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The Status quo and Problem of User Well-Being Related to Standard Design School Buildings: A Case Study of Primary School Buildings, Mueang District and Area, Nakhon Ratchasima Province

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Abstract

A building's environment is a major factor affecting the well-being of its users. Health conditions of a school building's users are related to several factors including location, physical appearance, and environment. This article presents an assessment of the current state of school buildings which were constructed in accordance with an approved standard design under the Ministry of Education in the area of Mueang District, Nakhon Ratchasima Province. Four standard designs of school buildings that have been highest constructed in the studied area were selected consisting of 8 buildings located in 6 schools. First, it was found that the Location of school buildings affected the conditions of noise and ventilation. School buildings located in urban areas, near main roads, and in areas of high–density communities, have a higher level of background noise than those in suburban areas. School buildings in suburban areas, and those located in agricultural zones with more open spaces than the urban ones, The maximum average wind speed is 0.48 m/s in the open space. There are no obscured buildings, resulting in school buildings not being able to operate openings because of the high wind speed. Secondly, in relation to Appearance there was an extension or adjustment of some areas for other functions that differed from the standard building design in 7 buildings, while one building was completely unused. Buildings currently in use have room–sizes and voids that support light and natural ventilation, while construction materials of these buildings do not have proper noise protection and absorption properties. Thirdly, with respect to Environment, standard measurements were taken in 23 classrooms from the sample school buildings, in both in Mueang District and suburban areas nearby, with high levels of background noise (35 dBA) being recorded; lower brightness (natural and artificial light) than the standard criteria (300 lx) was recorded in 3 classrooms, while 5 other classrooms exceeded the standard, with recorded values of 318 - 939 lx. Excessive brightness from the sunlight may have detrimental effects on visual comfort and thermal comfort of users from glare and burdened heat respectively. Moreover, one school building in the suburban area had 3 classrooms that were outside of a thermal comfort zone; measuring its average high temperature. A bioclimatic chart-based analysis of comfortable conditions found that three classrooms in Building C1 were outside the comfort zone, with the highest temperature in the afternoon (01:00 - 4:00 pm.)

being 31.2°C. Relative humidity 33.7%. Therefore, it can be concluded that the impacts on user well-being related to school building design and construction were noise, brightness and thermal comfort zone, respectively.

Keywords

School buildings; Well-Being; Primary school; Noise; Lighting; Thermal comfort

1. Introduction

According to the World Health Organization (2004), health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. The appropriate environment, therefore, is usually seen as a crucial factor that contributes to good health and well-being. In the educational sector of Thailand, assessment of building safety and supportive facilities in schools that promote good health and better learning has been practiced since 1998 (Lemsawasdikul, 2018). From 2011, five relevant aspects that include students, school buildings, physical environment, students' family, and the community have been used as assessment criteria. The physical environment mainly reflects architectural design and the built environment, with the learning support atmosphere in classrooms being the main focus, together with additional factors like landscape design, building safety and building performance monitoring systems. Moreover, a school's location and context also are considered, like those in the lower north eastern region under the care of Ubon Ratchathani University and ThaiHealth (Thai Health Promotion Foundation, 2018) or those that adopt the specific local philosophy (Angsanan & Mee-Udom, 2014). In order to effectively design buildings for good health, another set of five main criteria from the Thai Green Building Institute (2020) also should be considered: (1) surrounding areas and communities (2) architectural design (3) interior architecture design (4) environmental engineering systems and (5) health innovations. It can be seen that the heath related issues of building users have been addressed and are continuously reviewed and revised. So far, however, there are no studies that directly address health and well-being problems of school building users, particularly in the context of relevant built environment indicators. For example, passive designed school building complexes as well as old and deteriorating buildings are only assumed to cause more health issues than other types of buildings because natural ventilation cannot always guarantee an acceptable level of thermal comfort (Tantasavasdi, 2011). Despoina et al. (2017) also addressed similar problematic factors related to school building performances. Building age and some specific building and site characteristics can produce high building temperature and other conditions that are not optimal for learning.

For our selected study area in Nakhon Ratchasima province in 2020, there were 143 schools directly reporting to the Ministry of Education, with 3,525 school buildings in total (The Office of the Basic Education Commission, 2020). Most of the buildings (3,311) were in primary schools while 214 buildings were in secondary schools. With respect to the building users, 2,077 were staff and 35,953 were students. Therefore, the objective of our study was to explore existing conditions and problematic issues, including environmental variables, that affect users' health in primary school buildings in Muang district, Nakhon Ratchasima that have used a standard design approved by the Ministry of Education.

2. Literature review

2.1 Research on Health and well-being of school building users

Health and well-being of building users is closely related to the study of the internal environment quality (IEQ). Altomonte et.al. (2020) found that lighting, acoustics, temperature, and indoor air quality affect users' awareness of health and well-being. MacNaughton et al. (2017) examined the health and well-being of users in 10 high performance buildings where the intensity of vaporized organic substances is low based on the ASHRAE 62.1-2010 standard and also revealed similar outcomes to Altomonte et al. (2020). It was found that air quality, temperature, and natural light were influential to building users health and well-being. Moreover, the improvements of the indoor environment quality were closely related to the better health. Bluyssen et al. (2018) showed that noise was the most extensive cause (87%) of poorer health and well-being reported in schools, followed by bad smell (63%), too much sunlight exposure (42%), too high or too low room temperature (35%), and the variation of room temperature (34%). Physical elements that affect health and comfort in classrooms including location and orientation of the building, mechanical systems, building ventilation, window frames and other building materials, as well as cleaning and maintenance schedule, also were mentioned. Bluyssen et al. (2020) further studied problems currently found in primary school classrooms using workshops and seminars with the goal of finding design solutions for tomorrow's classrooms. Again, it was found that noise was the most commonly reported problem (58%) followed by room temperature (53%), air quality (22%) and natural light (16%).

2.2 Characteristics of a healthy school building

The promotion of health and well-being of school building users can be achieved through various physical factors such as school location, building orientation and characteristics, as well as interior environment including lighting, colour schemes, acoustics, ventilation, clean water supply, drainage and waste management (Sarayutpitak, 2018). Such criteria are similar to those introduced by the Thai Green Building Institute (2020) that include variables like temperature and humidity, acoustics, lighting, indoor air quality, and tidiness for the post occupancy evaluation to assess building users' well-being. Reviews of the currently available well-being manuals and guidelines reveal that most of them focus on similar factors of the architectural design, mechanical and electrical engineering, as well as building usage and maintenance. For example, the Handbook to Design Government Buildings by the Department of Public Works and Town & Country Planning (2019) aims to provide practical guidelines to make efficient use of public or private buildings through design or renovation. Data on resources consumption are collected while the use of alternative energy is encouraged to turn existing government buildings into green buildings. Building and Environmental Safety Standards for Early Childhood Development Centers by the Engineering Institute of Thailand (2014) was written for new built as well as renovation of pre-kindergarten facilities for the public and private sectors, with additional information on facilities for the disabled and child protection from outsiders. Standards for Happy Buildings by the Thai Green Building Institute (2020) can be used as a guide to design and construction for people's well-being. The distinctive aspects of this document are the design and preparation of outdoor space to cope with disasters, the criteria for thermal comfort assessment, and the active design for well-being based on technological advances.

In our research that explores the current condition and problematic aspects of health and well-being in standard school buildings, only data on building elements and the school building environment are collected in 3 areas: (1) the location of the school and school building (2) characteristics of the school building; and

(3) the indoor environment. The data are benchmarked against well-regarded quality based standards such as air quality, air contaminants, light intensity, sound quality, and ventilation as defined in the Handbook to Design Government Buildings or the Building and Environmental Safety Standards for Early Childhood Development Centers.

3. Research methodology

3.1 Selection of sample groups

There are 25 standard types of buildings in schools under the supervision of the Ministry of Education (The Office of the Basic Education Commission, 2015). Among the total 240 buildings designed and built using standard designs in primary schools in Mueang District, Nakhon Ratchasima province in 2019 (Figure 1), the top 4 types are Type C (87 buildings, 36.25%), Type A (53 buildings, 22%), Type B (30 buildings, 12.5%), Type D (30 buildings, 12.5%), and Other Types combined (40 buildings, 16.75%) (Table 1). Type A and B are now cancelled and are no longer included in the 25 standard types of school building. However, because of their existing predominance in Mueang District, these building types were included for evaluation in this study.

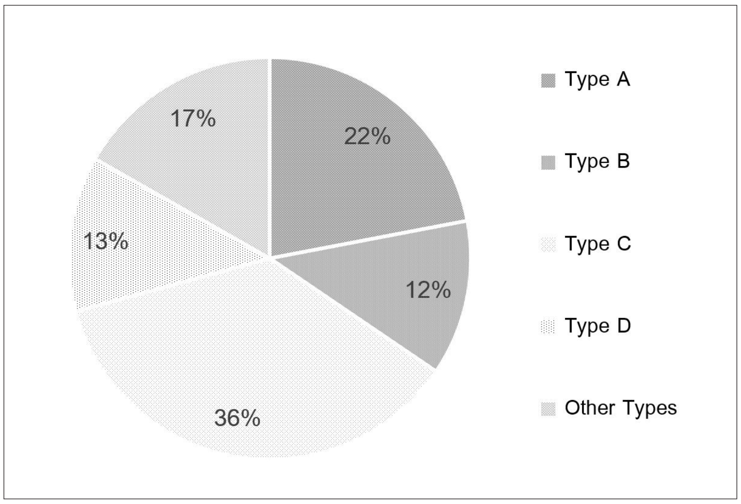


Figure 1 The proportion of standard school buildings in the Muang district.

Eight sample buildings were selected for study based on the criteria that they should be in small schools with no more than 120 students, which is the majority of schools located in Muang school district (Figure 2) (The Office of the Basic Education Commission, 2019). Furthermore, the buildings were to have been in use for no less than one year but not more than 25 years. An exception was applied to wooden structures that only had to be in good condition for use.

Table 1 Four types of school building standard design.

Type	Building characteristics	Exterior view
A	(Cancelled and not included in the 25 standard types of school building) - 2-storey wooden structure with no walls on the ground floor - 8 classrooms - Size of each classroom: 6m. x 9m. = 54 sq.m.	
B	(Cancelled and not included in the 25 standard types of school building) - 2-storey wooden structure with no walls on the ground floor - 8 classrooms - Size of each classroom: 6m. x 9m. = 54 sq.m.	
C	- 2-storey reinforced concrete structure with either no walls or with classrooms on the ground floor - 4-12 classrooms with total usable area = 630-936 sq.m. - Size of each classroom: 6m. x 9m. = 54 sq.m.	
D	- 3-storey reinforced concrete structure - 15 classrooms with total usable area = 1240 sq.m. - Size of each classroom: 7m. x 8m. = 56 sq.m.	

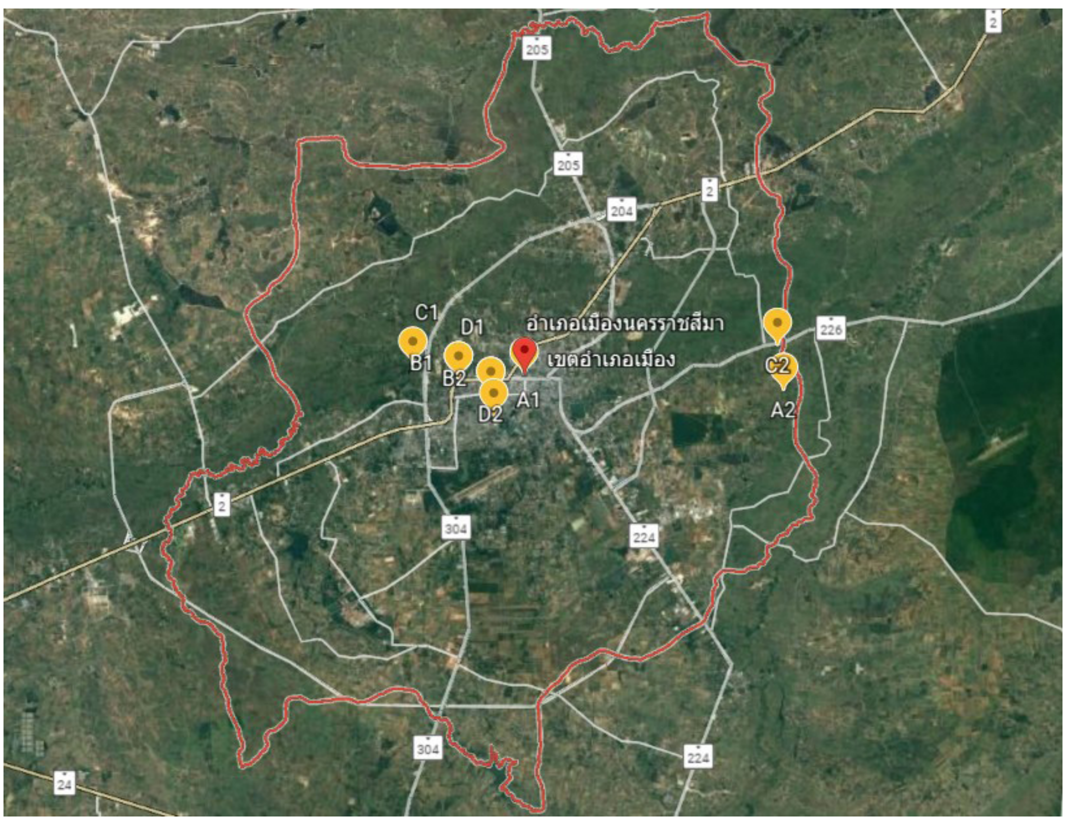


Figure 2 Locations of schools.

3.2 Physical survey of school buildings

The selected eight school buildings were assessed based on three main aspects: 1) locations of the buildings; 2) physical conditions and usage; and 3) internal environmental conditions. The internal environmental conditions measured included thermal condition and relative humidity using an Extech: SD 500 data logger, internal airflow using a CEM: DT-618 thermo anemometer, lighting condition using a Protos: LX-91 Illuminance meter and sound level using an IEC 61672-1 Type II sound level meter. All variables were only measured in active but empty classrooms. The measuring tool for lighting was placed at 0.75 meters above the floor level. Measuring tools for thermal condition, relative humidity, airflow and sound level were placed at 1.20-1.50 meters above the floor level (Figure 3). Dates of the physical survey were from November 9 – 16 2020. The morning sessions started from 9:00 a.m.-12:00 p.m. and the afternoon sessions were from 1.00 p.m. - 4.00 p.m. The average ambient temperature at the time was 26.4 degree Celsius (Thai Meteorological Department, 2020).

(a) (b)

Figure 3 Examples of measuring instruments installation: (a) for lighting condition and internal airflow measurement and (b) for thermal condition and relative humidity measurement.

4. Results and discussions

4.1 Locations of the buildings

The locations of all eight selected buildings can be divided into 2 categories: in and around the urban Amphoe Mueang area and in the suburban area. In the first category, the schools are located in the busy main thoroughfares and high density communities. Selected buldings in schools are surrounded by shophouses and low rise residential buildings no higher than 1-2 storeys (Figure 4). Therefore, many of the bulding features such as openings and outward views of those located closely to the land boundaries are affected by surroundings such as the level of background noise (Figure 5). On the other hand, 1-2-storey school buildings in the suburbs usually are located near agricultural plots, railway lines or low density community areas (Figure 6). These surroundings make it possible for such buildings to have full openings to the outdoor. According to natural wind speed measurements, the case of the use of openings and the use of openings in conjunction with the ventilation fans in the classroom, the working station has an average wind speed between 0.1-0.3 m/s and the maximum average wind speed measured is 0.48 m/s in the A2 school building, located on open space and without obscured buildings. As a result, school buildings cannot operate openings and require tall bush trees to reduce natural wind speeds. (Figure 7)

(a) (b) (c)

Figure 4 Adjacent buildings in and around the urban Amphoe Mueang area: (a) nearby 3-4 storey buildings, (b) a thoroughfare next to the building and (c) nearby 1-2 storey buildings.

(a) (b) (c)

Figure 5 Views from school buildings in urban areas: (a) view next to the main thoroughfare, (b) view next to a communal thoroughfare and (c) general view from school building.

(a) (b) (c)

Figure 6 Adjacent buildings in the suburban area: (a) nearby agricultural areas and a railway line, (b) nearby 1-2 storey buildings and (c) open space next to the building.

(a) (b) (c)

Figure 7 Views from suburban school buildings (a) view from a classroom on the 2nd floor, (b) view from a classroom on the ground floor and (c) outside view from school building.

4.2 Physical conditions and building usage

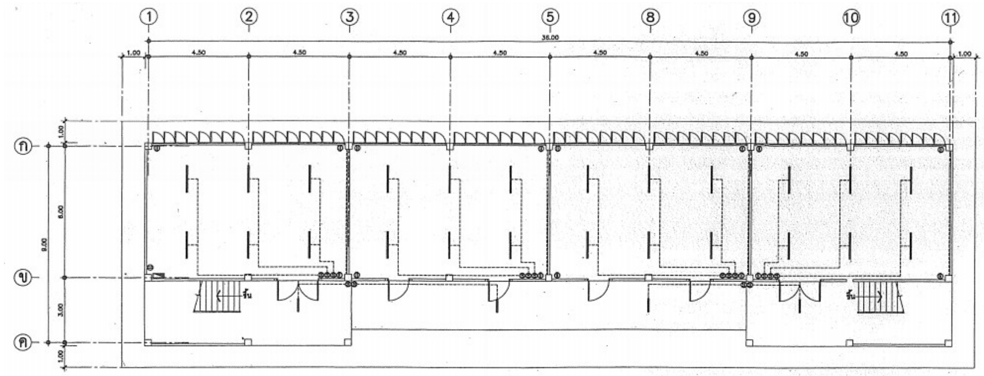
4.2.1 Interior physical analysis

A school building has to be designed to provide user comfort in various aspects from thermal and lighting comfort to visibility and acoustic quality (Thongkamsamut, 2010). In this study, the analysis of selected interior environmental factors that affect users' health included acoustic, visibility, and thermal comfort. All of these factors were based on the recommendations in the Handbook to Design Government Buildings by the Department of Public Works and Town & Country Planning (2019) and Building and Environmental Safety Standards for Early Childhood Development Centers by the Engineering Institute of Thailand (2014) (Table 2).

Table 2 Comparison of interior environment and performance analysis in selected buildings.

Aspects of interior environment	Standard applications for interior usage	Type A	Type B	Type C	Type D
Acoustic	Ceiling materials 50% has to be sound absorbing materials with NRC value no less than 0.7 (Department of Public Works and Town & Country Planning, 2019)	Fail	Fail	Fail	Fail
	Wall materials 25% has to be sound absorbing materials with NRC value no less than 0.7. Interior walls have to have the STC value = 40-50 dBA (Department of Public Works and Town & Country Planning, 2019)	Fail	Fail	Fail	Fail
Visibility	Working areas Distance from 75% of the working area is 7.5 m or less from the openings with external views (Department of Public Works and Town & Country Planning, 2019)	Pass	Pass	Pass	Pass
	Working areas: Control switches for any lamps closer to the openings at the distance calculated from height from the floor to the lower window jamb * 1.5 would have to be separated from the rest. Daylight sensors would also have to be incorporated. (Department of Public Works and Town & Country Planning, 2019)	Fail	Fail	Fail	Fail
Indoor temperature	Room size: Room width: For a room with cross ventilation, width (W) measured inward from the opening to the outside has to be $\leq$ 5H or the height from floor to ceiling (Department of Public Works and Town & Country Planning, 2019)	Pass	Pass	Pass	Pass
	Ratio of openings to entire wall: For successful passive ventilation design, at least one of the building's walls is an external wall. It has to have openings like doors or windows equal to 10% of the room area. (The Engineering Institute of Thailand, 2014)	Pass	Pass	Pass	Pass

It can be seen that all classrooms in the selected buildings pass some of the interior environment assessments. Furthermore, rooms that are 6 and 9 m in depth, should be no more than 5 times the value of the 3.40 m usual height (or 17 m). Secondly, almost all workstations are within the 7.5 m perimeter from openings with external views except those that use space near openings as storage. Thirdly, the selected school buildings are all designed to use a single loaded corridor with at least one external side that has openings like doors or windows equal to 10% of the room area (Figure 8).



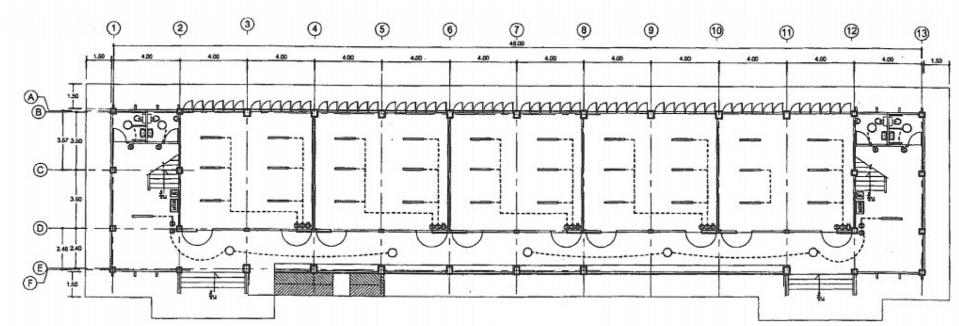


Figure 8 (a) An example of Type C school building plan with 7x8m classrooms and (b) Type D with 6x9m classrooms.

Other aspects that fail to meet the standards are: 1) Acoustics: since both ceiling and wall materials do not absorb sound. They are concrete surfaces with NRC = 0.00, wooden floor (NRC = 0.10), 12.5 mm gypsum board or cement board T-bar ceiling (NRC = 0.05), wooden ceiling (NRC = 0.1); and 2) Visibility: there are no separated control switches for lamps closer to the openings and no daylight sensors installed.

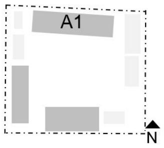
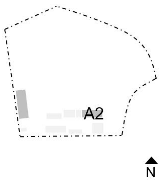
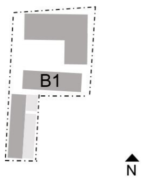
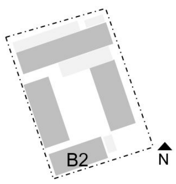
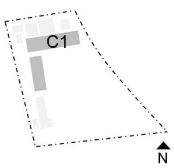
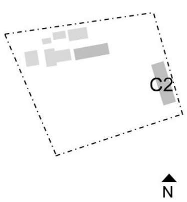
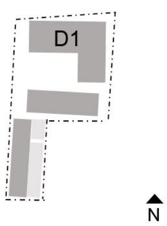
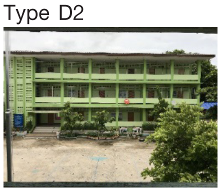
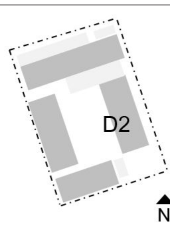
4.2.2 Building extension, adaptation or change of use

It was found that the current usage of all eight school buildings is different from the original design. Not all rooms are being actively used as classrooms. Some of the original space designed as an infirmary, meeting rooms, offices and storage have been altered and modified. The selected active classrooms for this study, three on each floor, are located in different parts of the building to represent all key orientations: north-south, east-west and central location (Table 3).

The 2nd floor classrooms of four school buildings, Type A and B, were no longer in use due to the decreasing number of students. These spaces have been reassigned as storage and other uses. For example, A1, A2 (Figure 9) and B2 (Figure 10) only use the 1st floor for kindergarten and primary level classrooms. Other areas are used as offices, kitchen and food preparation, and washing area. Moreover, furniture for storage has also been integrated in classrooms. In addition, there are some building extensions like toilets and wash basins in the kindergarten area. Wooden doors and windows were replaced with aluminum and glass panels as well as retiling and new paint as part of renovations of the wooden buildings,

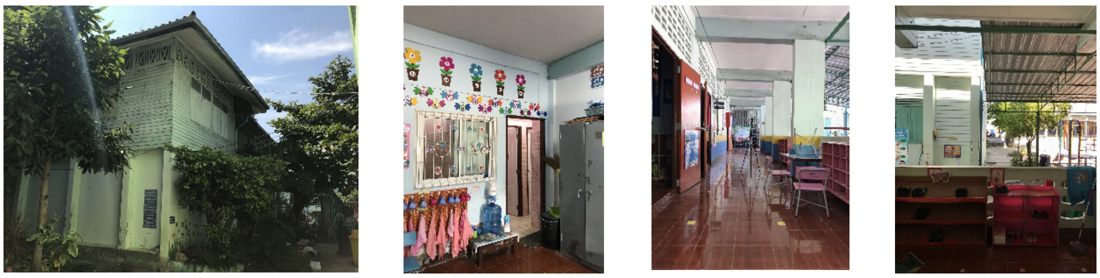
The same reason for space repurposing was observed at four of the 2-4 storey Type C and D buildings. Classrooms have been used as storage, infirmary, offices, and meeting rooms. The C1 building (Figure 11) and D1 building (Figure 12) use the 1st floor area without walls for common gathering space and as a canteen. There are toilet extensions in the space underneath the stairs and at the end of a walkway. In addition, a kitchen and a washing area have been added to accommodate the canteen in building D1.

Table 3 Current physical conditions and usage.

Building design type	Location	Percentage of building usage	Position of classrooms in building/number of classrooms in survey
Type A1 		• Total number of classrooms: 8 • Classrooms in use: 4 (50%) • Actively used as classrooms: 3 • Classrooms used for other purposes: 1 • Position of classrooms in use for any purpose: 1st floor	• 1st floor east, west and central • The number of classrooms in survey: 3
Type A2 		• Total number of classrooms: 8 • Classrooms in use: 3 (37.50%) • Actively used as classrooms: 3 • Position of classrooms in use: 1st & 2nd floor • Classrooms used for other purposes: 0	• 1st floor east, west and central • The number of classrooms in survey: 3
Type B1 		• Total number of classrooms: 4 only on 2nd floor • No walls on the ground floor • Classrooms in use: 0	• No data collected since the building has been closed. Only the ground floor is being used as a multipurpose area
Type B2 		• Total number of classrooms: 8 • Classrooms in use: 4 (50%) • Actively used as classrooms: 3 • Classrooms used for other purposes: 1 • Position of classrooms in use for any purposes: 1st floor	• 1st floor northeast, southwest and central • The number of classrooms in survey: 3
Type C1 		• Total number of classrooms: 4 • Classrooms in use: 4 (100%) • Actively used as classrooms: 3 • Classrooms used for other purposes: 1 • Position of classrooms in use for any purpose: 2nd floor -	• 2nd floor east, west and central • The number of classrooms in survey: 3
Type C2 		• Total number of classrooms: 8 • Classrooms in use: 7 (87.50%) o Actively used as classrooms: 5 o Classrooms used for other purposes: 2 • Position of classrooms in use for any purpose: 1st floor -	• 1st floor south and central • 2nd floor central • The number of classrooms in survey: 3
Type D1 		• Total number of classrooms: 15 • Classrooms in use: 9 (60.40%) • Actively used as classrooms: 5 • Classrooms used for other purposes: 4 • Position of classrooms in use for any purpose: 1st floor	• 3rd and 4th floor east and central • The number of classrooms in survey: 5
Type D2 		• Total number of classrooms: 9 • Classrooms in use: 6 (50%) • Actively used as classrooms: 3 • Classrooms used for other purposes: 3 • Position of classrooms in use for any purpose: 1st and 2nd floor	• 2nd floor north, south and central • The number of classrooms in survey: 3

(a) (b) (c) (d)

Figure 9 Extensions to Type A building: (a) additional roof structure; (b) added office space; (c) a new additional classroom and (d) extension of space in front of the building with new tiled floor.



(a) (b) (c) (d)

Figure 10 Extensions to Type B building: (a) a new plastered brick wall; (b) bathroom extension connected to kindergarten from the inside; (c) new tiled floor and (d) added roof structure at the front of the school building.

(a) (b) (c) (d)

Figure 11 Extensions to Type C building: (a) 1st floor space with no wall turned into a new dining area; (b) stairs landing used as shoe storage; (c) additional toilet was installed underneath the stairs and (d) a classroom used as an infirmary.

(a) (b) (c) (d)

Figure 12 Extensions to Type D building: (a) a classroom used as a storage; (b) additional toilet was installed at the end of a corridor; (c) a classroom used as an office and (d) fall prevention wall was added to the top floor of the building.

4.3 Internal environmental conditions

The study of interior environmental factors the affect building users' well-being from air quality, air contaminants, lighting condition, acoustics, and ventilation in selected buildings can be summarized as follow.

4.3.1 Indoor air quality

The CO2 measurement is required in high density spaces (more than 25 people per 100 square meters and in every 250 square meter occupied area or in every room). In general, the surveyed rooms can be divided into two sizes: 54 and 56 square meters and there is less 25 people per 100 square meters (Figure 13). The density of occupants in the classrooms included in this work was lower. Thus, the low number of users in each room reflects the low CO2 values.

(a) (b)

Figure 13 Classroom layout: (a) in D2 building; and (b) in B2 building.

4.3.2 Thermal comfort

Studying the comfort of sample school buildings with bioclimatic chart based on the highest air temperature measured in the sample building at morning and afternoon (09:00-12:00 am. and 01:00-04:00 pm.) Except building B1 does not measure the environment in the building because the school building is disabled. The results showed that during November, C1-style school buildings were school buildings outside the comfort zone, with the highest average temperature in the afternoon (01:00-04:00 pm.) being 31.2 relative humidity of 33.7 %RH (Figure 14).

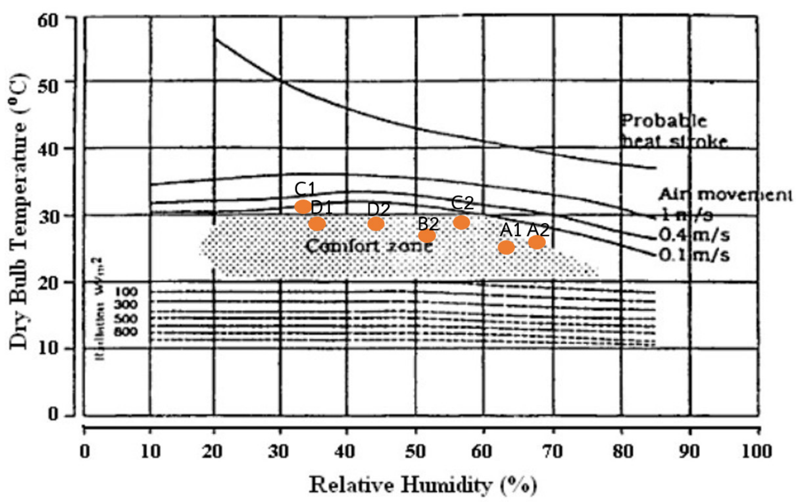


Figure 14 Thermal comfort in selected school buildings.

4.3.3 Level of internal brightness

The minimum level of brightness that is suitable for classrooms, according to the Engineering Institute of Thailand (2014) is 200-300 lx. The comparative measurement of internal brightness in selected building classrooms was based on artificial light from lamps and natural light from voids and openings both in the mornings (9: 00-12: 00 hrs.) and in the afternoons (13: 00-16: 00 hrs.). It was found that the brightness from artificial light was below 200 lx in 3 classrooms in the A1 and B2 buildings. On the other hand, the brightness from natural light was below 200 lx in 5 classrooms in the morning and 4 classrooms in the afternoon in the A1, B2 and D1 buildings (Figure 15)because building extensions blocked natural light and the external view from some of the openings even though the proportion of the rooms was right. There were cases that the rooms' brightness exceeded the standard. In the 2nd floor classrooms of buildings A2 and C1, the excessive brightness occurred because the width of the buildings was placed along the east-west axis without obstructions. In the 1^{st} floor classrooms of building C2, the excessive brightness occurred because the building was placed along the north-south axis.

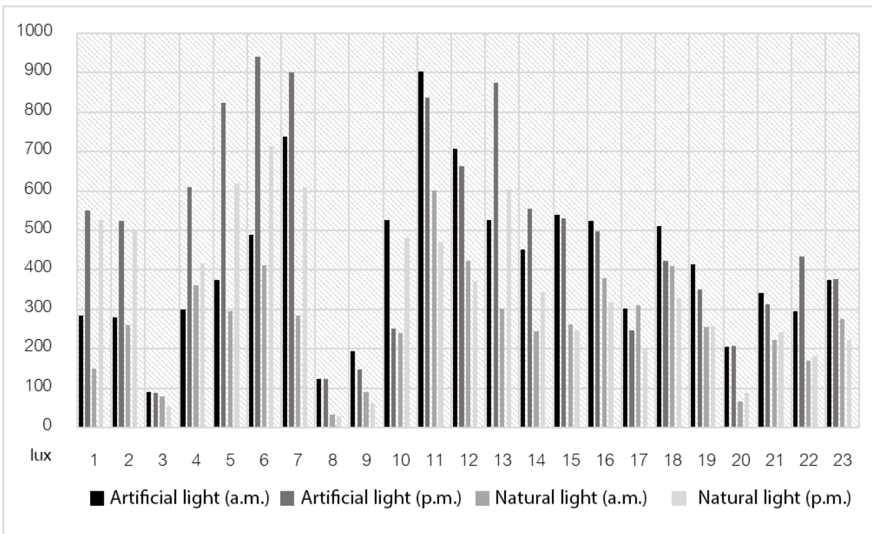


Figure 15 Level of brightness of artificial light and natural light at 09:00-12:00 am. and 01:00-04:00 pm.

4.3.4 Level of background noise

● The standard for noise level while doing general activities should not be higher than 80 decibels.

The level of background noise is defined as the noise in a ready-to-use room while there is no activity or users in the room, with the recommended level being no more than 35 DBA (Tantivanich, 2020). The survey revealed that in 23 classrooms of 7 school buildings, the background noise was higher than 35 DBA (Figure 16). Noise was highest at 61 DBA in the classrooms of buildings A1, C1 and D1 located next to main roads and high density community areas.

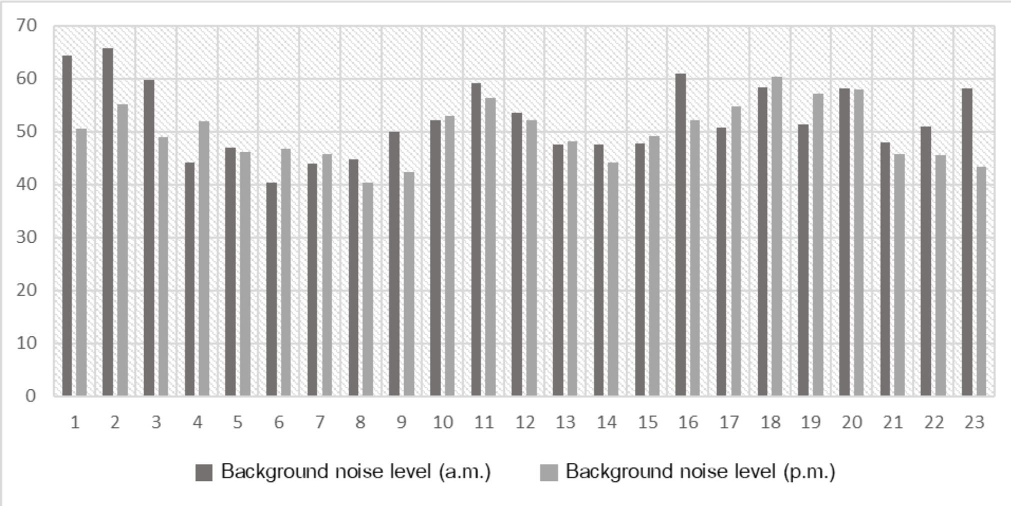


Figure 16 Background noise level at 09:00-12:00 am and 01:00-04:00 pm.

5. Summary of the school buildings current condition analysis and health and well-being problems in the buildings

There are potentially three aspects of school building condition that affect users' health and well-being as follows.

5.1 Location of the building

Building location in this study is divided into 2 categories. Firstly, school buildings in and around the urban Amphoe Mueang area on busy main roads and near high density communities. The environment affects the use of buidling opennings and the views. Moreover, the level of background noise was significantly higher at this type of location. Secondly, in school buildings located in the vast open space in suburban areas and close to agricultural plots, railway lines or low density communities, there is a higher speed of natural wind by working station has an average wind speed between 0.1-0.3 m/s and the maximum average wind speed measured is 0.48 m/s in the A2 school building

5.2 Physical conditions and building usage

Physical conditions and building usage can be divided into 3 cases. 1) Classrooms that were not being used due to the decreasing number of students. They were found as storage in all types of school buildings (A, B, C and D) usually on the top floor; 2) Classrooms that were modified as offices, meeting rooms, and infirmary. In the case that the 1st floor was designed with no walls, it was then turned into a multi-purpose area and canteen; and 3) Building extensions to enhance functional uses including external toilets that connected directly to the internal areas, extra toilets at the end of a corridor or underneath a staircase, and additional kitchen and washing areas to serve the new dining area.

5.3 Internal environmental conditions

Study of internal environment variables of actively used classrooms in selected school buildings compared to standard criteria showed that of all 23 classrooms the most problematic condition was the background noise that was higher than the standard level of 35 DBA for classrooms. Locations and building materials were the two main causes. Secondly, there was a problem with internal brightness. Both sources of light, artificial and natural light, produced lower than standard 300lx in 4 classrooms in buildings A1 B2 and D1. This lower than desirable lighting condition was caused by buidling extensions that obstructed opennings that allow proper light and view into well proportioned rooms. On the contrary, the level of brightness was higher than 300 lx (318 to 939 to be precise) in 5 classrooms in A2 C1 and D1 buildings. Light levels that are too high might affect visual comfort and level of generated in the building. Lastly, we can consider the combinations of temperature, relative humidity and wind/airflow speed. The analysis using bioclimatic chart based on the highest air temperature. The results showed that during November, C1-style school buildings were school buildings outside the comfort zone, with the highest average temperature in the afternoon (01:00-04:00 p.m.) being 31.2 relative humidity of 33.7 %RH.

6. Discussion

It can be concluded from the study that the most imminent health and well-being problems caused by school building environment based on the number of issues found in all classrooms was levels of noise, brightness, and thermal comfort, respectively. Those problems were consistent with research results by Bluyssen et al. (2018) that suggested the most problematic issues in the classrooms they studied were noise, smell, sunlight, and too high or too low classroom temperature. Noise, temperature, and brightness of light were also respectively identified by Bluysen (2020) in their research on problematic environmental conditions in primary school classrooms. The additional factor to the common ones was bad odor. On the contrary, health and well-being assessment criteria in other types of buildings varied. In residential buildings, the focus is on safety, air quality, thermal comfort, lighting, the use of building materials, and aesthetics (Thuvavong et al., 2017) while in condominiums, factors that affect health and well-being of users the most are indoor air quality (Sriaroon & Jarutat, 2020). Therefore, different principles and priorities are used to achieve users' health and well-being benefit

7. Suggestions

Data for this study (including environmental measurements using standard instrumentation) were collected from the physical survey of ready-to-use classrooms with no ongoing activities or users in the classrooms. It would be helpful to further confirm issues impacting health and well-being through surveys administered directly to the school building users as a bottom-up step towards identifying viable solutions.

Author Contributions

Author Contributions: Conceptualization, P.R. and Y.C.; methodology, P.R. and Y.C.; validation, P.R. and Y.C.; formal analysis, P.R. and Y.C.; investigation, P.R.; resources, P.R. and Y.C.; writing-original draft preparation, P.R.; writing- review and editing, P.R. and Y.C.; visualization, P.R.; supervision, Y.C., project administration, P.R.; funding acquisition, P.R. All authors have read and agree to the published version of the manuscript.

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