I am pleased with the outcomes I have received from attending online classes.		0.791
		0.738



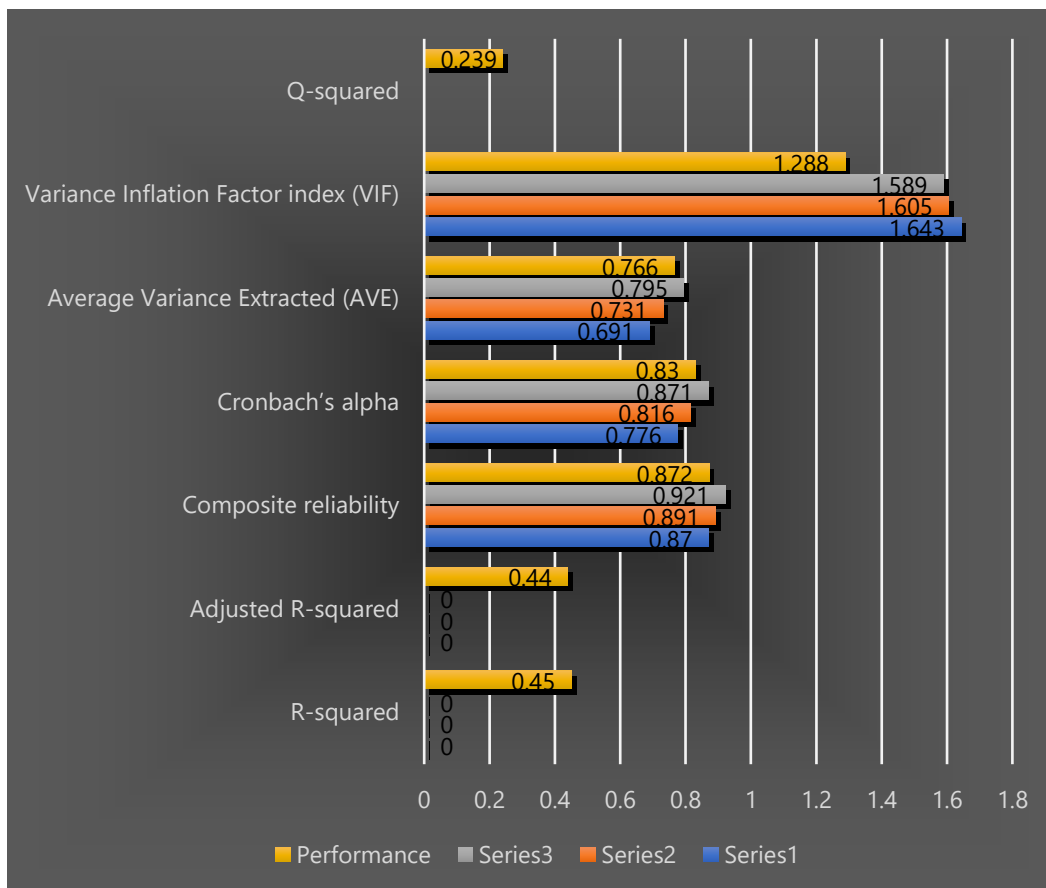


Figure 2. Validation of variables

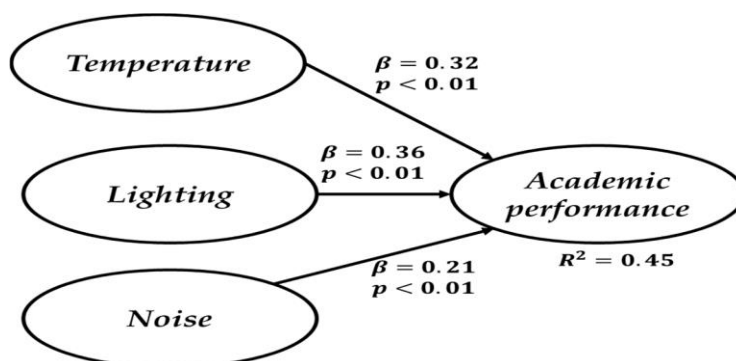


Figure 3. Model evaluation

**Validation of the Model**

These are shown in Figure 4. The results demonstrated that each index meets the methodology's minimal and maximum parameters. Aside from collinearity difficulties, this means that the model can accurately predict future outcomes.

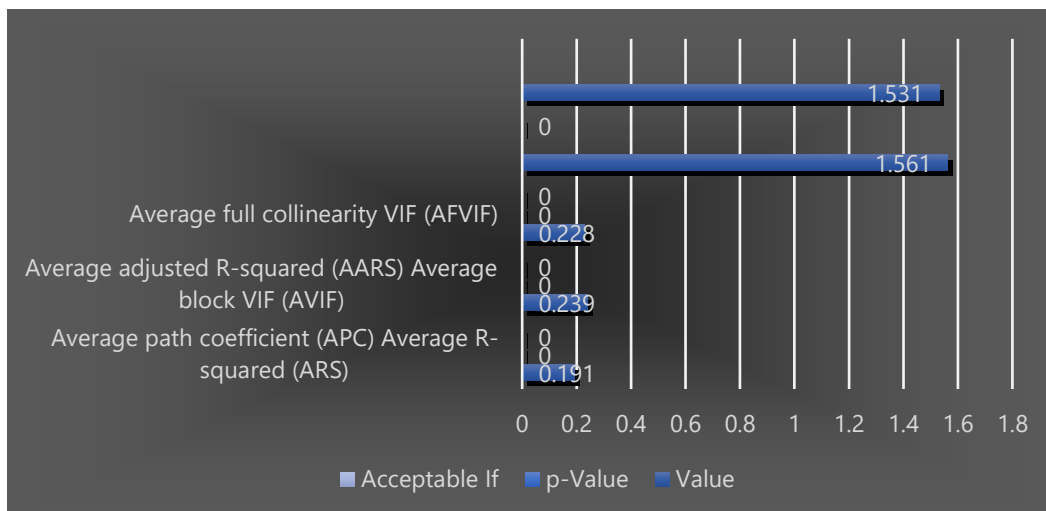


Figure 4. Validation of variables

**Direct Effects**

For each direct impact, the () value is shown, along with the corresponding p-value, in Figure 5. The significance level was set at a p-value of 0.05 or below. Since H2 and H3 have p-values less than 0.05 and H1 has a p-value greater than 0, it is decided to accept H2 and H3. Students taking online courses during the COVID-19 outbreak reported worse grades, and this was shown to be most strongly correlated with the noise variable's effect on the dependent variable.

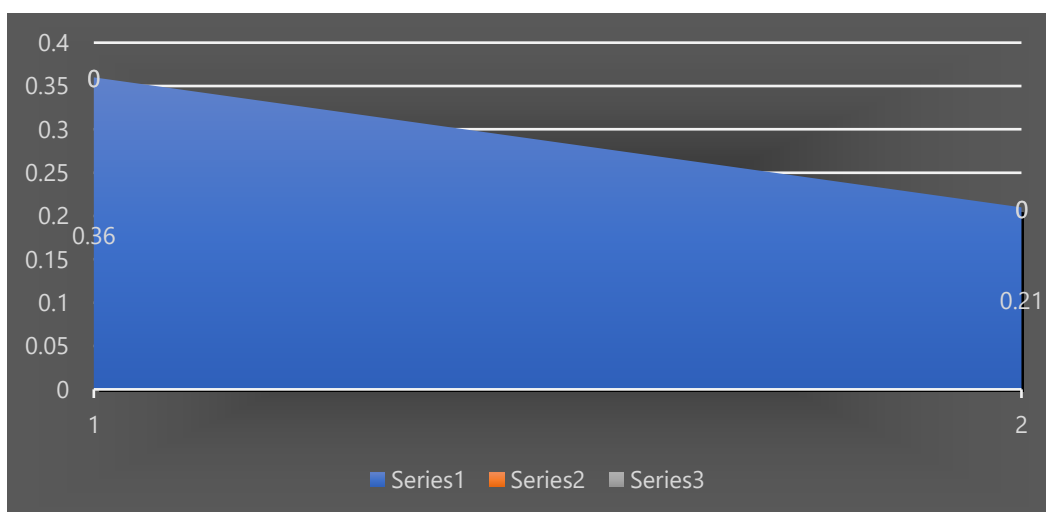


Figure 5. The decision to accept or reject the proposed hypotheses

Figure 5 portrays the results of each hypothesis, where the following was obtained: H1: It seems that during the COVID-19 epidemic, an increase in the standard deviation of illumination level correlates with improved academic success among students taking online courses from home.

H2: Academic performance improves by 0.21 units when students take online courses during the COVID-19 outbreak.

H3: Given that the temperature standard deviation rises by one unit during the COVID-19 pandemic, it is statistically shown that the temperature standard deviation increases by 0.32 units.

This indicates that the independent variables (lighting, noise, and temperature) accounted for 45 percent of the dependent variable (academic performance), with noise accounting for 26.8 percent, temperature for 11.3 percent, and lighting for 6.7 percent.

#### **4. Discussion**

This study's findings show that environmental circumstances at home during the COVID-19 epidemic might impair pupils' academic performance, which is consistent with earlier research. In terms of illumination, these findings are similar to previous writers. For example, Gil-Baez et al. (2021) state that illumination directly influences pupils' academic performance. In fact, these writers state that pupils cannot learn without proper illumination. This includes online students. A decent amount of illumination and sufficient ventilation can increase student academic performance, according to e Silva et al. (2021). According to Kudo et al. (2019), increases in indoor illumination are inadequate to enhance pupils' academic performance. The researchers found that 250 and 500 lux are optimal for improved school performance, as stated by Schlittmeier and Marsh (2021). Based on the evidence provided in this work, it is feasible to suggest that academic performance is significantly affected by adequate illumination and sufficient ventilation. Therefore, educational facilities should be able to address the environmental factors present in learning areas and provide students with the necessary materials and adequate lighting to foster success in their intellectual development.

The idea is the same for the noise variable as well. Lenz et al. (2021) found that noise disrupted students' concentration while doing cognitive tasks like math. Online students have the same challenges, owing to the increased level of background noise and other distractions at their residences. In this way, the study's conclusions are further supported. Nevertheless, Sibley et al. (2021) demonstrate that noise levels impact students' reading/writing abilities and hence their academic achievements. A positive school climate, according to Brink et al. (2021), is beneficial to student's academic development. As a result, excessive noise interferes with their ability to learn. As a final note, the results of this research resemble those of Phan (2021) in that both investigations discovered that student academic performance is negatively impacted by noise intensity. Therefore, higher sound levels can potentially affect university students' cognitive development in their online learning. Higher noise levels will lead to lower academic performance as the learners cannot concentrate on their lesson, which is caused by distraction. In order to prevent getting distracted by the sounds of their

laptops and other electrical gadgets, students taking online classes should have a quiet location at home.

Finally, the findings of this study agree with prior studies in that temperature affects students' academic performance. In recent research, Mohamed et al. (2021) discovered that classroom temperature influenced academic performance. These findings coincide with Tian et al. (2021). This is because the authors discovered that cold and hot surroundings severely impact pupils' academic performance compared to thermally neutral conditions. Similarly, Phan discovered a link between temperature awareness and academic achievement. This is in line with Kabirikopaei's (2021) findings that student performance increases when the temperature lowers from 25 to 20C (77 to 68F). Al-Kumaim et al. (2021) discovered that temperatures between 20 to 24C (68F to 74F) are appropriate to improve student comfort and academic performance. All these past investigations conceptually corroborate the findings of this study, which were also statistically supported. The prior research did not include a sample of schoolchildren during a pandemic. Based on the findings and previous research, it can be inferred that a learning environment with high or low temperatures could decrease the students' cognitive ability. It may be implied that the student's performance may differ by the classroom or home temperature that is being maintained. Students and institutions may benefit from a well-designed online classroom with climate-controlled spaces in terms of sustainability.

The terms sustainability and students are studied in some research. This research focuses on how colleges teach sustainability and students' grasp of the issue. For example, Sáez de Camara et al. (2021) explored whether or not students in Melbourne and Singapore had a distinct understanding of what sustainability education entails. On the other hand, Martinez-Martn and Lozano-Martn, (2021) assessed present student commitment to sustainability and its impact on future intention to use sustainable development concepts. This paper proposes three parameters to measure the economic sustainability of college graduates (Galleli et al., 2021). Using participatory ecological learning, Ulfiani Rahman (2021) investigated the impact of self-efficacy and self-concept on student sustainability. For the educational community to acquire professional competencies in student sustainability, Garca-Rico et al. (2021) suggest that all members must be involved. To promote sustainable education, these writers proposed many teaching-learning competencies. Regardless of the outcomes, none of the prior investigations used an ergonomic approach to include environmental influences. This underlines the study's uniqueness and shows the breadth of research on online students' ergonomics and sustainability.

For the limitations of the current study and future research directions, this paper solely focuses its scope on the three variables, namely light, noise, and temperature, as the variables affecting the academic performances of students utilizing online interventions as their tool during their learning. Aside from the variables mentioned, future studies could consider involving other variables that could affect students' performances in their online courses. The performance of

the respondents in their online learning should also be investigated further with the integration of the other personal profile aspects of the respondents.

## 5. Conclusion

For the COVID-19 epidemic, three hypotheses needed to be tested statistically. The environment has an impact on online students' academic achievement, attention, and comfort. This might affect their grades, education, and ambition to finish school. Making sure learners are happy is critical to getting the most out of them (such as study area design). Here, an unregulated study area design affects university students' academic performance. Students' academic performance also relies on factors other than how much time they spend studying or how well they remember the content. Therefore, institutions should encourage students to attend lessons in a pleasant atmosphere with regulated lighting, noise, and temperature. When it comes to homework, for example, teachers should not be doing it. Student computer time is reduced as a result. Mental strain and time spent in adverse environments are both reduced because of this. More participatory courses are encouraged. Game-based learning may be used to inspire students to study while also engaging them and improving their level of interest in the subject matter at hand. Students taking online classes should have a quiet area at home to avoid being distracted by the noises of their computers and other electronic devices. All these scenarios may prevent university students from achieving optimum learning and hence sustained human resource development. The following theoretical and managerial implications were addressed based on the direct influence of three environmental factors on academic performance analyses. Academic success at university is not just dependent on time spent studying or recalling knowledge. A private environment may assist in reducing student noise perception, which may enhance academic performance when taking online courses at home. A well-designed online classroom with quiet areas and climate-controlled rooms may help students and institutions to be more sustainable.

The COVID-19 epidemic has reportedly hampered online students' academic achievement. Other elements like illumination, noise, and temperature might also impact academic achievement. These factors include the student's desk/table and chair design, their technical gadgets (tablet, phone, computer), and the time they spend using them. Non-ergonomic furniture and equipment might cause students back and neck pain. These variables may also cause tension, anxiety, and headaches in learners. All these factors may affect children's academic performance and motivation, and the QEOC questionnaire covers all these topics. However, the COVID-19 epidemic has afflicted not just students but also faculty and staff at higher education institutions, affecting their capacity to survive. It is possible to combine both university students' and instructors' opinions in future research.

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