THE EFFECT OF CLASSROOM ENVIRONMENT ON STUDENTS'ACADEMIC PERFORMANCE AND MUSCULOSKELETAL DISCOMFORT

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Keywords

Academic performance, Musculoskeletal discomfort, Student, Physical environment, Green buildings

Abstract

Green buildings and their use in school settings, as an alternative to traditional buildings, have shown an enormous growth in the last decade. Besides the benefits of green buildings to our environment, it is equally critical to establish a comfortable, healthy, and productive atmosphere withindoors. Green buildings have significantly different classroom environments than conventional buildings in terms of natural ventilation, lighting, overall comfort, acoustics, carbon dioxide concentration, and thermal comfort. In this study, a two-part questionnaire was used to determine the effect of the physical environment of the classroom on university students' comfort, academic performance, and musculoskeletal discomfort in green building. The significance of this study is that it is the first Green Building in Northern Cyprus that physical classroom environment has been evaluated, and previous studies have not examined students' musculoskeletal discomfort in green building classroom environments. A Kruskal-Wallis H test, a post hoc analysis, and a Spearman rank correlation test were applied. The findings indicated that the physical environment of classrooms had a differential effect on academic performance and musculoskeletal discomfort of students across demographic groups, but no effect on student comfort.

SINIF ORTAMININ ÖĞRENCİLERİN AKADEMİK PERFORMANSINA VE KAS-İSKELET RAHATSIZLIKLARI ÜZERİNE ETKİSİ

Anahtar Kelimeler

Akademik performans, Kas-iskelet rahatsızlığı, Öğrenci, Fiziksel ortam, Yeşil binalar

Öz

Yeşil binalar ve geleneksel binalara alternatif olarak okul ortamlarında kullanımları her geçen gün artmaktadır. Yeşil binaların çevremize sağladığı faydaların yanı sıra binanın içinde de konforlu, sağlıklı ve üretken bir atmosfer yaratmak aynı derecede önemlidir. Yeşil binalar, doğal havalandırma, aydınlatma, genel konfor, akustik, karbondioksit konsantrasyonu ve termal konfor açısından geleneksel binalardan önemli ölçüde farklı sınıf ortamlarına sahiptir. Yeşil Bina'da, sınıfın fiziksel ortamının üniversite öğrencilerinin konforu, akademik performansı ve kas-iskelet rahatsızlıkları üzerindeki etkisini belirlemek için iki bölümden oluşan bir anket kullanılmıştır. Bu çalışmanın önemi, Kuzey Kıbrıs'ta ilk kez bir yeşil binanın sınıf ortamının değerlendirilmiş olması ve daha önceki çalışmaların yeşil bina sınıf ortamlarında öğrencilerin kas-iskelet rahatsızlıklarını incelememiş olmasıdır. Araştırma sorularını analiz etmek için Kruskal-Wallis H testi, post hoc analiz ve Spearman rank korelasyon testi uygulandı. Bulgular, sınıfların fiziksel ortamının, demografik gruplar arasında öğrencilerin akademik performansı ve kas-iskelet rahatsızlıkları üzerinde farklı bir etkiye sahip olduğunu, ancak öğrenci konforu üzerinde hiçbir etkisinin olmadığını göstermiştir.

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1. Introduction

Educational ergonomics is defined as a branch of ergonomic science that explores the relationship between educational performance and the design of learning environments (Smith, 2001). No matter what the school type is; the system in any school consists of different ergonomic elements, which both have micro and macro in nature (Legg and Jacobs 2008). Moreover, according to educational ergonomics, students' performance is extremely context-dependent-specialized in relation to certain design factors, and ergonomic interventions aimed at improving design may thus benefit academic institutions (Smith, 2007). Smith (2007) also pointed out that seven distinct categories of educational system design variables can on students' learning. These categories include academic program design features, classroom and building ergonomics, class organisation and scheduling, educational system administration, the teaching process, personal considerations, and the student family and community.

The term "physical environment" describes the room's physical qualities. The physical classroom environment is comprised of a variety of factors, including lighting, temperature, ventilation, room size, floor, walls, desks, chairs, carpets, whiteboards, and computers (Suleman and Hussain, 2014). The physical environment of classrooms has an effect on academic performance and student learning (Baafi, 2020; Caldwell, 1992; Hill and Epps, 2010; Jiang, Wang, Liu, Xu, and Liu, 2018; Samani and Samani, 2012; Suleman and Hussain, 2014; Stafford, 2015; Wang et al., 2018; Wargocki, Porras-Salazar and Contreras-Espinoza, 2019). Caldwell (1992) stated the assumption that inadequate classroom design and upkeep can result in student performance declines of 10%–25% is conservative. Inadequate parameters of classroom environmental elements such as air quality, temperature, lighting, and noise have a negative effect on academic performance (Baafi, 2020; Hill and Epps, 2010; Puteh, Che Ahmad, Mohamed Noh, Adnan, and Ibrahim, 2015). Suleman and Hussain (2014) revealed that the classroom's physical environment is critical in enhancing students' academic performance. They asserted that a classroom with adequate physical equipment had a considerable positive effect on academic performance.

In addition to the academic performance, several studies have examined the effect of the classroom's physical environment on students' musculoskeletal discomfort (Azuan et al., 2010; Grimes and Leggs, 2004; Gumasing, dos Santos, and Villanueva, 2021; Ismail, Tamrin, and Hashim, 2009). Inappropriate use of educational furniture in schools and hence students' sitting on this furniture causes an inappropriate position of the body, resulting in abnormalities of the spinal cord, back pain, neck pain, fatigue, and discomfort (Gilavand, 2016). Grimes and Legg (2004) realized a considerable frequency of neck and/or back pain complaints among the student population which may become more severe in the following years. This is critical since today's schoolchildren will become tomorrow's adults. Consequently, many researchers have investigated the relationship between sedentary position and musculoskeletal discomfort on the impact of students in the classroom (Azuan et al., 2010; Grimes and Leggs, 2004; Guirado et al., 2021; Ismail et al., 2009; Zeverdegani, Yazdi, and MollaAghaBabaee, 2021).

The literature review results revealed that the classroom environment is a significant determinant for students' academic performance and also their musculoskeletal discomfort. While we consider educational activities or environments, ergonomics is a key science not only to remove undesired design features from the environment or equipment but also to enhance the educational experience (Zunjic et al., 2015). For evaluating the physical environment of the classroom, several studies have analysed students' physical environment, such as lighting, classroom size, and technology (Guardino and Fullerton, 2010; Hill and Epps, 2009; Ramli, Ahmad, and Masri, 2013; Yang, Becerik-Gerber, and Mino, 2013; Widiastuti, Susilo, and Nurfinaputri, 2020). Yang et al. (2013) revealed that students are greatly influenced by spatial qualities, namely visibility and furniture, and ambient attributes, specifically air quality and temperature, both of which are significantly influenced by classroom design, administration, and maintenance. Widiastuti et al. (2020) stated that the greatest influence on the learning comfort of students comes from the physical conditions in the classroom.

The number of green buildings and their implementation in school environments as an alternative to conventional buildings is growing rapidly. (Liu and Wang, 2022). Green Building is defined by Federal Environmental Executives as the practice of increasing the efficiency with which

buildings and their sites use energy, water, and materials, and minimizing the impact of buildings on human health and the environment, through better site selection, design, construction, operation, maintenance, and removal the entire building life cycle (Howe, 2011).

Green building is concerned with the environmental impact, but it is also important to create a comfortable, healthy, and productive working environment (Olubunmi, Xia and Skitmore, 2016). In addition, Hedge and Dolsen (2013) mentioned that a Green to be energy efficient while effectively promoting the comfort, health, and productivity of its occupants. By this way, occupants will not be exposed to work-related musculoskeletal discomfort risks caused by insufficient workstation designs and office layouts. Therefore, it is associated with how these buildings promote the occupants' overall health, well-being, and productivity (Henge and Dolsey, 2013).

In this regard, it is a crucial research objective to investigate occupants' of green building in order to evaluate the effect of building design on ergonomics and musculoskeletal discomfort. Studies related to these kinds of buildings showed that working in these buildings decreases causes of sick building syndrome with less health symptoms and low absenteeism cases while increasing productivity and physical wellbeing (Gray, 2011; Henge and Dolsey, 2013; Howe, 2011; MacNaughton et al.,2016 ; Thatcher and Milner, 2014). The studies comparing conventional and green buildings also demonstrate that green buildings provide a higher level of satisfaction regarding health and efficiency, as well as better indoor air quality, especially in terms of thermal comfort and illumination (Abbaszadeh, Zagreus, Lehrer, and Huizenga, 2006; Hedge, Miller, and Dorsey, 2014; Paul and Taylor, 2008; Gou, Lau, and Zhang, 2012).

Nowadays, Green Buildings are being constructed as school buildings (Liu and Wang, 2022). According to studies, the classroom environments of green buildings are significantly different from those of conventional buildings such as natural ventilation, lighting, overall comfort, acoustics condition, carbon dioxides concentration and thermal comfort (Golbazi, El Danaf, and Aktas, 2020; Huang, Huang, Lin, and Hwang, 2015; Issa, Rankin, Attalla, and Christian, 2011; Liu and Wang, 2022; Radwan and Issa, 2017).

Cyprus International University (CIU) is a well-known higher education institute for its environmental stewardship both on and off-campus. Northern Cyprus's first institution to be featured in the UI Greenmetric World University Ranking. In 2021, CIU awarded as 111th World's Most Sustainable University. Additionally, the CIU campus, which is ranked among the top six in Turkey, is committed to sustainability.

The Science and Technology Building (ST Building) is built upon environmental considerations which provide its own energy and fully equipped technology such as shading structures, providing natural lighting while preventing direct solar irradiation, a natural air ventilation system and many sensors (light, temperature, windows, gas emission, etc.). In addition, a fully automated and monitored building management system is exist to thermo-hygrometric comfort (e.g. air temperature, relative humidity, air velocity, etc.) and for air quality monitoring of pollutants (e.g. VOC, PM, CO2). Moreover, the highly efficient LED lighting technology, a smart board and tablet-based digital lecterns are available inside the building environment.

ST Building was selected as a case in this research study. Since it one of a kind in Northern Cyprus with a three-story research and education building characteristics. It is a unique project with 15000 m^2 in floor area and equipped with applied energy conservation measures in the region.

There are few studies in the literature which investigate students' academic performance and green building considering the physical environment of classroom (Golbazi, El Danaf, and Aktas, 2020, Issa, Rankin, Attalla, and Christian, 2011, Vakalis, Lepine, MacLean, and Siegel, 2021). However, these studies do not include the investigation of student's musculoskeletal discomfort and green building considering the physical environment of classroom.

In accordance, the aim of this study is to investigate the effect of the physical environment of the classrooms in green building (ST Building) on musculoskeletal discomfort, comfort and academic performance of university students at Cyprus International University. The significance of this study is that the first Green Building in Northern Cyprus is examined according to the classroom environment and previous studies had not examined musculoskeletal discomfort of students in classroom environments in green buildings. The

following research questions are used to investigate the aim of this study:

- What is the effect of the physical environments of the classrooms on the comfort, academic performance, and musculoskeletal discomfort of students in ST Building? (RQ1)
- Are there any significant differences between demographics data (age, weight, height, education level, GPA) and effect of physical environments of the classroom on comfort, academic performance, and musculoskeletal discomfort? If yes, which group among demographic data groups are shown difference? (RQ2)
- Is there any relationship between SS-CMDQ? Score and the effect of the physical environment of the classroom on comfort, academic performance, and musculoskeletal discomfort? (RQ3)
- Is there any relationship between GPA and the effect of the physical environments of the classrooms on comfort, academic performance, and musculoskeletal discomfort? (RQ4)
- Which part of the body area suffered from the most musculoskeletal discomfort when academic activities are considered? (RQ5)

2. Method

Within the content of this study, a two-part questionnaire was applied to investigate the effect of the physical environment of the classrooms on university students' comfort, academic performance, and musculoskeletal discomfort in ST Building.

The first part of the questionnaire was designed to analyze the effects of classrooms on comfort, academic performance, and musculoskeletal discomfort. This part consists of demographic data section and three sections which contained 5-point Likert Scale questions. The demographic data section was used to collect gender, age, weight, height, education level, and Grade Point Average (GPA). The GPA value was used because it is the most commonly used measure of academic performance (York, Gibson, and Rankin, 2015). The further sections were designed to evaluate the effect of the physical classroom environment on students' comfort, academic performance, and musculoskeletal discomfort. The questions were designed by considering the factors affecting the physical environment of the classrooms such as chair design, lighting, projector sunlight, temperature, etc.

The collected data in these sections were used to learn the effect of the physical environments of the classrooms on the comfort, academic performance, and musculoskeletal discomfort of students (RQ1). In addition to this, analysing the significant differences demographic data and physical environments of the classroom based on comfort, academic performance, and musculoskeletal discomfort (RQ2) was used. Moreover, for further analysis, these data also were used to examine which students are more differently affected by the physical environments of the classroom on comfort, academic performance, and musculoskeletal discomfort (RQ2). Additionally, the relationship between between GPA and the effect of the physical environments of the classrooms on comfort, academic performance, and musculoskeletal discomfort were also examined (RQ4).

In the second part of the questionnaire, the SS-CMDQ was used to determine the frequency of pain or discomfort over the past week and whether any discomfort interfered with students' academic activities which is designed by Erdinç and Ekşioğlu (2009). The SS-CMDQ is divided into three sections that assess the frequency of occurrence, the degree of musculoskeletal discomfort experienced, and the effect of the musculoskeletal discomfort on academic activities. Students who reported experiencing aches, pains, or discomfort in the preceding seven days identified the problematic body parts using the SS-CMDQ's body map diagram. Only respondents who reported experiencing one or more episodes of discomfort in the preceding seven days were required to respond to questions about the severity of the problem or its interference with academic activities. The severity of musculoskeletal discomfort scales ranged from slightly uncomfortable to extremely uncomfortable (1-3), and the effect of the experienced musculoskeletal discomfort (interference) scale ranged from not at all to significantly interfere with (1-3). These scales are used to calculate discomfort scores for students who indicated that they were experiencing aches, pains, or discomfort in one or more body parts. The total discomfort score (SS-CMDQ score) for a specific body part is calculated by multiplying the

frequency, severity, and interference scales of musculoskeletal discomfort experienced. The calculated SS-CMDQ score was used to answer the research question which is related to answering the relationship between the comforts, academic performance, and musculoskeletal discomfort of the classroom physical environment (RQ3). Also, this part collected data was used to determine which body part suffered from the most musculoskeletal discomfort when academic activities are considered (RQ5).

Research and publication ethics were followed in this research. The research was approved on May 5th, 2019 by Cyprus International University's Scientific Research and Publication Ethics Committee. The procedures were explained in detail, and participants were free to interrupt or exit the questionnaires at any point without explaining.

The number of students attending lectures in ST Building is estimated as 9552 students based on Cyprus International University's Registrar's Office. Using Yamane's formula (1967), it was determined that a sample size of 370 respondents had a 95% confidence level and a 5% sample error. About 400 questionnaires were distributed to the randomly selected students, and 383 completed questionnaires were used in the study. Only English-language versions of the questionnaires were used, as the majority of students were foreigners enrolled in an English-language program.

Prior to the survey, pilot study research with 50 participants was conducted to determine the questionaries' reliability. Cronbach's alpha was used to determine all questions' internal consistency and reliability in the questionnaires (Bonett and Wright, 2015). Cronbach's alpha was 0.847 in the range of 0.70 to 0.95, indicating that the scale employed with this sample had a high level of internal consistency (Tavakol and Dennick, 2011).

IBM's Statistical Package for Social Science (SPSS) version 21.0 was used to analyse the collected data. The descriptive variables and questions were categorized and labelled according to their names and question numbers. In order, to conduct a more detailed analysis, three new variables were created using the SPSS compute variable command for examining the effects of the physical environment of the classrooms on the students' comfort, academic performance, and musculoskeletal discomfort in the first part of questionnaire. The average of the data from the questions in each section was used to create these variables. These variables were indicated by the terms “effect of physical environment of classroom on comfort" and “effect of physical environment of classroom on academic performance" and “effect of physical environment of classroom on musculoskeletal discomfort". After that, the data distribution was determined using normality tests (Kolmogorov-Smirnov and Shapiro-Wilk). The level of significance is less than 0.05. This significant value indicates that the data are from a population that is not normally distributed.

Due to the nonparametric distribution of the data, non-parametric test methods were chosen to evaluate the research questions. The first test was the Kruskal-Wallis H test was conducted to determine whether there was a significant difference between demographic data (age, weight, height, education level, GPA) and the effect of physical environments of the classroom on comfort, academic performance, and musculoskeletal discomfort. Furthermore, a post hoc test using pairwise comparisons was performed to investigate whether which students are more significantly affected from the physical environments of the classroom on comfort, academic performance, and musculoskeletal discomfort. Spearman rank correlation test was used to determine the relationship between

- SS-CMDQ score and the effect of physical environment of the classroom on comfort, musculoskeletal discomfort.
- GPA and the effect of the physical environments of the classroom on comfort, academic performance and musculoskeletal discomfort.

3. Results

3.1 Demographic Characteristics Of Students

Among the 383 participants, 58% were male and 42% were female. The demographic characteristics of the students are shown in Table 1. It can be realized from the results that 206 (54%) of students are between the ages of 21 and 25, 183 (48%) of respondents weigh between 61 and 80 kg, and 228 (60%) of respondents have a height of between 161 and 180 centimetres. The education level indicates that 243 (63%) are undergraduate students, 109 (29%) are master's students, and 31

(8%) are Ph.D. students. Additionally, Academic Performance demonstrates that 7 (2%) of students have a GPA between 0.01 and 1.00, 88 (23%) of students have a GPA between 1.00 and 1.99, 237 (62%) of students have a GPA between 2.00 and 2.99, and 51 (13%) of students have a GPA of 3.00 and higher. The participants' academic performance revealed that 75% (288) of them earned successful degrees in their respective fields.

Table1

Demographics of The students (n=383)

Category	Variables	Frequency (number)	Percent (%)
Age (yrs.)	17-20	48	13
	21-25	206	54
	26-30	104	27
	above 31	25	6
Weight (kg)	40-60	119	31
	61-80	183	48
	81-100	76	20
	above 101	5	1
Height (cm)	100-160	90	23
	161-180	228	60
	181-200	62	16
	above 201	3	1
Education Level	undergraduate	243	63
	master degree	109	29
	Ph.D. degree	31	8
Academic Performance (GPA)	0.01-1.00	7	2
	1.01-1.99	88	23
	2.00-2.99	237	62
	Above 3.00	51	13

3.2 The Effect of the Physical Environment Of The Classroom On Comfort

One of the sections in the first part of the questionnaire included questions about seven physical properties to ascertain the effect of the physical environment of the classroom on comfort. The results are shown in Table 2. Students were evaluated to determine whether the following classroom factors (temperature, the height of the board, design of the classroom, etc.) ensured their comfort in the classroom. The results showed that more than half of the respondents strongly agree or agree that the classrooms are comfortable. Based on these results, it could concluded that students are pleased with the classroom's overall comfort and no effect on the physical environment of the classroom on comfort.

Table2

Results of the Physical Environment of The Classroom provides comfort

Statement	Frequency (Percentage)					Mean	Standard deviation
	SD	D	N	A	SA		
Size of the class	18 (4,7)	77 (20,1)	90 (23,5)	66 (17,2)	132 (34,5)	3,39	1,13
Chair height	11 (2,9)	41 (10,7)	85 (22,1)	85 (22,2)	161 (42,1)	3,7	1,02
Chair design	56 (14,6)	52 (13,5)	98 (25,6)	60 (15,7)	117 (30,6)	3,19	1,27
Whiteboard height	6 (1,6)	35 (9,1)	111 (29)	62 (16,2)	169 (44,1)	3,64	0,91
Projector height	32 (8,4)	48 (12,5)	94 (24,5)	56 (14,6)	153 (40)	3,4	1,13
Lighting	37 (9,7)	32 (8,4)	75 (19,5)	90 (23,5)	149 (38,9)	3,58	1,21
Temperature	59 (15,4)	41 (10,7)	99 (25,9)	56 (14,6)	128 (33,4)	3,21	1,27

SD: Strongly Disagree D: Disagree N: Neutral A: Agree SA: Strongly Agree

3.3 The Effect Of The Physical Environment Of The Classroom On Academic Performance

Nine questions were asked to measure which physical environment of the classroom affects students' academic performance. According to the statistical findings given in Table 3, students stated that sunlight, temperature, and projector quality affect their academic performance more than other factors. These factors are interrelated with each other. Direct sunlight into the classroom affects the classroom temperature and eventually reduce the image quality of the projection. In addition, students did not give certain statements about the effects of lighting, whiteboard distance, and size of the classroom on their academic performance. However, they stated that their academic performance was not affected by chair design, height, and hand rest. This result is also consistent with the results stated in Table 2 since the students stated that the chairs in the classrooms are comfortable. As a result, most of the students agreed that some of the physical factors (sunlight, temperature, and projector quality) affect their academic performance. Therefore, it could be stated that physical environment of classroom influences academic performance. For further analysis, which students group more affected is explained detailly.

Table 3

Results Of The Effect Of The Physical Environment Of The Classroom On Academic Performance

Statement	Frequency (Percentage)					Mean	Standard deviation
	SD	D	N	A	SA		
Size of the classroom	29 (7,6)	98 (25,6)	114 (29,8)	62 (16,2)	80 (20,9)	3,13	1,18
Lighting	47 (12,3)	100 (26,1)	135 (35,2)	43 (11,2)	58 (15,1)	2,87	1,16
temperature	18 (4,7)	80 (20,9)	81 (21,1)	75 (19,6)	129 (33,7)	343	1,16
Sunlight	25 (6,5)	76 (19,8)	84 (21,9)	50 (13,1)	148 (38,6)	3,32	1,13
Whiteboard distance	38 (9,9)	101 (26,4)	121 (31,6)	18 (4,7)	105 (27,4)	2,91	1,06
Quality of projector	44 (11,5)	81 (21,1)	91 (23,8)	54 (14,1)	113 (29,5)	3,14	1,23
Design of chair	59 (15,4)	120 (31,3)	86 (22,5)	28 (7,3)	90 (23,5)	2,76	1,18
Chair height	26 (6,8)	123 (32,1)	101 (26,4)	36 (9,4)	97 (25,3)	2,98	1,11
Hand rest	33 (8,6)	103 (26,9)	97 (25,3)	63 (16,4)	87 (22,7)	3,11	1,22

SD: Strongly Disagree D: Disagree N: Neutral A: Agree SA: Strongly Agree

3.4 The Effect Of The Physical Environment Of The Classroom on Musculoskeletal Discomfort

The last section of the first part of the questionnaire investigates the effect of which physical environment of the classroom effects the musculoskeletal discomfort. The results shown in Table 4 revealed that students strongly disagree or disagree that these factors are affecting their musculoskeletal discomfort. In fact, results indicates that the physical environment of the classroom is suitable for students' comfort. It could be stated that this outcome is consistent with the results presented in Table 2. For instance, the results in Table 2 indicated that the chairs are comfortable. According to the results in Table 4, the chairs did not cause any musculoskeletal discomfort. Other factors also have the same consistency.

Thus, it could be concluded that the physical environment of classrooms has no effect on the students' comfort or musculoskeletal discomfort, but does have some effect on their academic performance.

Table 4

Results Of The Effect Of The Physical Environment Of The Classroom On Musculoskeletal Discomfort

Statement	Frequency (Percentage)					Mean	Standard deviation
	SD	D	N	A	SA		
Too high or low temperature	128 (33,4)	56 (14,6)	99 (25,8)	41 (10,7)	59 (15,4)	3,21	1,27
Writing for a long period	138 (36)	23 (6)	138 (36)	61 (15,9)	23 (6)	3,2	98
Text or images on the projector	131 (34,2)	69 (18)	104 (27,2)	63 (16,4)	16 (4,2)	3,45	1,09
The lighting and shadows	149 (38,9)	90 (23,5)	75 (19,6)	32 (8,4)	37 (9,7)	3,58	1,21
Projector height and light	153 (39,9)	56 (14,6)	94 (24,5)	48 (12,5)	32 (8,4)	3,4	1,13
Reflection from the board	169 (44,1)	62 (16,2)	111 (29)	35 (9,1)	6 (1,6)	3,64	0,91
Adjusting to the differences in light levels, concerning eyes sensitivity	137 (35,8)	59 (15,4)	117 (30,5)	53 (13,8)	17 (4,4)	3,44	1,05
The chair hand rest	152 (39,7)	56 (14,6)	110 (28,7)	49 (12,8)	16 (4,2)	3,48	1,03
The chair height	117 (30,5)	60 (15,7)	98 (25,6)	52 (13,6)	56 (14,6)	3,19	1,27
The chair backrest	117 (30,5)	60 (15,7)	98 (25,6)	52 (13,6)	56 (14,6)	3,19	1,27

SD: Strongly Disagree D: Disagree N: Neutral A: Agree SA: Strongly Agree

3.5 Analysis of Differences between Demographics and Effect Of Physical Environments Of The Classroom On Comfort, Academic Performance, and Musculoskeletal Discomfort

More advanced analyses were conducted to examine the differences in classroom on comfort, academic performance, and musculoskeletal discomfort. First, the Kruskal-Wallis H test was applied to test whether there was a significant difference between the demographic data and the physical environment of the classrooms on the effects of comfort, academic performance, and musculoskeletal conditions. Furthermore, a post hoc test with pairwise comparison was applied to determine which students' groups were affected more. The results are shown in Table 5.

Table 5

Kruskal-Wallis And Post Hoc Test Results Between The Demographic Factors And The Effect Of Physical Environment Of Classroom On Comfort, Academic Performance And Musculoskeletal Discomfort

		X^2	Sd	p	Mean rank	Post hoc
Age	effect of physical environment of classroom on musculoskeletal discomfort	11.886	3	0.008	207.71 (17-20) 200.53 (21-25) 183.90 (26-30) 125.20 (>30)	17-20 and > 30 (p< 0.05) 21-25 and > 30 (p< 0.05)
Weight	effect of physical environment of classroom on musculoskeletal discomfort	9.836	3	0.020	185.28 (40-60) 203.13 (61-80) 184.43 (81-100) 59.50 (>100)	61-80 and > 100 (p<0.05)
Height	effect of the physical environment of the classroom on academic performance	11.118	3	0.011	213.53 (100-160) 180.54 (161-180) 209.91 (181-200) 67.50 (>200)	
Height	effect of physical environment of classroom on musculoskeletal discomfort	11.329	3	0.010	181.31 (100-160) 193.11 (161-180) 212.37 (181-200) 7.5 (>200)	100-160 and >200 (p<0.05) 161-180 and >200 (p<0.05) 100-160 and 181-200 (p<0.05) 181-200 and >200 (p<0.05)
Education Level	effect of the physical environment of the classroom on academic performance	17.597	2	0.000	156.68 (bachelor) 200.89 (master) 226.50 (PhD)	bachelor and master (p<0.05) bachelor and PhD (p<0.05)
Education Level	effect of physical environment of classroom on musculoskeletal discomfort	7.488	2	0.024	179.83 (bachelor) 191.18 (master) 241.24 (PhD)	bachelor and PhD (p<0.05)
GPA	effect of the physical environment of the classroom on academic performance	30.673	3	0.000	355.36 (0.01-1.00) 244.14 (1.01-1.99) 173.65 (2.00-2.99) 182.58 (> 3.00)	0.01-1.00and2.00-2.99 (p<0.05) 0.01-1.00 and >3.00 (p<0.05) 1-1.99and2.00-2.99 (p<0.05) 1-1.99and> 3.00(p<0.05)
GPA	effect of classroom design on experiences musculoskeletal discomfort	29.252	3	0.000	308.43 (0.01-1.00) 255.45 (1.01-1.99) 171.79 (2.00-2.99) 182.19 (>3.00)	0.01-1.00and2.00-2.99 (p<0.05) 0.01-1.00and >3.00 (p<0.05) 1-1.99and 2.00-2.99 (p<0.05) 1-1.99 and >3.003 (p<0.05)

Based on the Kruskal-Wallis results, age and weight influence the effect of the physical environment of classroom design on musculoskeletal discomfort. Post hoc results showed that students older than 30 significantly experienced more musculoskeletal discomfort in the classroom compared to those aged 17–20 and 21–25 years old. In addition, students who weight greater than 100 experienced more musculoskeletal discomfort in the classroom compared to those who weight 61–100. Considering the effect of the classroom's physical environment on academic performance and musculoskeletal discomfort, a significant difference was obtained among the different heights of the students. The taller students experienced more musculoskeletal discomfort in the classroom compared to the shorter ones. Moreover, education level is found to be an influential factor in both academic performance and musculoskeletal discomfort. The results post hoc indicated that the PhD students experienced more musculoskeletal discomfort than the bachelor students. Another result revealed that GPA has an influence on both the effects of the physical environment of the classroom on academic performance and musculoskeletal discomfort. Considering the effect of the classroom's physical environment on academic performance, a significant difference was obtained among different GPA values. Similarly, there was a difference between the effects of the classroom's physical environment on musculoskeletal discomfort. Higher mean rank values showed that the students who have a low-value GPA were more affected by the physical environment of the classroom on academic performance and musculoskeletal discomfort.

It could be concluded from the advanced analyses that the physical environment of the classrooms have different results on the academic performance, and musculoskeletal discomfort among the demographic groups. However, it could also be stated that the physical environment of classroom does not affect the student's comfort.

3.6 SS-CMDQ Score And Evaluation Of The Experienced Musculoskeletal Discomfort

In the second part of the questionnaires', the SS-CMDQ was used to collect data on the frequency of pain or discomfort experienced over the previous week and to determine whether any discomfort interfered with students' academic activities. The SS-CMDQ scores are shown in Table 6.

Table 6

SS-CMDQ Score of The Participants

SSCMDQ Score	Frequency	Percent
0-50	356	92,95%
51-90	11	2,87%
91-150	4	1,04%
151-200	8	2,09%
201 and above	4	1,04%

Erdinç and Ekşioğlu (2009) did not specific discomfort scores for high-risk respondents. Therefore, in this study, a score of 90 or above was assumed to be high risk. The reason for giving a respondent a "high score of 90" in the category of high inconvenience was that the respondent was at their highest score of 90 when there was a problem in one of the mentioned body regions. According to SS-CMDQ score, only 16 (4.18 %) students (out of 383) who had discomfort scores above 90 were identified as being in the high-risk group. This value shows that 95.85% of the students feel mild pain or no musculoskeletal discomfort that affect their academic activities. This result has consistency with the first part of the questionnaire since most of the students agreed that the physical environment of the classrooms did not have any effect on their musculoskeletal discomfort.

In addition to the above score, Table 7 displays how often students experienced aches, pains, and discomfort in 20 body regions. It states that physical discomforts among students in the classroom are mostly experienced in the neck, right shoulder, upper back, and forearm right regions. However, the values of discomfort are less than 16%. This value indicated that students only experience mild discomfort. Most likely, this discomfort is caused by spending the majority of academic activities in a seated position and adopting an improper sitting posture. This finding indicates that the currently available classrooms may not affect musculoskeletal discomfort. In addition, this finding is consistent with data examining the effect of the physical environment of

classrooms on students' musculoskeletal discomfort.

Table7

Analysis of the experienced musculoskeletal discomfort (n=383)

Body region	Experience discomfort		Body region	Experience discomfort	
	Yes	No		Yes	No
Neck	15.93%	84.07%	Wrist left	6.01%	93.99%
Right shoulder	14.62%	85.38%	Fingers right	5.48%	94.52%
Upper back	12.27%	87.73%	Fingers left	5.48%	94.52%
Forearm right	10.97%	89.03%	Knee left	4.44%	95.56%
Thigh right	10.44%	89.56%	Left shoulder	4.18%	95.82%
Thigh left	10.44%	89.56%	Lower leg right	3.66%	96.34%
Hips	7.57%	92.43%	Lower leg left	3.66%	96.34%
Forearm left	7.31%	92.69%	Knee right	3.40%	96.60%
Lower back	7.05%	92.95%	Upper arm right	2.09%	97.91%
Wrist right	6.01%	93.99%	Upper arm left	2.09%	97.91%

3.7 Spearman Rank Correlation Analysis

Spearman Rank Correlation analysis was conducted to determine the relationship between SS-CMDQ score, GPA, and the effect of the physical environment of the classroom on comfort, academic performance, and musculoskeletal discomfort. The correlation and significant values are shown in Table 8. The results indicated that there is no relationship between the SS-CMDQ score GPA and the effect of the physical environment of the classroom on comfort, academic performance, and musculoskeletal discomfort. However, GPA has a negative significant between the effects of the physical environment of the classroom on academic performance and musculoskeletal discomfort. That means the low value of GPA has more affected on the physical environment of the classroom academic performance and musculoskeletal discomfort. This result is also consistent with the results indicated in Table 5. Since it was stated that students who have a low-value GPA were more affected by the physical environment of the classroom on academic performance and musculoskeletal discomfort.

Table 8

Summary of Correlation And Significant Values

Spearman's rho		effect of the physical environment of the classroom on comfort	effect of the physical environment of the classroom on academic performance	effect of the physical environment of the classroom on musculoskeletal discomfort
GPA	Correlation Coefficient	0.009	-0.164**	-0,170**
	Sig. (2-tailed)	0.858	0.001	0,001
SSMDQ	Correlation Coefficient	0.040	0.049	-0.040
	Sig. (2-tailed)	0.431	0.335	0.431

**. Correlation is significant at the 0.01 level (2-tailed).

4. Discussion and Conclusion

The main purpose of this research study was to evaluate the effect of the physical environment of the classroom on musculoskeletal discomfort, comfort, and academic performance in ST Building which is the Green Building. In this study, five research questions were analyzed using a Kruskal-Wallis H test, a Post hoc analysis, and a Spearman rank correlation test. The findings reveals that the physical environment of classrooms has no effect on the students' comfort but does have some effect on their academic performance. According to the findings, students indicated that sunlight, temperature, and projector quality affect their academic performance more than other factors. More advanced analysis proves that age and weight have a direct impact on the effect of the physical environment of classroom design on musculoskeletal discomfort. Considering the effect of the classroom's physical environment on academic performance and musculoskeletal discomfort, a significant difference was obtained among the different heights of the students. The taller students experienced more musculoskeletal discomfort in the classroom compared to the shorter ones. Moreover, education level is found to be an influential factor in both academic performance and musculoskeletal discomfort. Another result revealed that GPA has an influence on both the effects of the physical environment of the classroom on academic performance and musculoskeletal discomfort. The values showed that the students who have a low-value GPA were more affected by the physical environment of the classroom on academic performance and musculoskeletal discomfort.

These findings have a similarity to Golbazi et al. (2020), Issa et al. (2011), Tantawy, Rahman, and Ameer (2017). According to Golbazi et al. (2020), students who study in green buildings report higher comfort levels of thermal, lighting, and overall. They also stated that their study environment has a greater beneficial effect on their studies. As stated by Issa et al. (2011) that green buildings perform quite well in terms of lighting, thermal comfort, indoor air quality, heating, ventilation, and air conditioning when compared to conventional buildings. Additionally, they stated that absenteeism among students, teachers, and staff decreased by 2–7.5 percent in green buildings, while student performance improved by 8–19 percent when compared to conventional buildings. In addition, Tantawy et al. (2017) examined the prevalence of musculoskeletal discomfort in healthy students and the association between the development of musculoskeletal discomfort and academic pressures and body mass index. They revealed that academic stress was associated with musculoskeletal discomfort in the neck, shoulders, lower back, and hips, body mass index, academic stress, and GPA. Morover, the review by Vakalis et al. (2021) summarises existing research on the relationships between green school building features and student performance results. According to the review, green buildings have the most significant research-based connections with

academic performance, which is mostly determined by the physical environment. Therefore, to make the transition to a lower-carbon future, schools must be designed with their energy implications in mind, and this assessment benefits those involved in the planning and construction of green schools that promote students' academic performance.

According to the SS-CMDQ score, only 16 (4.18 %) students (out of 383) were identified as high-risk due to discomfort scores greater than 90. These results indicated that during their academic activities, 95.85% of students experience mild pain or no musculoskeletal discomfort. Additionally, the results indicated that physical discomfort is most frequently felt in the neck, right shoulder, upper back, and right forearm by students in the classroom. However, the proportion of people experiencing discomfort is less than 16%. This value indicates that students are only slightly uncomfortable. These results are similar to previous studies, which demonstrated the frequency of musculoskeletal discomfort in university students. Parvez, Tasnim, Talapatra, Ruhani, and Hoque (2022) showed that the lower back, buttock, neck, and shoulder regions were the most affected body regions in their studies which analyses the relationship between furniture dimensions and musculoskeletal discomfort. On the other hand, most of the studies investigated the relationship between information communications technology devices and the musculoskeletal discomfort of university students. Yang, Chen, Huang, Lin, and Chang (2017) stated that most students have neck and shoulder pain from smartphone use. Calik, Yagci, Gursoy and Zencir (2014) revealed that the neck, lower back, and upper back areas were found to be the most affected areas due to computer usage in university students.

As a result, the purpose of this study was to determine whether the classroom's physical environment had an effect on students' comfort, academic performance and musculoskeletal discomfort. It was found that the physical environment of classrooms had a differential effect on academic performance and musculoskeletal discomfort of students across demographic groups. However, the analysis revealed that the classroom's physical environment has no effect on the students' comfort. In a subsequent investigation, measurements of classroom furniture and environmental factors will be conducted, and the differences between these data and student evaluations will be compared.

The contribution of researchers

In this research; Banu NUMAN UYAL completed a literature review, analysed and discussed data, wrote the manuscript, and prepared manuscript formatting. Muhammad Usman UMAR designed the questionnaire, completed the literature review, collected and analysed the data.

Conflict of interest

Conflict of interest was not declared by the authors.

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