Evaluation of indoor environmental quality conditions in secondary schools' classrooms in Sharjah

تقييم جودة البيئة الداخلية لصفوف مدارس الحلقة الثانية في إمارة الشارقة

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ASMA AL ANSARI

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Professor Bassam Abu Hijleh

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Abstract

Good Indoor Environmental Quality (IEQ) is essential to enhance better productivity and performance of teachers and students. Research was conducted at four selected schools in residential areas of Sharjah. The schools were selected according to building age and gender differences in order to investigate the influence of indoor environment condition on student's health and performance. The IAQ, light and sound levels have been determined by using questionnaire and automatic portable devices. The result show the IEQ factors in all schools were either below or above the recommended level suggested by Dubai municipality and ASHRAE, these factors includes the following: concentration level of CO_2 indoor air temperature, ventilation, humidity, artificial and natural light and acoustic conditions. The indoor environmental conditions were similar in all four schools. Results show that poor IEQ can increase the risk of sick building syndrome and affect student's health and productivity. Results also show that female students are more sensitive to poor IEQ as compared to male students.

نبذة مختصرة

تعد الجودة البيئية الداخلية أمرًا ضروريًا لتحسين الإنتاجية والأداء الأفضل للمعلمين والطلاب. أجريت البحوث في أربع مدارس مختارة في المناطق السكنية في الشارقة. تم اختيار المدارس وفقًا لعمر البناء والاختلافات بين الجنسين من أجل التحقق من تأثير حالة البيئة الداخلية على صحة الطلاب وأدائه . تم تحديد جودة الهواء الداخلي , ومستويات الضوء والصوت باستخدام الاستبيان وأجهزة القياس المحمولة.

تظهر النتائج أن عوامل الجودة البيئية الداخلية في جميع المدارس كانت إما أدنى أو أعلى من المستوى الموصى به من قبل بلدية دبي والجمعية الأمريكية لمهندسي التدفئة والتبريد وتكييف الهواء, وتشمل هذه العوامل ما يلي: مستوى تركيز ثاني أكسيد الكربون ، ودرجة حرارة الهواء الداخلي ، والتهوية ، والرطوبة ، والضوء الاصطناعي والطبيعي ، والعوامل الصوتية.

كانت الظروف البيئية الداخلية متشابهة في المدارس الأربع. تشير النتائج إلى أن الجودة البيئية الضعيفة يمكن أن تزيد من مخاطر متلازمة المباني المريضة وتؤثر على صحة الطلاب و إنتاجيته. كما تظهر النتائج أن الطالبات أكثر حساسية تجاه جودة البيئة الداخلية الفقيرة مقارنة بالطلاب الذكور.

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1. Introduction

1.1.Overview

This report analyzes Indoor Environmental Quality (IEQ) in UAE schools. It also highlights the negative impact of these parameters on student's health and performance. It emphases on three main parameters in IEQ, such as Indoor Air Quality (IAQ), lighting and acoustic factors. "Indoor environmental quality (IEQ) refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it"(Cdc.gov, 2018). IEQ is determined by several parameters such as IAQ, acoustic, lighting, spatial organization, colors, etc… Factors such as cleansing agents, construction materials, interior finishes can also influence the IEQ in a space. Appropriate indoor environment is able to influence student's health, performance and behavior. Building type, age, location and function should also be taken into consideration while studying IEQ. However, poor indoor environment can cause Sick Building Syndrome (SBS) symptoms such as dizziness, flu, respiratory illness heart symptoms and other types of disease.

This research concentrates on indoor environmental conditions in schools located in Sharjah. The study was conducted in four public schools, two female schools and two male schools. The schools were selected in terms of gender difference and building age - old schools and new schools buildings. Grade 8 students were selected from each schools to fill up the necessary requirement. The indoor environmental parameters of the selected classroom's were measured and with the help of qualitative and quantitative survey. This investigation took place in November 2017.

Inadequate IEQ increases the rate of absenteeism in schools. Children are more susceptible to diseases as compared to adults since their immunity system is not fully developed. The risk of respiratory illness increases because children inhale large volumes of indoor airborne particles since they are close to ground, due to their height. Contaminated air and inadequate ventilation can increase the risk of respiratory symptoms among students. Poor IEQ can cause negative impact on students wellbeing if not treated properly. Each parameter can has its own effect on student's health. Recent studies showed that occupants in most building complain from SBS, this case is common in among old buildings especially when there is no regular maintenance or renovation.

Polluted indoor air consist of various contaminants such as microorganism's, particulate matter, organic compounds and inorganic compounds. disregard of the type and size, the airborne particle can be very harmful on human health. The small particles can reach the blood stream by passing through the lungs and can result in respiratory illness. Irregular maintenance and Inadequate ventilation can increase the concentration of the contaminated particles in schools.

Thermal comfort should be achieved to improve students' performance in schools. The thermal comfort consist of five physical parameters : partial water vapors pressure, relative humidity, mean radiant temperature, air velocity and indoor air temperature. The thermal comfort is also influenced by clothing insulation, activity level, sex and age.

The light parameter is comprised of two types of lighting: sunlight and artificial light. According to researcher, sunlight is able to enhance both mental and physical health among people. Day lighting in indoor environment should be balanced: because excess of it will disturb students comfort and health. On the other hand, artificial lighting can cause senior impact on students and teachers health because they emit VOC's into the interior environment. The dynamic lighting are preferred since they enhance students behavior and task performance.

Inadequate acoustic conditions can disrupt students and teachers comfort. The acoustic conditions is influenced by the background noise and the reverberation time in a room. The acoustic environment is effected by the materials used for indoor finishes, room geometry and school location. Inappropriate acoustic environment can result in hearing impairment, mental fatigue and vocal load

1.2. Motivation for the study

The education system of the United Arab Emirates (UAE) is relatively new. in 1952 the number of schools buildings were less in UAE. the education system was expanded in the 1960s and 1970s, due to the presence of school building programs. Now, the education is universal among primary and secondary level. About 60% of all students were enrolled in public schools. The public schools are funded by government and are designed to meet UAE development's goals and values.

Many research studies explore the IEQ in commercial and residential buildings, but there are limited studies relating to IEQ in school buildings in UAE. Students at secondary level spend most of their time in school. Therefore, classrooms environment should be appropriate to reduce the disease risk among students. This research analyzes the impact of indoor environment on students health because UAE is a developing rapidly, therefore elderly and children are the worst affected due to long-term exposure to toxins, particulate matter and ozone. As a result, number of disease's among school students is widely due to polluted environments and polluted indoors. Students health and performance can be enhance by improving the IEQ in schools. Appropriate environment can create a good reputation for school which can improve the marketing strategy and financial statement. Furthermore, it may also help to decrease the maintenance and operations cost.

1.3. Significance of the study

This study explores the indoor environment condition in Sharjah public schools. This report can help future researcher to understand and asses the issues of IEQ in schools. It may also assist the policy makers to put standards that meet the requirements of indoor environment. With the help of this report, the designers will be able to design appropriate indoor environment that meet students requirement and improve their health and performance.

The analysis was carried out in four public schools located in Sharjah, two male and two female public schools. The schools were selected with regards to building age; from each school one classroom was selected for further investigation and evaluation. Field investigation and questionnaire methods were used to analyze the indoor parameter and to point out the factors that influence student's productivity and performance. These researches assess the impact of IAQ, lighting and acoustic condition on student's health and comfort.

2. Literature Review

2..1. Sick Building Syndrome

Gibson et al (2013) stated that, the main cause of death in United Arab Emirates is poor IAQ. Indoor air pollution is a leading cause of death in United Arab Emirates; U.A.E stood the second place globally. Al Sallal (2010) recommended appropriate indoor environment solutions for schools in U.A.E after observing the poor performance of children due to inappropriate design with regard to natural lighting. Behzadi and Fadeyi (2012) explored the indoor environment quality of schools located in Dubai city, and according to their research they concluded that: Most of the indoor environmental parameters exceeded the recommended limit's assigned by Dubai authorities.

2.1.1. Migraine and Headache

It's difficult to figure out or to achieve accurate data of students suffering from migraine or headache. But Bener et al (1998) was able to figure out during his empirical study, the number of students suffering from SBS symptoms. The results are summarized in below table. All data's are collected from Table 2.1 1. (Bener et al. 1998)

Table 2.1 1 Comparison variables between children with headache and those without headache (Bener et al. 1998)

City	Headache %	Migraine %
Al-Ain	37.8	3.6
Dubai	38.4	4.1
Sharjah	34.5	3.7

TABLE 2. *Comparison variables between children with headache and those without headache.*

Variable	Children with headache	Children without headache	*P*-value
	N=428	N=731	
Family problems	78 (18.2%)	78 (10.7%)	0.0003
School problems	97 (22.7%)	103 (14.1%)	0.0002
Parent(s) often complaining of headaches	196 (46.2%)	479 (68.9%)	0.0001

The above study was cited in various studies and was conducted in Shizan (Iran), Doha (Qatar) and in Riyadh (Saudi Arabia). There is no evidence of such studies conducted in UAE. According to Bener et al (2000) headache range increased by 36.9 % and the migraines increased by 13.7% (Taha 2013).

2.1.2. Wheezing and Asthma

Benaer et al (1998) during his research in UAE schools he discovered that asthma is the most popular and a long- lasting disease spread among school students. Studies showed that 5.4% of girls and 8.1% of boys suffer from asthmatic disease during academic survey that was conducted on 1991-1992 in primary schools. This disease increases the rate of absenteeism among students in class by 4.9% (Taha 2013). Whereas, Abdulrazzak et al (1994) stated that asthma is a genetic disease and asthmatic children get this disease from parents carrying asthmatic disease. While on the other hand, International Study of Asthma and Allergies in Childhood (ISAAC) concluded that asthma is increasing widely among the seven emirates and the genetic factor is not the principle cause for this disease. ISAAC also showed the number of students suffering from IAQ symptoms: hay fever 14.9,

eczema 11%, coughing 21%, wheezing 15.6% and asthma 13%. Furthermore, Mahbouob (2012) stated that further studies must be conducted in UAE to point the causes for spread of asthma, since the range of asthmatic patients is widely increasing among UAE people. Researchers recommend further studies to reduce this disease in order to achieve healthy society.

2.1.3. Calcium metabolism and Vitamin D

Lack of calcium and vitamin D worldwide problem, especially among people in UAE. With regard to age group, children are mostly affected with such deficiencies. Deficiency in calcium or vitamin D can cause negative impact on children brain growth, teeth and bones. Muhairi et al (2013) founded Al-Ain school girls suffer from lack of Vitamin D. Rajah et al (2012) reported that 37% of children in UAE suffer from vitamin D deficiency. As a result, the impact of IEQ must be highlighted and resolved in order to achieve healthy society and to improve students' performance. This can come to existence by creating appropriate indoor designs in UAE schools.

2.2.Indoor Air Quality

Recent papers focuses on gender differences in thermal comfort. Studies conducted by Indrāvati and Rao (2010) highlighted the relation between thermal comfort and sex differences. Rao stated that female gender show a little greater thermal suitability (88%) as compared to male gender (83%) (Kim et.al 2013).

While on the other hand Aries et al. (2010) concluded that females express thermal dissatisfaction with 74% more than male, and are less satisfied with IEQ factors as compared to males (Female 30.5%: male 39.5%) (Kim et.al 2013). According to Schellen et al. (2013) the thermal comfort sensation and the SBS are highly felt among males than females. Furthermore, Zalejska-Jonsson and Wilhelmsson (2013) claimed that complaints related to IEQ were usually reported by females than males, insufficient lighting, odors, stuffy air, too low/high temperature etc… (Kim et.al 2013).

Studies associated with health symptoms and internal environment founded that female suffer from various indoor symptoms such as cough, headache, dry throat, eyes, nose, eye irritation, concentration difficulties and fatigue and skin symptoms. This is because women's are more sensitive to indoor HVAC system, dust, draught and stuffy air. However, the thermal comfort response of males and females is associated with clothing (clo). Parts of female body surface are covered by the clo-insulation differently than males, which leads to increase in the level of thermal unacceptability for women's (kim et.al 2013). The thermal comfort can have an impact on age group as well, female lass than < 30 year of age express high probability relating to thermal dissatisfaction as compared to males (Kim et.al 2013).

Ventilation plays an important role in indoor environment. Appropriate indoor ventilation can improve the IAQ and can create healthy indoor environment for students and teachers. Insufficient and inadequate ventilation can pollute indoor air, create uncomfortable indoor environment, increase SBS and reduce productivity in school students. According to Santamouris et al. (2008) mechanically ventilated schools produces high median flow values as compared to naturally ventilated schools (from 8 Ls p to 3 L s p) with significance on CO_2 concentration. Mumovic et al 2009 report showed that indoor windows are insufficient to provide natural ventilation. And mechanical ventilation (MV) can produce cold draughts and internal ambient noise (Dhalluin and Limam 2014). NV strategies consist of single sided NV (window opening) and self-opening and shading system SOS (controlled window opening). Dhalluin and Limam 2014 argued that NV warm up the indoor air supply and increase the level of humidity in indoor environment due to absence of filters, which leads to poor evacuation of water vapor produced by students and outdoor humid. Opening of windows can increase indoor air temperature, CO_2 concentration and repairable suspended particulate matter (RSPM) this includes PM1, PM2.5 and PM10. As a result, the SOS modes were highly preferable because they can improve the IAQ as compared to other strategies. The NV is not preferred to be used in schools. The SOS mode is highly comfortable in case of thermal and acoustic satisfaction.

Croome et al. (2008) pointed out that polluted indoor schools can cause short and long-term health problems for both teachers and students; polluted environment can also have adverse effect on student's productivity and performance. Schools indoor environment can be polluted by the following

ways such as (i) using building construction and furnishing material that emits high toxic substances (ii) lack of maintenance (iii) poor air conditioning nits and ventilation (iv) small areas for landscaping with poor drainage system (v) polluted outdoor environment (transportation) (vi) cleaning detergent's (vii) Activities carried out in class i.e. craft work (viii) level of occupancy. There are other architectural factors that influence the indoor environment such the floor plan, number of windows and doors, quality and type of ventilation system and location and age of school building. It's been reported that schools located in heavy traffic, rural and industrial areas are highly polluted because of the outdoor pollutants (de Gennaro. et al 2014)

de Gennaro. et al (2014, p.469) summarizes the indoor pollutants when he stated that:

"The most common pollutants found in schools and childcare facilities are the following: PM, VOCs, Formal- dehyde and Carbonyl compounds, other Inorganic Gases: NOx, CO, SO2, CO2 and O3, Each indoor pollutant has its own features, which can leave negative impact on students' health and performance.

Chemical composition and the duration of exposure of airborne particles can affect human health (de Gennaro. et al 2014).

In schools, the Particulate Matter (PM 10) is usually found in gymnasium, labs, computer room and high-occupied rooms. Various activities such us, Cooking and smoking, inadequate ventilation, dusty interiors vehicular emission and physical activities can increase the PM 10 concentration in a classroom. Other factors can contribute to PM 10 in a space this includes construction materials and interior finishes i.e. gypsum wall plaster and presence of carpet. The particulates from this material can effect students health by causing Respiratory or cardio- vascular disease which leads to death, Fell in lung function, Alterations in respiratory tract, structure lung and Premature death (de Gennaro. et al 2014).

Volatile organic compound is found in classrooms that create arts, crafts and science activities. The VOC's consist of various components such as Styrene, Xylenes, Toluene, Dichloromethane, Alpha-pinene, Limonene, Toluene, Formaldehyde and Benzene and Naphtha- lene. VOC's is present in

various products such as: Painting materials and collage, Solvent based paint and spray paints, School furnishing and wood based products e.g. cabinets and writing desks, Cleaning detergents and Vinyl chloride flooring. Students may develop allergic reaction, asthma and Impaired neural behavior function when exposed to VOC's for a long period of time. Furthermore, recent studies showed a strong association between central nervous system and mucus membrane irritation symptoms (de Gennaro. et al 2014).

Formaldehyde and carbonyl compounds on the other hand, can cause Human carcinogen, decreased pulmonary function, congestion, asthma, Lung injury and oxidative stress. This gas is usually released from wooden material such as: Wood-based materials made in interiors, (1) Particleboard (PB), medium density fiberboard (MDF) and hardwood plywood paneling used in interior finishes e.g. cabinets, wall and furniture coverings, shelving and sub-flooring. It is found in classrooms that use wooden furnishing (de Gennaro. et al 2014).

N Gases, carbon oxide and sulfur dioxide is able to disrupt transfer of oxygen to human tissues, which leads to respiratory illness. This gas is released by vehicular traffic, electric stoves and coal fire industries. CO_2 control ventilation system (with CO2 sensors) was used in computer classrooms to measure the impact of CO_2 on students. Norbak et al. demonstrated that headache, dizziness and tiredness reduces significantly when levels of CO_2 decreases in classrooms (Norbäck, Nordström and Zhao 2012). In school environment, CO_2 is considered as a proxy indicator of IAQ rather than pollutant. ASHRAE Standard 62-2016 (2016) recommended that the indoor CO_2 levels must not exceed 800 ppm (Dubai municipality 2010). The CO_2 level increases due to several indoor factors such as low air exchange rate, room plan, poor ventilation system and high occupancy level. Furthermore, In schools the CO2 level increases in beginning of lessons, at day time, when windows or doors are opened and during physical activities. The CO_2 level also raises in winter season since the classroom are not well ventilated as compared to summer season (de Gennaro. et al 2014).

2.3.Lighting

According to Kenz (1995) lighting can cause negative impact on students' performance and vice versa. This negative impact can be reduced by applying the most suitable light setting in student's

classroom in order to create comfortable environment for students and teachers, because teachers are also effected by poor indoor lighting (Bruin-Hordijk and Groot 2007). Appropriate light setting light setting must be recommended in every school to enhance students and teachers performance (Abramson et al 2007).

In UAE, people prefer to use the fluorescent white light with blue wavelength in the indoor environment. Karcher et al (2009) explained how people became used to white light and how it became a norm among people. According to him people refuse to accept other type of artificial lighting system, even though they know that white light can cause health symptoms. Holzman (2010) indicated that blue light could also be harmful if pupils are exposed to it for a long period of time.

Egan (1983) assumed the function of light occurs with the help of perception. Perception occurs with the availability of light and human body. There are two light sources primary and secondary source. Artificial light and day light are primary light source since they illuminate the space and environment. On the other hand, the secondary light source is any body that can modify the light source, this includes interior objects, louvers, dust, water vapor, weather etc (Taha 2013).

Cumming (2000) explored the benefit of day lighting, by highlighting the importance and benefits of natural lighting on human health. According to his Meola (2005) day lighting can be used as a therapy to enhance mental and physical health in people. So the presence of natural lighting is a must in our indoor environment. Color therapist can treat people with the help of both light and color. On the other hand, Holzman (2010) argued that lighting can cause health problem if not applied properly with color.

Jones (2008) stated that lighting could cause senior impact on students and teachers health. Artificial lighting can emit VOC's into the interior environment when they interact with bodies present in atmosphere, which in return pollutes the indoor environment and results in harmful health impact (Taha, 2013).

Boyce (2010) indicated that artificial lighting radiation can harm the circadian system, the visual system and the skin if not applied in a studied manner, (i) when visual system gets disturbed it can cause visual discomfort, eye strain and migraine (ii) The circadian system can affect the sleep/awake

cycle and can cause tuberculosis, calcium and vitamin D metabolism (affecting teeth and bones), multiple sclerosis, Alzheimer's, seasonally affective disorder (SAD) and other forms of cancer . Studies show that human body tissues are being distressed on using inappropriate light radiation such as infrared and ultra-violet radiation. Depending on the strength and length of exposure, the effect might lead to breast cancer and other types of cancer. As a result, the power of light can have an impact on human health, performance, behavior and mood.

Heschong et al (2002) observed that day lighting can enhance student's health and performance, students can achieve better results in their evaluations and exam when they are placed under sky lights or near windows. Figuerio et al (2002) highlighted the importance of daylight in workers task. Compared to other forms of light, on daylight the workers spend most of their time performing their task and waste less time with phones (Taha 2013).

Boyce et al (2006) and Veitch (2001) suggested controllable lighting in working environment because there is a relationship between controllable lighting and personnel mood. Workers are able to produce more and achieve successful results under controllable lighting since this type of light can enhance workers mood and health. Veitch (2001), Kenz (1995) and Veitch and Gifford (1996) designed conceptual model showing the relationships between individual outcomes, individual processes and lighting conditions.

Human eyes can visible the light that consist of electromagnetic radiation with a wavelength reaching within 380 to 780nm. Color temperature and IL luminance are two The most important factors of light is luminous flux per square meter that is used to measure the light in an area, lux (lx) is the unit used. Light consists of low and high proportion. Short wave radiation in high proportions produces high color temperature, which show as cold colors, such as blue or white. Long-wave radiations in high proportions generate low color temperature, which look like warm colors, such as yellow or red (Barkmann, Wessolowski and Schulte-Markwort 2012).

Van Bommel and van den Beld, (2004) showed that vision can be improved while increasing the illuminace. According to Viola et al., (2008) and Mills, Tomkins and Schlangen, (2007) the concentration levels among students can be increased in cooler color temperature (17,000 K) and high

luminance. On the other hand, student's social behavior and communication can be improved when using warmer color temperature and lowering the illuminace (Barkmann, Wessolowski and Schulte-Markwort 2012)

For this reason, a study was conducted under two control groups (IG and CG) in various schools to show the effect of variable illuminace (VL) on students concentration, attitude, reading speed and comprehension. Results showed that students under VL4 "Concentrate" settings made fewer mistakes of omission and are able to read more words as compared to students under VL1 "Standard" setting. Students under VL4 concentrate setting were improved by 16.8%, while students under VL1 standard settings improved by only 7.1%. Moving towards student's attitude, results did not show any change in student's behavior when changing the VL. Light effect the neuronal and hormonal mechanism on vision which result in short-term impact on concentration (Barkmann, Wessolowski and Schulte-Markwort 2012)

The relax lighting did not influence the reading and learning achievements. Instead, it created working atmosphere willingness to perform their academic task. Other studies founded that lighting can change and improve student's social behavior in schools (Mills, Tomkins and Schlangen 2007) (Baron, Rea and Daniels 1992).

Studies proves that lighting color temperature and intensity can produce various physiological impact on human well –being such as melatonin, core temperature, EEG, heart rate variability and blood pressure (DEGUCHI and SATO, 1992). One of the useful biological effects of lighting is the suppression and inhibition of melatonin and cortisol in students subjects when exposed to dissimilar lighting settings (Cajochen et al. 2005). For example, reports show that artificial lighting can have positive effect on students' performance, concentration and working speed. Studies indicated that brighter light (500 lux) can have positive effect on students writing, reading and mathematics as compared to standard lighting (300 lux).

A recent was conducted by Sleegers et al. (2012) to show how dynamic lighting can affect student's mood and behavior in schools. This dynamic lighting consists of four lighting setting (i) Energy setting (650 lx-12000 K) - used to motivate the students after lunch break and before the day starts. (ii)Focus

setting (1000 lx-6500K) enhance students concentration (iii)Calm setting (300 Lx-2900K)- creates a relaxing atmosphere to ensure joint learning and finally, (iv) Standard setting (300 lx-4000K)- used for schoolroom activities. This study was conducted in various schools, results showed that students perform well, concentration level increases and errors decrease under focus lighting as compared to other types of lighting. In addition, females can perform better under focus lighting as compared to males this is due to gender differences. Age group are also affected by lighting settings for instance children in grade 6 concentrate better than children in grade 4 under focus light setting.

2.4.Acoustic

Studies have proved that inappropriate acoustic environment has a negative impact on students learning, teaching and on health and performance (Klatte et al. 2010). Dockrell and Shield (2006) stated that noise in schools can affect student's behavior and can disturb children from performing their task properly. Noise can have more impact on older students as compared to smaller student. Studies conducted in schools indicates that background noise levels in unoccupied school rooms is around 40-48 dB; while other researchers stated that background noise level ranges from 33dB to 54 dB But the background noise level increases to 77 dB when students get engaged in noisy activities (Shield et al. 2015). The unoccupied noise levels is known as indoor ambient noise level (IANL), the highest range can reach to LAEQ, 30min and this can take place during teaching hours. The IANL consist of noise from different sources such as external noise and ventilation system but excludes the noises that comes from teaching activities in schools (Shield et al. 2015) .

"Reverberation times are stated in terms of the "mid-frequency reverberation time" (Tmf) which is the average of reverberation times at 500,1000 and 2000 Hz" (Shield et al. 2015 p.p.178).

Shield et al (2015) conducted acoustic study in primary schools in England. This study focuses on acoustic parameters such as speech transmission index and reverberation times. The aim of this study was to find out the impact of poor acoustic conditions on students and teachers performance, moreover, the schools were selected in terms of type of teaching, location (urban, sub-urban and rural), age and type of building (open and closed-plan) and external environment. It was observed that the external noise level was between 49 to 53 dB for majority of schools. Results showed that there are

several factors that affect the acoustic parameters in indoor environment, these factors are mentioned below (Shield et al 2015).

(i) Location of schools for instance, schools located in city center are stated to have high unoccupied ambient noise due to transmission of noise from external environment (i.e. construction noise) to the façade of school building.

(ii) Noise from adjacent spaces can effect the speech intelligibility in open plan classrooms (Shield, Greenland and Dockrell, 2010)

(iii) Background noise level-Gymnasium and sport hall cannot be used for listening and learning due background noise and reverberation time.

(iv) Room design- the acoustic properties of classroom are affected by room geometry and materials, such as glazed wall area, room height, floor area and room volume. Reverberation time is closely linked with room parameters for instance; the reverberation time increases with high room height and ceiling. And, when reverberation time increases the speech clarity and intelligibility decreases. As a result, we can achieve proper acoustic condition, by reducing the room height to 2.4M, which in return the reverberation time decreases to 0.8s. High ceiling require sound absorb material.

(v) Acoustic design s can shorten the reverberation time and lower the indoor ambient noise level. In case of open-plan classrooms, the amount of glazing and the percentage of glazing should be studied and fixed within a proportion. The amount of glazing should be taken in to consideration to create proper acoustic environment for speech clarity.

(vi) The reverberation time is affected by using sound absorb materials in interiors, this includes carpets on floors and sound absorb panels on walls and ceilings.

(vii) Age of students and number of pupils can affect the noise levels during lessons. The smaller the students the higher the noise level. The greater the number of students the higher the noise level during lessons.

Sheild et al (2014) concluded that high noise level could reduce students' performance and effect teacher health. Teachers are unable to transfer their message to children in poor acoustic conditions.

Furthermore, Clausen et al (2013) observed that poor acoustic condition can result in high rate of absence among students and teachers. Noise can cause negative effect on student's performance because it will distract the perception of speech and disturb the ongoing activities that takes place during class (Ljung et al 2009). Studies indicated that teachers are being exposed to distracting noise at most of their working hours (1/4 at least).

A recent study was conducted by Kristiansen et al (2014) in Danish schools, the aim of this study was to analyze the indoor acoustical environment in classroom's. The researcher tried to explain the relation between noise exposure and vocal load and mental fatigue among schoolteachers. To measure the voice activities more precisely, a microphone was placed near the throat of the teachers, close to the larynx a questionnaire was distributed among teachers and an interview was conducted with the teacher after lesson is being finished. Moreover, a field investigation was also conducted in schools in order to achieve the following results:

Firstly, the classroom volume is associated with the reverberation time, the RT changes along with the volume of the classroom. The Post hoc showed that the noise exposure during subject lesson (61.8-81.8 Db(A)) is lower than the noise exposure during sport activities (73.9 -83.0 Db(A)). As a result, the differences between schools was absent with regards to noise exposure. In addition, the room volume, the teacher's age or sex and the student's age also showed no significant impact on noise exposure.

Secondly, during measuring period, vocal loads (61% of lessons) was equal to talking with a loud or raised voice. And in the remaining (39% of lessons) the vocal load was equal to normal or low voice. Whereas, in sports class the results were very loud. The voice measurement was not influenced by student's age or teacher's gender. But, a significant relation was observed between voice load and teacher's age. Overall there were no association of the mean RT on speaking time, vocal load and noise.

Thirdly, a voice symptom is correlated with teacher's average noise during working hours. In general classrooms, change in teacher's vocal load and voice symptoms is been observed. A feeling of fatigue in the head occurs when teachers are being exposed to noise. There is no significant correlation

between energy score or stress regarding noise exposure. The voice symptom is influenced by the duration of exposure during working hours.

Finally, results also show that sports teachers can develop hearing impairment symptoms since they are exposed to excessive noise for long period of time. Kristiansen et al. (2014) suggested that sport activities should be practiced in outdoors during summer time to reduce the noise burden over sports teachers.

Voice symptoms are widespread among educators (Russell, Oates and Greenwood, 1998). Thus, studies indicate that vocal load of teacher's can be increased when the classroom noise increases. Voice disorders among teachers can reduce students' performance since voice problems can lead to absenteeism among teachers. Beyond teacher's voice symptoms, students also get distracted with loud voices. Very-Loud or raised noise can disrupt student concentration during lesson (Kristiansen et al., 2014).

3. Aims and objectives

The purpose of this report is to understand and develop the IEQ in schools

- To analyze the IEQ of public school in UAE
- To evaluate and compare the indoor environmental parameters of old school and new school buildings
- To highlight the important of indoor factors on students' performance and health, factors such as IAQ, acoustic and lighting parameter.
- To identify the impact of poor IEQ on students health and performance

4. Methodology

4.1. Overview

Recent studies were selected and studied based on methodology type. As shown below, field investigation and questionnaire methodologies was used in many papers, especially in reports that discuss or analyze the impact of IEQ in indoor environment.

Behzadi and fadeyi (2012) measured the indoor air pollutant in schools by using various instruments such as Thermo Scientific pDR- 1500, Formaldehyde gas monitor (model RK-FP30) and Direct Sense IAQ-IQ probe 610. These instruments were used to measure the organic and inorganic gases in classrooms. The Direct Sense IAQ-IQ probe 610 was used to measure ozone, temperature, relative humidity, VOC's, carbon dioxide and carbon monoxide. This instrument was used at different range and accuracy based on type and size of particulate matter. The researcher monitored the formaldehyde by using Formaldehyde gas monitor (model RK-FP30) , the instrument was operated at a Range of 0–0.4 ppm for detection time of 30 min. Furthermore, the researcher also used the Thermo Scientific pDR-1500 instrument to measure the total particle concentration in classrooms'. This instrument was operated at a Range of 0.001–400 mg/m3; accuracy: +5% of reading + precision (+0.2% of reading) during monitoring period. The author analyzed the results by using Microsoft excel.

Huang et al (2012) analyzed the indoor environmental condition of offices in United States. The author used two types of methodologies: field investigation and questionnaire survey. This study analyzes the indoor temperature and other parameters such as lighting and acoustic parameter. The field survey was carried out to monitor the temperature, lighting and noise level. During the monitoring period the indoor air temperature was controlled by air conditioning, shutters and adjustable lighting system was used to control the lighting parameter and the noise level was monitored by adjusting the fan noise. the researcher employed different kind of devices to measure the respected parameters, PPD and AM-101 PMV indices meter was used to measure relative humidity, airflow velocity, mean radiant temperature (MRT) and air temperature. The luminous environment was evaluated by illumination intensity (used us parameter), the luminous environment was measured a portable TES-1330A digital illuminometer. And finally, the acoustic environment was measured by a AWA6270B noise spectrum meter.

Furthermore, questionnaire survey was conducted to measure the satisfaction level of indoor environment by distributing questionnaire relating to subjective sensation.

Fadeyi et al (2014) evaluated the ieq conditions in elementary schools in the United Arab Emirates. The indoor environmental parameters were investigated and measured with help of measuring devices. The researcher measured the indoor parameters with the following devices: the indoor temperature, rh, co2 level and ozone were measured by Direct Sense IAQ- IQ probe 610; the Formaldehyde was measured by Formaldehyde gas monitor (model RK-FP30) ; TSI Optical Particle Sizer 3330 to monitor the indoor particles. Furthermore, SL130G EXTECH Sound Level Alert with Alarm, HD450 EXTECH Data Logging Light Meter and measuring tape were used to monitor the he acoustic, lighting and spatial organization. The Range and accuracy of each device was modified according to ISO guidelines.

De Guili et al (2018) monitored the Indoor Conditions in Italian School Buildings using devices, data loggers and questionnaire method. The author employed Briiel & Kjaer Indoor Climate Analyzer to measure air velocity, RH, radiant temperature and air temperature. All the collected data was recorded by HOBO U-12 data-loggers. The co2 levels was monitored and recorded by using AirBoxx IAQ monitor. Foreword to lighting conditions, the lght iluminance and RT was logged and measured in Minolta CL 200 lux meter and four- channel Svantek 948 real-time analyzer

De guili et al (2018) used set of measuring instruments that consist of the following devices: Briiel & Kjaer 4231 micrqjhone calibrator; a LAB.GRUPPEN LAB300 power amplifier; a Brüel & Kjaer Type 4296 omnidirectional dodecahedron sound source; a four-channel Svantek 948 real-time analyzer with ftilel & Kjaer 4188 microphones to measure sound pressure level in room and Norsonic tapping machine to measure sound impact level. Furthermore, the author created and distributed set of questions relating to occupant's sensation, SBS, occupant-building interaction and indoor conditions. Both teachers and students were asked to fill the questionnaire survey.

Kristiansen et al (2014) explored the impact of acoustic parameters on student and teachers in Danish school environment. This study aimed at investigating and analyzing the classroom's acoustic conditions and school teachers noise exposure, voice load and speaking time during teaching, and the

effects on vocal and mental fatigue development. The final results were achieved from questionnaire and field investigation method. The questionnaire survey consists of questions relating to fatigue symptoms and energy levels and it was distributed to teachers only. Whereas, the field investigation method includes monitoring devices such as Bru¨el & Kjær 2260 to measure sound level, Bru¨el & Kjær 7830 Qualifier to analyze the octave bands, three different microphones in different positions, microphones on teacher's shoulder, Bru¨el & Kjær's SoNoScout recorder to record wave files and Bru¨el & Kjær Type 4445 to measure and store the sound pressure level. Furthermore, the author also included two-back test (TBT) in order to evaluate the working memory function of the participants

Sleegers et al (2012) used four different dynamic light systems to highlight the positive effects of dynamic light on student's concentration and activity in Dutch schools. The author placed the light settings along with five buttons and wall-mounted control panel; all classrooms had the same light settings. Each class consist of energy setting (cold, white, blue-rich light -12000K), focus setting (a bright white light-6500K), calm setting (white light with red color tone – 2900 K) and standard setting (4000K). Also, the author used Konica Minolta CL - 200A to measure the illuminance at horizontal plane and Philips Savio luminaire fitted with a diffuser (TCS770 3xTL5-49W/452/827/452 25/90/25 to create the above setting by mixing light-color.

As a result, the questionnaire and field investigation methodology were selected to analyze the indoor environmental parameters for this research. Because results achieved through field investigation method are more accurate as compared to other type of methodologies. The indoor environmental parameters can be measured with the help of devices, these devices make the research process easier for the researcher because they contribute in achieving accurate readings within limited time, in addition to perfect readings the collected data can be restored for later preferences. The field measurements save time, cost and reduces mistakes, doubts and bias information. On other hand, the questionnaire method makes us understand what people feel or sense about indoor environment. The subjective sensation cannot be reached with field investigation method alone, so it's important to use and combine both methods while studying the indoor environmental parameter. But sometimes the questionnaire survey is returned from occupants to researcher's with bias information or answers, due to several factors such us occupants background, age, education and many other factors can contribute

to bias answers. For this reason, both methods should be used to achieve accurate results relating to studied subject.

These two methods were implemented in all four public schools to analyze the indoor environment condition and its impact on student's health and performance. All selected schools were in Sharjah, 2 boy's schools and 2 girl's schools. To better understand the indoor environmental conditions, schools were chosen in regards with gender difference, building age and school location.

The investigation process started after receiving a permission letter from ministry of higher education. The approval was given for public schools, students in secondary level. Grade 8 students were selected from each school; the age range was between 13 to 14 years old. From each school 100 students were selected, only grade 8 could fill up the questionnaire. This study consists of several methodologies and was performed on Nov 2017:

i. Walkthrough
ii. Field Investigation
iii. Questionnaire Survey
iv. Computer Simulation

4.2. Sharjah Climate

UAE has a desert climate, in summer the weather is very hot and sunny and in winter the weather is very mild. Humidity coming from Persian Gulf make the heat in UAE unbearable. UAE share boundaries with the Persian Gulf and Arabian sea. The annual perception is concentrated and high in winter months and is below 100 millimeters in remaining seasons. The rain is very rare, and it occurs in form of downpours or showers, but in can be intense in winter season. The country is comprised of seven emirates Umm al-Quwain, Sharjah, Ras al-Khaimah, Dubai, Ajman and Abu Dhabi. Since the selected schools are in Sharjah this research will focus on geography of Sharjah (ThoughtCo, 2018).

Sharjah emirate is located on the west coast of UAE. This city is linked from both sides, Indian Ocean on one side and Arabian sea on other side. On east coast, the city has 3 provinces known as Kalba, Khor Fakkan and Dibba Al Hisn including Sir Abu Nu'air and Abu Mousa islands. Sharjah covers a

total area of 2,590 km² (1,000 mi²) of UAE. From November to April, the weather is warm and humid (low), days are sunny days and evenings are cool. In November, the average high temperature is 30.9°C and the average low temperature is 16.4°C. And in April, the average high temperature is 34°C and the average low temperature is 18.3°C. From May to September Sharjah city experience humid and hot climate, the temperature during day time reach to 43°C and 25°C at night time. (Sharjah.com 2018). All data's are collected from Figure 4.1. (Maps 2018)

Figure 4 1 Sharjah city can be seen using Google Maps (Author 2018)

4.3. School Building's and their sites

All schools are in Sharjah city. Schools were selected based on building age, location and gender differences. The old schools were build before 30 years and the new schools were build before five years. As shown in Figure 4.2, all schools are located in residential area of Sharjah, the new schools are located nearby each other in an area separated area away from old schools; these schools are also located close to each other, in a separate area. The study was conducted in four secoudry public schools, School A (girls school-old building), School B (boys school- new building), School C (Boys school-old building) and School D (girls school-new school building), refer to Table 4.1 1. (School building). One class from each school was selected for further investigation and measurement, each class consist of 25 students. All the four schools had the same design concept, courtyards in middle of each building.

Table 4.1 1 School Buildings

Gender	Old Building	New Building
Girls School	**School A**	**School D**
Boys School	**School C**	**School B**

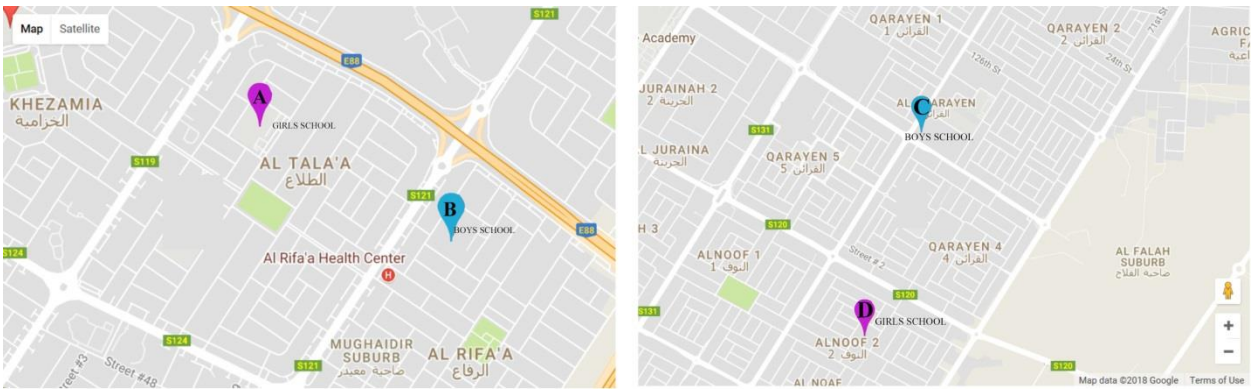

Figure 4 2 Al Talaa elementary school for girls (A), Mohammaed Al Fatah elementary school for boys (C), Abdallah Al salem elementary school for boys (B), and Al Nouf secondary school for girls (D) (Website, 2018)

4.4. Walk through Investigation

The walkthrough investigation was conducted in all the four schools in order to analyze the indoor environmental condition in schools. This phase consist of observation and interviews with the student, nurses and environmental health teachers. The most important feature of this phase was the visual evaluation of indoor environmental conditions in school buildings. Documents and data relating to school architecture, indoor environment and mechanical systems were collected and recorded. A checklist table was used to ensure that all research requirements are being fulfilled. The tools used for this phase were laptop; check list paper and a camera. The information was gathered with the help of schoolteachers.

4.5. Questionnaire

Questionnaire was used to analyze the IEQ in school buildings. The aim of this phase was to identify the impact of indoor environment on student's health. This questions focuses on the following parameters: IAQ, temperature, light quality, acoustic environment and students health and comfort, refer to Figure 4.3 (Questionaire sample).

The questionnaire was prepared in two languages, English and Arabic questionnaire. As most participants used Arabic as their first language. And it was distributed among school students only. The handouts were distributed for grade eight students. From each school four classes were selected, each class consists of 25 students. However, 100 handouts were handed for each school. Only grade 8 students were allowed to fill up this questionnaire. This survey consist of the following questions:

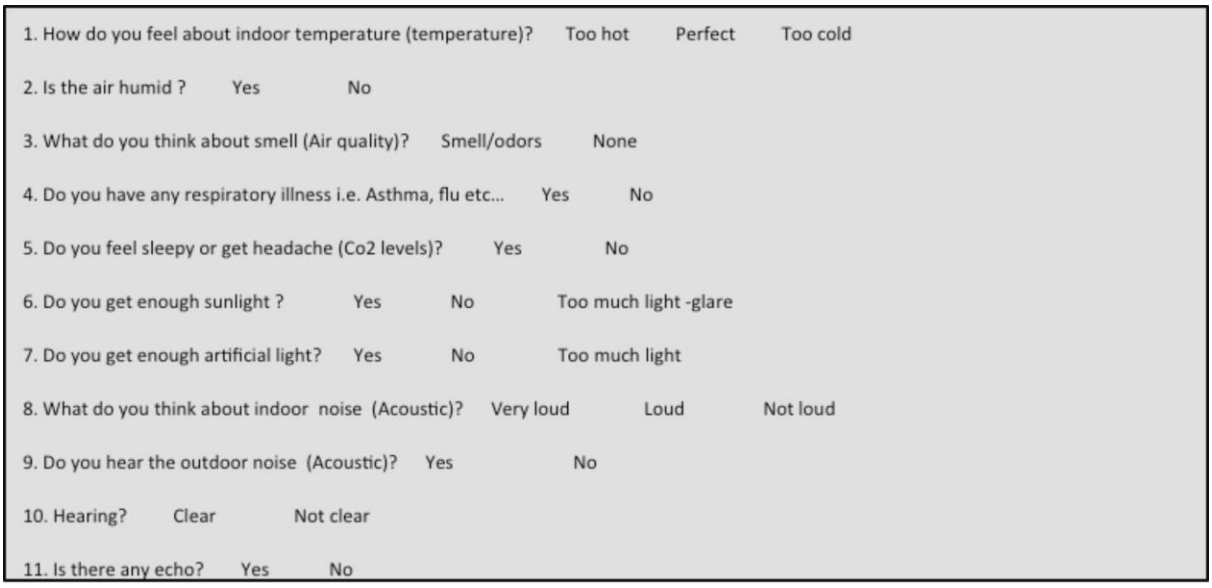

Figure 4 3 Questionnaire Sample

4.6. Field Investigation

A Field investigation was conducted in all the four schools; the aim of this phase was to measure the indoor environmental parameters with the help of equipment's. These tools were used in classroom's to measure the IAQ, light quality and sound level. The IAQ equipment is able to measure the temperature, humidity level, CO2 levels, wind velocity, wet bulb and dry bulb. The light-measuring

tool can measure the artificial light and the natural light in a space. The sound equipment is able to measure the noise level in a space. Four main instruments were used to measure the indoor parameters:

i. Extech CO240
ii. Extech 45170
iii. Sound Level AlertModel sl130g
iv. Powerlock Measuring tape

Extech CO240

Extech CO240 is an Air Quality Meter and it's easy to use, this meter is used to measure the indoor humidity, air temperature and carbon dioxide levels in air. It can also calculate the wet bulb and Dew point. The CO2 level can be measured precisely when placed in enclosed area (TECH, 2018). This device also helps us to understand weather the air ventilation functions properly or need to be adjusted. This device was used during the field investigation phase and was place in classroom to identify the humidly, air temperature and CO2 levels in a classroom.

Extech 45170

This device is 5-in-1 Environmental Meter with CMM/CFM. The Extech 45170 is used to measure light, temperature, humidity, airflow and air velocity (TECH, 2018). During field investigation the 5-in-1 meter was used to measure air velocity and natural and artificial light. The device was placed on student's desk's to check the lux level in classroom. The instruments was places near the windows or below interior lighting to check if light in classroom is sufficient for students to complete their tasks.

Sound Level Alert Model sl130g

The sound level alert was used to monitor the indoor sounds. The sound level will be shown on a small screen. This device was used to check the indoor sound level in classes; the device was placed in each classroom. The device was used in both cases: when classroom was occupied and when class was unoccupied. This instrument was placed on teacher's desk.

Power lock Measuring tape

The measuring tape was used to measure the size of the classroom such as room height, width and length.

4.7. Computer Simulation

The computer software was used to draw the floor plan and a Reflected Ceiling Plan (RCP) for each classroom. With the help of Archicad helped us to analyze the RCP of each classroom. The dimension is same for all classrooms in all the four schools. All classroom's are similar in length and width, the only difference is in ceiling level.

4.8. Limitation of the study

There were several limitations with the present research. These limitations must be solved in order to achieve effective results and enhance future researchers for further investigations.

- Seasonal study was required. The research was conducted on November only , further analysis is required during other seasons of the year in order to achieve more précised results.
- Only four public school s among all school in Sharjah welcomed the investigation
- In school A it was very difficult to measure some of the IEQ parameters such as IAQ, because students move from class to class.
- In School C, the measurements were done within less time due to school administrations directions.
- Few questionnaire handouts were eliminated from the analysis, since some students didn't take it seriously.
- School buildings did not provide mechanical and architectural drawings; the comparison and assessment could be easy if full set drawings were available.
- Teacher's comfort was disrupted when putting the instruments in middle of the room.
- Photos not allowed to be taken in female schools due to religion, traditions and customs. Sine majority of students and teachers are Muslim's.

5. Results

The final results were achieved after analyzing the IEQ of selected classrooms in each school. Results from walkthrough investigation, field measurement, questionnaire and computer simulation are discussed below:

5.1. Walkthrough investigation

The walkthrough investigation was conducted in selected classrooms of all four schools. The impact of IEQ has been analyzed and described below. The critical components were identified with the help of final results. Most of the designated classrooms had similar materials and indoor furnishing. They also had a similar type of students chair and desk, constructed from steel and plastic (polypropylene). The desks of the teachers were made from pressed wood and the chairs are made up of plastic, steel and fabric. The selected classrooms are similar in terms of painted finish walls. The classrooms flooring and ceiling is different in old schools and the new schools. The classrooms in old schools had ceramic flooring (School A and C) and paint finish ceilings (School A only). Whereas, classrooms in school B and D have linoleum flooring and gypsum board ceilings. In addition, all four schools uses smart teaching system, so all classrooms consist of projector, smart screen and marker boards for further explanations. All classrooms are similar in terms of volume and layout. One classroom was selected from each school.

The field measurement was conducted in grade 8 only. The room volume is same in all four schools, that is around 48.m.sq. The questionnaire survey was distributed to grade 8 students. The age of grade eight girls is between thirteen to fourteen years old. Each classroom contains between 25 to 30 male students. The working hours for all schools start from 8:30 am and ends at 3:30 pm and classrooms are cleaned after students leave the classes. In all four schools students move from class to class based on subject lessons.

5.1.1. School A

Walk Through of School A

Al Tal'aa School is located in residential area as shown in Figure 5 1 (Website 2018). This school is only for female students and it consist of 547student. The total number of the students was around 95 pupil's. school consists of one-story building, parking area in front on the building (at the entrance) and a small courtyard in center of the building. The age of the school building is around 40 years. But in 2016 maintenance was done for the whole building. The measurement was conducted on Nov 6, 2017. Painting and renovation of classrooms took place during December 2016 on winter vacation. The mechanical systems were replaced completely with new ones. Maintenance for air conditioning system takes place every 3 months.

Figure 5 1 School A location map (Website, 2018)

Classroom A1

All classroom of school a have same parameters and features. Due to insufficient lighting and ventilation the classroom was dull, dark and it contain of bad odors. The back noise are heard clearly inside the classroom's, this includes: sounds of students playing in courtyard, bird sounds and sounds from adjacent classroom. The classroom ventilation system is comprised of 3 large windows, 6 small windows, 1 split air-conditioning system and 2 ceiling fans. The large windows are always closed and covered with fabric curtains. During the investigation, the door only was used as natural ventilation. The fans were turned off. The artificial lighting was the main source of lighting system in classroom.

The classroom walls were painted light green and consist of 6 small window opening located high on wall. The volume of the small window size is 0.25 m.sq. These windows are tinted and closed. Due to their location they are shaded with the roof of building. During the visit, the students complain from headache.

School clinic was visited and the school nurses were interviewed during investigation to collect data relating to students health. According to school-clinic records, 9 students suffer from asthma, 2-3 students daily suffer from tonsillitis, headache and influenza. Asthma increases in school because the air-conditioning filters are dirty and are not cleaned frequently. The fungus from air-condition filters can cause negative effect on students health. Moving students from class to class increased the symptoms of tonsillitis, headache and influenza because classroom environment is very cold as compared to the outdoor air.

5.1.2. School B

Walk through School B

As shown in Figure 5 3. (Website 2018) this school is located in Al Qarayen 3 area. This area is surrounded by residential homes from one side and school buildings from other side. School B is situated on a corner and can be accessed from two roads. This building was built in 2015. And accommodates 487 male students. It consists of two-story building, parking area and a courtyard in the center of the building. The parking area is located in front area, close to main entrance. Classrooms on the ground floor open to courtyard. The measurement was conducted on Nov 12, 2017.

Figure 5 2 School B location map (Website, 2018)

Classroom B1

The investigated classroom is located on second floor of the building. The classroom consists of 3 large windows, artificial light and central air conditioning system. Through walkthrough investigation several issues were noticed: classrooms were cold, there was excess of light (both artificial and natural light) and high reverberation time due to high ceilings. The classrooms walls were painted with light beige paint, which led to reflection of light and glare. Students move from class to class through out the day.

5.1.3. School C

Walk through School C

As shown in Figure 5 4. (Website 2018) , school C is situated in Al Riffaa area in Sharjah, for male students. There are 208 students in this school. School building is surrounded by residential homes from all 3 routes and it can be accessed from the main road. This school consists of one-story building, parking area and a courtyard in center of the building. The classrooms are located around the courtyard area. School C is a new school building. Measurement was conducted on Nov 7, 2017.

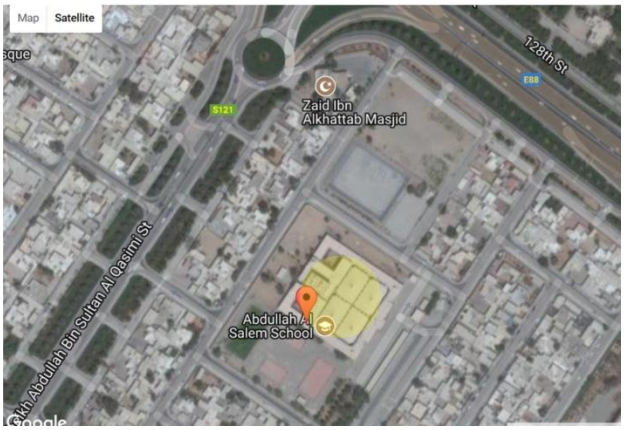

Figure 5 3 School C location map (Website, 2018)

Classroom C

The classroom consist 2 split air-conditioning system and 3 window openings. Classroom looks clean and bright. And it consists of both artificial light and natural light. The lower part of the windows is tinted with frosted vinyl. Due to inadequate mechanical and natural ventilation the classroom is very smelly and has bad odors. The acoustic condition seems to be poor since outdoor sounds are heard clearly during lesson time. The classroom walls were painted beige in color.

According to school clinic reports, school nurse reported that the case of asthma is being widely spread among students because student are playing in outdoors area and outdoors are very hot. There are also daily reports from students suffering from headache, influenza and dizziness

5.1.4. School D

Walk through School D

As shown in Figure 5 4. (Website 2018), al Nouf School is located in Sharjah, for female students only, it consists of 728 student's. The school consists of two-story building, parking area in front of the building (at the entrance) and a small courtyard in center of the building. Age of school building is only 5 years. During investigation school building was dull, dark and smelly. Students play in the indoor area they have no access to the outdoor area. The measurement was conducted on Nov 12, 2017.

Figure 5 4 School D location map (Website, 2018)

Classroom D

The selected classrooms are located on the second floor. And they consist of 3 large windows, artificial light and central air conditioning system. During investigation the classrooms were dark, and students didn't allow to turn -on the artificial light because they get eye irritation. Students complain from excess of light when they turn on the artificial light since they get more natural light from windows. Students seating in middle row suffer from insufficient light whereas, students seating near windows complain from excess daylight. As a result, natural light increased the indoor air temperature and made classrooms hot. Due to insufficient ventilation the classrooms are hot and smelly. The background noises are heard clearly during the lesson. The students and vehicle noise are heard inside the classrooms.

School nurses were interviewed to identify student's health problems. According to school nurses student always complain from headache, fever, throat pain, flu and coughing. Large number of students suffers from Asthma and vitamin D deficiency. The viruses and disease are spread quickly among school students because the indoor ventilation is poor in classrooms and school building, no natural ventilation.

5.2. Field investigation

The field measurement was conducted in one classrooms from each school. Different instuments were used inorder to measure the indoor parametres this includes; air temprature, relative humidity, air

velocity, CO_2 level, lighting and acoustic conditions. Four main devices were used during field investigation: Extech CO240, Extech 45170, Sound Level AlertModel sl130g annPowerlock Measuring tape, thiese devices were used to measure the indoor parameters of classroom.

6.2.1. School A

The classroom was occupied between 9:00 am to 12:00 pm, the maximum indoor temperature was 25.8˚C at 10:00am and the minimum indoor air temperature was 23˚ C at 12:00 pm. On the other hand, the maximum relative humidity (RH) was 50% and minimum RH was 40%. As shown below, the temperature falls to 23˚C when classroom is unoccupied and rises to 25.8˚ C when it's fully occupied. Humidity and temperature increases when class is fully occupied. Whereas, the RH fall to 40 % and temperature decreases to 23˚ C when classroom is empty. During monitoring time the outdoor temperature was 28˚ C. The outdoors temperature has an influence on indoor air temperature, refer to Figure 5.6. (School A indoor air temperature).

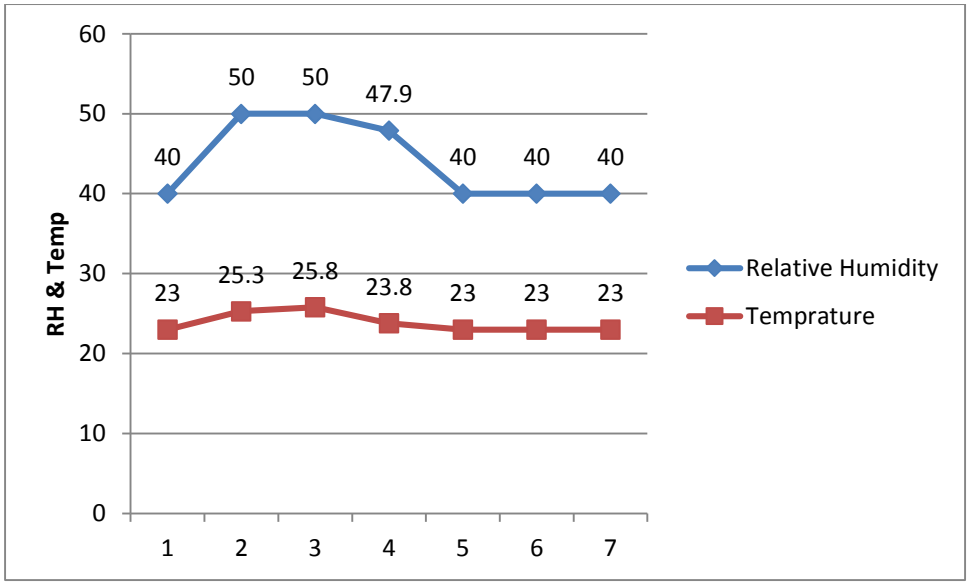

Figure 5 5 School A indoor air temperature

When room is full the CO_2 level is between 689 ppm to 713 ppm and falls to 597 ppm when classroom is empty. Monitoring was conducted during class lesson's, without inclusion of any physical activity. The students are in their positions. When student opened the classroom door for natural ventilation the total CO_2 level increased to 713 ppm. Furthermore, the CO_2 level fell to 597 ppm at 12:00 pm because the classroom was empty, , refer to Figure 5.7. (School A CO2 level) .

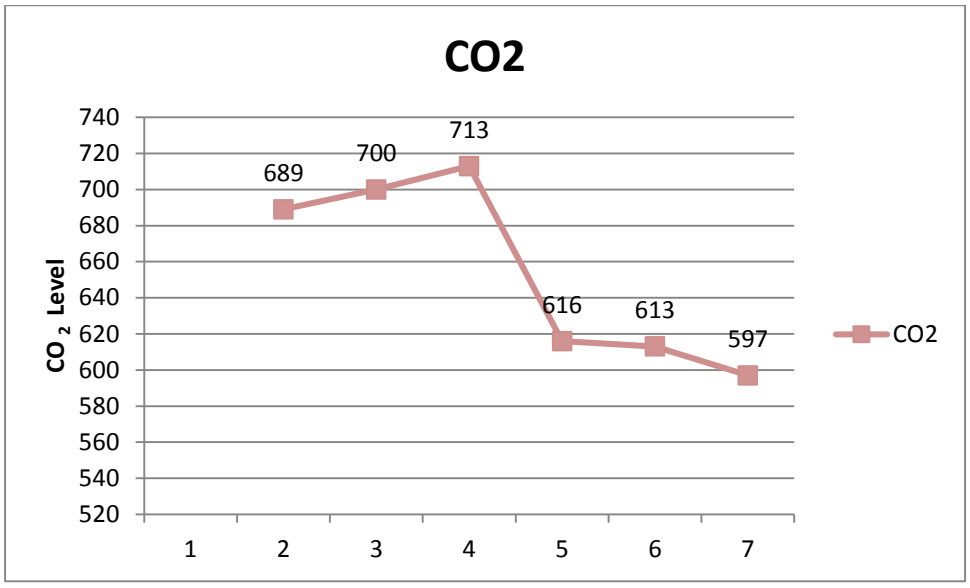

Figure 5 6 School A CO2 level

Forewords to lighting parameter, the indoor windows were covered with fabric curtains. Artificial light or ceiling light was the main source of light for students in classroom. The instrument showed 350 lux (maximum artificial light) when placed on desk under artificial light, desk was located in middle of room. Whereas, light level increases from 350 lux to 405 lux because of presence of small opening located high on wall, as mention in previous section, this opening allow the transmission of daylight in to the classroom.

As shown in Figure 5 8 (School A RCP plan) this classroom consists of four fluorescent lights, 3 large windows and four small windows. The indoor light is insufficient because the number of the fluorescent light s limited.

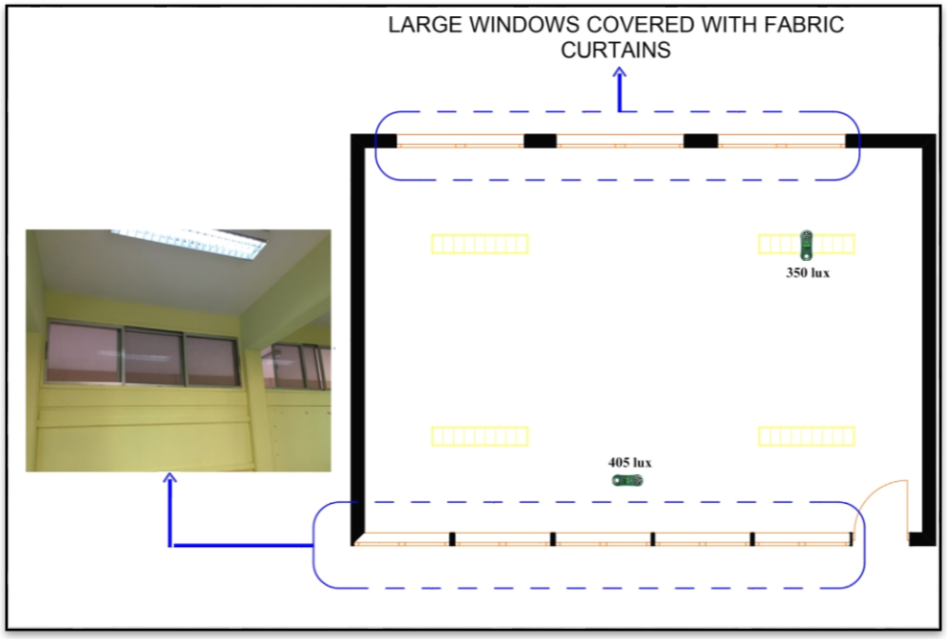

Figure 5 7 School A RCP plan

The background noise was very clear during lesson time. The instrument scale was adjusted on 30 -80 Decibel (db). When classroom was occupied the noise level was between 72.9 to 80.6 db, the noise level change when students participate in class and when ventilation system is turned to switch-on mode. Because of the background noises the sound level is 58.5 db when classroom is empty . Background noises consist of bird sounds. The ventilation system was turned-off when monitoring unoccupied classrooms, refer to Figure 5 9. (School A sound level).

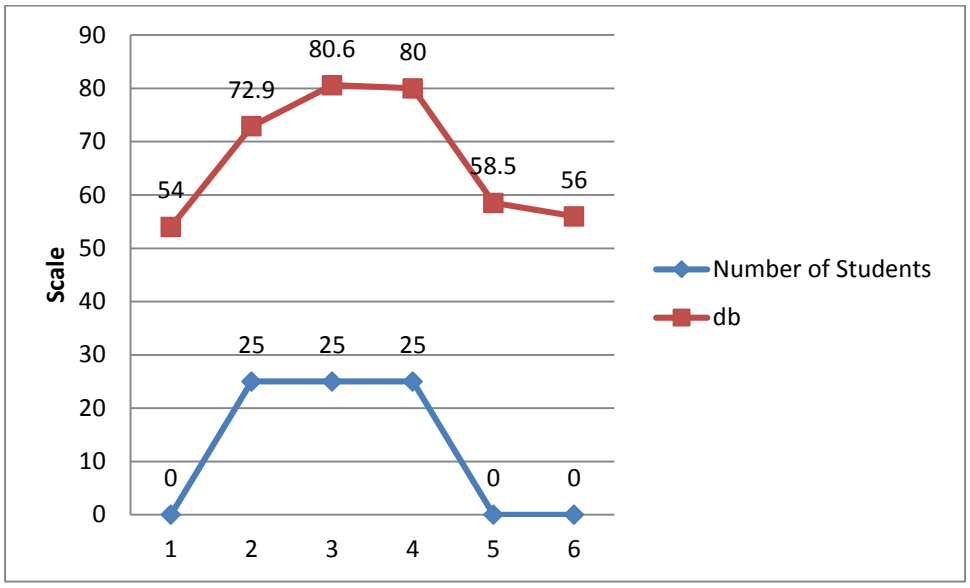

Figure 5 8 School A sound level

5.2.2. School B

Due to school administration rules, the classrooms were monitored for five hours only, when class was occupied.

The maximum indoor temperature was 25.6 ˚C at 10:00am and the minimum indoor air temperature was 24.4 ˚C at 12:00 pm. On the other hand, the maximum relative humidity (RH) was 40.9% and minimum RH was 38.7%. During monitoring time the outdoor temperature was 28˚ C. The outdoor air temperature can influence the indoor air temperature. As shown below, when the temperature increases the RH decreases and vice versa. The maximum RH was 40.9 % when the temperature was 24.4˚ C, refer to Figure 5 10. (School B indoor air temperature) .

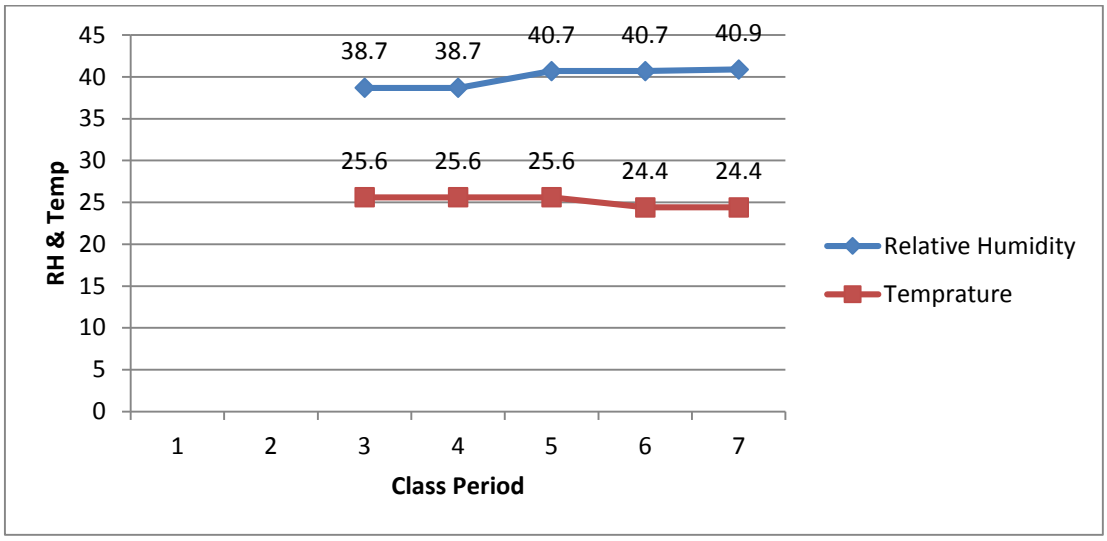

Figure 5 9 School B indoor air temperature

When classroom was full the total CO_2 level was between 2846 ppm to 3100 ppm. The students were seated in their positions, without inclusion of any physical activity. Movement of students towards teacher desk and opening and closing classroom door increased the CO_2 level in classroom. The instrument showed 3100 ppm when it was placed on a desk located near to split air-condition system, refer to Figure 5 9. (School B CO2 level).

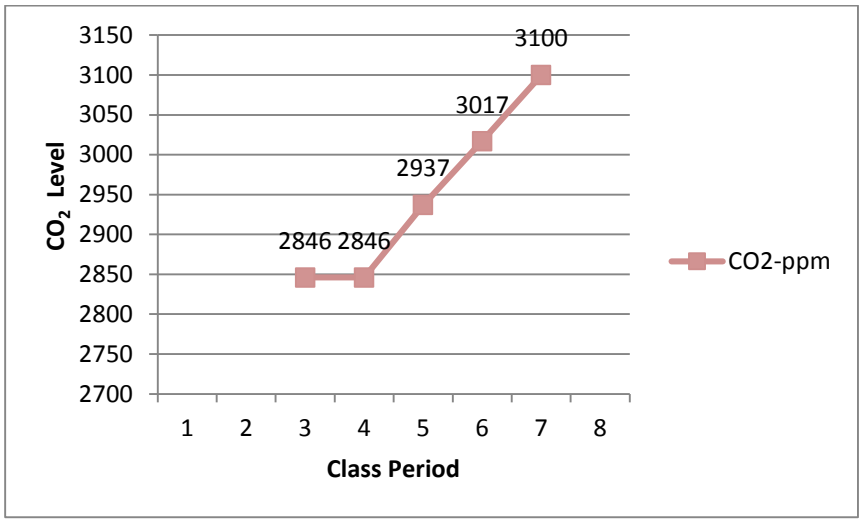

Figure 5 10 School B CO2 level

Foreword to lighting parameter, the classrooms in school B consist of four large windows, which allow the entrance of daylight. But two of the windows were covered with fabric curtain. Both natural light and artificial light or ceiling light was used in classroom.

The lighting instrument was positioned on student's desk in 2 different locations, when the device was placed near the window it showed a reading of 748 lux, the reading changed to 817 lux when placed in center of the room under artificial light. Below diagram shows Reflected Ceiling Plan (RCP) of Classroom B1. Each classroom consist of six 60*60 cm fluorescent lights as shown in Figure 5 12 (School B RCP).

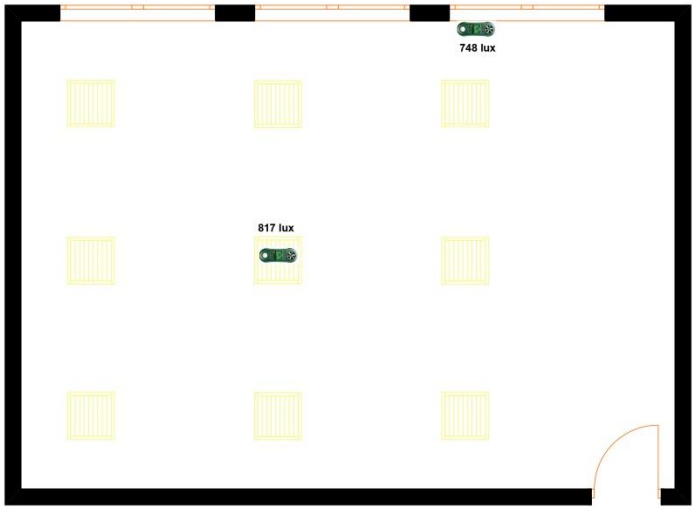

Figure 5 11 School B RCP

Since the classes are located on the second story, the outdoors noises i.e. vehicles and birds noise are not very clear except the noises within the school building can be heard clearly. The below readings is for occupied rooms only. Due to several factors' the classroom noise was between 73.6 to 73.9 db, this factor includes: teaching, noise from ventilation system and students participating in class. Because of high ceilings, the classrooms consist of high reverberation, refer to Figure 5 13 (School B sound level).

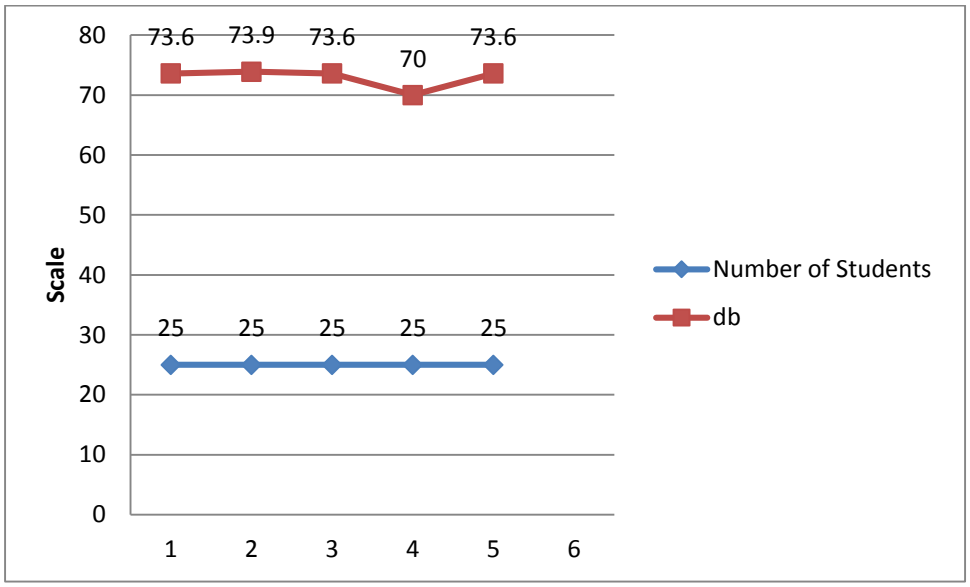

Figure 5 12 School B sound level

5.2.3. School C

The classroom was occupied between 11:00 am to 1:00 pm; during this period the indoor temperature was between 25.8 ˚C to 26.5˚ C, the RH was 42.5%. The indoor air reach its maximum when students open classroom door, at this moment, the temperature increases to 26.5˚ C and RH increases to 48%. Whereas, in empty classroom the indoor air temperature fall to 24.9˚ C and RH to 40 %. As shown below, the temperature falls to 24.9 ˚C when classroom is empty and rises to 26.5 C when it's occupied. During measuring time, the outdoor temperature was 25 ˚C, refer to Figure 5 14. (School C indoor air temperature).

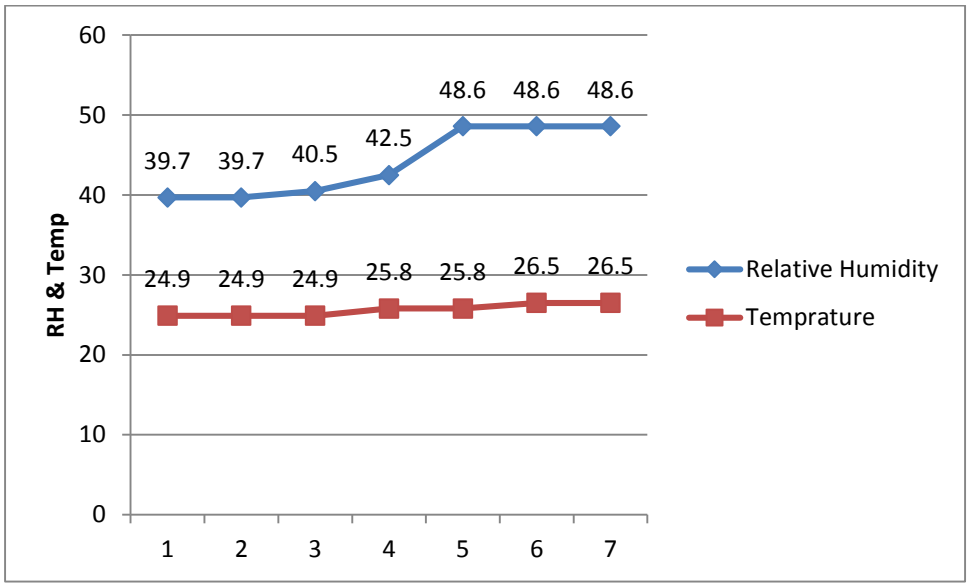

Figure 5 13 School C indoor air temperature

At 8:00 am and when the classroom was empty the CO_2 level was 3000ppm. And when classroom get occupied the CO_2 level raised to 3281 ppm. As showed below, the CO2 level can be influenced by number of students present in classroom. The CO_2 level falls to 3133 ppm when number of student's decreases, only five students were present in classroom. Furthermore, CO_2 level also increases when students open classroom door or when students move inside class refer to Figure 5 15. (School C CO2 level).

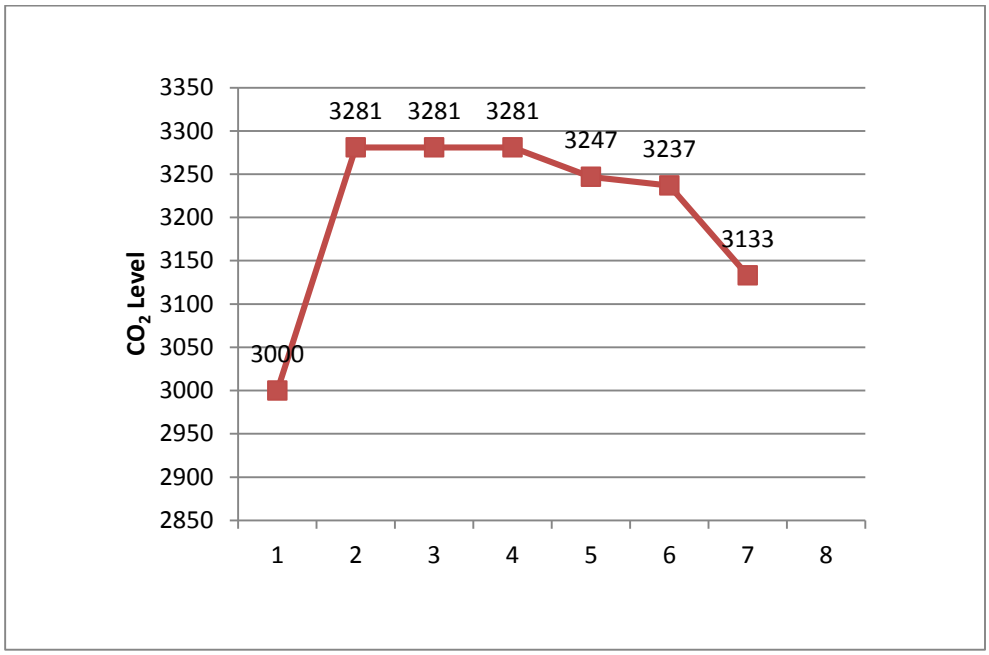

Figure 5 14 School C CO2 level

Foreword to lighting parameter, this classrooms use mixed mode lighting system – both artificial light and daylight. The classroom consists of four large windows to allow daylight to pass through the room. Artificial light or ceiling light is also used because the daylight is insufficient; the natural light is concentrated only on desks located near the window opening. Whereas, students located far from windows depend on artificial light to complete their tasks.

Lighting instrument was placed on student's desks in 3 different locations (i) near window (ii) under artificial light (iii) Far from artificial light and natural light. The device showed a reading of 440 lux when placed near window, 743 lux when placed under artificial light and 362 lux when placed far from artificial and natural light.

Below Figure 5 16. (School C RCP) shows Reflected Ceiling Plan (RCP) of Classroom C1. This classroom consist of six 60*60 cm fluorescent lights, the distribution of light is same in all four rooms.

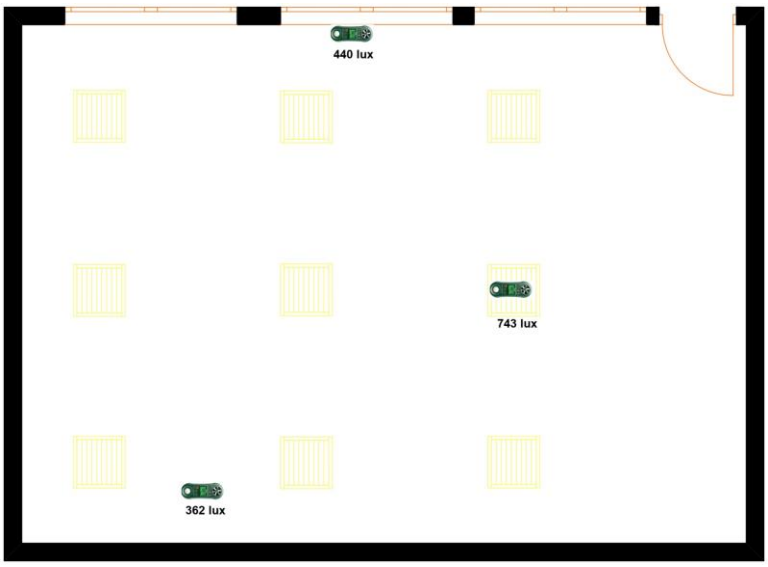

Figure 5 15 School C RCP

The background noise was very clear during lesson time. The instrument scale was adjusted on 30 - 80Decibel (db). Once the classroom was occupied the noise level was between 69.6 db to 74.9 db, the noise level is unstable. Several factors can affect the indoor sound level; this includes students participating in class, ventilation system, students playing outdoor and absence of acoustic materials. Due to background noises the reading even 52.6 db, even though the classroom is empty, refer to Figure 5 17. (School C sound level).

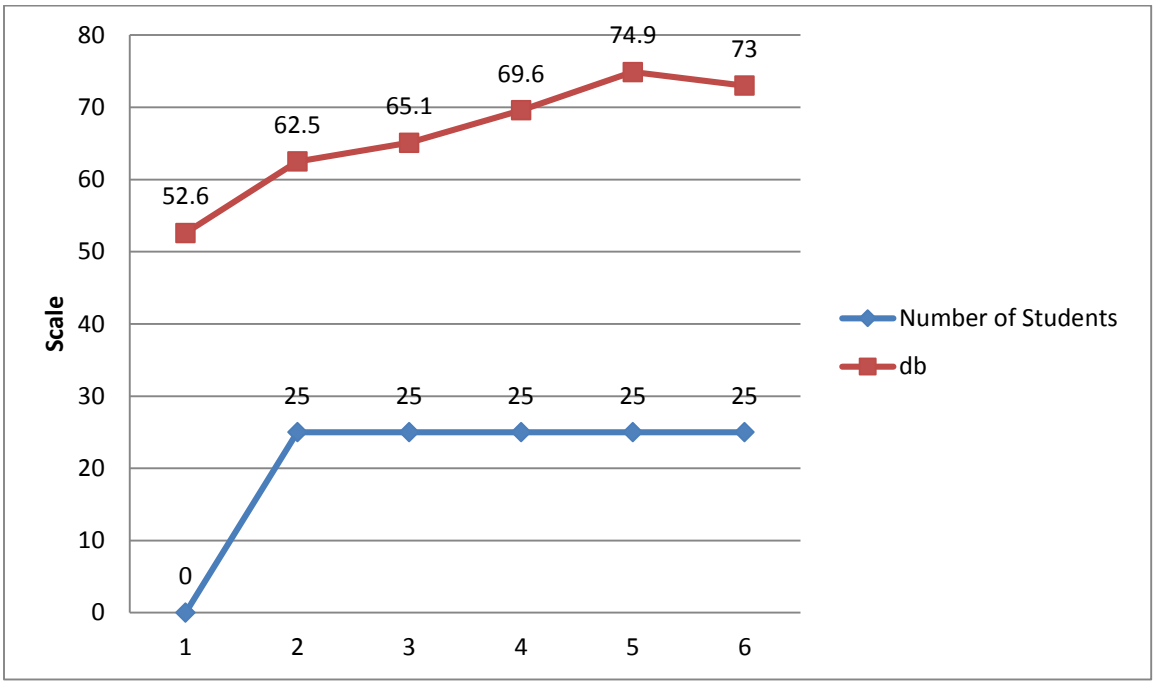

Figure 5 16 School C sound level

5.2.4. School D

The classroom was occupied from 8:00 am to 12:00 pm and from 2:00 pm to 3:00 pm, the maximum indoor temperature was 27.2˚ C and the minimum indoor air temperature was 24.5 ˚C, the number of students present in class had influenced the indoor temperature. On other hand, the maximum relative humidity (RH) was 60.5% and the minimum RH was 50%. Between 10:00 am to 12:00pm the RH and indoor temperature range its peak, because the class at this time was completely occupied by students and teachers. Whereas, the RH fall to 50 % and temperature decreases to 24.5˚ C when the classroom gets empty. During monitoring time the outdoor temperature was 26 ˚C , refer to Figure 5 18. (School D indoor air temperature).

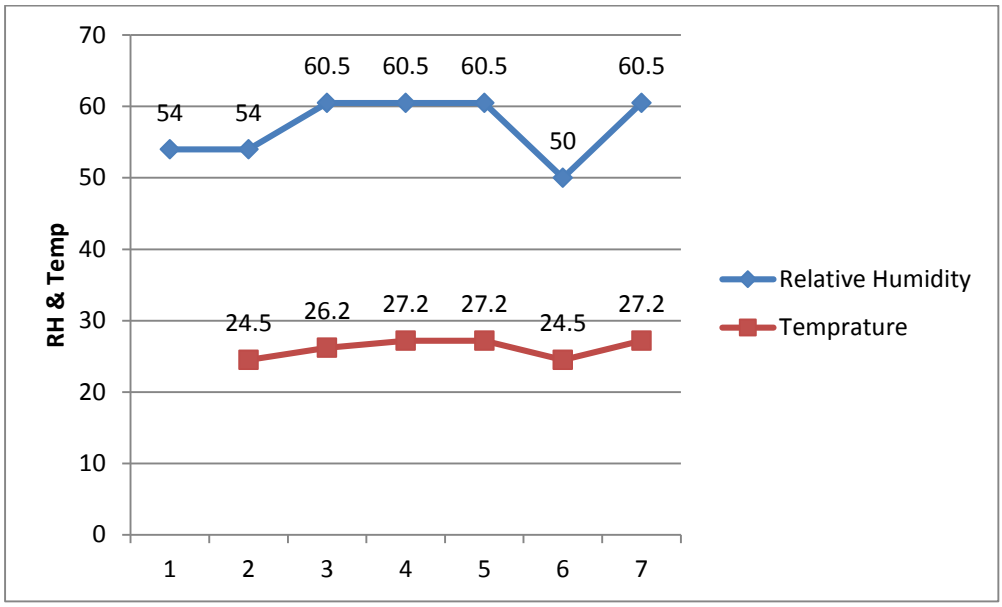

Figure 5 17 School D indoor air temperature

When classroom is full the CO_2 level raises to 2156 and falls to 1900ppm when students leave the class. As shown below, the CO_2 level can be influenced by number of students present in class. The CO2 level falls when number of students decreases. Moreover, the CO2 level also increases when students open the classroom door or and when students move inside class, refer to Figure 5 19. (School D CO2 level) .

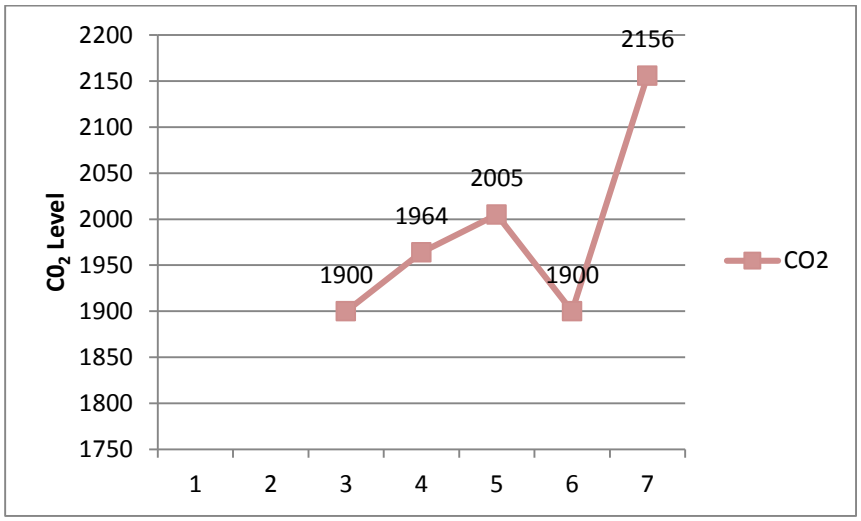

Figure 5 18 School D CO2 level

Foreword to lighting parameter, this classrooms use daylight only. The classroom consists of four windows that allow the sunlight to pass through the room. Student in classroom switch-off artificial light due to excess daylight. Students get eyestrain from artificial light. The daylight disturbs the students located near the window opening. Whereas, students located far from windows suffer from insufficient daylight and absence of artificial light.

Light instrument was placed on student's desks in 2 different locations (i) near window and (ii) under artificial light. The device showed a reading of 432 lux when placed near window and 816 lux when placed under artificial light.

The below Figure 5 20. (School D RCP) shows a Reflected Ceiling Plan (RCP) of Classroom D1. The classroom consists of six 60*60 cm fluorescent lights.

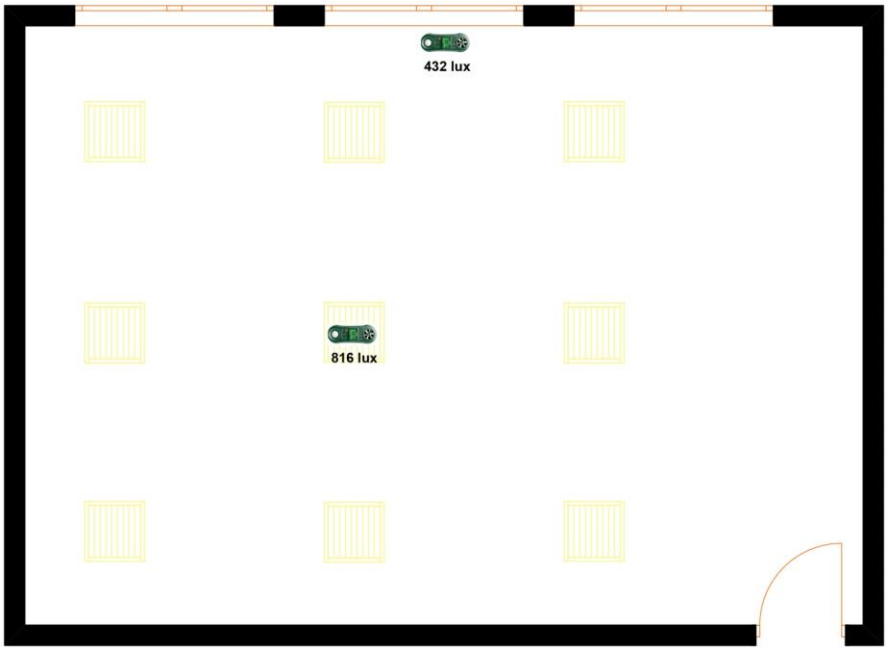

Figure 5 19 School D RCP

The background noise was very clear during lesson time. The scale of instrument was adjusted on 30-80 Decibel (db). Once the classroom was occupied the noise level was between 78.6 db to 80 db, the noise level is unstable. Several factors can affect the indoor sound level; this includes students participating in class, ventilation system, students playing outdoor and absence of acoustic materials. Due to background noises the reading is 56 db, even when the classroom is empty. The classrooms also consist of high reverberation, refer to Figure 5 21. (School D sound level).

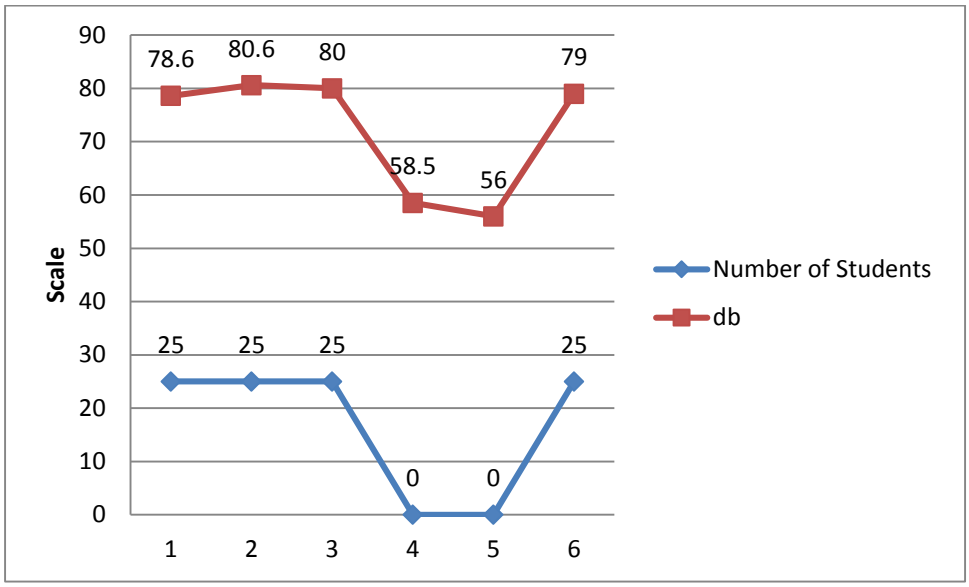

Figure 5 20 School D sound level

5.2.5 Comparison

The indoor air temperature for school A and B was close to Dubai municipality requirements. The CO_2 concentration in all schools exceeded the suggested level except school A the CO_2 concentration was below the suggested level. All school failed to meet the requirements suggested for light and sound, dB and lux levels were very high in all school. As results, the indoor environmental conditions in all schools is poor and need to be improved in order to reduce the impact on students health and performance. All data's are described below in Table 5.1 1(IEQ in school A, B, C and D).

Table 5.1 1 IEQ in school A, B, C and D

Schools	IAQ	CO_2 Level	Lighting	Indoor Noise
School A	Min Temp-23 ˚C Max Temp-25.8 ˚C	Max CO2-713 ppm Min CO2-597 ppm	A.L- 350 lx N.L- 405 lx	Max I.N- 80.6 dB Min I.N- 56

	Max RH-50% Min RH-40%			dB
School B	Min Temp-24.4˚C Max Temp-25.6˚C Max RH-40.9% Min RH-38.7%	Max CO2-3100 ppm Min CO2-2846 ppm	A.L- 817 lx N.L- 748 lx	Max I.N-73.9 dB Min I.N-70 dB
School C	Min Temp-24.9˚C Max Temp-26.5˚C Max RH-48.6% Min RH-39.7%	Max CO2-3281 ppm Min CO2-3000 ppm	A.L-743 lx N.L- 440 lx	Max I.N- 74.9 dB Min I.N- 52.6 dB
School D	Min Temp-24.5˚C Max Temp-27.2˚C Max RH-60.5% Min RH-54%	Max CO2-2156 ppm Min CO2-1900 ppm	A.L- 816 lx N.L- 432 lx	Max I.N- 80.6 dB Min I.N- 56 dB
Dubai Municipality Recommendations				

Indoor air temp should be within 22.5˚C to 25.5˚C RH should be within 30% to 60%	The CO_2 concentration should not exceed the 800ppm	Light level should be 300 lux	Sound level should be 35dB

5.3. Questionnaire

The questionnaire survey was conducted in all the four schools; it was distributed among grade 8 students only. Total of 400 copies were printed, 100 prints was given for each school. But a total of 367 copies were received back from schools, 3 were lost and 30 were not answered because students were absent. In all school, the questionnaire was distributed with the help teachers. The survey consists of ten questions. The questionnaire is divided into four sets, set 1 consist of question relating to IAQ condition, set 2 is related to students health, set 3 consist of light question and set 4 contain questions related to noise issues. During survey, some of questions were not answered correctly because students did not understand the meaning of this question. IEQ question relating to humidity, background noise and echo were answered incorrectly by student because such parameters cannot be understood or even felt, especially when student doesn't have any background related to such topics. However, device was used to measure the impact of such parameters on student's health and performance.

5.3.1. School A

In school A, one hundred prints was handed out to health environment teacher, 93 copies were received back from school. Total of 7 students were absent during survey. Below graph shows how students feel when exposed to indoor environment. As we can see below more than half of students in class complain from following issue: background noise (64%) and headache and dizziness (63%). As a result, these two factors can disrupt student's attention and reduce their performance. Thus, developing the acoustic condition can reduce the negative impact.

Set 1- Around 10% of students felt hot, 45% felt warm, 38% felt cold, 29% felt the air was humid and 38% smell bad odors in class, refer to Figure 5 22. (School A questionnaire-set 1).

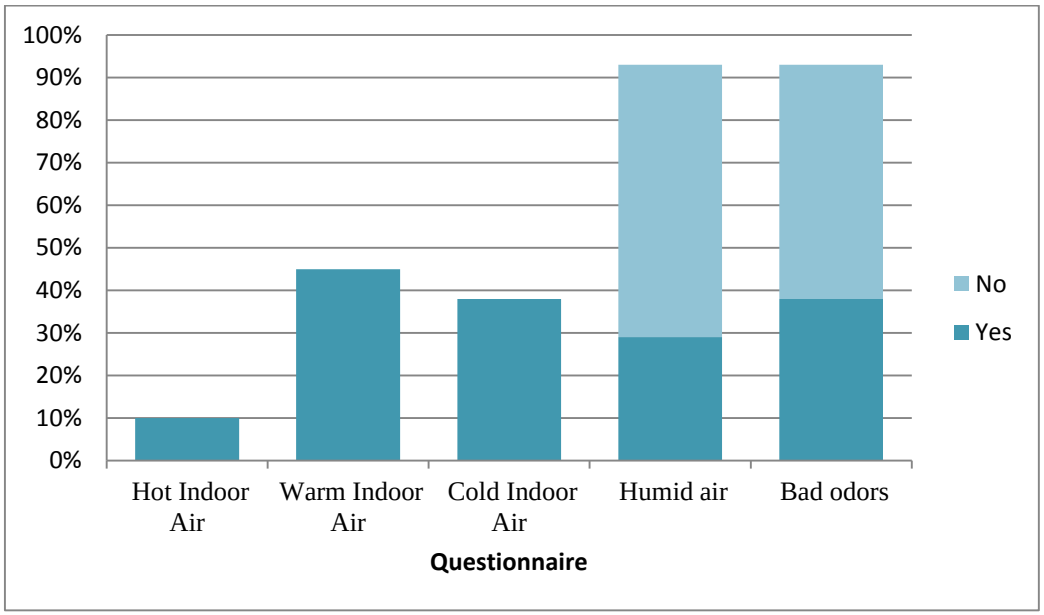

Figure 5 21 School A questionnaire-set 1

Set 2 - This set consist of questions relating to student health. About 10% of students suffer from respiratory illness such us flu and asthma and 63 % suffer from headache and dizziness, refer to Figure 5 23. (School A questionnaire-set 2)..

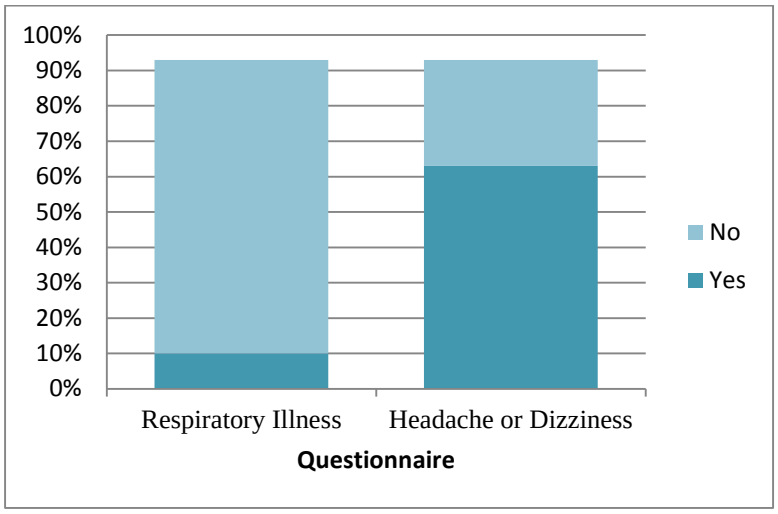

Figure 5 22 School A questionnaire- set 2

Set 3 - Around 54% of students are happy with daylight and 38% are pleased with artificial light. On the other hand, 24% of students complain from excess daylight and 15% criticize form excess artificial light, refer to Figure 5 24. (School A questionnaire-set 3). .

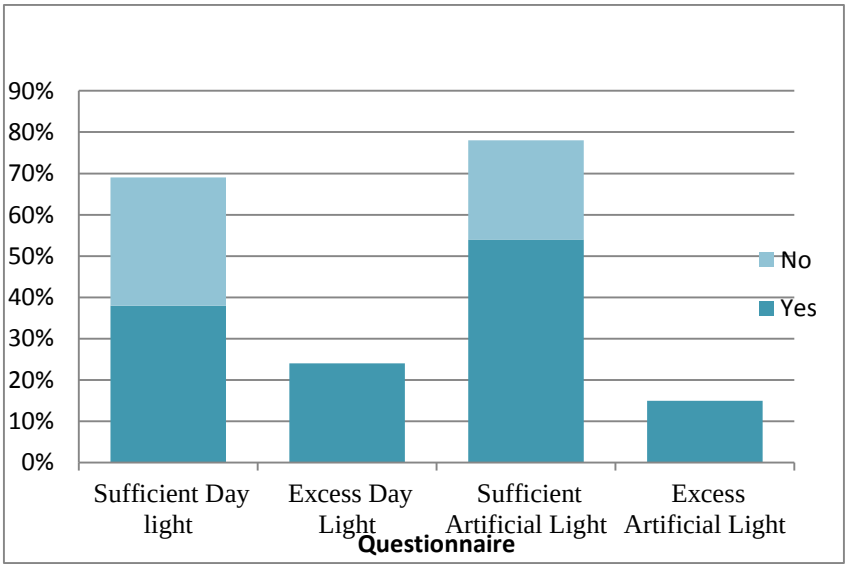

Figure 5 23 School A questionnaire- set 3

Set 4 -This set contains acoustic questions. About 64% of students criticize background noises, 15% hear background noise and 11% complain from echo in class. And, the last part of this set was answered incorrectly due to the limited knowledge of students, refer to Figure 5 25. (School A questionnaire-set 4).

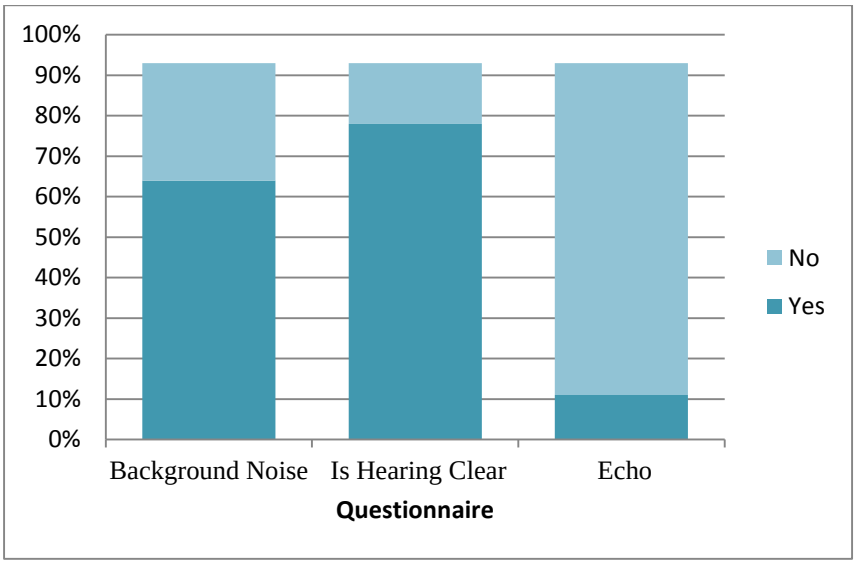

Figure 5 24 School A questionnaire- set 4

5.3.2. School B

Total of 90 prints were received back from school B. The rest 10 copies were not filled up because students were absent. Factors that affect student's comfort and performance have been identified with the help of questionnaire survey. The below figure shows majority of student complain indoor air temperature and background noise, 50% of students felt the classroom was cold and 42% were annoyed by background noises. As a result, the IAQ and acoustic parameters should be improved to reduce negative impact on students' comfort, health and performance.

Set 1 - This set consist of IAQ questions. Around 4% of students felt hot, 44% felt warm, 50% felt cold, 16% felt the air was humid and 24% smell bad odors in class, refer to Figure 5 26. (School B questionnaire-set 1).

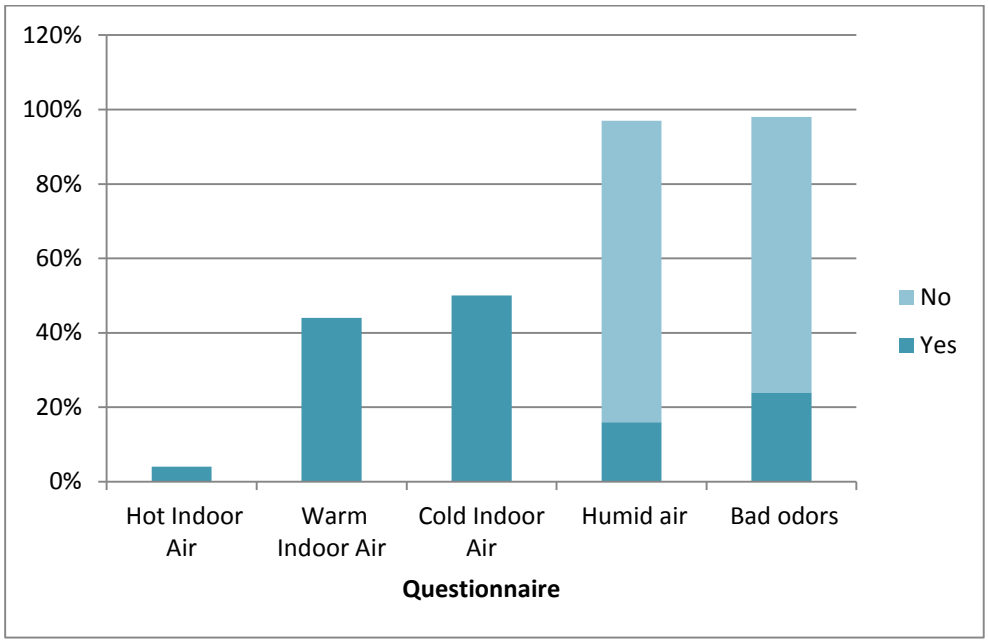

Figure 5 25 School B questionnaire –set 1

Set 2 - About 7% of students suffer from respiratory illness such us flu and asthma and 31 % suffer from headache and dizziness, refer to Figure 5 27. (School B questionnaire-set 2).

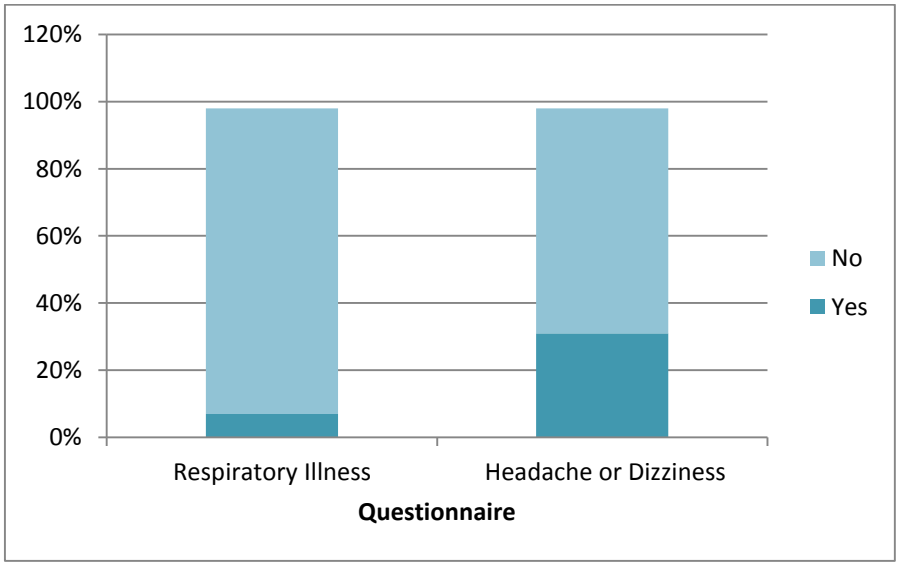

Figure 5 26 School B questionnaire- set 2

Set 3 - This set includes question relating to artificial and natural light. Around 40% of students of are happy with daylight and 55% are pleased with artificial light. On the other hand, 21% of students complain from excess daylight and 6% complain form excess artificial light, refer to Figure 5 28. (School B questionnaire-set 3).

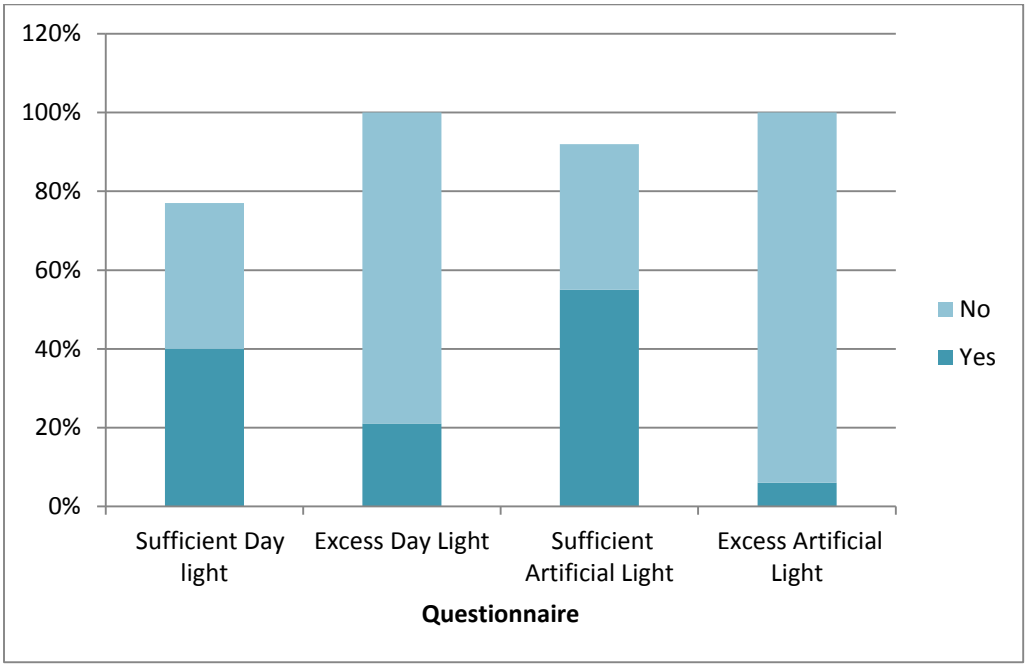

Figure 5 27 School B questionnaire- set 3

Set 4 - About 42% of students complain from background noise, 11% heard background noise and 14% complain from echo in class. The last part of this set was answered incorrectly due to the limited knowledge of students , refer to Figure 5 29. (School B questionnaire-set 4).

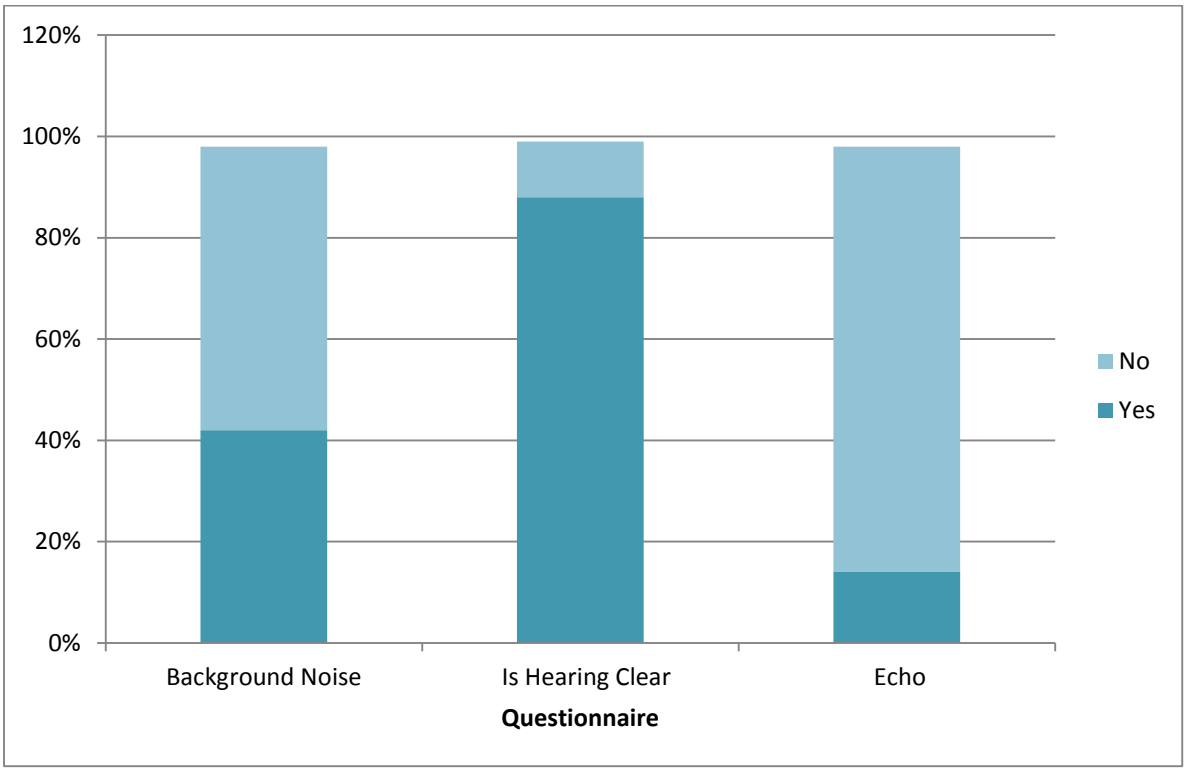

Figure 5 28 School B questionnaire- set 4

5.3.3. School C

In school C only 86 students answered the questionnaire survey. Total of 14 students were absent during survey. Below graph shows the impact of indoor environmental condition on student's health and performance. As we can see below, Due to poor IAQ, majority of students in school C complain from various issues such as hot indoor air (43%), bad odors (50%), headache and dizziness (54%) in class. As a result, impact of thermal environment can reduce student and teacher performance.

Set 1 - Around 43% of students felt hot, 15% felt warm, 28% felt cold, 32% felt the air was humid and 50% of students smell bad odors in class, refer to Figure 5 30. (School C questionnaire-set 1).

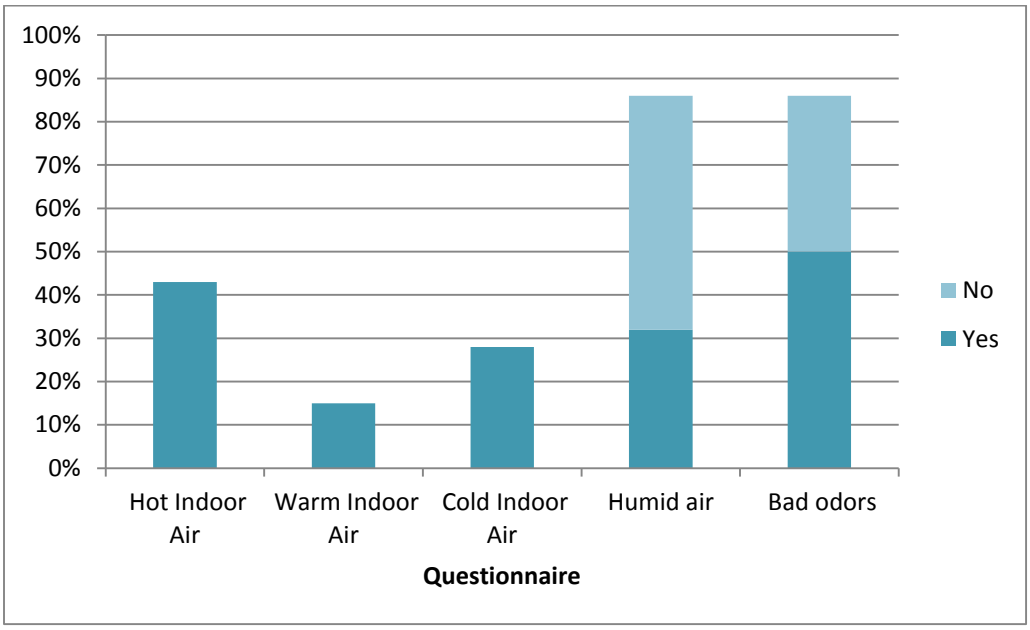

Figure 5 29 School C questionnaire- set 1

Set 2 - This set consist of questions relating to student health. About 17% of students suffer from respiratory illness such us flu and asthma and 54 % suffer from headache and dizziness. Number of students complaining from respiratory illness and headache and dizziness is high because of high concentration of CO2 level in classrooms, the CO2 level in this school was 3237 ppm refer to Figure 5 31. (School C questionnaire-set 2).

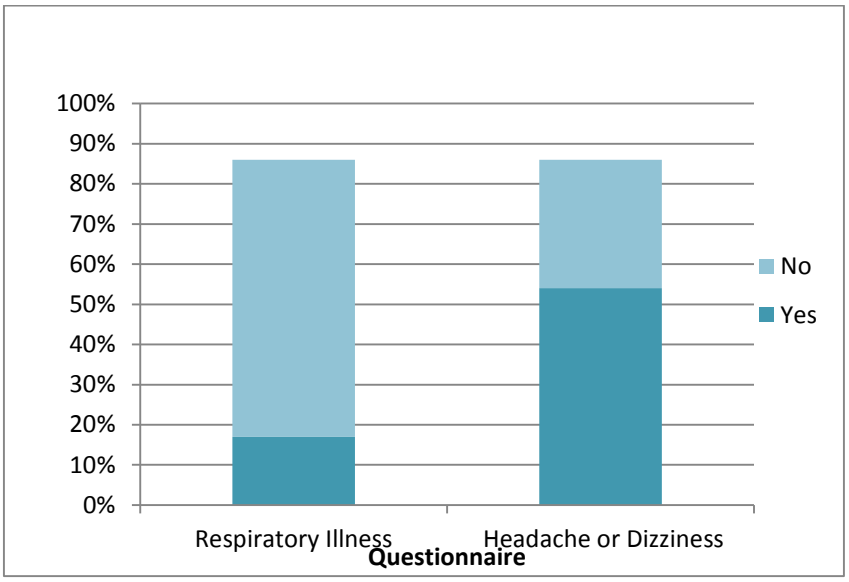

Figure 5 30 School C questionnaire- set 2

Set 3 - Around 40% of students of are happy with daylight and 42% are pleased with artificial light. On the other hand, 8% of students complain from excess daylight and 12% complain form excess artificial light refer to Figure 5 32. (School C questionnaire-set 3).

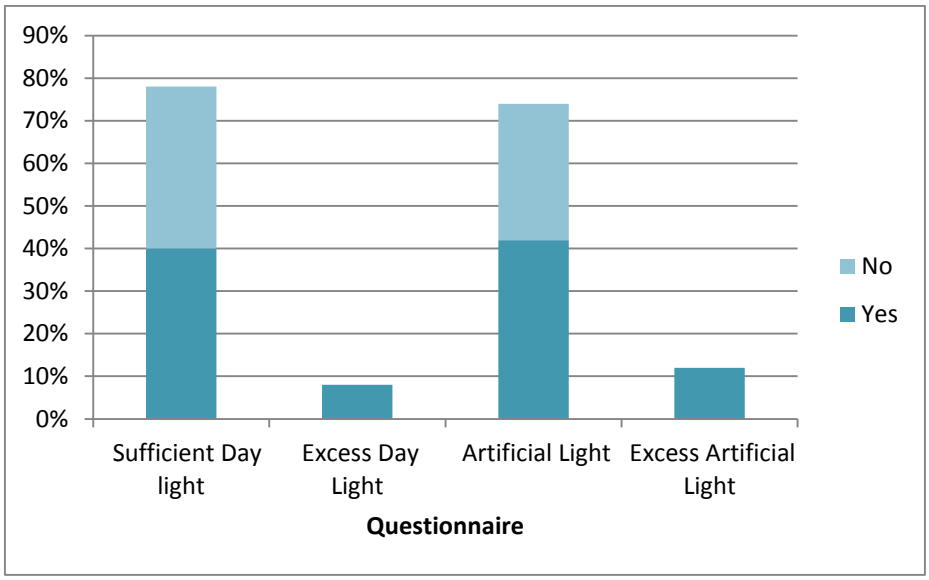

Figure 5 31 School C questionnaire- set 3

Set 4 - This set contains acoustic questions. About 58% of students complain from background noise, 40% heard background noise and 30% complain from echo in class. The last part of this set was answered incorrectly due to the limited knowledge of students refer to Figure 5 33. (School C questionnaire-set 4).

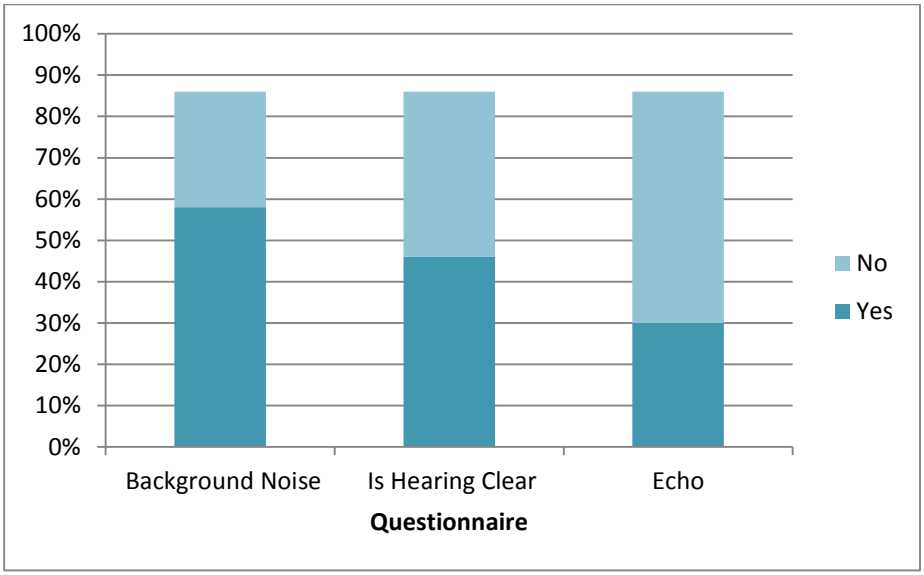

Figure 5 32 School C questionnaire- set 4

5.3.4. School D

Total of 90 questionnaire copies were received back from school B. The rest 10 copies were not filled up because students were absent. Majority of student in school D complain hot indoor air (48%) and loud background noises (47 %). As a result the acoustic condition and in IAQ must be improved to enhance student's performance.

Set 1 - Around 48% of students felt hot, 33% felt warm, 9% felt cold, 21% felt the air was humid and 49% of students smell bad odors in class, refer to Figure 5 34. (School D questionnaire-set 1).

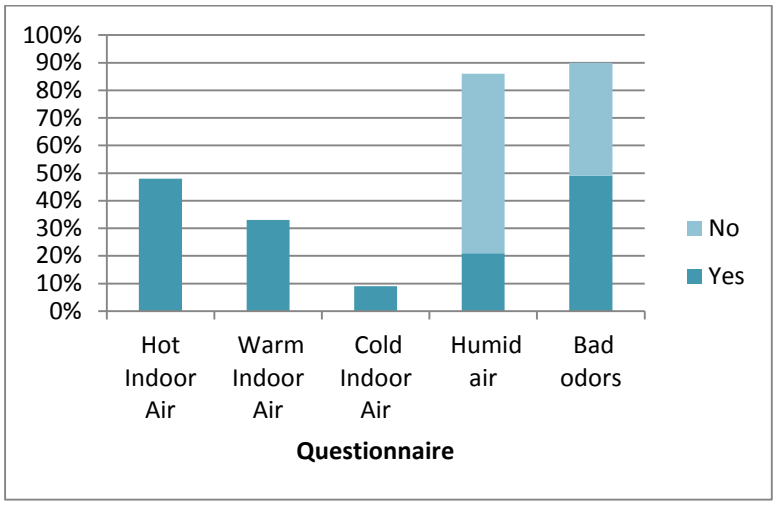

Figure 5 33 School D questionnaire- set 1

Set 2 - This set consist of questions relating to student health. About 12% of students suffer from respiratory illness such us flu and asthma and 47 % suffer from headache and dizziness. Number of students complaining from respiratory illness and headache and dizziness is high because of high concentration of CO2 level in classrooms, the CO2 level in this school was 2156 ppm, refer to Figure 5 35. (School D questionnaire-set 2).

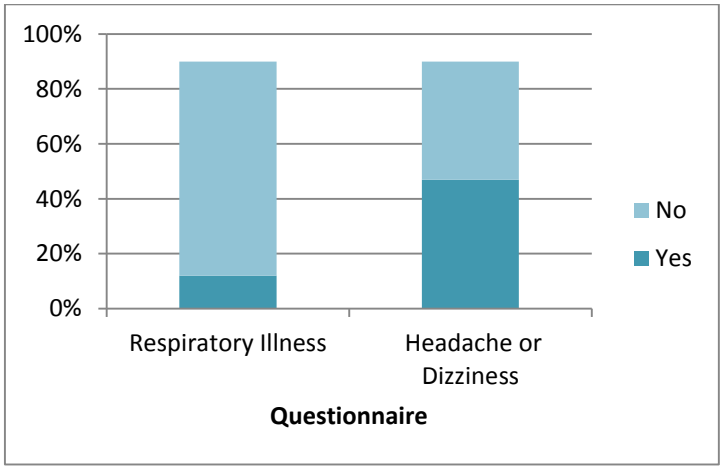

Figure 5 34 School D questionnaire- set 2

Set 3 - Around 59 of students of are happy with daylight and 61% are pleased with artificial light. On the other hand, 7% of students complain from excess daylight and 6% complain form excess artificial light, refer to Figure 5 36. (School D questionnaire-set 3).

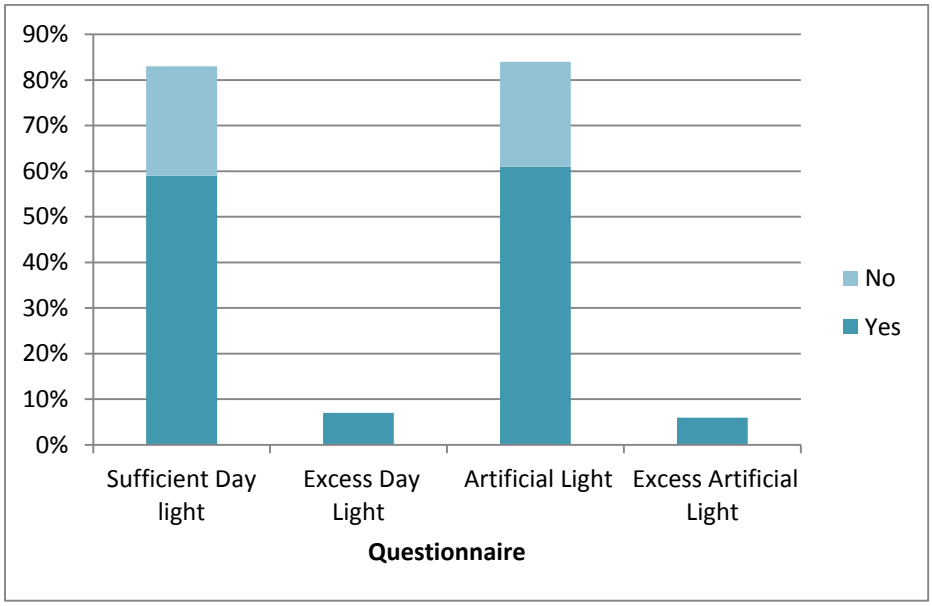

Figure 5 35 School D questionnaire- set 3

Set 4 - This set contains acoustic questions. About 47% of students complain from background noise, 10% heard background noise and 9% complain from echo in class. The last part of this set was answered incorrectly due to the limited knowledge of students, refer to Figure 5 37. (School D questionnaire-set 4).

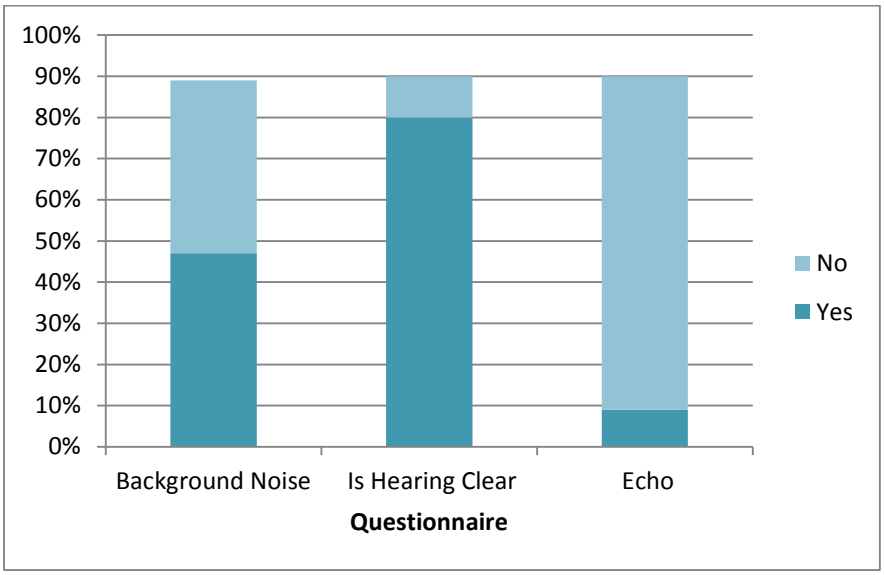

Figure 5 36 School D questionnaire- set 4

5.4. Computer Simulation

Various computer software's and programs were used in this research, in order to collect and analyze the final results. The data of this report was collected from different resource such as EBSCOhost research database, Google map, Google scholars and Google image. Microsoft word 2012 was used to document the collected data and to put all them all together in same format. Archicad 2015 software was used to the draw floor plans and identifies the space volume for each room. Furthermore, Cad 2015 software was also used to show the distribution of light (RCP) along with the location of each device on RCP plan. And finally, Microsoft Excel 2012 software was used to create the statistical analysis.

6. Discussion

Four identical classrooms were selected from four different public schools of Sharjah, these rooms were investigated during winter season. The rooms were measured in order to study the influence of IEQ on student's health and performance. Schools were selected with regard to building age and student gender. This report analyze and compare the indoor environmental conditions of new school buildings and old school buildings in Shrajah, it highlights the importance of building architecture and age with regard to IEQ in a classroom . Two male schools and two female schools were selected to study the effect of IEQ on gender differences. The main conclusion is that poor IEQ can cause a negative impact on student's health and performance and can disrupt student's comfort level. As a result, appropriate measurements should be implemented in schools to improve the indoor the environmental parameters in order to achieve healthy and safe environment for students and teachers.

Questionnaire survey showed that female students express thermal dissatisfaction more than male students, this finding was similar to Aries et al. (2010) study. Questionnaire survey showed that female students expressed lower satisfaction levels across the IEQ factors. Even though the indoor air temperature was similar in all schools, students in School D were unsatisfied with the indoor temperature as compared to school B, this is because the occupants were female students, School B is male's new school and D is female new school. However, the thermal comfort response of males and females is also associated with clothing (clo).

Moreover, female students also complain from background noises and bad odors. The background noises were usually reported by female students more than male students, even though school locations were similar: For instance school A is located close to school C and school B is located near to school D. Even though, indoor acoustic condition was better in female schools as compared to male schools, the female students still complain from high background noise, school A 64% and school D 47%, as compared to male schools B 58% and C 42% only. In addition, 38% of female students in school A and 49% of female students in school B complain from bad odors. These findings was similar to Kim et.al and Zalejska-Jonsson and Wilhelmsson (2013) findings when they observed that female occupants are highly sensitive to poor indoor environment conditions as compared to male occupant.

Questions associated with health symptoms showed that both male and female occupants suffer from SBS, this finding does not match with kim et.al and Schellen et al. (2013) study when he indicated that thermal comfort sensation and SBS are highly felt among males than females. According to this research, SBS can be felt by both genders and can cause health impact for both male and female occupants.

According to field investigation, the indoor air temperature and the relative humidity is similar for all the four schools, in school A the max temp was 25.8 and the RH is 50%, in school B the max temp was 25.6˚C and the RH is 40.9%, in school C the max temp was 25.8˚C and the RH is 48.6% and in school D the max temp was 27.2˚C and the RH is 60.5%. According to Dubai municipality standard the temperature level in schools must be between 22.5˚C to 25.5˚C and the RH should be within 30% to 60% (Dubai Municipality, 2010). The maximum indoor temperature in all school was higher ten 25.5˚C, as a result high temperature can affect students' performance and health, since bacteria and fungus will grow quickly under high temperature levels which can result in various health symptoms. All new schools and old schools experience similar indoor air temperature even though the air-conditioning system in old schools is different from new school.

Also, ventilation plays an important role in indoor environment. Dhalluin and Limam 2014 stated that inadequate ventilation could create uncomfortable environment, cause SBS and increases indoor air pollutants in schoolrooms which results in absenteeism. Results achieved during investigation period was similar to Dhalluin and Limam findings, for instance: Firstly, inadequate ventilation raises the CO_2 level in all classrooms, the maximum CO_2 concentration in school A was 713 ppm, 2156 ppm in school B, 3281ppm in school C and 3100 ppm in school. The recommended level for CO_2 should not exceeded 800ppm (Dubai municipality 2010) according to Dubai municipality. The CO_2 in all classrooms exceeded the recommended level. High CO2 levels polluter the indoor environment and results in negative impact on students health and performance such as headache. Secondly, insufficient ventilation is also responsible for student's headache and dizziness, when CO_2 level raises the number of students complaining from headache and dizziness also increases, this issue can result in low productivity and high rate of absenteeism among school students. Number of students complaining from headache and dizziness according to questionnaire survey, school A 63%, school B 31%, school

C 54% and school D 47%. School A is rated the highest in terms of headache and dizziness, although the CO_2 level is very low in this school as compared to other schools. This is because there are other factors such as ventilation, bad odors, material finishes, transportation, level of occupancy and building age and architecture and can contribute to CO_2 levels, this results in headache and dizziness in students. This result is similar to Norbäck, Nordström and Zhao study when they founded that headache, dizziness and tiredness reduces significantly when levels of CO_2 decreases in classrooms. Thirdly, Basu and sammet stated that poor ventilation could increase respiratory illness such as asthma and flu, number of students complaining from respiratory illness were as follow: school A 10%, school B 7%, school C 17% and school D 12%. The respiratory illnesses are widely increasing among students due to poor ventilation and dirty air filters. Finally, insufficient ventilation can cause bad odors inside classrooms. Number of students complaining from bad odors was similar in both old and new school buildings. Students complaining from bad odors were slightly higher among old school than new schools. In old schools 78 student and in new school's 73 students complain from these bad odors. This shows that all four schools have poor indoor ventilation system. Thus, insufficient ventilation must be treated to avoid or reduce the harmful impacts on student's health productivity.

Polluted indoor schools can cause short and long-term health problems for both teachers and students. In both old and new school buildings, large number of students suffers from various diseases. Students in old schools suffer from asthma, flu, dizziness, headache, and tonsillitis and skin symptoms. Whereas, large number of students in new school buildings suffers from continuous flu, eye irritation and other contagious diseases because schools are completely enclosed and have high CO2 levels. The viruses and diseases spread quickly and widely among new school students because classrooms and other part of school building such us assembly point and sports area depend on mechanical ventilation system only. in new school buildings the NV system is totally absent and MV system is inadequate or insufficient to meet student's requirements. These results are similar to Zhangzu findings when he demonstrated that lack of maintenance, poor air conditioning units and type of ventilation system can increase students health problems.

Fluorescent white lighting was used in all the four schools. School A depends on artificial light, school B and C consist of natural light and artificial light whereas, school D consist of natural light only,

artificial light was always switched-off. School A consists of 350 lux that is considered to be the lowest in terms of natural lighting as compared to other schools. Lighting in school A was not applied in a studied manner, they are placed randomly. On the other hand, school B consist of 817 lux, rated the highest in terms of artificial lighting, refer to Figure 6 1.(Artificial light and daylight comparison in school A, B, C and D). According to Dubai municipality, the recommended lighting level should not exceed 300 lux (Dubai Municipality, 2010), but unfortunately not even a single school fulfilled the Dubai guidelines. Whereas, students in school B and D switched-off the light all time since they get eyestrain and migraine when they use both artificial and natural light together. However, students seating in middle of class suffer from insufficient lighting and feel discomfort because they are seating far away from natural light, they can't use both artificial lighting and natural lighting. These results are similar to Boyce finding when he stated that artificial lighting radiation can cause discomfort, eyestrain and migraine if not applied in a studied manner.

Boyce discovered that day lighting is must in indoor environment since power of light can influence human health, performance, behavior and mood, the final results for this reports were similar to Boyce and Meola study for instance: student in classroom A1 feel out of mood and sleepy this is because the daylight inside the classrooms was insufficient for students, this issue can effect students mood which results in low-productivity. Whereas students in classroom D1 felt discomfort because heat from daylight raises the indoor air temperature in classrooms, which results in high indoor temperature. Students in school B, C and D complain from high indoors temperature, glare and eyestrain due to excess day light in classrooms. Thus, excess daylight can reduce performance and effect mood and health. Moreover, students in new school building (school C and D) suffer from calcium and vitamin D deficiency because the schools are enclosed and students are not exposed to sunlight. As a result, the power of light can have an impact on human health, performance, behavior and mood. However, no test were conducted in relation to students social behavior, thus there is no evidence that lighting can effect students behavior.

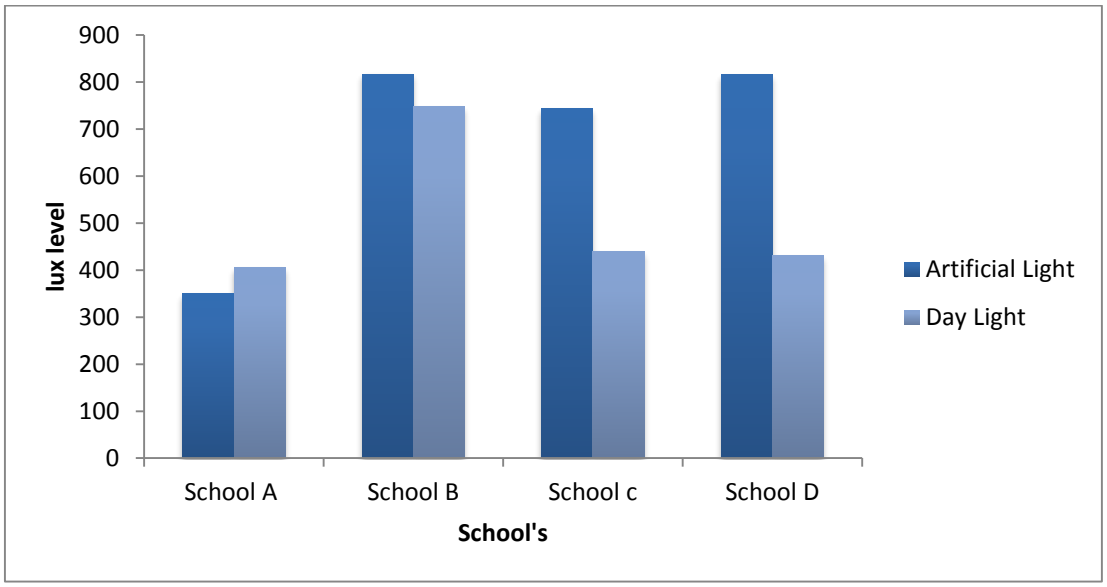

Figure 6 1 Artificial light and daylight comparison in school A, B, C and D

All four schools were located in residential area and all classrooms were similar in volume floor area. Due to high glazing percentage all school had the high indoor noise even when classroom was empty. The indoor sound level is influenced by number of students present in class, the greater the number of students the higher will be the noise level during lesson. This finding is similar to Shield et al study.

For effective learning and teaching environment, Dubai municipality recommended the indoor sound level to be 35dB. School A and D have the highest sound level (80.6 dB), when room was occupied, as compared to school B and C (73.9 dB and 74.9 dB) , refer to Figure 6 3. (Indoor noises , in unoccupied and occupied room, comparison in school A, B, C and D). All four schools didn't fulfill the sound level requirements suggested by Dubai municipality (2010). New buildings (School B and D) have high reverberation time as compared to old school buildings, due to high ceiling levels. The reverberation time increases with high room height and ceiling level (Shield et a 2015). Due to poor acoustic conditions the background noise was very high and clear in all classrooms. The background noises were measured when classrooms were unoccupied, in order to figure out the level of noises transmitting in to the room. As a result, noises disrupt student's attention during lesson time and thus this reduce students' performance.

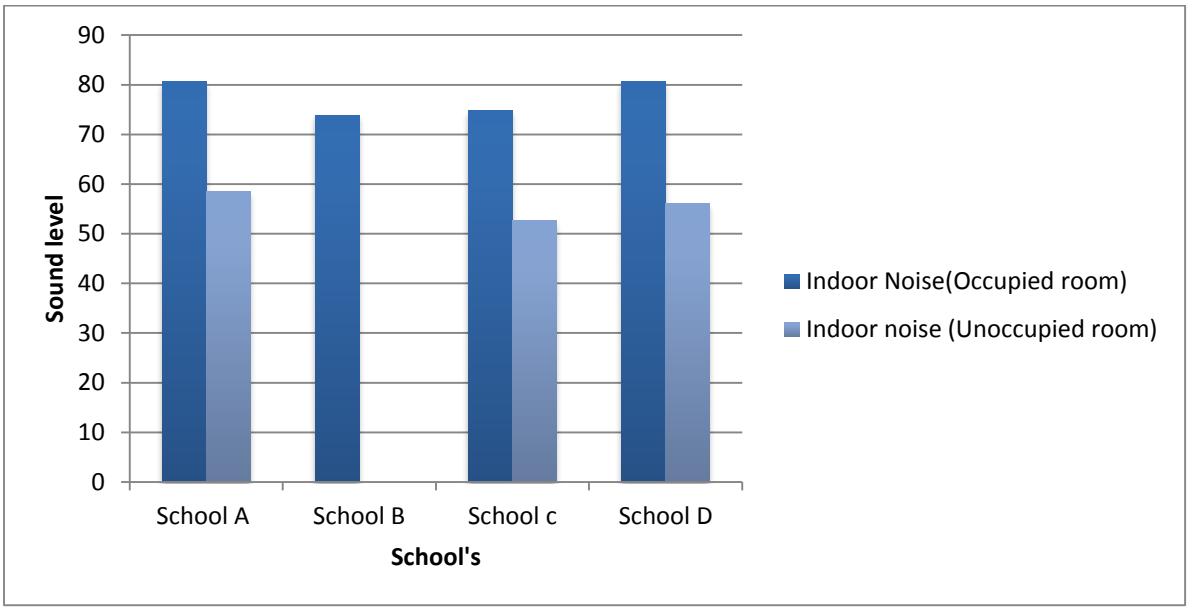

Figure 6 2 Indoor noises , in unoccupied and occupied room, comparison in school A, B, C and D

7. Conclusion and Recommendation

This study analyses the IEQ conditions of 4 public school buildings in Sharjah. According to this study, students in the studied classroom were exposed to poor indoor environmental condition with regard to thermal condition, IAQ, light and sound level. Study showed that poor IEQ condition led to negative impact on student's health and performance.

The IAQ condition includes CO_2 concentration. Maximum CO_2 level measured in the studied classrooms were 713 ppm, 2156 ppm, 3281ppm and 3100 ppm. Whereas, the CO_2 recommended by Dubai Municipality was 800 ppm. School A had the most suitable environment as compared to other schools, in terms of indoor air temperature, CO2 level, lighting and sound absorb system. Even though, school A is an old school building but still it was near to the recommended level as compared to recently build schools.

In all schools except for school A, RH and indoor air temperature was far from the recommended limits of 30% to 60% and 22.5 1C to 25.5 1C respectively. Both artificial light and natural light level in all studied classroom was above the recommended levels that is 300 lux. Artificial light in studied classroom was 350 lx, 817 lx, 743 lx and 816 lx, whereas the daylight level was as follow: 405 lx, 748 lx, 440 lx and 432 lx. The sound level measured in the studied classrooms was 80.6 dB, 73.9 dB, 74.9 dB and 80.6 dB, while suggested 35 dB for sound level. Poor IEQ led to SBS symptoms, increased student rate of absenteeism and decrease student performance and productivity.

There are very limited studies addressing the issues of poor IEQ in UAE secondary schools. This present report emphasizes on the typical IEQ conditions in UAE secondary schools in relation to suggested IEQ levels. This paper provides useful knowledge that can helpful future studies. Studies relegating to the effect of outdoor conditions on UAE classrooms should be investigated. Student's sociology and psychology should be considered while assessing the IEQ factors. More studies should be conducted to create friendly environment for students in order to improve their productivity and performance.

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