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THE INFLUENCE OF ENVIRONMENTAL QUALITY IN CLASSROOMS ON INTERNAL RESPONSE AND ACADEMIC PERFORMANCE IN CONVENTIONAL AND ENERGY-EFFICIENT BUILDINGS

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ABSTRACT

Humans spend a lot of time indoors, and this cannot be separated from teaching and learning activities. Teaching and learning activities must be conditioned so that the best academic performance can be achieved through adequate aspects of indoor environmental quality. The purpose of this study is to analyze the relationship between Indoor Environmental Quality (IEQ) on internal responses and academic performance in classrooms in two different building types. Where one building is a conventional building and the other building is a building that applies the concept of energy saving. A qualitative method was used in this research by conducting interviews with a purposive sampling technique then the results of the interviews were analyzed using a thematic analysis approach. The results of this study reveal that perceived comfort conditions are stated to positively affect the physiological, cognitive, and emotional status as well as the academic performance of students and lecturers, and high-efficiency buildings are more satisfying than conventional buildings.

Keywords: *IEQ, conventional building, energy efficiency building, internal responses, academic performance*

INTRODUCTION

Energy use in buildings is considered the largest contributor to energy consumption in the world, as well as greenhouse gas (GHG) emissions. Improving environmental quality is important to implement to achieve the global goals set out in the Paris Agreement, namely maintaining the increase in average temperature to no more than 1.5oC above pre-industrial conditions (X. Liang et al., 2016; Miraj et al., 2021; Neupane et al., 2020; van Someren et al., 2018; Zalejska-Jonsson, 2014). Carrying out the “greening” of existing buildings is important in terms of reducing energy consumption and GHG emissions (X. Liang et al., 2016). Net-zero carbon emissions can be achieved by combining "green" features in the building sector (Neupane et al., 2020). Green building is one way to support and provide opportunities to save energy and reduce resource consumption and carbon emissions (Mahesha, 2020; Samosir et al., 2020).

The implementation of green building has many indicators and varies depending on the reference standard. One indicator of green building is Indoor Environmental Quality (IEQ). In one of the Green Building Council Indonesia (GBCI) rating tools, namely Greenship Existing Building version 1.1, IEQ is identified as Indoor Health Comfort (IHC), which consists of fresh air, asbestos content, formaldehyde levels, room odor, Volatile Organic Compound (VOC) levels, thermal comfort and humidity, visual comfort and noise levels (GBCI, 2023). Then, in

Leadership in Energy and Environmental Design (LEED) from the US Green Building Council (USGBC), IEQ consists of air quality, thermal comfort, interior lighting, natural lighting, and view quality (USGBC, 2023). The next rating is WELL V2, IEQ consists of air quality, ventilation, natural and artificial lighting, thermal comfort and humidity, and noise (IWBI, 2023) Agyekum et al. 2023divide IEQ parameters into 12, namely; sound privacy, noise level, temperature, humidity, water quality, natural and artificial lighting, layout, visual privacy, view out of the building, room size, and cleanliness to analyze IEQ in EDGE certified buildings in Ghana. Brink et al. 2023 researched to understand how classroom environmental conditions affect academic performance by dividing IEQ into 4 major sub-groups, namely, indoor air quality, thermal comfort, lighting comfort, and acoustic comfort. This division is in line with research that has been conducted (Brink et al., 2022; H. H. Liang et al., 2014; Mallawaarachchi et al., 2017; Nimlyat, 2022; Yu et al., 2015; Zalejska-Jonsson, 2014).

Humans spend a lot of time indoors (Andersen et al., 2016). Maintaining IEQ is the key to the comfort, productivity, and health of room users because there is a significant relationship between these indicators (H. H. Liang et al., 2014; Mahesha, 2020; Mallawaarachchi et al., 2017). Nimlyat 2022 Suggests that indoor health is greatly influenced by the thermal quality, lighting, and IAQ of the room. Conversely, poor IEQ results in poor health and discomfort (Nimlyat & Zin Kandar, 2015). In addition, the application of IEQ is closely related to human psychology and physiology (Ma et al., 2023). Brink et al. 2022 added that students' perceptions of IEQ, and their physiological and cognitive responses were significantly related to IEQ indicators. Air quality, thermal, light, and acoustics influence teachers and students in teaching and learning activities. In poor IEQ conditions, teachers can end teaching activities early, from the student's perspective, this condition affects concentration, emotional status, and learning quality (Brink et al., 2023). Users of rooms that are in a good IEQ are indicated to be more satisfied than rooms in conventional buildings (Zalejska-Jonsson, 2014). Therefore, it is important to implement good IEQ indoors.

Brink et al. (2023) identify IEQ-related aspects within the framework of Brink et al. 2022 to explore IEQ conditions that influence teaching and learning activities within the scope of short-term academic performance in one building. By developing the model framework in the research of Brink et al. 2023, this research aims to analyze the relationship between IEQ and perceived internal responses and academic performance in classrooms in two different types of buildings. One building is a conventional building and another building is a building that applies an energy-saving concept, so do buildings that apply an energy-saving concept have better performance in terms of user comfort than conventional buildings?

METHOD

This research uses a qualitative approach. With this approach, the problem being studied can be seen broadly, comprehensively, deeply, and diversely (Brink et al., 2023). The rooms in the buildings that will be studied are classrooms in two buildings at Multimedia Nusantara University (UMN), namely building B, where this building is conventional, and building C or New Media Tower, where this building applies an energy-saving concept and has received many awards even though has not yet received green building certification, building C has implemented the concept of green building itself. Figure 1 shows Building B and Building C (Right). Building B consists of 6 floors, classrooms are on floors 3 and 5. Building C consists of 12 floors, classrooms start from floor 3 to floor 10. The rooms included in the object of this research are classrooms on the outer side of the building. Open space concept spaces, auditoriums, and the like are outside of this research. Classrooms in both buildings have a capacity of 40 people. Classrooms are equipped with tables and chairs for both lecturers and students. Furthermore, there are computers, projector screens, and whiteboards to support learning activities. Room lighting comes from lamps and natural light. Natural light directly illuminates the classroom from the windows on the side of the classroom. The types of windows in Building C classrooms are openable windows and fixed windows, while the windows in Building B classrooms are fixed windows. All classrooms have an air conditioning system using a chiller. In terms of the interior, all rooms are decorated with ceramics and white paint. Figure 2 shows a representative class that will be discussed in this research.

Figure 1
Building B is a box-shaped building and Building C is a ball-shaped building
Source: https://www.umn.ac.id

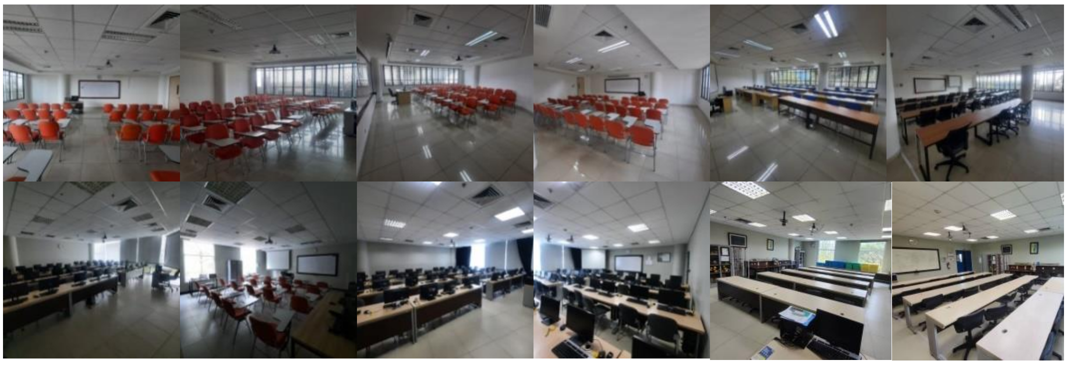

Figure 2
Representative classrooms in buildings B (Lower) and C (Upper)
Source: Created by the author

Research respondents were selected using a purposive sampling technique. Purposive sampling is usually used in qualitative research. With this technique, the researcher decides what needs to be known from the sample and looks for respondents who are willing and able to provide information based on their experience and knowledge regarding the research being conducted (Etikan, 2016). 24 respondents participated, consisting of 6 lecturers and 18 students. Lecturers and students were interviewed in the form of Forum Group Discussions (FGD). FGD for lecturers was carried out in 2 groups containing 3 lecturers and FGD for students was carried out in 6 groups consisting of 3 students. A similar sample size has been applied by (Granito & Santana, 2016). The students selected were Physics and Electrical Engineering students who had studied for at least 2 years (semester 4) with the consideration that during the 2 years, they had used classrooms in building B and building C. The lecturers included were lecturers with more teaching experience. from 1 year at UMN with the same considerations as students. Lecturers and students fill out a Google form containing their name, gender, semester of study (students) how long they have been teaching at UMN (lecturers), and agreement that the FGDs conducted will be recorded for data analysis purposes. Table 1 shows the profile of student respondents, and Table 2 shows the profile of lecturer respondents.

Table 1
Details of Student Respondents

Respondent Code	Age	Gender	Study Program	Entry Year UMN
ML1	20	Female	Electrical Engineering	2021
MY1	20	Male	Electrical Engineering	2021
MV1	20	Male	Electrical Engineering	2021
MM1	21	Male	Electrical Engineering	2020
MG1	21	Male	Electrical Engineering	2021
MS1	20	Female	Engineering Physics	2021
MH1	21	Male	Electrical Engineering	2020
MS2	21	Male	Electrical Engineering	2020
MR1	21	Male	Electrical Engineering	2020
MC1	19	Female	Electrical Engineering	2021
MM2	20	Male	Electrical Engineering	2021
MV2	20	Male	Engineering Physics	2021
MR2	21	Male	Engineering Physics	2021
MM3	20	Male	Engineering Physics	2021
MN1	20	Male	Engineering Physics	2021
MM4	20	Male	Electrical Engineering	2021
MK1	20	Male	Electrical Engineering	2021
MF1	20	Male	Engineering Physics	2021

Table 2
Details of Lecturer Respondents

Respondent Code	Age	Gender	Lecturer Study Program	The year he started teaching at UMN
DN1	40	Male	Engineering Physics	2019
DM1	35	Male	Engineering Physics	2016
DR1	42	Male	Electrical Engineering	2016
DF1	30	Female	Engineering Physics	2019
DR2	50	Female	Engineering Physics	2018
DC1	44	Male	Engineering Physics	2016

In the end, the findings in this qualitative research were integrated into a conceptual framework that includes IEQ parameters in conventional and energy-efficient buildings, internal response, and academic performance (Figure 3).

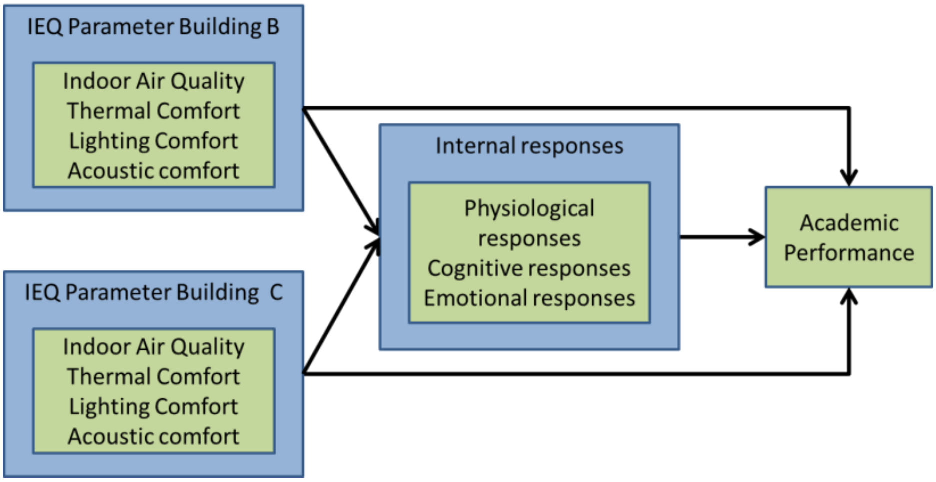

Figure 3
Conceptual Framework
Source: Created by the author

FGDs were conducted online using Microsoft Team in August and September 2023 following the availability of respondents' schedules, with an FGD duration of approximately 1 hour. Researchers act as moderators. When starting an online FGD, the researcher informed that the FGD would be recorded. Figure 4 is displayed on the presentation screen during the FGD to familiarize respondents with the related variables along with the questions. In addition, Figure 4 shows the IEQ parameters, internal response, and academic performance along with the categories and related aspects that have been developed from research (Brink et al., 2023). The questions asked are as follows:

Q1. What is your experience regarding IEQ parameters in building spaces B and C?

Q2. What would you change regarding the IEQ parameters in building spaces B and C? Why?

Q3. Any other aspects you'd like to discuss further?

Respondents were free to discuss various aspects even though the aspects in the model were not discussed during the FGD, which was also done by (Brink et al., 2023). The results of the FGD recordings were transcribed manually and using Salyns software. Data were analyzed using a thematic analysis approach to answer research questions, as follows:

- How IEQ affects physiological, emotional, and cognitive responses and the quality of teaching and learning in classes in buildings B and C
- What are the preferences of lecturers and students regarding class IEQ conditions in buildings B and C
- Do high-efficiency buildings have better IEQ than conventional buildings

This approach is carried out by assuming that researchers do not have previous theories about the 3 questions above. Apart from that, respondents were given the freedom to convey honestly about their experiences, this was a form of an open point of view and did not hypothesize anything (van Someren et al., 2018). The next section will discuss the findings from the FGD and present illustrative quotations from lecturers or students.

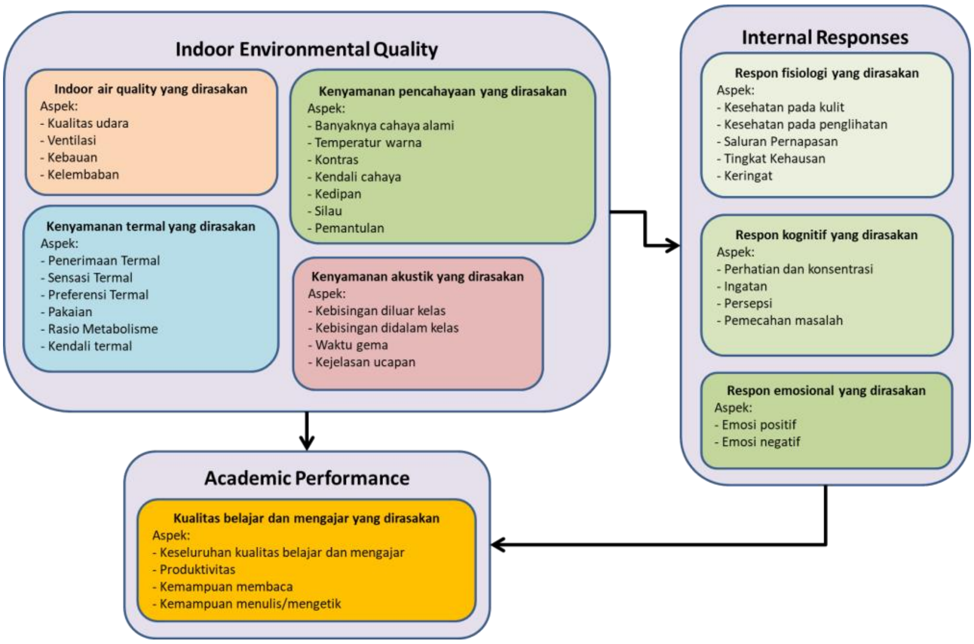

Figure 3
Categories, sub-categories, and aspects have been adapted from previous research
Source: Brink et al. 2023

RESULTS AND DISCUSSION

The relationship between perceived IEQ, internal responses, and academic performance

Indoor air quality

When there are items that have a strong aroma, such as the aroma of food and ingredients chemistry in the classroom of building B, the aroma could be smelled and disappear after 5-6 minutes (FGD 3, FGD 4). This is supported by inadequate ventilation to exchange air in the classroom (FGD 7). Even though there is an exhaust fan in the classroom which is used as a practical room, this is not enough to circulate the air.

"During the practical activity, it was measuring alcohol gas levels. The results of measuring the stagnant gas level did not decrease because the alcohol gas did not come out. We had to open the door."

Lack of air circulation causes a lack of oxygen supply which causes students to become sleepy quickly (FGD7). Apart from that, this condition causes students and teachers to feel stuffy and damp both when entering the room and during teaching and learning activities which causes sweating (FGD 3) and complaints about uncomfortable conditions (FGD 5).

"So when I enter class, I ask students to open the windows and doors so there is circulation. "Incidentally, this classroom has windows that can be opened, unlike the other classrooms in building B."

On the other hand, the problem of odor in Building C classrooms can be quickly eliminated by opening the windows. Operable windows provide adequate air circulation. However, when you just want to start class where the windows are still closed, air circulation becomes a problem that arises afterward (FGD 8) so that the level of concentration and alertness of students decreases (FGD 7)

"When the AC is on, there aren't many problems. However, when the AC is off for too long, the class becomes stuffy, especially on Mondays, when Saturdays and Sundays the class is not operational, as soon as Monday is used, I feel stuffy."

Thermal comfort

6 of the 8 FGDs conducted agreed that the temperature was very cold when in building B classrooms, even though full sunlight came in, it could not compensate for the cold temperature (FGD 7). Feeling cold causes impaired learning effectiveness (FGD 7), lack of focus (FGD 2), and loss of concentration (FGD 3). Based on the results of the FGD, the quality of learning was disrupted because they were busy warming themselves in various ways; frequent use of the toilet (FGD 7, FGD 5), permission to leave class (FGD 6), warming the body by rubbing hands and feet, wearing a jacket and putting hands in the jacket (FGD 2, FGD 3, FGD 7). Apart from interference with the quality of teaching and learning, there are also emotional disorders that tend to have negative emotions and physiological disorders such as sneezing (FGD 3) and causing red spots on the skin (FGD 1).

"If you're really cold, your skin will turn red, but it's not too bad and it's temporary and will go away when it's no longer cold."

Control over thermals in the classroom does not have a significant impact on indoor temperature conditions (FGD 3). Various thermal comfort responses occurred in classrooms in building C. Respondents felt hot because not 100% of the sunlight was blocked by the double façade so it entered the classroom (FGD 7). When the AC is turned on, it does not immediately compensate for the heat from the sun, it takes some time to compensate (FGD 1). Apart from that, even though the temperature has been adjusted, sometimes there is no significant change, you can only feel the wind (FGD 6). The heat felt causes loss of focus, easily causes negative emotions, sweating, easy thirst (FGD 6), and laziness (FGD4).

"When it's hot, I start to sweat, I feel like I want to go home quickly, so I can't concentrate, especially in robotics and engineering mathematics classes, where these subjects require a conducive situation."

To overcome this problem, both students and lecturers use windows that can be opened and portable fans (FGD 6)

"The classrooms in building C feel hotter, if it's hot, I can't focus. I even had to bring a small portable fan."

Furthermore, respondents also experienced cold at various times, such as when it rained (FGD 8). Feeling cold causes sneezing (FGD 3) and drowsiness (FGD 5). Also in FGD 2 and FGD 4, respondents felt comfortable with the existing thermal conditions, cold and hot feelings could still be tolerated.

Visual Comfort

As a comparison between air quality, and thermal and acoustic conditions, students are satisfied with the visual conditions of the classrooms in building B. The incoming natural light can be adjusted by having curtains on the windows so that they can reduce glare on the blackboard and projector screen. When the incoming natural light is inadequate due to clouds or being blocked by objects such as trees, it can still be supported with indoor lights. The lights in the room were deemed sufficient to illuminate the classroom. However, in FGD 8, a lecturer experienced contrast due to natural light entering from the back of the classroom so that the students could not be seen clearly and it was dark.

“When I entered the classroom, I faced the outside window, I saw the students were dark. However, students see that the blackboard is safe."

In contrast to the classrooms in building B, among the IEQ parameters, the visual comfort of classrooms in building C is the least satisfactory. Glare from natural lighting is the main problem felt while in the classrooms of building C. Glare occurs because the building's classrooms do not have curtains to control the remaining sunlight that enters after passing through the double façade. Glare due to excessive natural light causes whiteboards and projector screens to reflect incoming light so that writing becomes unclear, dim, and not sharp. This results in students' reduced reading and writing abilities which leads to a loss of focus and concentration and even gives rise to negative emotions. Because there are no curtains, students try to adapt by finding a place to sit where they won't be dazzled when looking at the whiteboard and/or projector screen. In terms of artificial lighting, in this case lamps, can be sufficient when it is cloudy.

“Glare, there are no curtains and in some conditions, it becomes very dazzling. "The reflection of light from the blackboard makes the lecturer's writing on the blackboard unclear and even the projector screen can become unclear because of the glare."

Acoustic comfort

Acoustic comfort was satisfied for a small number of FGD respondents. Even though there are voices, this is not a significant problem for them. Most experienced discomfort during teaching and learning activities in building B classrooms. The noise was dominated from within the building itself, such as the activities of other students in the classroom hallways, namely talking, shouting, laughing, and mobility and activities from adjoining classrooms.

"In the next class, there is an English class, the English class has frequent vocal frequencies, like talking and so on. There is still frequent sound leakage between rooms.”

"Sounds from outside the classroom often come into the classroom, for example from another class that has finished, there is a roar of footsteps and the sound of laughing and chatting between students, it can be heard inside."

This kind of noise causes students to lose focus (FGD 2, FGD 4), and not concentrate on studying which leads to laziness and playing with cell phones (FGD 4),

Apart from noise from inside, there is noise outside the building, namely vehicle mobility, but this does not cause significant disturbance

Similar to the classrooms in building B, the classrooms in building C experience the same thing as the classrooms in building B but with added noise from the AC which sounds like a hum, sounds that can echo, and the sound of rain. Classrooms on the 3rd floor often experience noise interference from outside the classroom because of their location close to the canteen and event stage (FGD 4). The noise experienced by most respondents was not a problem, but a small number experienced difficulty hearing lost focus and concentration, and even had a condition where the class was finished before the time was up because the noise they experienced was very disturbing (FGD 3).

"Once while studying, students were waiting in front of the class because maybe they would use their class after us. "The longer it gets louder and louder, the lecturer ends up speeding up his learning."

In FGD 7, a lecturer felt that his speech was not clear until the end of the class, and in FGD 8, a lecturer experienced an echo in the sound of his students' chatter.

"When students are chatting in the background, even if it's not loud, it echoes everywhere, so it just gets annoying."

Lecturer and student preferences regarding class IEQ conditions in buildings B and C

Lecturer preferences for building B classrooms

For the lecturers, the air quality is quite good and safe. Ventilation in the form of exhaust can be used to increase air circulation in spaces that often experience stuffiness and lack of oxygen. Moisture and odor are not a problem in this regard. In terms of thermal comfort, some lecturers felt comfortable with the existing conditions (FGD 8), while others experienced extreme cold even when wearing jackets (FGD 7). Apart from that, there needs to be a controller to regulate the temperature more adequately. The next IEQ condition is visual comfort. The natural lighting experienced by lecturers varies greatly. In FGD 7, one lecturer felt that there was no problem with natural lighting because the room geometry was correct, and 2 others felt that natural lighting was lacking. However, this is resolved with the help of artificial lights. Incoming natural light also causes the projector screen to become unclear, but this only occurs when the curtains are open (FGD8). The lecturers in FGD 8 did not feel disturbed by the noise coming from inside or outside the classroom or building. On the other hand, the lecturers in FGD 7 felt noise coming from neighboring classrooms and the classroom hallway.

Lecturer preferences for building C classrooms

Indoor air quality is still felt to be poor even though the windows are opened. The ventilation is not utilized properly. In terms of thermal comfort, cold conditions are experienced by all lecturers, and wearing a jacket is the best way when experiencing cold conditions (FGD 7). The next IEQ condition is visual comfort. Classrooms in building C have sufficient natural lighting, but often when excessive natural light causes glare on the blackboard, it is necessary to have lighting controls such as curtains or blackboards that can be replaced with non-glossy ones (FGD 7) and rearrange the location of the projector screen (FGD 8). When it is cloudy, the existing lamps are sufficient to accommodate indoor lighting. The lecturers explained that the acoustics in the classrooms in building C had leaked from outside the classroom but this did not affect their learning activities. Apart from that, outdoor noise in building B is still relatively stable (FGD 7). The design and layout of the classrooms in both buildings need to be re-evaluated to create a more effective learning environment.

Student preferences for building B classrooms

Students in all FGDs emphasized the implementation of adequate ventilation. Apart from that, cleaning the exhaust fan and optimizing the air filter needs to be done, apart from improving air quality, the odor problem can also be resolved. Thermal sensation is the IEQ condition that least meets the thermal comfort of almost all students. The ease of control and control of the AC is the main highlight for students so they can adjust the temperature according to their individual preferences. The students in FGD 6 were more comfortable in a cold room because they were not bothered by heat and sweat, and their emotions remained intact. Placing curtains on the windows of building B classrooms is considered very appropriate because it helps control natural light entering the classroom. Artificial light also provides lighting when the windows are closed. So that acoustic comfort can be met, the addition of sound dampeners between doors needs to be considered (FGD 2). Apart from that, security officers on each floor control students who make noise in the hallways (FGD 3).

Student preferences for building C classrooms

Air circulation is acceptable for students. Supporting factors are the rapid disappearance of odors from the classroom (FGD 4, FGD 2) and windows that can be opened when the air quality no longer meets student comfort. The thermal sensations felt by students varied, some felt satisfied with the room temperature conditions, some felt cold and some felt hot due to the incoming sunlight. They highlight the controls and controls of the air conditioner to be able to adapt to individual thermal preferences. Of all the IEQ conditions, the lighting aspect is the most unsatisfactory aspect for students. Glare from the reflection of incoming sunlight interferes with vision when looking at the whiteboard and projector screen. Students suggest installing horizontal blind curtains (FGD 3) or other light controllers to control the amount of incoming light. Light grouping can be applied to classroom points that are somewhat dark even though sunlight enters (FGD 5). Furthermore, to reduce the humming sound of the AC system, students suggested having a small hole so that the humming sound could disappear. While studying in class C, the buzzing will disappear every time the door or window is opened and buzz again after it is closed again. Therefore, permanent ventilation or holes need to be added so that students do not need to go back and forth to open openings in the classroom. Apart from that, providing soundproofing is an additional suggestion so that acoustic comfort can be achieved.

Comparison of IEQ of building parameters B and C

The air quality in the classrooms in Building C is better than in Building B, this is because the classrooms in Building C have windows that can be operated so that air circulation is smooth and the smell can disappear quickly. The thermal comfort felt by students and lecturers is more acceptable in building C classrooms. Building B classrooms have very cold temperatures which the majority of students and lecturers are not satisfied with. Meanwhile, building C classrooms have varying responses to thermal conditions but are still acceptable. On the other hand, in terms of visual IEQ parameters, building C classrooms are very unsatisfactory due to excessive light which causes glare and there is no control over the light. Visual comfort in Building B classrooms is more satisfying and acceptable than in Building C classrooms. In terms of the last parameter, namely acoustics, in both building B and C classrooms, students and lecturers both experience noise originating from both inside and in the classroom.

Discussion

Interviews with UMN building managers were conducted to enrich their perspective on the steps that have been taken to maintain the IEQ condition of classrooms in good condition. In terms of air quality in classrooms, the management washes AC filters every month and services the units once every three months. Then open all classroom windows and doors at night. Wall mold and mildew were not found during this building's operation. To improve air circulation, several classrooms in building B are provided with exhaust fans. The occurrence of stuffiness or an odor that persists for a long time is indicated by not turning on the exhaust fan when the class is in use. In the aspect of thermal comfort, the type of AC system used is a water-cooled chiller. With this AC system, temperature changes made in the classroom do not change immediately but undergo a technical process so that it takes time for the desired temperature to be reached. Temperature adjustments in buildings B and C have different treatments because these types of buildings are different. In building C, as the day progresses, the number of compressors working becomes smaller. In the morning 3 compressors are turned on, but from midday to evening only 1 compressor is working, whereas in building B from morning to evening 3 compressors are turned on. This is done because the walls and glass are directly exposed to the sun so they transfer more heat. Room users will feel cold in the morning, but when it is noon or evening, the cold starts to decrease because of the heat. This is also related to what was mentioned by respondents in FGD 7 where building B has laboratory equipment that must be maintained in good condition. Furthermore, when in building C, the cold temperature in the classroom can be stabilized by air infiltration from unconditioned windows and corridors so that the temperature in the classroom is not too cold. A different thing happened in the classroom in building B, the cold classroom became even colder because air infiltration from the corridor was already cold.

Regarding the third aspect, namely visual comfort, building managers have predicted since planning regarding solar rotation. This is adjusted to the location of the whiteboard and projector screen so as not to experience frequent glare. At certain times, some classrooms are exposed to excessive sunlight so glare occurs, but the duration is not long and the frequency is small. Building materials, especially for classroom walls, use the M-system. M-system is a wall layer that uses Styrofoam on 2 sides. The purpose of using Styrofoam is as a sound-dampening material that enters the room and maintains a stable indoor temperature. However, no matter how good the dampening system is in this classroom context, it will leak through the door because the door has even a small gap. When there is a leak from the corridor or neighboring classroom, the noise must have exceeded the threshold of the wall's ability to reduce the sound, so a leak occurs and this is normal. Regarding the humming noise from the AC system, the management has appealed to lecturers to direct their students to open the windows slightly, but sometimes students who sit near windows are worried about feeling hot, which is not possible.

Limitation

This research does not focus on the IEQ conditions in classrooms in buildings B and C but focuses on the experiences of lecturers and students as classroom users who are influenced by aspects of IEQ. Their experiences cannot be generalized as the experiences of the faculty and student population. This research uses their experience in scope to explore the relationship between IEQ, internal responses, and academic performance during teaching and learning activities. Furthermore, the experience of both lecturers and students is used as a basis for determining which building is deemed more satisfying. This research also did not measure IEQ conditions in classrooms in buildings B and C.

CONCLUSION

This research reveals the relationship between perceived IEQ parameter categories and internal responses submitted by students and lecturers. The relationship is positive when the perceived indoor air quality is acceptable. The relationship is negative, for example, when the perceived visual comfort is unacceptable, students and lecturers experience glare on the whiteboard and projector screen, thereby reducing their reading and writing abilities as well as their concentration. Then the thermal discomfort makes students and lecturers frequently go to the toilet and try to warm up in their way which causes a bad effect on their ability to concentrate. Furthermore, the relationship between perceived IEQ parameter categories and academic performance was identified. In poor IEQ conditions, lecturers can speed up the pace of learning or end it earlier than the existing schedule. The perceived comfort conditions are stated to positively influence the physiology, cognitive and emotional status as well as the academic performance of students and lecturers. Apart from that, high-efficiency buildings still have shortcomings in terms of meeting the comfort of students and lecturers in the teaching and learning process, but overall high-efficiency buildings are more acceptable than conventional buildings. It can be concluded that maintaining acceptable IEQ conditions, options for control, adjusting temperature and lighting conditions, preventing noise, and implementing high-efficiency buildings are important aspects of supporting teaching and learning activities in classes at higher education institutions.

REFERENCES

Agyekum, K., Akli-Nartey, E. E. K., Kukah, A. S., & Agyekum, A. K. (2023). Importance-performance analysis (IPA) of the indoor environmental quality (IEQ) of an EDGE-certified building in Ghana. *International Journal of Building Pathology and Adaptation, 41*(1), 73–95. https://doi.org/10.1108/IJBPA-03-2021-0040

Andersen, R. K., Fabi, V., & Corgnati, S. P. (2016). Predicted and actual indoor environmental quality: Verification of occupants' behavior models in residential buildings. *Energy and Buildings*, *127*, 105–115. https://doi.org/10.1016/j.enbuild.2016.05.074

Brink, H. W., Lechner, S. C. M., Loomans, M. G. L. C., Mobach, M. P., & Kort, H. S. M. (2023). Understanding how indoor environmental classroom conditions influence academic performance in higher education. *Facilities*. https://doi.org/10.1108/F-12-2022-0164

Brink, H. W., Loomans, M. G. L. C., Mobach, M. P., & Kort, H. S. M. (2022). A systematic approach to quantify the influence of indoor environmental parameters on students' perceptions, responses, and short-term academic performance. *Indoor Air*, *32*(10). https://doi.org/10.1111/ina.13116

Etikan, I. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11

GBCI. (2023). *GREENSHIP Rating Tools Existing Building*. https://www.gbcindonesia.org/greens/existing

Granito, V. J., & Santana, M. E. (2016). Psychology of Learning Spaces: Impact on Teaching and Learning. In *Journal of Learning Spaces* (Vol. 5, Issue 1).

IWBI. (2023). *WELL v2 Concepts and Features*. https://v2.wellcertified.com/en

Liang, H. H., Chen, C. P., Hwang, R. L., Shih, W. M., Lo, S. C., & Liao, H. Y. (2014). Satisfaction of occupants toward indoor environment quality of certified green office buildings in Taiwan. *Building and Environment*, *72*, 232–242. https://doi.org/10.1016/j.buildenv.2013.11.007

Liang, X., Peng, Y., & Shen, G. Q. (2016). A game theory-based analysis of decision-making for green retrofit under different occupancy types. *Journal of Cleaner Production*, *137*, 1300–1312. https://doi.org/10.1016/j.jclepro.2016.07.200

Ma, X., Liu, H., Zhang, Z., & Li, Y. (2023). How does the indoor physical environment differentially affect learning performance in various classroom types? *Building and Environment*, *234*. https://doi.org/10.1016/j.buildenv.2023.110189

Mahesha, A. (2020). *A sustainable business case for green buildings*. https://ssrn.com/abstract=3713835

Mallawaarachchi, H., De Silva, L., & Rameezdeen, R. (2017). Modeling the relationship between the green built environment and occupants' productivity. *Facilities*, *35*(3–4), 170–187. https://doi.org/10.1108/F-07-2015-0052

Miraj, P., Berawi, M. A., & Utami, S. R. (2021). Economic feasibility of green office building: combining life cycle cost analysis and cost–benefit evaluation. *Building Research and Information*, *49*(6), 624–638. https://doi.org/10.1080/09613218.2021.1896354

Neupane, Pujan, Afroze, D., & Phommasone, P. (2020). Cost Benefit Analysis of Green Building: A Case Study of Public Office Building in Nepal. *Saudi Journal of Engineering and Technology*, *5*(10), 382–391. https://doi.org/10.36348/sjet.2020.v05i10.005

Nimlyat, P. S. (2022). The impact of indoor environmental quality (IEQ) on patients' health and comfort in Nigeria. *International Journal of Building Pathology and Adaptation*. https://doi.org/10.1108/IJBPA-06-2021-0089

Nimlyat, P. S., & Zin Kandar, M. (2015). *Subjective Assessment of Occupants' Perception of Indoor Environmental Quality (IEQ) Performance in Hospital Building Sustainable Architecture View project THERMAL PERFORMANCE OF RECESSED FACADE WINDOW SHADING IN TROPICAL OFFICE BUILDINGS View project Subjective Assessment of Occupants' Perception of Indoor Environmental Quality (IEQ) Performance in Hospital Building*. https://doi.org/10.7763/IPCBEE

Rathi, R., Jain, S., & Garg, R. (2023). Exploring young consumer's adoption of secondhand luxury: insights from a qualitative study. *Journal of Fashion Marketing and Management*. https://doi.org/10.1108/JFMM-11-2022-0236

Samosir, D. K. B. M. T., Murwaningsari, E., Augustine, Y., & Mayangsari, S. (2020). The benefit of green building for cost efficiency. *International Journal of Financial, Accounting, and Management*, *1*(4). https://doi.org/10.35912/ijfam.v1i4.152

USGBC. (2023). *LEED certification for existing buildings and spaces*. LEED certification for existing buildings and spaces van Someren, K. L., Beaman, C. P., & Shao, L. (2018). Users' experiences of lighting controls: A case study. *Lighting Research and Technology*, *50*(7), 1091–1106. https://doi.org/10.1177/1477153517709063

Yu, L., Sun, Z., Ding, R., Wang, S., & Feng, G. (2015). Research on the Post Occupancy Evaluation of Green Public Building Environmental Performance Combined with Carbon Emissions Accounting. *Procedia Engineering*, *121*, 1454–1460. https://doi.org/10.1016/j.proeng.2015.09.068

Zalejska-Jonsson, A. (2014). Parameters contributing to occupants' satisfaction: Green and conventional residential buildings. *Facilities*, *32*(7–8), 411–437. https://doi.org/10.1108/F-03-2013-0021