



**Evaluating Impact of the Lighting and Acoustic  
Environments on The Learning Development of  
Children with Cognitive Disabilities in Special  
Education in UAE**

تقييم مدى تأثير مستوى الإضاءة و الصوتيات في البيئة التعليمية على  
تطور المستوى العلمي لدى الأطفال ذوي الإعاقات الإدراكية في مراكز  
التعليم الخاص في دولة الامارات العربية المتحدة

by

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**A dissertation submitted in fulfilment  
of the requirements for the degree of  
MSc SUSTAINABLE DESIGN OF THE BUILT ENVIRONMENT  
at  
The British University in Dubai**

**October 2017**

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## **Abstract**

Educational facilities are one of the most important establishments in society. Schools and learning institutions have the highest density of occupants, where children spend 25% of their day in classrooms indoors. For schools, a poor IEQ can easily interfere with total learning experience of students inside the facility, resulting in discomfort & disruption of the learning experience; poor classroom conditions reduce students' performance by 30%.

With the 2015 launch of the Dubai Inclusive Development Forum, aiming to make Dubai a disability-friendly city, this study aims to bring awareness to the importance of good indoor environmental quality (IEQ) for individuals who suffer from disabilities, be it mental, physical, or emotional, highlighting the different types of limitations and restrictions that building management of special needs centers face in order to provide the optimum services to their students.

Using qualitative and quantitative analysis, as well as the human factor of students and teachers/therapists alike, the study used the mixed method to backup and verify the findings. It's been found that the human factor alone cannot be solely reliable as special needs individuals were found to adapt to the surrounding environment and/or might face difficulties in identifying the source of their discomfort. The study focuses on two factors of IEQ (light and sound) and their impact on the students/occupants' behaviours using spot measurements, as well as questionnaires and interviews, drawing comparisons and connection between the international standards and the existing conditions in the selected case studies in the UAE.

This study looks into finding connection between objective and subjective assessment of environmental factor of lighting and acoustic characteristics in three types of special needs centers in three different building structures. The study focuses on highlighting the vulnerability the population of special needs towards lighting and acoustic environment in the special educational environment. The category of developmental disabilities was chosen as subjects of the study. A total of 44 pupils participated in the study (23 female, 21 male). The study evaluated two therapy rooms: 1) Speech and Language Therapy 2) Occupational therapy. Explanatory mixed method design tool was utilized. Subjective data was collected from student and therapists, while objective data was collected through spot measurement. The study was conducted between February and March of 2017.

Findings of the study are:

- 1) The selected case studies for this research did not have the suitable/appropriate indoor environment qualification for the users of the facility, compared to the international standards and guidelines for this type of disabilities.
- 2) The importance of providing an adaptable and flexible indoor environment to suit all categories of individuals with disabilities who attend the centers, due to their individualized requirement.

3) Special educational environments to provide a high quality indoor environment and physical environment considering the needs of students with developmental disabilities not only looking into the requirements for students with physical disabilities.

The findings in this study bring an important contribution to the field of special education, specifically, and to the educational sector in general. It will help schools, targeting the inclusion of students with disabilities, to take further considerations towards the sensitivity of the students and create a healthy environment for all of its students by presenting a school environment that promotes productivity as well as mental wellbeing, supporting the UAE 's vision of "Accessibility for all".

### ملخص

تعد المراكز التعليمية من أحد أهم المؤسسات المجتمعية، المدارس والمراكز التعليمية العامة تتميز باحتوائها لمجموعات كبيرة من الأفراد وذلك لطبيعة الخدمات المقدمة من قبلهم. وتشير الإحصائيات أن الأطفال يقضون ٢٥٪ من يومهم في المدارس، داخل أجواء مغلقة مثل الفصول الدراسية. كما تشير الدراسات أن الناس بشكل عام يقضون ما يقارب ٩٠٪ من الوقت في بيئة داخلية، موضحين بأن نسبة تركيز الملوثات في الأماكن المغلقة تزيد بـ خمس مرات عن نسبته في الهواء الطلق.

في البيئة المدرسية، وتحديدًا في الفصول الدراسية، إذا لم يتم توفير بيئة داخلية مناسبة للطلبة تساعد على التركيز، وتوفر الراحة اللازمة، هذا قد يتسبب في تراجع مستوى أدائهم بنسبة ٣٠٪.

في عام ٢٠١٥ خلال منتدى دبي للتنمية الشاملة، تم وضع استراتيجية لجعل إمارة دبي مدينة صديقة لذوي الإعاقات (أصحاب الهمم).

وفي هذا الإطار تهدف هذه الدراسة إلى رفع الوعي عن أهمية جودة البيئة الداخلية في المباني التعليمية للأفراد الذين يعانون من إعاقات جسدية أو ذهنية. كما توضح المتطلبات اللازمة للفئات المختلفة من ذوي الإعاقات، مشيرة إلى تأثير العوامل المحيطة على هذه الفئة من الطلبة في رفع أو خفض مستوى استيعابهم في الفصل، بالإضافة إلى تقديم حلول وسبل عملية لتحسين الوضع الحالي في المباني المختارة.

تم اختيار ثلاث مراكز تعليمية في مباني ذات طبيعة مختلفة في إمارة دبي وإمارة أبو ظبي لدراسة العوامل البيئية الحالية في كل الفصول المختصة لعلاج النطقي والتخاطب، والعلاج الوظيفي، مع التركيز على عاملين أساسيين من البيئة الداخلية لهذه الفئة من الطلبة وهي الإضاءة والصوت.

المنهجية: تم اتخاذ عدة سبل لإنجاز هذا البحث بشكل متكامل آخذين بالاعتبار جميع العوامل. تم قياس مستوى الإضاءة والصوت في أماكن معينة باستخدام أجهزة قياس الصوت والضوء.

كما تم تحضير استبيان ليتم تقييم مستوى وعي الطلاب ومدى جودة البيئة التي يقضون أوقاتهم بها. شارك في الاستبيان ٤٤ تلميذاً (٢٣ انثى و ٢١ ذكر). بالإضافة تم إجراء مقابلات مع متخصصين ومعالجين لهذه الفئة من الطلاب للتأكد من مدى فعالية نتائج الاستبيان من الطلبة والتعرف على الحالات المختلفة بشكل أعمق. تم إجراء المراحل المذكورة أعلاه في الدراسة خلال شهري فبراير ومارس ٢٠١٧.

النتائج المستخلصة من البحث تشير إلى عدم قدرة الطالب على استدراك العوامل البيئية المحيطة حوله بشكل دقيق، وذلك إما لعدم المقدرة على التعبير، أو لعدم الاستطاعة على تحديد مصدر الإزعاج. ولذلك وجد تباين واضح في إجابات الطلبة مقارنة بالمعلومات الواردة من المتخصصين والأرقام التي تم الحصول عليها من خلال قياس العوامل البيئية المذكورة.

من خلال دراسة المراكز المختارة، والحالات المختلفة تبين:

١. أن المراكز التي تمت دراستها لا تتوفر فيها البيئة المناسبة اللازمة لمستخدمي المكان وذلك قياساً للإرشادات العالمية لهذا النوع من الاعاقات.

٢. أهمية توفير بيئة قابلة للتغير لتناسب مع جميع فئات ذوي الاعاقات المختلفة الذين يرتادون المركز نظراً لمتطلباتهم المختلفة.

٣. ضرورة وضع المتطلبات البيئية اللازمة للحالات المختلفة من ضمن خطة العلاج لتساعد الطلبة على تسهيل مسيرة التطور عند الطلبة وتكيف الطلبة مع بيئتهم.

٤. تجهيز المراكز التعليمية بحيث توفر بيئة تتميز بجودة عالية للطلبة من ذوي الاعاقات الذهنية وعدم التركيز فقط على الاعاقات الجسدية.

يعتبر هذا البحث إسهاما هاما في مجال التربية الخاصة في الدولة وذلك لعدم وجود دراسات سابقة، آملين أن توفر المعلومات الواردة في البحث البداية لوضع قوانين والارشادات اللازمة التي تنص على إيجاد متطلبات بيئة داخلية واضحة للمراكز التعليمية لذوي الإعاقات.

## **Dedication**

“Believe that what you do matters and will make a difference in people’s lives. You don’t have to save the world in one stroke, but you can make a difference one person at a time.” Anonymous

First, I would like to dedicate this work to my parents, Mohammad Reza Karima, Monira Ibrahim Karima. I am immensely grateful for everything you taught me and for raising me to always look at life experiences as a raw solid rock that only I am responsible for shaping it. To always be supportive of the choices I make. For their patience throughout this long journey. And mostly, for believing in me in times where I had little faith in myself.

I would also like to dedicate this research for all the special needs centers I have worked with across Sharjah, Dubai and Abu Dhabi. And for all the wonderful families whom gave me the trust to be involved in their children’s lives. Allowing me to be part of their journey. I dedicate this research in the hope to create a positive, effective efficient learning environment for the population of disabilities.



## **Acknowledgment**

First and foremost, I have to thank my research adviser, Professor Bassam Abu Hijleh. The door for Prof. Bassam office was always open whenever I needed guidance. Thank you for your none stop support. He consistently allowed this paper to be my own work, but steered me in the right the direction whenever he thought I needed it.

Getting through my dissertation required more than academic support, and I have many, many people to thank for listening to and, at times, having to tolerate me over the past three years. I cannot begin to express my gratitude and appreciation for their friendship. Wessam Farag, Rana El Khayyat, Hawra Askari, Salma Al Zahabi, Rasha Gafar and Bilal Siddiqui have been unwavering in their personal and professional support during the time I spent at the University.

Finally, I must express my very profound gratitude to my parents and siblings, specially my dear sisters Maryam and Mehrnoosh for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.







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## List of Abbreviation

AC	Acoustic Comfort
ADHD	Attention Deficit Hyperactivity Disorder
ANSI	American National Standard Acoustical
ANSI	American National Standard Institute
ASA	Acoustical Society of America
ASD	Autism Spectrum Disorder
ASHA	American Speech Language Hearing Association
ASHA	American Speech Language Hearing Association
ATRA	American Therapeutic Recreation Association
BRI	Building Related Illness
CP	Cerebral Palsy
CRPD	United Nations Convention on the Rights of Persons with
Disabilities	
dB	Decibel
DD	Developmental Disability
DF	Daylight Factor
ED	Emotional Disability
EDA	Electro Dermal Activity
GCC	Gulf Cooperation Council
HVAC	Heating Ventilation and Air Conditioning
Hz	Hertz
IAQ	Indoor Air Quality
IAQ	indoor air quality
ICT	Information and Communication Technology
IEP	Individualized Education Plan
IEQ	Indoor Environmental Quality
NHAPS	The National Human Activity pattern Survey
OT	Occupational Therapy
PMV	Predicted Mean Vote
PPD	Predicted Percentage Dissatisfaction
RDE	Regular Dental Environment
SADE	Sensory Adapted Dental Environment
SBS	Sick Building Syndrome
SEN	Special Educational Needs
SLT	Speech and Language Therapy
SNF	Special Needs Future Center
SNR	Sound to Noise Ratio
TC	Thermal Comfort
UAE	The United Arab Emirates
VC	Visual Comfort
VOC	Volatile Organic Compounds

# Chapter 1

## 1. Introduction

### 1.1 Indoor Environment

It is human basic need to create a physical shelter, as a representation/ statement of social and cultural values. Over the years, closed environments have evolved to become more than just a habitat; more than just a living space. Human activities have become more diversified creating the need towards more specialised and defined spaces. Social interaction and activities have shifted from outdoors to indoor environments; hence people's tendency to spend the majority of their time indoors has increased exponentially.

An extensive research study, the national human activity pattern survey (NHAPS) done under the supervision of the United States Government and The Regents of the University of California in 2001 (Klepeis et al. 2001) has concluded that people spend 89 percent of their time indoors, 5 percent outdoors, and 6 percent in transportation & commuting in automobile/ enclosed vehicles. See Figure 1.1 Moreover, according to the same study, it has estimated that the concentration levels of indoor pollutants were 5 times higher than outdoor levels. This simply indicates an alarming signal towards the indoor environmental quality and its correlation with human wellbeing and health, resulting in what is called as Sick Building Syndrome (SBS).

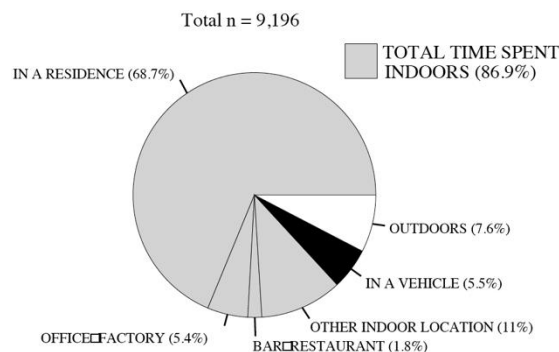


Figure 5.1: NHAPS Percentage time spent indoors (Klepeis et al. 2001)

### 1.2. Indoor Environment and Health

In 2010, Al-Rajhi and Rasmuswamy et al. quantified that the average adult intakes of air, stating that it is higher compared to that of food and water. To be specific, the intake of air per person is 15 kilogram a day from the breathing process alone, while the total intake of water is 2 kilograms and only 1 kilogram of food.

Since people spend the majority of their time in closed spaces, i.e. indoors, it is clear that the quality of the indoor environment will automatically have a directly proportional impact on the occupants' mental and physical status/health. Researchers have investigated the relationship between a building's indoor conditions and the wellbeing of its occupants. These conditions are classified

into factors that form the very intricate fabric of what is called Indoor Environmental Quality (IEQ) (LEED Green Assoc, V4, 2015). These factors are: moisture/humidity, mould, thermal comfort, Acoustic performance (noise levels), Lighting/improper lighting, suspended solid particulates and chemical compounds known as VOC (Volatile Organic Compounds).

When confined to a closed space with inefficient ventilation system/ air change rates, carbon dioxide that is released from the breathing process will accumulate in the air causing discomfort to the user of the space and symptoms like drowsiness. Extended exposure to such a poor indoor air quality (IAQ) can cause a condition known as SBS (sick building syndrome). SBS symptoms can be manifested as short term health issues, such as fatigue, eye irritation, headache, asthma that disappear once the occupant leaves the building, and/or long-term ones such as chronic diseases and legionnaires disease.

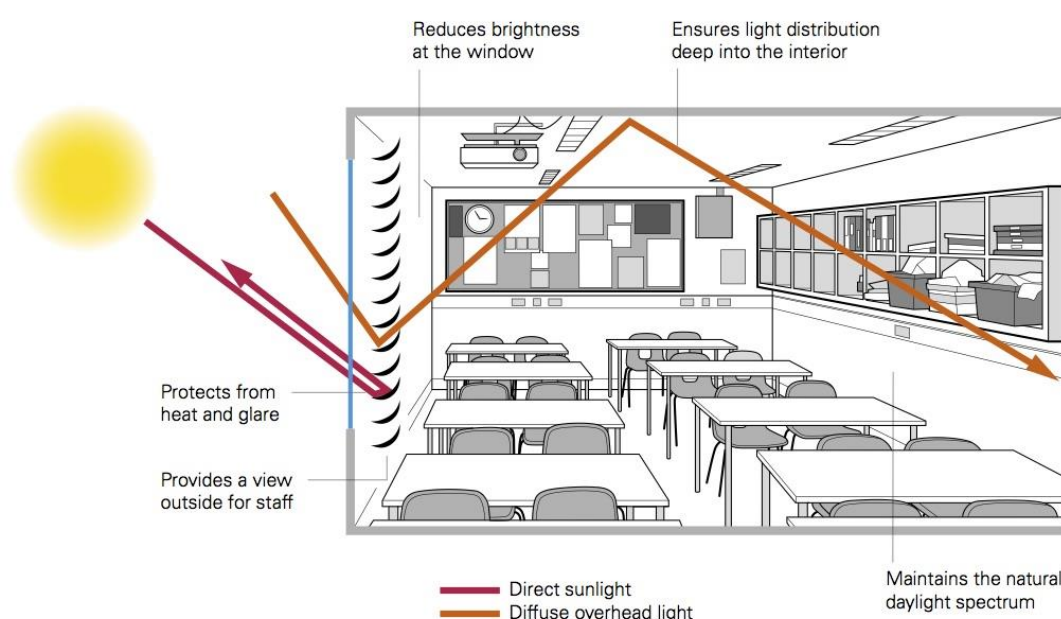


Figure 1.6: Benefits of Daylight Blinds in Classroom Environment (Carbon Trust, 2012)

There are four indoor environment categories that are responsible for creating indoor environment comfort:

1. Thermal Comfort -TC
2. Indoor Air Quality -IAQ
3. Acoustic Comfort -AC
4. Visual Comfort -VC

Over the past two centuries, scientists, engineers and architects have diverted their focus towards achieving sustainable health-focused indoor environments in an attempt to increase the wellbeing & life quality of the average occupant, while being environmentally conscious towards global issues such as climate change, especially global warming.

It was not until the early twentieth century that a connection was recognized between human needs and the parameters defining heat, sound and lighting in a building. This has led to more insights into the dynamics of these parameters and their direct correlation to the wellbeing of occupants; in fact, highlighted health problems has triggered the urgency and necessity of more developmental research as well as action in this field.

One of the key breakthrough studies on indoor environmental quality (IEQ) is a study by Fanger in 1970. Fanger developed a thermal comfort equation that addresses the building users' predicted mean vote (PMV) and the predicted percentage dissatisfaction (PPD). Fanger's equations has since been commonly used in standards and design guidelines. Later on, in 1989 Fanger published another research on comfort level associated with indoor air quality (IAQ).

With the drastic increase in building construction, resulting from more developing countries aiming to progress in faster paced industrial world, levels of carbon dioxide and air pollutants have recorded a parallel increase. Similarly, the building indoor environment has been affected as well by this increase of air pollution. Not only are buildings being designed to be more energy saving and energy efficient, reducing ventilation rates and maximizing natural daylight, but also buildings are now required to be more insulated and sealed to protect the occupants from the external environmental changes. This resulted in pollutants to be accumulated and trapped indoors when proper ventilation is not applied. The more exposure to pollutants, the more health problems started to arise.

Alongside the common SBS (Sick Building Syndrome), there is a more serious health sickness symptom called the Building Related Illness (BRI). BRI are hazardous illnesses that occur when building users are directly exposed to the lethal airborne pollutants causing illness such as Legionnaire disease. BRI require building investigation to locate the source and diagnosis for the effected individuals. (Larsson et al., 2009)

The correlation between the IEQ & IAQ of a building and the performance and productivity of its occupants has also been proven to be primarily effected and co-dependant on the quality of each of the indoor stressors (Larsson et al., 2009). Further studies have found association between building environment and mental health and obesity, two conditions which manifest themselves on the long run and develop over time.

In the last decade, the focus on the built environment has emerged as a powerful platform for building rehabilitation. Mihai & Lordache (2016) discusses that indoor environmental quality is not only an indicator of occupants' wellbeing and level of comfort, but can also be used as a tool to evaluate the building's energy consumption and an opportunity to locate the source(s) of energy waste in order to effectively treat it.



### **1.3. Educational Indoor Environment**

Educational facilities are one of the primary and most important establishments in a society existing in large numbers. Schools and learning institutions have a high density of occupants. Children spend 25 % of their day in classrooms (Cartieaux, Rzepka, and Cuny, 2011). Lordache (2016) defined educational environments as environments where the act of studying (writing, reading) or constant focusing on certain surfaces such as; monitors, computers and whiteboard is required from pupils.

Since indoor environment parameters collectively have an impact on the total experience of an individual, discomfort from one element/factor can result in disturbance in the total comfort of the individual and cause the inability to preform efficiently for a given task. For instance, visual comfort is related to lighting, the ability to concentrate is immediately effected when the classroom has insufficient daylight; even if the ventilation, temperature and noise were all at satisfactory levels. A study by Wargocki & Wyon (2013) stated that poor classroom conditions can reduce students' performance by as much as 30%.

### **1.4. Educational Environment and Energy**

Although the main determent factor for energy use is the age of the building, other factors include:

1. Frequency of maintenance services.
2. Occupancy time.

An independent energy institute called Carbon Trust; United Kingdome, has published an energy report on educational buildings in 2012 to look into energy use in relation to the actual cost required to operate such facilities. The study found that 30% of the energy consumed in schools is being wasted.

Energy demands are from the below sources:

1. Space Heating.
2. Hot water.
3. Building fabric.
4. Lighting.
5. Technological learning tools.
6. Electrical equipment.

The study found out that energy cost does not necessary correlate with energy use of factors. Figure 1.3 shows the percentage of energy consumption in schools. A little over half of the energy consumption was attributed to heating purposes. However, it is notable that although the energy use of lighting is 8%, the equivalent energy cost is 20%, compared to heating which actually costs 13% less than the actual consumption. This brings the attention to the fact on how one element/factor contributes profoundly to the total efficiency of any building, and especially educational facilities, and on the impact of internal built elements and design, in general, on the total energy cost of these buildings.

Moreover, modern school systems rely heavily on information and communication technology (ICT). This ICT learning system has started to replace books and notebooks with laptops, projectors, and interactive classroom technology such as whiteboards. The escalating demand on utilizing ICT equipment is increasing the electricity demand, bringing the annual electricity closer to that of fossil fuel.

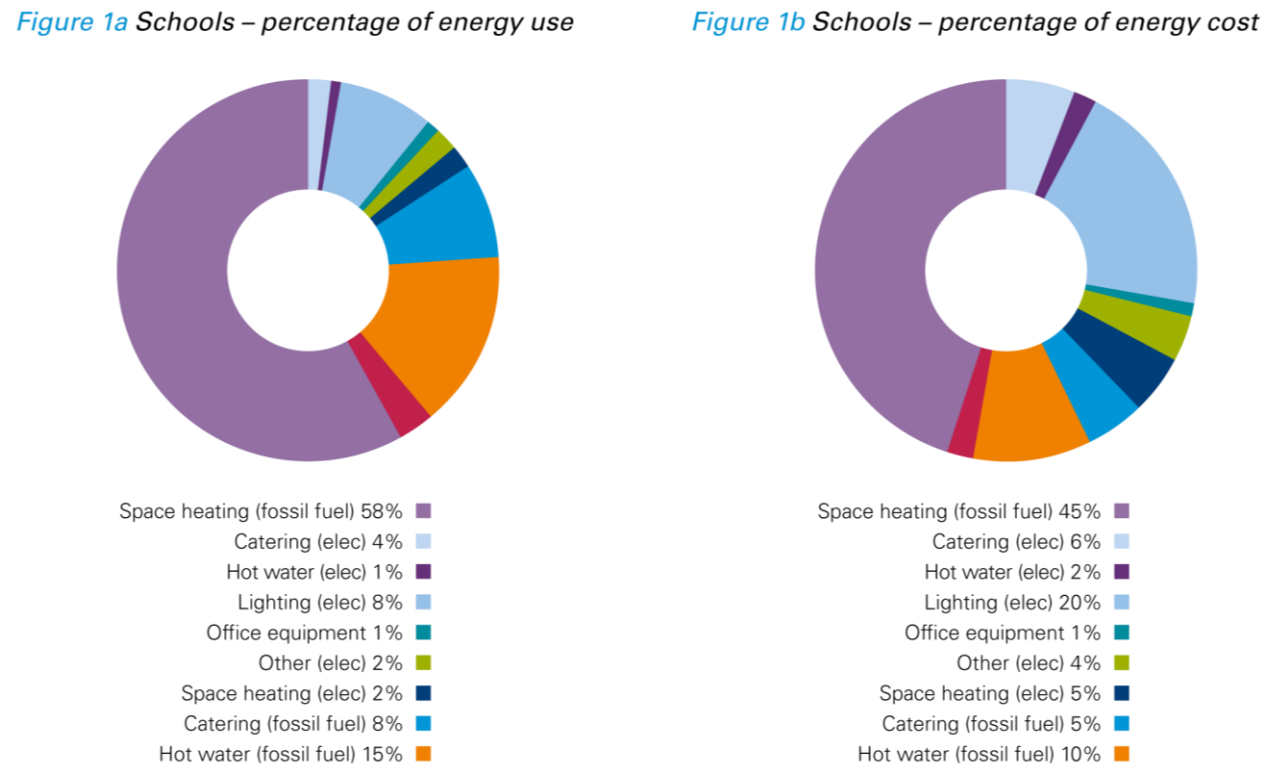


Figure 1. 7: School Percentage of Energy Use and Energy Cost (Carbon Trust, 2012)

A comparative study of sensory processing in children with Autisms Spectrum Disorder ASD and typically children in classroom environment by Fernández-Andrés et al. (2015) revealed that participants with ASD were more difficulties in sensory processing, social participation, planning ideas and hearing. Study findings indicated that hearing was the most affected sensory modality. Participants were found to show low auditory adaptability, facing difficulty to concentrate due to excessive and unpredictable noise from classroom fixture and background noise.

Shapiro et. al, (2009) conducted a comparative study between typical children and children with developmental disability. The study aimed to find how participants reacted in two different environment for a stress provoking dental procedure. One environment mimicked the regular dental environment while the second environment setting was changed from lighting, sound and sensory tools to help participants have less anxiety during the dental performance. The study found that children with developmental disabilities had a more anxiety behaviour and longer duration of anxious behaviour compared to the typical

children in both setting. Participants performed better in the adapted environment.

This concludes, that pupils in SEN are more sensitive to IEQ than typical (regular) students. Thus, there is higher demand to have IEQ in SEN educational facilities.

## **1.2. Motivation of The Study**

This study aims to be a major contribution to research on the indoor environmental quality for special needs educational facilities and facilities with occupants with disability by investigating the impact of two indoor environmental factors in three different building structures and built environment limitation.

This research will assess the impact of light and sound factors of the indoor environmental quality on occupants of special needs school in different building structures. The study highlights limitations and restrictions caused by the building management.

The purpose of this investigation is to explore the relationship between light and sound, individually and coexistent, on the developmental progress of children with disabilities, specifically children with cognitive disabilities, also known as intellectual disabilities.

In the UAE, institutes that support children with disabilities are divided into; 1) Clinics for therapeutic services & diagnosis, and 2) Centers/school that rehabilitate the children as educational sectors, similar to school based organizations. It has been noticed that only a few of these special needs facilities, if not almost barely any, are designed or built with proper consideration of the very purpose of the nature of their operation. The majority are located in villas or as part of a compound, and sometimes in commercial apartments. Hence the main drive and motivation for this study, and the need to have a closer look and assess the suitability of such buildings.

The aim of this study is to find whether there are any consideration for indoor environment features, characteristics and qualities set for special needs schools, centers, clinics and therapy rooms. Such considerations are usually identified by the management of the school, as the criteria of occupants are not that of normal individuals. This study seeks to obtain field data which will help to address these barriers/ limitations and give solutions to enhance the indoor environment, with sustainable methods, that helps the occupants in their learning journey to be independent, understand themselves and their surroundings, and adequately interact with them.

In this study, children with developmental disability are chosen to take part of the environmental assessment, excluding Autism Spectrum Disorder.

### 3. Aims and Objectives

The overall aim of this study is to bring awareness on the importance of good indoor environmental quality in creating the suitable/ proper setting for individuals who suffer from any type of disabilities; mental, physical, emotional. Globally, individuals with disability are the most underserved groups of the society. This study takes a deep look into educational facilities dedicated for children with disabilities, specifically children with developmental disabilities. More details will be presented in the literature review chapter about developmental disabilities characteristics.

The focus of this study will be towards exploring the impact of light and sound, two indoor environment parameters, on the learning progress of children with developmental disabilities; also known as intellectual disabilities in three educational institutes for children with disabilities. This study also aims to find the relationship between light and sound collectively on the behaviour and mood of children with development disabilities, through looking into the performance and productivity of students that is associated with the quality of classroom settings.

It is known that the Indoor environment setting consists of four main elements/factors, however for sake of this research; the focus will be on two factors only (light and sound). Objective of the study are:

- 1) Qualitative assessment: Evaluation of luminance and noise in three types of therapy classrooms, in three different categories of building structure of educational centers for children with development disabilities.
- 2) Quantitative assessment: Assessing occupant's perception on luminance and noise; whether they are aware of these factors, and their ability to identify the luminance/ noise source. Also, identifying how it affects their mood, performance, and behaviour.
- 3) Defining the connection between qualitative and quantitative subjective assessment to find any link, trend or cause and effect relationship.
- 4) Identifying environmental barriers and limitations in the case study of these building facilities.
- 5) Propose solutions to enhance luminance and acoustic dynamic for the selected classrooms to create a proactive indoor environment that contributes to visual and acoustic comfort. As well as mitigate the anxiety or stress causes in their environment, caused by these two factors.

The study looks to answer questions related to light and sound in special education environments in the UAE, these questions are:

- Is there any consideration for indoor parameters in special education facilities in UAE?
- What are the limitations in the existing built facilities that have occupants with disabilities?
- What is the impact of luminance and noise on performance and productivity of children with development disabilities in special needs educational facilities?

This study considered three hypotheses related to indoor environment quality in special education facilities;

The first hypotheses suggests that the buildings itself has limitations, creating barriers for classrooms settings, which by its turn will have an effect on the indoor environment quality, hence affecting the performance, productivity and wellbeing of students and their ability to balance their consciousness and focus on the given activity/task. These architectural limitations may not have been given importance by decision makers, due to lack of awareness and knowledge, or these barriers have been taken lightly and not given as much importance compared to the special equipment needed in these facilities.

The second hypothesis is that daylight/natural light has the most impact on mood, comfort and relaxation on children with development disabilities due to psychological impact of circadian rhythmicity.

Third hypothesis indicates that difficulties to concentrate and reactive behaviour, such as maladaptive behaviour caused by anxiety and panic, can be improved by effectively mitigating noise. It is predicted that a quiet classroom for children with developmental disabilities must sustain in the average noise/sound ratio of 40- 65 dB to achieve acoustic comfort, keeping in mind the conditions of children who have hearing deficiencies.

A good understanding of the relationship between parameters will help us optimise previous and future models. This optimisation lets us define better indoor conditions. Hence, it is necessary to have an appropriate standard tailored to the needs of students with disability.

This study will not only help identify the environmental barriers to the learning process of children with disabilities, but also it will promote the educational sector to move towards better proactive learning environment for children with special needs.

The findings are hoped to make an important contribution to the field of special education, on a specific level and in general to the educational sector as well. It will help schools, targeting the inclusion of students with disabilities, to take further considerations towards the sensitivity of the students and create a healthy environment for all of its students by presenting a school environment that promotes productivity as well as mental wellbeing. Finally, this study will support UAE 's vision of *“Accessibility for all”*.

## **5. Research outline**

The research is composed of six chapters. The structure of the presented study is constructed as follows:

This first chapter, chapter one, presents an overview of indoor environment, and its relation to health and wellbeing, key definitions such as IEQ, IAQ, and educational environment, a general orientation about disability, introducing key concepts.

Chapter two gives an over view on disability, role of the environment on enabling individuals with disability, followed by critical analysis of the impact of light and acoustic environmental stimuli in educational environments as well as special education environments. Comparison between standards and guidelines for educational facilities and special educational facilities is made. The chapter will also review previous relevant work in this field.

The third chapter illustrates the methodologies used in studies assessing environmental quality for individuals with disability. Moreover, critical description is presented on criteria selection of method, participants, case study used in this research.

Chapter 4 presents details of the three case studies selected; similarities and differences.

While chapter 5 will present the findings, results and discussion of the collected data.

Chapter 6 is the conclusion.

## Chapter 2

## **Chapter 2: Literature Review**

### **1. Overview**

To be able to assess and evaluate the indoor built environment, it is fundamental to have background knowledge on the occupants of such environments, and the type and nature of activities in the designated case studies. This chapter focuses on defining and highlighting the nature of disability and the role of the environment in supporting or limiting the cognitive skills of these occupants. Special Education is presented as well as an in depth review on lighting and acoustic features in educational facilities.

Furthermore, this chapter sets forth a comprehensive review of the existing performance standards and guidelines for lighting and acoustics in main stream schools and in special education ones, as well as presenting a comparison between the two. An over view of disability in the GCC and UAE vision for disability is also included, as the selected case studies are from this region.

### **2 Understanding Disability**

Disability is a condition that results from a birth defect, disease, accident and/or the environment that the individual associates with. Disability Discrimination Act 1995 defines the term disability as;

*‘A disabled person is someone who has a physical or mental impairment which has a substantial and long-term adverse effect on his or her ability to carry out normal day-to-day activities.’*

Disability is categorized into three areas:

1. Physical disability.
2. Developmental disability.
3. Emotional disability.

*Physical disability* refers to deficiencies in impairments such as visual impairments, hearing impairments, multi- sensory impairments and physical disability such as incomplete growth of limbs and internal organs. The cause of physical disability is genetic such as Muscular Dystrophies, Acquired Brain or Spin injuries, Spinal Bifida. Individuals who suffer from physical disability are partial or fully physically paralyzed. Other cause of physical disability is accidents and injuries that lead to physical paralysis.

*Developmental Disability (DD)*, formerly called mental retardation, is the condition where the individual face functioning difficulties due serious damage in the brain (Nervous system damage or incomplete brain development) that affect the system of the body causing them not to function or have limited ability to control/ utilize the body. The cause of DD is genetic neurological disorder that affects the nerve system such as Autism Spectrum Disorder (ASD), Cerebral Palsy (CP), Down syndrome, Attention Deficit Disorder ADD (Also known as Attention Deficit Hyperactivity Disorder ADHD), and Learning Disabilities. Other causes of DD is the complex interaction of genes and the



environment, some conditions are solely caused by environmental toxicants. National Academy of Science scientists stated that “3% of DD are directly caused by environmental toxicants and 25% are caused by interaction of environmental factors and individual genetic susceptibility” (National Research Council, 2000).

*Emotional Disability (ED)*, results from a combination of physical and social environmental of the individual. It is the inability to control or express emotions, attention span and ability to focus is affected in individuals with emotional disability. The cause of emotional disability is brain damage, malnutrition (caused by lack of having fundamental nutrition), genetic factors and physical disability. (Isa et. al, 2016)

Although the general/common perceptions of developmental disorders are believed to be genetic such as Down syndrome, other disorders are caused by complex interaction between genes and the environment. However, other disorders are caused only by environmental toxicants.

The qualitative subjective assessment will be obtained from this category because this category of occupants physically appears normal (it is difficult to assume they have certain disability); since their overall features look normal, many people assume they would easily adapt to any environment and any situation. Furthermore, it's the only category that has the capability to express and reflect their perception on their surroundings. Hence, it fits the aim of the research to get the occupants perception and satisfaction towards the school environment.

## **2.1. Enabling and Disabling Environment**

*“The physical and social environment can either disable individuals with impairments or foster their participation and inclusion”* (world health organization 2011).

Environmental stressors play a major role in accumulating/increasing levels of impairments. Hence, to improve the quality of life for individuals with disability, it is essential to address factors associated with the development of their disability.

Realizing the impact of poor indoor environment on occupants has led researchers and scientists to look into IEQ causes and results of health problem in individuals with disabilities. World Health Organization report on disability (2011), brought up major discussions reviled at United Nations Convention on the Rights of Persons with Disabilities CRPD. CRPD emphasized on environmental barriers as a definite cause to disability, as the barriers limits the interaction of the individual with impairment and restrict the effective participation in activities of daily living on an equal basis to/with their peers.

(Altman, 2014), discussed the disability process and the role of the individuals' interaction with environment to the level/ severity of their disability condition.

When individuals with disability face functional limitations in environments that lack accessibility, or support for specific type of function, these environmental limitations increases their adaptability restrictions which create a risk factor for further limitations. Figure 2.1 illustrates the relationship between disability and the environment.

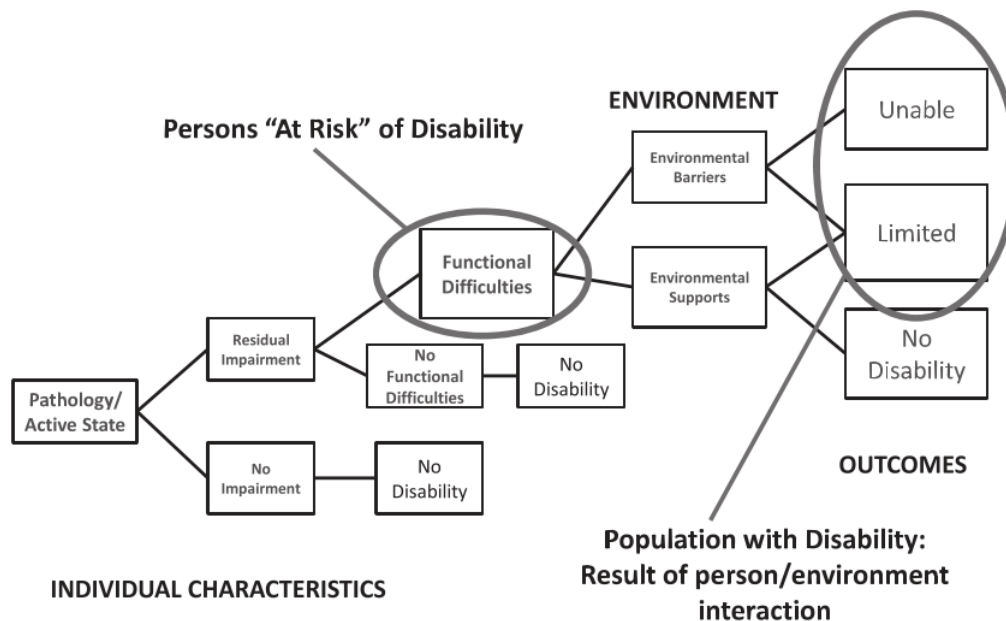


Figure 2.1: Visual Model of Elements of Disability Process (Altman, 2014)

Modification of the built environment is necessary to achieve a friendly environment for individuals with disability. This has been a global targeted aim for many developed and developing nations. The United Nations Convention on the Rights of Persons with Disability (CRPD) demanded for drastic consideration to be applied on the road and the built environment, transportation and information communication.

Modifying the environment to tailor the need of individuals with disability is a strategy aimed to reduce/ minimizes barriers, which enable individuals with disabilities to achieve certain tasks in a more favourable way. There are different forms of environmental modification: modifying physical structure, using assistive tools, and object modifications are some examples. Furthermore, qualifying the built environment is thought to be a form of prevention, safety net and comfort to the end user.

Although these studies highlight the importance of the physical environment, yet the majority of studies are concerned with the category of physical disabilities. While physical disability requires higher environmental considerations, mental and emotional disability also needs special environmental considerations. For instance, individuals suffering from hearing impairments (Deaf) may face difficulties in an environment where there are no sign language or guiding system (braille signage) to help them find their destination.

There have been very little studies on the impact of the physical environment on mental, developmental and emotional disability. These individuals may suffer the most as they don't have any apparent physical defect that defines their impairments; as their impairments are their disability is due to brain defect. Their perception of the surrounding environment differs making them highly sensitive towards the environmental features. For example, a child with autism spectrum disorder will be highly distressed in an environment with excessive physical setting (furniture) and bright colours. Another example, a child with visual impairment will face extreme difficulties to find pathway or completing a task in an environment with dim lighting.

## **2.2. Sensory Adaptive Environments (SAE)**

Children with developmental disabilities are strongly influenced by the surrounding physical environment. The root of the impact/problem lies in the sensory processing dysfunction, which is common in developmental disabilities as well as autism spectrum disorder. Engel et al explains sensory processing dysfunction as *"difficulties that occur when sensory stimuli are processed by the brain to an incongruous response."* (Engel- Yeger et al. 2011; Stein et al. 2013)

Sensory dysfunction affects the perception of the individual in seven main areas, according (Kuhaneck and chilsholm 2012). These areas are:

- Tactile
- Vestibular
- Auditory
- Visual
- Proprioceptive
- Gustatory
- Olfactory

These stimuli cause distress and discomfort for children with developmental disabilities. The impact of environmental stimuli are more prominent and strongly visible when multiple stimuli happen at the same time or simultaneously, such as walking through a mall with so many visual imagery, mixed background noise, vibration from moving objects, flash lights, people moving in different places and different lighting levels.

Being in such environment puts a child with developmental disability (DD) in a great discomfort where he/she may find huge difficulties to avoid and/or being able to allocate what is the source of the annoyance. For a vulnerable sensitive child with developmental disability (DD), the stressful environment provokes reactive response called Maladaptive Behaviour.

### 2.3. Maladaptive Behaviour

Maladaptive behaviour is commonly described as a reaction/ behaviour that naturally occur when confronting a stressful situation. Behavioural patterns of maladaptive reaction can express itself in one of the following:

- Physical withdrawal (Avoiding).
- Physical aggression.
- Vocalizing (Screaming).
- Crying.
- Vomiting.
- Self-harm.

Two of the most common behaviour performed/expressed by children with DD is physical withdrawal (Avoidance) and self-harm. Although stepping away and avoiding the cause of the discomfort may seem a good tactic, psychologists have found that it causes more anxiety and fidgety to the child. (psysci.co, 2017)

In a review of epidemiology of mental illness and maladaptive behaviour. Rojahn and Meier (2009) suggested that risk factors leading to maladaptive behaviour in individuals with intellectual disabilities is from multiple factors of biological, psychological, developmental, emotional, social and environmental.

While self-harm is seen as a manifestation of the child's inability to express the feeling of discomfort, some individuals with disability (most commonly in non-verbal individuals and those with communication impairments such as visual and hearing impairments) tend to deliberately cause body injury as a reactive behaviour when feeling trapped and unable to express their needs. It is important to clarify that this reaction is not caused by suicidal thoughts, rather that self-harm is a manifestation/ expression of annoyance which then converts into a habit by the individual.

Common forms of self-harm behaviour trait are: biting hands/ fingers/ arms, forcefully hitting hard surfaces such as table/ wall, pulling hair, scratching healing wounds. These acts of self-harm are spontaneous, and only occur when the individual feels anxious and find it difficult to hide their frustration. The later behaviour varies depending on type of disability and level of communication skills. Hence, the physical environment can have a drastic impact, in promoting and/ or degrading, the maladaptive behaviour . (psysci.co, 2017)

On the other hand, physical environment has the potential to initiate / encourage positive engagement for users with disabilities. A successful model of utilizing the indoor environment in special education is a Kagoshima, Prefectural Kagoshima School for the Blind in Japan (2011). Indoor environment strategies were taken to simplifying the accessibility of students in different intelligent solutions. Corridors are paved in textured installation for easy circulation and identification of the school divisions for children with visual impairments, positioning of classrooms at right angle of the corridor for students

to easily navigate their classes. Continuous handrails on the walls are also installed on doors to insure support for students to be fully independent in circulating. Resting space/ benches are built in the walls for easy access as well as avoid disturbance in circulation. National Institute for Educational Policy Research. (2012). Figure 2. 2.



Figure 2.2: Prefectural Kagoshima School for the Blind in Japan (National Institute for Educational Policy Research, 2012)

## 2.4. SAE and the environment

On the other hand, other studies investigated the role of the physical environment in upsurge in sensory processing dysfunction for some children. One of the most in-depth early studies is a study by (Dunn et. Al. 2002). The study stated that individuals who suffer from sensory dysfunction are likely to experience intense experiences resulting from two propositions. The first proposition is that individuals experience low sensory abilities; this happens when the individual fails to engage with the environment to collect enough awareness/ cognition/ understanding to react to the environmental stimuli. The second proposition is that the sensory dysfunction condition intensifies and becomes aggravated because the surrounding environment is not modified/ adapted to suit the needs/ limitations of these individuals, which by its turn affects the total engagement level of the individual. Following Dunn et. Al's findings, further investigations supported the second statement.

## 2.5. Therapeutic Recreation

The term therapeutic recreation defined by (Carter &Van, 2011) refers to health and human service profession, in which specific activity type is proposed for

individuals for the purpose of improving health, functional abilities and quality of life.

American Therapeutic Recreation Association (ATRA) defines therapeutic recreation as: *“a systematic process that utilizes recreation and other activity-based interventions to address the assessed needs of individuals with illnesses and/or disabling conditions, as a means to psychological and physical health, recovery and well-being.”* (“American Therapeutic Recreation Association”, 2017)

In therapeutic recreation, the applied program relies on utilizing daily life activities and social interactions as a tool to improve cognitive, physical, emotional and social deficiencies of individuals with disabilities. The key difference/ importance of therapeutic recreation is that it evolves around the interest of the individual. Unlike educational systems, activities are not scheduled; classrooms are assigned to facilitate particular therapy and planned individually with certain setting/ equipment/ specialists.

Recreational system moulds therapy techniques and methods into stimulating activities. As a result, the individual develop skills, knowledge and improve behaviour in the context of practicing fun / playful daily life tasks. Therapeutic recreation also encourages community involvement; this helps individuals with disability to gain independency and self-control.

The advantage of such therapeutic recreation center is the flexibility of the proposed programs. The center offers scheduled activities in which the parents/ guardians select the activities for their child. Unlike main stream schools where the educational program is continuous for 4 – 5 hours, recreational centers offer individual activities that can be attended solely or a combination of activities in selected days of the week. Before and after school activities are also adopted in these recreational centers.

### **3. Special Education**

Special education is a learning system created for individuals who find difficulties to learn independently or/ and the standard educational curriculum for these individuals is difficult and unachievable due to their disabilities and/or behaviour al problems.

Considering the broadness of disabilities and the individuality of each person, based on their impairments, Special Educational Needs (SEN) learning structure is a holistic and applicable to all disabilities.

SEN practice is based on four main areas:

- Cognition and learning.
- Behavioural, emotional and social.
- Communication and interaction.
- Sensory, physical.

Three levels represent the mental capabilities of the child. These levels are:

- Low Functioning.
- Moderate.
- High Functioning.

Based on Assessment and professional evaluation by specialists, the level of functioning is determined and an individualized education plan (IEP) is designed as per the needs of the child. Since the study focuses on evaluating the impact of light and acoustic feature on occupants in special needs' learning environments, two major areas that rely on light and acoustic quality in SEN is selected as a focus area. These are:

- Communication and interaction (Speech and Language Therapy).
- Sensory, physical (Occupational Therapy).

The reason to choose these two departments is the significant role of light and sound in the activity type.

Studies that focus on evaluating and assessing indoor environment in educational facilities consider three main dynamics in the evaluation process. These factors are:

- The investigated environmental factor (temperature, air quality, light...etc.).
- Occupants.
- Research methodology.

The majority of IEQ studies have looked into evaluating comfort for common typically- healthy occupants , leaving less studies focusing on the sub- set pf occupants with challenging health conditions that require a different environmental conditions to achieve IEQ that supports their comfort and well-being.

Since these occupants are the primary focus, it is therefore necessary to have a brief yet comprehensive background knowledge with regards to children with developmental disabilities conditions, and what affects their perception and outlook towards their experienced physical environment.

Unlike the typical category of children (healthy children) who attend educational facilities/environments, children with disabilities have more internal struggles that must be taken into consideration. Therefore, the literature in this study will not only be a mere presentation of data related to lighting and acoustics quality in school environments, but also it will discuss; a) what factors trigger the discomfort and comfort for children with disabilities (especially developmental disabilities), b) what sensory and/or neurological dysfunction causes their behaviour, and c) their perception and experience when being in poor indoor environment.

It is very important to have a better understanding on these causes/triggers as it opens up possibilities to enhance and improve the living/ experienced environment for these children/individuals. It also aids in finding solutions for

the current problems that are formed/shaped from/through the experiences and perspective of these occupants.

One major limitation that faced the author in the preparation of/presenting this literature was the lack of environmental studies and investigations in school environments with population of children with special needs. Moreover, environmental studies mostly critically viewed the architecture of the building and limitations with less consideration given to the profile of the occupants.

Therefore, the author investigated and studied closely the following topics to gain a holistic approach towards the core aim of this study:

- Indoor environmental studies in main stream schools. As there are many evaluation studies and more recent findings on the visual environment and acoustical environment in schools.
- Studies on children with developmental dysfunction/disabilities, sensory adapted environments, sensory processing dysfunction, maladaptive behaviour, and how do lighting and acoustical environments impact those children.
- Speech and language therapy rooms and occupational therapy rooms. Because these two types are the primary therapy required in special education due to its significance in the children's cognitive developmental skills as well as social and communication skills.

It is worth mentioning that the extent of this literature does not stop or aim solely at providing assessment studies of indoor environment quality, as common in existing studies on IEQ. Taking into account the type of occupants presented/ addressed here, it was more necessary, and crucial, to understand the environmental triggers that face children with developmental disabilities in their learning environments.

This necessity is also arising from the shortage of IEQ studies that focuses mainly on this group/category of occupants. Another reason stems from the fact that special education is different than mainstream schools in their system, classroom divisions and type of learning approach. Hence, environmental studies are required for further development and opportunities in creating a sustainable environment for all.

In this literature/study, the author demonstrates, presents and investigates what is the significance of proper lighting and acoustic features in classroom indoor environmental quality and the impact of the physical applications of this in the learning progress of the students, keeping in mind their impairments and disabilities respectively.

### **3.1. Research Background on Individual with Disabilities**

It is noticeable that researchers who focused on children with disability tend to select a certain type of disability to asses/ evaluate their reaction or perception to the studied matter; for instance, a study on Autism Spectrum Disorder. One advantage of such approach is that this kind of studies help to contribute a



better understanding about individuals with the specific condition, hence there will be more focus to find solution to enhance and better life quality/ experiences for this category of individuals.

However, on the other hand, the concern is that disability has a wide spectrum; most of the time the individuals have multiple disabilities in their conditions. Furthermore, the individuality of characteristics and limitations in some disability conditions vary massively that it is not possible to assume one certain solution that suits everyone.

Consequently, some conditions get more recognition and importance in research topics while other (less severe or more complex) disabilities are left unattended. This resulted in less/fewer studies on certain types of disabilities, which in the long term is likely to result in less awareness about them and less considerations on their special conditions that will have an impact on enhancing their life quality; making environments more accessible/ flexible to their needs and most importantly to find possible solutions/ cure to their conditions. (Soukakou, 2012)

This study focuses on the developmental disabilities as a category in disability. The study is intended to look into the special education environment in the UAE, since the majority of (School based) special education embraces children with multiple disabilities in one classroom. It is then most suitable to see their perception towards their environment and most importantly how students cope with their limitations in the learning environment.

Moreover, since this research aims to evaluate and assess the indoor environmental quality, the basis of the research and finding is relevant to subjective feedback of the occupants. Hence, individuals with developmental disabilities are the most suitable for the research as they have the ability to respond and elaborate on their choices, keeping in mind that their feedback will rely on the level of their functioning.

Furthermore, individuals with developmental disabilities have higher chances to develop and be included in the society. They have the ability to join main stream schools and later to join the working field and become effective members in the /their society. Hence it is very important to gain a better perspective on the environmental barriers they face and improve the built environment and create future opportunities for them. (Soukakou, 2012)

#### **4. Acoustic in Educational Environment**

Environmental factors have an important role in the comfort and well-being of individuals with disabilities. Children with disabilities are reactive to the environment around them due to their sensitivity towards the external stimuli. This is caused by neurological disorder related to the nerve system. Neurological dysfunction has an impact on how the individual perceive and interact with the surrounded environment. A good IEQ is necessary for a successful participation/ use of the environment.

In special education and therapeutic environment, specialists find working in a simplified environment is the most appropriate manner for the users of the environment (children with disabilities). Where a classroom with too many furniture and bright colours is perceived distracting for this category of children. Although many elements such as furniture and learning tools can be changed to get the required settings such as walls, flooring yet, other classroom parameters have been given less importance to modify such as lighting, auditory features, air quality. This could be due to lack of awareness by decision makers on the short and long-term impact on the individuals of neurological dysfunction.

#### **4.1 Impact of Noise on Children with Developmental Disabilities**

Sound is a very important factor in the indoor environmental quality (IEQ) of any building. It is considered a major role player in achieving the optimum comfort level for the building occupants and a major stressor when neglected or not carefully integrated into the building design.

Sound factor in architecture is referred to as “Acoustics”. While some types of building structures require less stringent measures for acoustics, educational facilities (including academic buildings, schools, learning/training centers...etc.) are the main type affected by the tiniest inefficiency in this field.

**Sound** is a fluctuation in pressure of a given medium (air, water, solid...etc.) travelling in longitudinal waves causing consecutive compressions resulting in the vibration of molecules of the medium it's traveling in. Once these vibrations reach the human ear, it is transformed into nerves signals to the brain where it is decoded into audible sound.

#### **4.2 The Characteristics of Sound**

To be able to understand the effects of sound on the quality of the indoor environment inside a building and especially in educational facilities, we need to briefly understand the characteristics of sound and range of human hearing and comfort. These characteristics are: frequency, intensity and sound level (loudness).

The frequency determines the pitch of the sound and it's measured in Hertz (Hz). The human ear hearing range is between 20Hz t 20,000 Hz. Unlike other members of the animal kingdom who can detect infrasound and ultrasound waves, above or below this range is not distinguishable by the human ear.

Intensity is the power of the emitted sound; the more intense the sound is, the louder it appears. However it's worth mentioning that the increase in loudness of the sound occurs when the intensity increases 10 times (i.e. for each 10 times increase in sound intensity, the sound level/loudness is increased by 1

level). This makes Sound level/ loudness to be defined as “Sound intensity level measured by decibel (dB).

As seen in the chart below, the human ear can detect as low as 10 dB, where the threshold of hearing starts at 0dB and ends at the threshold of pain 120-140 dB. It's worth noting that exposure to sound levels exceeding 120 dB causes irreversible hearing damage and at 150dB the human ear drum ruptures. Figure 2.3.

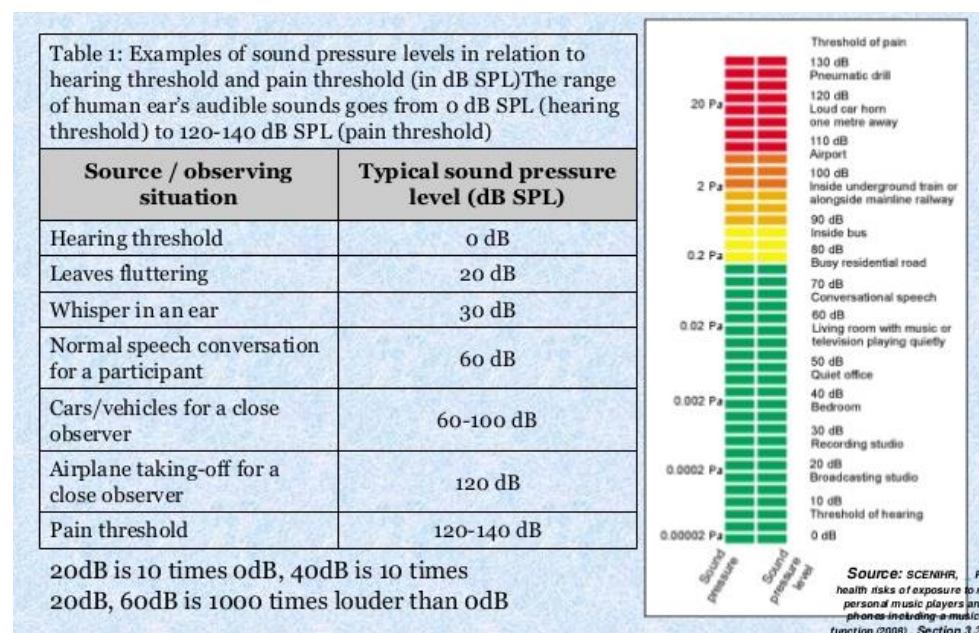


Figure 2.3: Sound Pressure (Dep James et al, 2012)

Like any other environmental factor, sound behaves differently in closed spaces than in open spaces. While you might find echo in open vast spaces, sound waves are affected by the indoor environmental space. It can be reflected, refracted, bounce off surfaces and barriers, travel through different media and be absorbed. Smooth solid surfaces reflect sound more than rough textured surfaces, while partitions, walls and ceiling systems that are not properly insulated can easily transfer sound across spaces and even amplify background noise.

In a research paper on acoustics in schools by InformeDesign Research Desk, “Background noise can come from outside the school building (road traffic, air-traffic), outside the classroom (hallways, adjacent classrooms), or inside the classroom (HVAC systems, instructional equipment, shuffling furniture).” (InformeDesign Research Desk, 2009)

To be able to control the level of background noise, another factor/behaviour of sound must be considered, called “sound reverberation”. Sound reverberation occurs when sound waves are reflected off surfaces, such as floors, walls, ceilings in a room, and bounce back into the space. This reverberation phenomenon will continue until all the sound waves are either

absorbed or dissipated (InformeDesign Research Desk, 2009). The time taken for sound to dissipate from the initial source is referred to as “Reverberation Time”.

According to the American National Standard Institute (ANSI), ANSI S12.60-2002 on the “*Acoustical Performance Criteria, Design Requirements and Guidelines for Schools*” in learning spaces that are 20, 000 cubic ft. in volume, the background noise should not exceed 35dBA, and above 20,000 cubic ft. it shouldn't exceed 40dBA (acoustics.com,2009). This is accompanied with reverberation time limit of 0.6 seconds and 0.7 seconds respectively for unoccupied classrooms, and a limit of 50dBA for occupied classrooms. (Asha.org, 2016).

However, it's worth mentioning that these standards/guidelines do not take into account classrooms or educational facilities that host children with disabilities, hearing malfunction/disabilities, or children with special cognitive and mental needs such as autistic children. While children with hearing disabilities might require a higher SNR (sound to noise ratio) of +20dBA to +30dBA above background noise level, autistics children might require less than the required standard (+15dBA above background noise level) due to their sensory sensitivity to surrounding stimuli especially sound related ones. (InformeDesign Research Desk, 2009)

In a research by Dep James et al (2012), regarding the *cost benefit analysis of providing a 'sound' environment in educational facilities*, he explored the direct relation between speech and language development and classroom acoustical design, where he anticipated/ demonstrated that classrooms with improved acoustics aided in fast development of speech and mental cognition of students which by its turn improved their skill level and hence had a positive impact on the overall economy which surpasses the initial high cost of providing such appropriate educational environment (Dep James et al, 2012).

From this study we can infer that facilities with special needs occupants are even greatly affected by poor acoustics and poor sound management which, by its turn, affects the progress and development of these students.

The most recent update from World Health Organization (2017) on deafness and hearing loss presented alarming statistics on youth health. The figures state that 32 million children are suffering from hearing loss. Although some causes of hearing loss is genetic and due to disabilities/ conditions occur at birth, other reasons are exposure to extreme noise. The same report also indicated that 60 % of childhood hearing loss is resulted from preventable causes.

When acoustical conditions in a classroom are poor/ low in quality, students suffer negative learning experience. Where performing tasks becomes challenging and focusing becomes difficult. Both teachers and students get affected by poor acoustical conditions. The negative impact of noise does not

only create hurdles to the learning of students and performance of teacher, it also has negative impact on the students' behaviour.

## **5. Lighting in Educational Environments**

Light is one of the primary elements in the indoor environmental quality (IEQ) of any building. Natural light, also known as daylight, is considered an essential element, if not the most important one, for sustainable building structures as it is considered a major role player in achieving the optimum comfort level for the building occupants and possesses a proven impact on the occupants' health, wellbeing, and developmental skills.

Since schools and learning institutions are characterized by their indoor activity type of nature, and with much attention and focus required in the learning process, it is by no doubt that the indoor environment of such facilities have a great impact on the progress and development level of its occupants. With 25 % of the day spent in classrooms by students, properly lit spaces are of the utmost importance in achieving the ideal IEQ in terms of visual comfort. Thus light, and daylighting in specific, is considered the most important factor in the indoor environmental quality (IEQ) of any building.

In a research study done by Heschong Mahone Group in 1999, 21,000 students test scores were analyzed in the light of investigating the relationship between daylight and human performance in schools. The resulting data and findings that prove students in schools with improved daylight quality (such as skylights with celestials) showed higher scores in 20-26% faster learning rate than those with poor or no daylight (small windows or only artificially lit classrooms). The study attributed this conclusion to the correlation between daylight and several factors that it impacts: like improved visibility, better distribution of light, better colour retention, absence of flicker (induced by artificial lighting light bulbs), sparkle or highlights, and improved health. It went further into explaining how improved health came from the biological attributes of daylight and its effect on the production of vitamin D and suppression of the excessive production of melatonin which by its turn helped in decreasing the symptoms of seasonal affective disorder (SAD), improved mood and alertness, due to the improved visual quality (Heschong, 1999).

### **5.1 Impact of Light on Children With Developmental Disabilities**

From the previously mentioned research, it becomes clear that the presence of daylight in the indoor environment of classrooms in educational facilities has a direct impact on the cognitive development, as well as the psychological and physiological aspects of the students. This applies to facilities with special needs children. However, a slightly more careful approach needs to be regarded in special needs education as each child/student is affected differently with regards to the exposure of daylight.

In Building Bulletin 90 report on *Lighting Design for schools, 1999*, and Building Bulletin 77 report on *Designing for Pupils with Special Educational Needs and*

*Disabilities in Schools*, 2005, an attempt to address this topic as there are little guidelines with regards to these children. Both reports, an emphasis on daylight and daylight factor, glare control and attention to reflections and reflective surfaces was set forth taking into account several cases of special needs, from children with visual impairment (partially or fully)- where glare causes immense discomfort- to children with hearing impairment that depend primarily on visual methods of learning. Also it's worth mentioning that excessive daylight with no glare control could also affect children with other types of disabilities through over stimulation which causes irritation and accumulation of stress and hindering their learning development. Finally, the report indicated that activity type and duration spent in the classroom which determines the required lighting criteria/ characteristics in special education.

A recent study by (Michael and Heracleous, 2017), investigated the significance of daylight performance on the students' visual comfort in typical educational school in Cyprus. Findings of the study suggested that light uniformity in the classroom provides visual comfort to students. Students in classrooms with east and west orientation experience discomfort from high light contrast and bright visible light source at desk level, which was due to improper shading devices used.

## 5.2 The Characteristics of Light

Since light has a wave property, it can reflect and refract, diffuse and be absorbed fully or partially (emitted). Light reflecting back off an object onto our retina is what makes vision possible. When there is no light, we are unable to see anything (pitch black). Little or dim light would render the space/room to be dark and thus hinder/affect our vision quality. Similarly, direct sunlight reflecting off surfaces with high reflectance property (such as mirrors, glossy surfaces...etc.) would cause glare that would also cause visual discomfort.

To achieve the optimum comfort for occupants, "the ratio of outside illuminance over inside illuminance" known as the Daylight Factor (DF), needs to be calculated and taken into account upon design. This DF is expressed in percentage, where "the higher the DF, the more natural light is available in the room". (Costanzo, Evola and Marletta, 2017)

**Uniformity** refers to the even distribution of daylight in a given space, expressed in a percentage ratio between the mean/average illuminated area of the space and the lowest illuminated area due to its distance from the source of light (windows, skylights...etc.). (Phillips, 2004)

**Glare** is another issue that comes with naturally lit spaces. It is important to control the glare and reflections as they cause visual discomfort for the occupants and reduces the IEQ of the space. (Phillips, 2004)

The key lighting factors that are accountable for visual comfort rely on four components:

1. Amount of light.

2. Uniformity of light, as it is necessary to achieve successful daylighting.
3. Quality of light.
4. Prediction of risk of glare.

## 6. Standards and Guidelines for Educational Environments

Standards and guidelines are an indicator of level of knowledge and awareness for the selected field. The primary goal/ objective of creating these guidelines is to draw a baseline of practice in order to assure/ obtain high quality for the end user. Hence it is important to look at the existing standards which decision makers/ architects/ consultants use for educational facilities and environmental consideration given to the population of children with disabilities. This section will review and analyze the existing standards and guidelines followed in designing / retrofitting educational facilities.

First, the environmental criteria for children with disabilities in special education environment are presented showing similarities and differences between the guidelines, followed by guidelines set of main stream school.

Since the focus of the study is on visual comfort and acoustic comfort, a comprehensive view will be on two environmental factors (Lighting and acoustics). A comparison between the two educational spaces will be presented (Main stream educational standards and special education standards).

This section highlights the differences between the two different educational disciplines that serve different type of occupants and different educational disciplines. However, both categories have the same objective; which is providing the ideal learning environment for the students to reach the optimum of their potentials and achievements.

The purpose of critically reviewing the guidelines is first, to understand the main environmental factors these guidelines consider and second, to see the differences of consideration of climatic and regional differences. This will help identify if these guidelines are suitable to be followed in a region with different climatic features.

Literature shows that in developed countries, the two most followed international standards for special education are:

- Building Bulletin 102 from United Kingdom.
- American National Standards Institute ANSI.

Table 2.1 shows the required characteristics of light and acoustic in guidelines made for special needs educational and/ or therapeutic environment.

The presented guidelines are; a) Building Bulletin 87, b) Building Bulletin 77, c) Building Bulletin 102, d) British Association of Teachers of the Deaf, e) American Speech Language Hearing Association, f) ASHARE- EN 15251.

While searching for the guideline it was noted that, it was found that UK Building Bulletin guidelines are have more holistic standards for common practices. While guidelines from US was found generally separated as per different association covering specific disability types, for example; ASHA American Speech Language Hearing Association. This indicated that the guideline do not cover all disabilities, as well as only covering environmental factors that relates to the disability. As seen from table (2.1), ASHA guidelines and ASHAREA EN 15251 only stated acoustic characteristic recommendations for SEN. This shows that the guidelines do not cover all aspects regarding the quality pf light and comfort for the individual's needs. As seen from table 2.1 only acoustic characteristic recommendations were given for SEN. Therefor practitioners will find a gap in finding standards for all the four elements in educational environment in classrooms. While UK Building Bulletin guidelines have given a holistic approach in addressing all environmental requirements to support different types of occupants to have a successful learning experience.

As seen in the table 2.1, most guidelines recommend lighting level to be at the range of (350 to 500 Lux) level, while the recommended daylight factor in a classroom in the range of (3%to 5%) of to the total area. Regarding acoustic specifications, sound level to be in the range of (30 – 35 dB) with maximum noise level to not exceed 60 dB. Reverberation time in the American guidelines and UK building Bulletin guidelines were (0.4 s).

Table 2. 5: SEN Guidelines (2017)

Guideline	Light			Acoustic	
	Lux level	Daylight factor	uniformity	Sound level dB	Reverberation Time s
Building Bulletin 87	350-500 lux	3-4%	0.3-0.4 & 0.7 for roof lights	Teaching space intended specifically for students with special hearing and communication needs2 New Building (30 dB) Refurbishment ( 35 dB) (Noise should not exceed 60 dB)	0.4
Building Bulletin 77	350-500 lux	4-5% 2% (main stream)	0.3-0.4 min 0.7 for top-lit surfaces		0.4



Building Bulletin 102- UK		4-5% 2% (main stream)		Refer to BB93	Refer to BB93 0.4
ASHA American Speech Language Hearing Association	/	/	/	30-35	0.4
BATOD British Association of Teachers of the Deaf	/	/	/	35	0.4
ASHAREA – EN 15251	/	/	/	45	/

## 7. Disability Population in the GCC

Hayhoe, S. (2014) reviewed the literature focused on sustainability of the disabled population in the GCC. The study looked into the cultural factors which influences the evolution of this population. The study also highlighted the necessity to increase awareness and stoical registries of the disabled population as the GCC countries are going through a structural shift / growth in their economies. Findings of the study supported other studies (Gharaibeh, 2009, Hadidi & Al Khateeb, 2015, Alkhateeb, et. Al, 2016) which stated that overall development of disability agenda are still at early stages in the GCC, hence governments must give priority into structuring a static database on the nature and cause of disability and prepare a solid agenda for the increasing population.

Furthermore, despite the strong ties between the GCC countries economically, culturally and socially, the author did not find any consistent evident of strategization or planning of recourses, institutions and policies for the disabled population.

## 8. Studies on Disability in UAE

(Eapen et al., 2007) conducted the prevalence study in the UAE regarding developmental disability. The study highlighted the shortage in inclusive studies on developmental disorder specifically and disabilities in general in the UAE and in the region. Results of the study found the prevalence rate of developmental disabilities were 29 per 10,000 in children of 3 years old of UAE national population.

Findings of the study strongly suggested to increase community awareness about the conditions and needs of populations with disabilities, and looked into effective services that support the quality of life and their development such as

special education, inclusion. Planning appropriate developments in the medical field and rehabilitation services were also recommended.

## 8.1. UAE Vision for disability (accessibility for all)

In the past forty-six years, United Arab Emirates has gone through a remarkable development phase in many aspects, specifically in economic development. UAE vision is to be among the top developed countries by 2021, as it is the year of golden jubilee of the emirates union from 1971. In October 2015, the executive council of Dubai announced the launch of Dubai Inclusive Development Forum. The forum aims to make Dubai a disability- friendly city that gives equal opportunities for persons with disability.

Five primary strategies were presented to ensure the protection of right for the category of persons with disability, these strategies are; social protection, availing public services and utilities, employment, education, health, habilitation and rehabilitation. Moreover, the forum also aims to create opportunities for this category of the society to be more effective and present in the community and to have concrete role in contributing to the development of the United Arab Emirates.

Furthermore, the forum underlined the importance to build accessible environments that enables individuals with disability to easily integrate and reach out to the community. These services include public transportation, roads, the built environment and utility services. The forum also necessitated the importance of giving individuals with disabilities the empowerment through better healthcare, habilitation and rehabilitation services and educational opportunities.

## 8.2. Statistics and Demography of Disability

This section represents statistics on disability in the UAE. Information listed below is obtained from UAE's Federal Competitiveness and Statistics Authority. The presented information is from the recent data collection from the year 2014 to 2015 for Special Needs care and rehabilitation centers. The registered centers do not include health clinics and clinical institutions for special needs individuals.

Table 2. 6: Number of Special Needs Care and Rehabilitation Centers by Sector in the Emirates 2014- 2015. (UAE's Federal Competitiveness and Statistics Authority, 2017)

Sector	2014-2015			Total
	Federal Government	Local Government	Private Sector	
	5	19	45	69

Table 2. 7: Number of Special Needs students in Care and Rehabilitation Centers by Sector in the Emirates 2014- 2015. (UAE's Federal Competitiveness and Statistics Authority, 2017)

Sector	2014-2015			Total
	Federal Government	Local Government	Private Sector	
	539	2,437	1,862	4,838

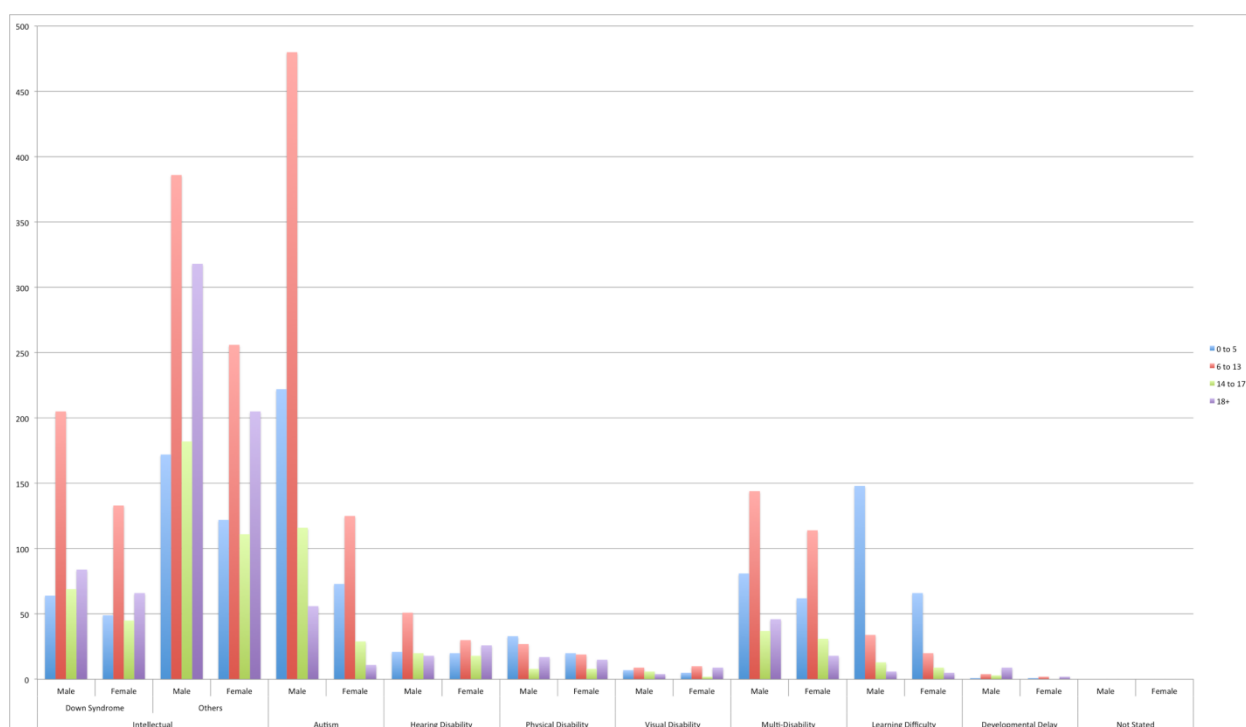


Figure 2.8: Number of Students in Disabled Care and Rehabilitation Centers by Age Groups and Disability Type 2014 - 2015 (UAE's Federal Competitiveness and Statistics Authority, 2017)

Table 2. 3 shows that centers run by privet sectors are more than federal and local government. On the other hand, it is noticeable that students attending local government facilities are the highest population compare to the federal government and privet sector.

Figure 2. 4, indicates that the percentage of male individuals with disability is higher than female individuals with disability. This is due to the fact that in most disabilities are found in male population than female.

Numerous studies have attempted to explain why male fetes are more likely to face genetic mutation than female fetes. The study by (Jacquemont, et. Al, 2003) provides the most comprehensive empirical analysis of this statistic. The longitudinal study analyzed 16,000 DNA samples from individuals with neuro-developmental disorders. Findings of the study stated that female brain

requires extreme genetic alternation (mutation) compared to the male brain in order to develop neuro-developmental disorder and autism spectrum disorder.

### 8.3 Types of Available Centers

In the UAE, there are selection types of institutes/ facilities for individuals with disabilities. These institutes can be divided into clinical based institutes; where the individual is exposed to one to one therapy program over short period of time such as three months physical treatment sessions. The other types of institutes are educational based institutes which embrace children into a special educational environment (SAE) similar to school based environments.

Students in SAE follow an educational program called individualized educational program (IEP), where the student is exposed to several therapy sessions during their day in a classroom setting amongst peers with same age group and/ or level of functionality. More details about special education will be elaborated in the below section.

In the U.A.E there are three primary types of institutions dedicated for individuals with disability:

1. Governmental servicers/ institutes/ organizations, controlled by the local government. Serveries are often given for free of charge for local citizens of the U.A.E.
2. Semi-governmental Centers, created by non- profit charitable organizations. Services are often given free of charge or at semi free (Reasonable prices).
3. Privet Centers/ schools/ Rehabilitation clinics and Centers/ Recreational Centers. Created by privet individuals. Services are charges per session / months/ year.

Services and programs vary based on two primary factors:

- 1) Type of disability.
- 2) Age group.

Table 2. 8: SEN Programmes Based on Age Range (2017)

Age Group	Program
<b>0- 6</b>	Early intervention Center. Children's Center. Integrated nursery program. Rehabilitation Center. Special needs Center.
<b>6- 15</b>	Schools for children with disability. Rehabilitation Center.
<b>15- 20</b>	Schools for children with disability. Vocational and training Center. Social club/ sport club for individual with disability. Integration with mainstream school and program.
<b>21- and above</b>	Job recruitment project for individual with disability. Social club/ sport club for individual with disability. Center / homes for adults with disability. Other social organization.

For this study, three institutes were chosen. Two of the case studies are from the private sector and one case study is a semi-governmental school for special needs. Each of the case studies represents certain educational system/program. Each of the selected case studies also represent different types of building structure in different urbanized locations across the UAE. More information will be mentioned in chapter 4.

In 2016, there has been a substantial increase in facilities serving individuals with disabilities, specifically recreational centers and rehabilitation centers for young adults with disability aged 18 and above. The main reason for this upsurge was due to the lack of institutions set for rehabilitation of young adults with disability. The second reason was that many special needs centers do not have enough capacity to welcome more students, and lack of experts they tend to have, and has age based limitation in which they graduate students after certain age regardless if the students achieved their goals into being more independent and adaptable in their environment or not. This has led many specialists and parents initiated to open recreational centers to cover this gap.

The majority of special needs schools take children up to 18 – 20 years old only, this does not necessarily mean that the child is aware of their restrictions and abilities and/or their readiness to their inclusion to society and become an affective person in the community.

Another crucial point to be added regarding special needs education/ system is that this population requires time and extensive therapy in a consistent manner in order to witness progress and development. Occupants of SEN have many sensitivities and requirements which makes running a center far more difficult than running school; due to so many factors. Below is a list of some of these factors:

- Variety of type of disabilities in the Center.
- Individualized program per student.
- Every student progress in a different pace. Some students progress in a very fast rate and some need more one to one therapies and sessions for the progress to be steady.
- Consistency of programs.

Often new special needs institutes facilitate in villa-like buildings or apartments. With the increase of special needs centers, there is a need to create a guide to help the organization to overcome the built environment limitations and most importantly to provide a healthy and accessible environment that enables students to achieve their learning target and perform better.

#### **8.4. Special Education in the UAE**

In 2006, United Arab Emirates Introduced federal law No. 29 related to individuals with disabilities (Uaecd.org, 2017). The law announced the concept of inclusive education of students with disabilities at mainstream schools

(Public or private schools), promoting equalities access to educational opportunities. The inclusion philosophy is to give children with disability even opportunities to get education that meets their abilities and age with other children equals who do not suffer from disability in mainstream educational setting (school). Academically all students will be studying the same subjects, while students with disabilities will be offered assistance, regardless of its category; physical disability or intellectual disability.

Inclusion not only allows children with disability to have/ obtain main-stream syllabus, it also allows children to participate in the least restrictive environment and elaborate/ show the optimum of their intellectual strength; Including the students in mainstream environments rather than segregating them in different school settings. Furthermore, inclusion aims to put children with disability in safe and stimulating environment which will aid the child to progress/ develop faster intellectually, emotionally, socially and physically. Finally, inclusion embraces the culture of acceptance with youth and the growing generations.

## **9. Knowledge Gap**

Nowadays, the knowledge of building performance assessment has become increasingly necessary and crucial to guarantee the suitable IEQ in energy efficient buildings. In fact, energy and IEQ audits contribute to identifying the weaknesses of any given building and provide potential improvements. From the above, we can conclude that it is clear that improving and implementing audits on educational buildings is substantial.

In modern education institutions, student's educational activities are interactive, where the physical space is a dynamic component of the learning experience. However, in most studies about indoor environment quality, thermal comfort and indoor air quality has been seen/considered as the most influential factor with the greater impact on the subject's experience, sensation and satisfaction, leaving much less studies solely focusing on other indoor environmental factors like light and sound.

Existing research recognises the critical role played by all indoor environment factors on the wellbeing and productivity of the occupants. In the educational environment, the main challenge for school management is to ensure the learning services and facilities are being utilized in such a way that the student experience a positive learning journey. Whereas architects are focused on building an educational facility that accommodates all types of learning activities.

However, observations have shown that there are few detailed studies on the role of the indoor environmental quality in special education facilities. Apparently, there is lack of grounded standards and guidelines, pertaining the mental healthcare of these individuals, stemming from the inadequate and scarce information availability and knowledge on the different varieties of disabilities in the society, and how regulations are kept very general towards

their needs. More details on guidelines for special education will be presented in chapter 2.

Architects, interior designers must be well versed, as well as be able to access the required information, with these different types to be able to incorporate each of these needs when approaching a special educational indoor environment. Authorities must priorities and enforce regulations and guidelines that ensure the translation of these needs into reality; provide support, treatment and services, in order to give a decent and enabling society for all.

A study by Systems (2009) proved that the interaction with environmental factors have substantial impact on the severity of disabilities, even if the disability is genetic. Environmental factors have significant and direct impact on the neurological development of the brain, equally in healthy children and profoundly in those with one or several disabilities. In the Systems study, special needs centers *“often do not have the knowledge and skills to provide the services. Unfortunately, these barriers result in denial of services or provision of inappropriate services to this population”* (Systems, 2009).

Although extensive research and studies have been carried out on the impact of the indoor environment on children in the educational environments, very limited studies highlighted the impact of indoor environment factors on children with development disabilities. To be able to help special needs centers improve their indoor environment quality, there is a great need for awareness on the importance of the intangible factors that have a huge impact on the occupants.

# Chapter 3



## **Chapter 3: Methodology**

### **1. Overview**

Many studies have focused on evaluating the indoor environmental quality of buildings to be able to assess and document the three important factors: energy consumption, occupants comfort and well-being. Researchers have been immensely interested in optimizing the well-being and comfort level of tenants and building occupants through assessing indoor environmental factors, and the extent of their impact on the human behaviour. These assessments & evaluations were done to:

- Determine indicators and guidelines that can benefit the end users/public.
- Create a bench mark of database and studies for future researchers in the field to continue developing and proposing solutions.

Authors and researchers followed different research approaches depending on various factors: such as the nature of the topic, level of accuracy aimed to achieve, the expected findings and the collected research data. In this sense, Methodology, as a term, represents the process of which documents and data are being collected, examined, construed and reported in a research. Selecting the suitable method will determine the quality of the work, making research methodology one of the most important and critical part of any research.

This chapter presents methodologies used in previous studies with regards to evaluating the impact of IEQ - specifically light and acoustic features - in special educational environments, on the progress of individuals with developmental disabilities. Pros and cons of each method will be discussed, followed by the selected method for this study and justification for its suitability.

### **2. Research Parameters**

As mentioned in the previous chapter, this study is considered a social research, based on three main purposes, which are:

- 1) Evaluating the impact of indoor environmental quality (Light and sound) on individuals with developmental disabilities.
- 2) Gain in depth knowledge and understanding of the group of individuals with disabilities with regards to their perception of the indoor environmental factors.
- 3) Creating a bench mark for special educational environments, as it does not exist in the common/international/practiced guidelines and standards of IEQ (in Light and acoustic features), that are tailored to improve the occupants' performance and encourage their progress in the learning environment.

Many previous IEQ studies on educational facilities have looked into the structure of the building, the characteristics of the IEQ elements, and collectively assessed occupant's satisfaction level/comfort with the experienced IEQ. Some studies evaluated the existing environment, while

others created a controlled environment; experimenting to find the impact of each environmental factor individually on their participants in different setting. However, fewer studies have been concerned with the occupant's sensitivity as a primary issue to tackle.

It is important to take into account that individuals with development disabilities experience discomfort due to sensory dysfunction. Stimuli such as light, sound, odour etc. can be perceived with higher intensity unlike neuro-typical individuals (healthy individuals) that do not get affected by these stimuli. Consequently, these individuals score higher rates towards experiencing extreme/negative sensations. Therefore, the selected methodology also considers the later sensory disturbance that may be experienced during data collection phase.

Conclusively, this study draws light on the occupant's mental health and limitations, and emphasizes on the importance of IEQ in creating a challenging environment for this population, especially in the educational environment. Moreover, to explore, find and understand the impact of IEQ on this group, the research will evaluate visual characteristics (Lighting: Lux levels) and acoustic characteristics (Acoustic: Sound level Decibels (dB)), evaluating the impact of IEQ -with regards to Light and sound- on the progress of children with developmental disabilities.

The study design approach and methodology selected to answer the hypothesis is a explanatory method for selective three case studies with three different building features, each representing popular built environments in facilitating special educational programs in the UAE. These case studies are commercial apartment building, villa and purpose-built center for special needs children. All the three case studies have the same type of occupants

Similarities between the three case studies lies in the function of the centers; as they all follow one special needs educational program and they have the same category of occupants with developmental disability. Differences, however, lies in the location of each building type (urban area, rural area, and residential area). There are different sizes of the buildings, different total numbers of occupants, as well as the specialty of the center (Special needs school, rehabilitation center, family support center). More details on each case study is presented in chapter 4.

### **3. Methodologies and Indoor Environment**

Studies on evaluating the IEQ are commonly found to be using the mixed method. This section will look into different methodologies used to evaluate educational environment and presents IEQ researches in educational facilities.

The presented research samples in this section are a mixture of IEQ studies in educational buildings and research studies dedicated to individuals with developmental disabilities. Due to the lack of studies on evaluating the indoor parameters on this group, it was necessary to look into previous studies that

analyzed the impact of sensory environment on the children with developmental disability.

### 3.1 Questionnaire and Interview

Questionnaire and interview method offer an effective way to get an insight into what people think about a certain phenomenon. Hence, qualitative data is descriptive. In IEQ studies, building occupants are a valuable source to indicate the quality and condition of the indoor environment. After all, it is their comfort and well-being that is connected to the quality of the indoor environment. Hence, many studies tend to involve the occupants in the study to get an indication on the searched / investigated dynamics of the building. Although feedback is subjective, as response may differ due to age, gender, expectations and well-being, findings of qualitative data help in generating common trends. Moreover, depending on the focus of the study, researchers may target random selection of occupants with various backgrounds, in order to obtain a wider range of feedback for IEQ perception.

There are two main approaches taken for collecting qualitative data: Questionnaire/Survey and Interview.

#### **1) Questionnaire:**

Generally, questionnaires are self-completed/filled in by the participant. Questions must be clear, logically structured, short and easy to follow. Surveys and questionnaires are the most common technique for collecting quantitative data. **Questionnaire** is considered one of the most effective tools used to get an insight on trend/ patterns of behaviour of the end user. Depending on the targeted participants, most researchers use different types of questionnaire structure to help the participant easily understand and answer the questionnaire.

Questionnaires are mainly structured into segments; each segment is articulating and leading to the following segment. Ideally, for studies on IE questionnaire, they are divided into four segments; starting with participant's background information (Gender, Age, Weight, Height), then clothing checklist to get a perspective on their clothing insulation, proceeded by a segment on the participants' habits, ending with a segment about the position of the student in the classroom, whether it's close to direct daylight and noise sources.

#### **2) Interview:**

The purpose here is to obtain a better knowledge of the topic from specialists and individuals who have defined knowledge in the area due to profession or experience. In this method, the researcher gives the interviewee the freedom to elaborate on his/her answer; because the goal is to get more details on the topic. Depending on the study, the researchers will determine the interviewed individuals who are eligible to be part of the research and their level of involvement in the investigated study. For example: some studies involve parents and/ or the care giver to partake in the responsibility in answering the questionnaire as well as

the interviewee, because they live with the children and know more about their behaviour patterns...etc.

It's worth highlighting that the researcher background knowledge about the participants is important, as it defines the format of questions that is developed in the questionnaire, in addition to the format of the answers. Furthermore, a question format is an indication on how accurate and relevant the obtained data is in the investigated factors. It also helps the participant to build up knowledge and new perspective on how to look at the selected subject matter. For instance, through investigating the indoor environment quality; participants will broaden their knowledge on identifying parameters and in what area it affects their well-being and performance. Question format commonly used in IEQ studies are: 1) Likert 2) Rating scale 3) Yes/ No question, 4) Open/ closed questions.

On the other hand, disadvantages of this method is the individuality of the participants. Meaning, the reaction and response to the environmental stimulus may differ from one person to the other. Moreover, as the questionnaire is taken in a certain timing and/ or environmental setting, the collected data represents only that temporary phase and it does not reflect the participant's response in a different time of the year and/ or alternative setting that may alter their perception of comfort, unless the research is carried to a longer extent of time and looks to evaluate IE in different times of the year and several climatic conditions.

Additionally, participants may be affected by some external factors that may, by its turn, affect their understanding of what are the causes behind their discomfort. Therefore, the purpose of the study is to assess the connection between IEQ and students' academic performance and health.

Khakzand and Aghabozorgi (2015) conducted a study to identify and review factors that help improve students' performance in educational environment. The study targeted children with intellectual disabilities, including children with visual and hearing impairments, Deficit Hyper Activity Disorder, and multiple disabilities. The questionnaire was formed based on the psychology of exceptional children or area of environmental studies. The aim of the questionnaire was to evaluate and measure the effect of the below factors on the students (light, kind of materials, sound, colours, and proportions). Questions were in the form of images and figures. Visual questionnaire is a good approach to be used with children with disabilities, as it helps participants to easily understand. Furthermore, students answered the questions with the supervision of the school psychologist. This is another advantage that needs to be considered. Where teacher's can support students who require more help in answering the questions as well as they can communicate with student's and interpret what the research authors are evaluating.

Researchers took approval from the school and specialists to specify the suitable time for students to answer the questionnaire, as the amount of effort by students and energy was taken into consideration causes delay in their study timetable. Moreover, to compensate the one on one time the psychologist had to assist the students during their time to answer the questionnaire. Collected qualitative data was analyzed using statistical software SPSS for descriptive and inferential data.

A similar study by (Ramli, Ahmad and Masri, 2013), investigating the perception of students and teachers about classroom indoor environments. The study relied on a qualitative data-questionnaire format. The study took two phases, in which a gap of one week between the two phases was considered. Phase one employed questionnaire targeting students' judgement on their classroom. Three main segments were formed: a) Background information, including a set of questions b) Questions on classroom environment elements (Lighting, Seating arrangement ..etc.) c) Open end questions on the preferred classroom environment.

For the second phase of the study, selected classrooms was rearranged based on students' preference of the ideal classroom environment. Classrooms were used by the same group of students whom participated in the first phase. Second round of questionnaire given to the students after their experiencing the new setting of the classrooms. The questionnaire targeted students' opinion on the preferred classroom environment. The researcher used visual questionnaire created by Sanoff (1991), for the second phase.

Questionnaire and interview- based research method targets occupants of the buildings or individuals that occupancy the investigated location. The purpose of this method in IEQ studies is to get an insight of the occupant's experience on the environment in order to have a better understanding on the occupant's perception of IE comfort.

### **3.2 Monitoring and Observation**

This method is particularly useful in environmental sciences, where obtaining actual measurements of the environment is the basis of the analysis. Quantitative data is numerical measurement, considered more accurate as it's based on tangible measurements. Depending on the research focus, indoor environment researches vary in the use of this method. The method depends on the use of devices and/ or judgment of experts in their analysis of the environmental variables and individual's reactions/ behaviour towards the experienced environment.

Some IEQ studies utilize this method to get readings of the environmental stimuli in the selected environment without changing the setting of the environment. While other studies aim to measure different environmental variables/ stimuli in a specific setting. Here, the researcher creates a controlled different setting to evaluate variables individually.

Other studies observe the environmental setup without changing the environmental variables in order to see the natural reaction of occupants as what they experience on a daily basis. Site observation and monitoring method varies depending on the focus of the research; the factor:

- Location of the Spot measurement.
- Duration of recording the measurement: (Long term monitoring) and short term monitoring.
- Type of measuring devices; its status of accuracy, fixed recording frequency, and the used calibration.

A field measurement study conducted by (Bellia et al., 2015) investigated existing lighting quality in school in Italy. The purpose of the study was to highlight user's eye level in evaluating/ analyzing lighting characteristics in educational environment. The study looked into analyzing lighting characteristics that is linked to non-visual responses in a particular light at the occupant's eye level. Non- visual responses are related to the occupant's alertness, comfort, productivity and well-being. Two methods were developed by the authors:

- Analysis of luminance m (HDR imaging technique).
- Evaluation of non- visual effect of light.

Both methods included measuring devices. Devices were used simultaneously measuring several visual tasks and several locations in a classroom. The first method involved a video luminance meter. The characteristics of the video luminance meter are: it gives high resolution (HDR) technique, wide field view and high dynamic range, which is beneficial in capturing the daylight casting in the classroom as it varies rapidly. Luminance levels were captured in shutter time of 2s, 1/15s, 1/500s to measure low, medium and high luminance levels. Daylight was recorded in two separate days, featuring a clear sky and an overcast sky.

The second method was evaluating the non-visual response. The later evaluation measured light characteristics at the user's eye level. Measurements took three different locations and at tilted angles, taking into account that individual's head position is not fixed.

(Shapiro, et. al. 2009) adopted the monitoring and observation method in a sensory adapted environment to evaluate the impact on children with developmental disabilities in an anxiety provoking environment. The research assessed SAE in dental setting. Specific objectives were to measure the effect of the sensory-adapted dental environment (SADE) on the number, duration, magnitude of negative dental behaviours, levels of dental cooperation, and on electro- dermal activity during dental scaling and polishing, as compared with a regular dental environment (RDE). Participants were observed in two dental setting, one with the typical dental setting and the second was more equipped with sensory adapted strategies/setup. Participants went through the same dental treatment "Basic scaling and polishing". The treatment was suitable because it allows standard and uniform procedures for all participants.

SAE setting addressed the following stimuli: Tactile, Auditory and Visual. For visual stimuli; direct overhead light was replaced by adopting lighting of reflective light (30- 40,000 Hz). Dentist replaced direct assisting lights with head-mounted narrow spectrum light. Acoustic stimuli were integrated to the environment by playing rhythmic music at 75 dB. Participants were treated once in each environment respectively with a four months gap between each clinical treatment. Anxiety level of children was registered using “Anxiety and cooperation” scale used commonly by dentists, created by (Veerkamp et al., 1995). The scale rate is (0 – 5), 0 being extreme behaviour (Maladaptive behaviour), and 5 being cooperative, comfortable and relaxed. The treatment was video-recorded throughout the session. Duration of the treatment lasted between 20 to 25 minutes. Since the research was focusing on the behaviour of children in the two environments, qualitative data input from observation was based on type of anxious behaviour, how frequent the behaviour was, duration of the behaviour till it ended.

Findings from this method were significant with their accuracy, specifically in environmental studies where there are many factors affecting the user or the intensity/ level of impact. Results of the study found significant reduction in maladaptive behaviour of the children; this includes behaviour of resistance, screaming and stress as well as reduction in the duration of stressful/anxious behaviour. As such, massive increase at the cooperation behaviour was observed by the dentist.

There is more room for comparison in this method to test the impact of IEQ parameters on several groups of users. This method is convenient when the researcher strives to find differences and similarities for occupant’s behaviour / performance/ wellbeing based on the quality of the indoor environment.

Researches evaluating the effectiveness of SAE Sensory Adaptive Environments had different approach when it came to children with disabilities. (Shapiro et al., 2007) investigated the SAE effect on both typical children and children with disabilities. The experiment was conducted in two phases with two selected group of children. The purpose of the study was to see the extent of the SAE effect on the focus group during the dental treatment. Both groups took the same dental treatment in two different environmental setting where light, acoustics and sensory features differed. The experiment aimed to:

- The child’s anxiety behaviour (stress level): assessed by filming the subjects during dental care and coding their anxious behaviours.
- Physiological arousal states, evaluated by the assessment of EDA changes in the electrical conductance of the skin.

8 children with disabilities were assessed in SAE. In the next visit to the Dentist, the group was treated in a regular treatment environment, with four months gap between the two sessions.

After the treatment of children with disabilities, the second phase of the research, the same sequence of the treatment was carried out for typical children. Duration of treatment was 20 to 25 minutes. Each treatment session was filmed and behavioural analysts were present at the session to record

the patients' behaviour. Children with disability and typical children were split into two groups per category. Then each group had a sequence that they were alternating between SAE and RE environments. During the treatment sessions, behaviour analysts were measuring the behaviour and duration of anxious behaviours with NDBC (EDA electro dermal activity). Measurements and results were then analysed using an analysis-software called SAS, version 9.

### 3.4 Mixed method

Researchers adopted/ created four primary forms of mixed method designs. These methodologies are:

1. Triangulation Design.
2. Embedded Design.
3. Explanatory Design.
4. Exploratory Design.

The mixed methods differ by their use (based on the topic of research and the required data), and the procedures taken to get the data.

**Triangulation Design:** Mostly used in literature researches.

The purpose of the method is to collect strength and weaknesses of quantitative method. This approach used with quantitative data which is large in sample size, generalization and trends comparing it to qualitative method which is small in sample size, focused and rely on details.

In this design approach, authors intend to answer the research question by associating quantitative findings with qualitative data, or by comparing quantitative statistical findings with qualitative findings. Procedures of this method occur at the same time, where the researcher directly analyses the quantitative and qualitative data in one phase at the same time; Figure 3.1 demonstrates this mixed method research:

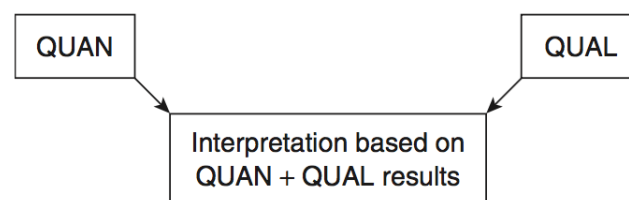


Figure 3.1: Triangulation Design (Creswell and Clark, 2007)

Advantages of this design approach:

- As both types of data are given the same significance and importance to the research question, research flow has intuitive flow.
- Efficient approach, in which both data is collected at the same time in one phase.



- Although data was collected in one phase, each data type is analysed separately without being or having an effect on the results and findings of the other data.

Disadvantage of this design approach:

- As quantitative and qualitative data are analysed separately, expertise and good understanding of both types of data is needed.
- Challenges will occur if results from quantitative and qualitative do not match.

**Embedded Design:** Mostly used experimental or correlation research.

This mixed method is suitable for large scale studies where researchers rely on one primary data to answer the research question, yet in this type, secondary data is required to support the primary data.

Researchers use embedded design mixed methodology when the research topic presents questions that require different approach to obtain the answer and/ or when the research question require different type of data. Procedures of this mixed method are designed at the early stages of the research, where the author determines what data is the primary data in which the secondary data is embedded within the process of the primary data; Figure 3. 2 demonstrates this mixed method research:

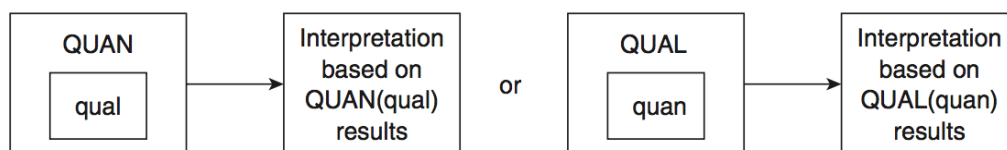


Figure 3. 2: Embedded Design (Creswell and Clark, 2007)

Advantages of this design approach:

- Research topics have limited resources.
- More manageable compared to other mixed methods.

Disadvantage of this design approach:

- Difficulty to integrate and connect the findings from qualitative and quantitative when each data type is answering relatively different aspect of the research.

**Explanatory Sequential Design:** Mostly used in experimental research.

Each data type is collected and gathered separately, prioritizing the quantitative data as it's considered more relevant to what the researchers want to explain or empathize on.

The purpose of the research determines quantitative data the base to build the proposition which leads to the qualitative data. In this mixed method, researchers seek qualitative data in order to explain the findings of quantitative (where the qualitative data justifies the assessed/ evaluated phenomena). This method is considered appropriate for studies in which different setting/ phenomena is tested where quantitative data provides evidence for each setting. Subsequent to this phase, researchers then include qualitative data to explain/ justify results from quantitative results.

Unlike the previous mixed methods, this approach is takes two phases. The first phase, quantitative data is collected and analyzed, followed by subsequent qualitative data collection and analysis.

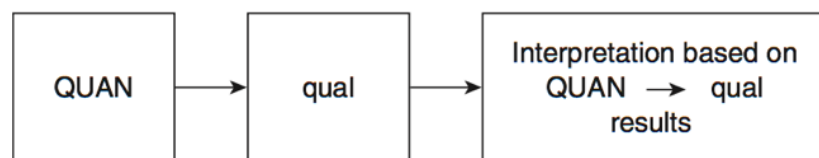


Figure 3. 3: Explanatory Design (Creswell and Clark, 2007)

Advantages of this design approach:

- Separating the two types of data in different phase can give direct/straightforward data.

Disadvantage of this design approach:

- Process of the method takes more time as there are two different phases; each phase may take different time period and require different research tool/ effort.
- Complexity of tools/ devices/ setup requirement for quantitative data. In some studies, the study evaluates multiple settings in which the researchers must be very accurate and consistent with positioning the devices in each setting, to avoid the risk of missing data or measurement.
- Depending on the research topic, the researcher must determine if the subjects in the qualitative phase are also involved in the quantitative phase, such as experimental study with focused group.

**Exploratory Design:** Similar to the explanatory design mixed method; it is used in studies where researchers are testing the possibilities of instruments, and studies where they are evaluating and identifying variables.

The exploratory design is commonly used in experimental research and data collected in two separate phases:

Qualitative data is taken place first to develop guidelines needed for the quantitative data. This design approach is mostly used in researches that explore certain phenomena with unidentified variables, or no standardized

framework. Procedure of the method, qualitative data takes place in the first phase, in the second phase quantitative data is collected.

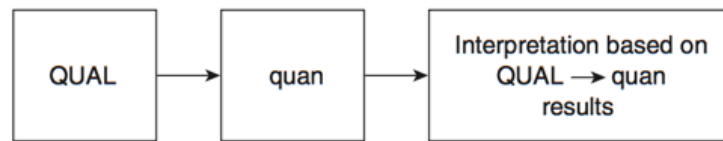


Figure 3.4: Exploratory Design (Creswell and Clark, 2007)

Advantages of this design approach:

- Separating the two types of data in different phase can give direct/straightforward data.

Disadvantage of this design approach:

- Procedures and details for the second quantitative phase may be vague at the initial design stages of the research because determining the requirement for it depends on the findings and results of the first phase, the qualitative data.

Depending on the research topic, the researcher must determine if the subjects in the qualitative phase are also involved in the quantitative phase, such as experimental study with focused group.

Ghita and Catalina (2015) took an evaluation/feasibility study on IEQ in three schools, the used methodology was mixed between physical long term field measurement, for thermal comfort and indoor air quality, and questionnaire survey for visual comfort(light) and acoustic comfort. Findings in the study elaborated an interesting and valuable outcome regarding visual comfort in classrooms; in the three studied case studies, three school buildings in different conditions (New, old, renovated) were examined, where it was found that students were satisfied for lighting conditions. However, the findings in (Catalina) showed that the majority of students were satisfied with lighting ambient, even though classroom lighting conditions varied among the three case study buildings. This finding indicated that students are able to adapt to poor lighting environments and/or lighting environment where the lighting features are not seen as a factor that can trigger their discomfort.

Consequently, authors in this study recommended that to obtain more accuracy on visual comfort, physical measurement should be used along with survey/questionnaire. In this way, the occupant's satisfaction is more relatable to the existing environmental characteristics and all environmental differences will be considered and detected.

#### 4. Comparison Between Methodologies

Different methodology tools have been used to evaluate the IEQ. However, this section focused on comparing 3 methods that are the most related to this research which are; a) Questionnaire and Interview b) Monitoring and Observation c) Mixed Method.

There are several differences between the three methodologies. The first difference is the target of the data; Questionnaire and interview targets occupants of the space, or individuals who experience the evaluated space, data type of this method is qualitative. In terms of time duration, questionnaire and interview are relatively time consuming as data is collected individually per every participant. Specifically interviews where the participant is given time to elaborate on their opinion. Keeping in mind the target sample size effects on the time needed to complete the target. Depending of the study, some studies requires data from large numbers of participants, while other studies require smaller group. It was noticed that studies on population with disabilities take small group of participants. Accuracy level for this method varies, as it depends on the topic of the research and the targeted audience. However, basic knowledge is required to be able to answer the questions. For interview data collection, expertise in the studied field is required, hence the given data is accurate and relatable to the topic of the study.

The second method was monitoring and observation. This methodology targets numerical data such as environmental parameters like temperature range, lighting level, Humidity level. This method required different types of tools and devices to obtain the actual reading on the environmental element. Regarding time, the study could utilize long term measurements of the chosen area/facility. Some studies require months and years where to get the accurate reading, the author requires several readings. On the other hand, short term spot measurement is also used. Data in this method has high accuracy level, as data obtained is numerical data from specialized devices.

The third method was mixed method. Type of data obtained in this method can be both quantitative and qualitative. Studies following this method tend to seek understanding of existing environmental feature of the space, and occupants view and opinion about these factors. Duration for this study is relatively long term as each data type is collected together. Data obtained in this method is considered at high accuracy level.

Table 3.1 is a summary of advantages and disadvantages of the three methodologies.

Table 3.1: Advantages and Disadvantages of Research Methodologies (2017)

<b>Criteria</b>	<b>Questionnaire Interview</b>	<b>Monitoring Observation</b>	<b>Mixed Method</b>
Advantages	<ul style="list-style-type: none"> <li>• Direct response from occupants.</li> <li>• Variety of question format to help the user express their idea of comfort/discomfort.</li> <li>• Effective tool to find trend and pattern of cause and effect of environmental parameters in human behaviour and performance.</li> </ul>	<ul style="list-style-type: none"> <li>• liability and accuracy of measurements,</li> <li>• Flexibility in choosing what environmental parameters to measure. Each parameter can be recorded individually or collectively with other devices depending on the complexity of the used device.</li> <li>• Data can easily be obtained by the devices. With detailed readings, graphs.</li> <li>• Registered data can easily be transported.</li> </ul>	<p>Qualitative and quantitative data have significance in explaining, supporting the hypothesis, giving depth to research.</p> <p>Different research approach in mixed methodology can lead to different findings in IEQ studies.</p>
Disadvantages	<ul style="list-style-type: none"> <li>• Collected data does not necessary capture user's reaction in different scenarios in different environmental conditions.</li> </ul>	<ul style="list-style-type: none"> <li>• Devices sensitivity must be maintained and watched constantly to insure precision and accuracy.</li> </ul>	<ul style="list-style-type: none"> <li>• Devices sensitivity must be maintained and watched constantly to insure precision and accuracy.</li> </ul>

## 5. Selected Research Method

Studies on evaluating the IEQ are commonly found to be using mixed method. Mixed methodology of quantitative and qualitative approach is more convenient for assessing the IEQ as it offers flexibility as well as the combination of data collected in both approaches. This has the significance in revealing potential findings especially when data is collected by the researcher rather than relying on literature and previously collected data.

This approach brings upfront the possible valuable findings and valuable data. Mixed method introduces an open door for finding trends, correlations of cause and effect. Furthermore, more evident comparison can be found between the case studies and the qualitative and quantitative data. Mixed method is very efficient for targeted studies where the author has hypothesis / expected results. Henceforth, explanatory design type of this mixed method is chosen for the study.

This study will take explanatory mixed methodology (Monitoring/ observation and Questionnaire/ interview). Monitoring and observation is used to register/ record occupants' reaction and behaviour patterns of students affected/ triggered by these environmental stimuli. Following the monitoring and observation method, questionnaires are answered by occupants (Students) regarding their opinion on each specific stimulus (light and sound).

Although getting feedback and data from the end user is critical for this study, what must be taken into consideration is: the staff, teachers and specialists who work closely with the students who are aware of each student's profile and conditions. Hence, specialists and teachers were interviewed as well to get their perspective and a closer understanding on what triggers behaviours based on the students' condition and mental/ neurological problems. This allowed a holistic understanding of the medical reasoning behind the occupants' reactive behaviour to be formed, as well as supporting the proposed solutions presented in this study; as they will be most suitable to the needs of the students. That's why the most appropriate methodology to conduct this research is mixed methodology; having both quantitative and qualitative research, having measurable data from monitoring devices and having a better jest of the level of how much these stimuli affect the students.

The question placed at the core of this investigation is whether those limitations are affecting the quality of the indoor environment and, by their turn, affecting the students. Looking into the three selected examples, the best case scenario is the purpose built case study, followed by the villa-like center, rendering the worst case scenario to be in the commercial apartment center, due to the different limitations arising from the nature of the building structure, which influences the quality of the IEQ.

As a social science research, in which the primary target is to understand human behaviour, it is recommended and important to explore the practices and the existing standards that consider the sensitivity of special needs occupants towards indoor environment stimuli/ elements, in order to discover relevant findings. This determines that the field study using mixed methodology is the most convenient way to answer the research question. The independent variables in the study are visual comfort and acoustical comfort, while the dependent variables are indoor environment quality (Light and sound).

## **5.1. Selection Criteria**

This study targets to evaluate the IEQ (visual and acoustical comfort) in three types of building facilities that facilitate special education for individuals with disabilities. The primary criteria is building type, in which the research aims to highlight the different limitations that accompanies the structure of the building itself.

### **5.1.1. Subjects**

The study Criteria for selecting the subjects were as follows:

#### **5.1.1.1 Subjects**

A total of 50 students with developmental disabilities and cognitive impairments participated in the research from the three selected case studies. Age group of 8 – above 18 years old.

It is crucial to clarify that some cases of individuals with developmental disabilities have their mental capacity (mental age) to be incoherent to their actual age, for instance an individual of the age 25 could be profiled / diagnosed to have mental capabilities of 15 year old. More details will be presented in findings and results chapter regarding the later consideration.

Therefore, the criteria for selecting the participants are as follows:

- Functional level/ abilities of the students, their awareness and cognition
- Their ability to verbally or through device or tools to express their opinion.

Participant's inclusion criterion for this study is developmental disabilities. Selecting the group which will participate in the study was random. However, the group selected lie in the range of moderate to high functioning in terms of their communication abilities. As the questionnaire aims to obtain their satisfaction feedback, it is crucial to exclude students who will not be able to accurately deliver or respond to the questionnaire. Exclusion criteria included children suffering from moderate to severe Autism ASD, moderate to severe mental disorders, Attention Deficit hyperactivity ADHD, Asperger syndrome, Down syndrome, Cerebral Palsy and children who are treated medically. These diagnostic profiles were reported by the administration of each case study chosen for this study.

#### **5.1.1.2. Specialists and Therapists**

Questionnaire and interview were conducted at the end of the class period. The last 15 minutes of the class was dedicated for the researcher to take the questionnaire and interview the students. Therapists and specialists assisted students whom needed support to answer *Student's Questionnaire*, as well as help researchers understand student's expressions and behaviour regarding

the environmental stimulus. Therapists and specialists were interviewed regarding each student and their behaviour traits towards the chosen stimuli.

## **5.1.2 Monitoring and Observation**

### **5.1.2.1 Monitoring**

Instruments were set to short term observation period of 15 minutes; as it is the average time for children with developmental disabilities to sustain their attention span and their ability to complete a task. Devices were placed in different positions in the classroom, referring to different spots relative to light source, like the window/ balcony/ ceiling and wall lighting. Devices were also located in different positions related to noise source (away from window/ close to the door/ teachers table... etc.)

In speech and language therapy room, devices were positioned at a working desk level, as it is most appropriate to get readings from the children's perspective/ experience.

In occupational therapy room, devices were placed in different locations in the room as the activities and practices vary depending on the child's level and what area needs to be tackled; for instance, some readings are registered on the ground as the activity accrued on the floor.

Measurements were taken in two to three different timings during the duration of the class in different locations. Ideally at the beginning of the class, half way through the class and at the last 15 minutes of the class. These timings differed based on the duration of the class, at some case studies speech and language therapy sessions period was 30 minutes, while in another center it was as long as 45 minutes. This was based on the number of students in the class and the type of lesson plans set for that group of students.

### **5.1.2.2 Observation**

*Observation:* Children's reaction and behaviour pattern were observed by the author.

The primary focus was on:

- Children's visual ability to perform during the class when given writing tasks.
- Their body language to see if there are any sort of discomfort and anxiety Reactions towards external noise.
- The therapist's sound level during the class, if it varied for different students.
- Communication between the therapist and students, and students with their peers.



The device used for monitoring lighting levels is Extech 4 in 1 environmental meter model 45170. The device measures four environmental factors: Temperature, Humidity, Light and Air Velocity. Light meter specifications: Lux range 0 to 20,000 Lux, with accuracy rate of  $\pm(5\% \text{ rdg} + 8 \text{ digits})$ .

The device used for monitoring acoustic features is Extech sound level meter model SL130G. Features of this model its capacity to monitor sound levels for continuous time and gives the highest registered dB level. Green and red light LED light indicators for when sound is at acceptable range or when it exceeds the set point entered by the user.

The device has three measurement ranges (30 to 80 dB, 60 to 110 dB, 80 to 130 dB). The recommended sound level at school and educational environments is 30 dB to 60 dB, hence the appropriate set point for this study is 30 to 80dB. Frequency Bandwidth is 31.5 Hz to 8 kHz. Response time is 125 m/s as fastest set and 1 s as the lowest. Accuracy specs meets EN 60651 and ANSI standards and compliant to OSHA standard.

## **6. Questionnaire**

Questionnaire is one method used in this study as a tool to get the opinion of occupants' satisfaction level. Questionnaires were answered by students after the collecting physical data from the devices. Students were handed an electronic version of the questionnaire using tablet, as it is much easier to be answered, and viewed. The purpose of interviewing the students at the end of their class is to get their perception on how they felt regarding light and sound. The nature of the questions are simple, one page questionnaire. Simplifying it for the students the questions are repetitive, targeting feeling instead of scale rate/ open ended questions. The answers explain emotions.

Two satisfaction questionnaires were developed for students and specialists/ teachers. The following section presents the structure of the questionnaires.

### **6.1. Questionnaire for Students**

The purpose of the questionnaire is to assess the student's awareness and identification of the tested environmental stimuli. Identification of the sources will indicate the student's perception of that stimuli. For instance; recognizing noise and where it comes from is an indication of the student's awareness and level of discomfort/ comfort toward this stimulus.

Questionnaire given to the students were structured to be simple and clear enough for the students to answer it on their own. However, in case the student failed to answer the question, the specialist/ teacher assisted them to interpret what they are trying to express/ communicate.

The questionnaire was filled from an electronic device (a tablet). Tablets were chosen as a friendly tool for the students, as it is easy to fill and less time

consuming and automatically takes the respondent to the next question/ segment of the form. All questions were in the form of multiple choice questions, giving only 3 options keeping in mind that questions must be short, clear and direct for students to answer effortlessly. Questions on students' perception and satisfaction of lighting and acoustics are in the form of illustrations of expressive faces. Presented emotions are: Happy, Relaxed, Tired, Sad, Irritated, Angry.

The questionnaire was structured as follows:

- General information: Name of school, Gender, Age range, Level.
- Satisfaction questions: how do you feel, targeting emotions.
- Noise and light: targeting student's awareness and ability to identify stimulus.

## **6.2. Interview with Therapists**

The purpose of interviewing the teachers/ therapists:

- The baseline of each students will be given by them.
- They can elaborate the case/ effect interaction of the students.
- They can relate to previous experiences.
- They have more information on the students' behaviour.
- They can share the target/agenda of each student and what level they are, thus might be link to the level of sensitivity of students toward the environment.

Samples of the questionnaires is provided in the appendix.

## **7. Procedures**

The author dedicated two to three days per case study for data collection, Spending full day for each selected therapy zone.

Physical data was collected during the therapy session/classroom, while questionnaires were given to the students at the end of the session. Interviews with therapists and specialists were carried out either at the end of the break time or at end of school hours.

As the subject of the study narrowed down on individuals with disabilities, ethical consent from case study administration and parents was filled to insure the confidentiality of participants. The ethical permission included two forms; one for the center and the other for participants' parents. Participants' families where given a form including the research brief explanation of the nature of the study, purpose of the study and their contribution to the study.

The observation step occurred during the class, where the class function was not interrupted. The author only was manually registering reading from the devices every 15 minutes in different locations in the classrooms, considering the device location near/ location to light source and different areas where there is sound source of sound leakage. Data collection duration in every case study differed due to different opening hours and the days where the suitable students for the research were present.

As mentioned in previously, environmental physical readings is collected from monitoring devices set in the assessed therapy rooms in addition to questionnaire and interview from students, teachers, specialists. As mentioned in the previous section, the expletory method used for the study consists of field study; monitoring the two types of classrooms for three different types of activities: 1) Speech and language Therapy room 2) Occupational Therapy room.

Data collection summary for case studies are as follows:

- **Case study A:** *Special Needs Future (SNF) Development Center*, February 2017. Time frame in which measurements were recorded (9:15AM to 12:30PM). 7 sessions were evaluated. 15 participants (9 females, 6 males) answered the electronic questionnaire.
- **Case study B:** *Tender Hearts Arena*, February and March 2017. Time frame in which measurements were recorded (11AM to 3 PM). 9 sessions were evaluated. 18 participants (6 females, 12 males) answered the electronic questionnaire.
- **Case study C:** *Future Center*, March 2017. Time frame in which measurements were recorded (9:15AM to 1PM). 11 sessions were evaluated. 15 participants (8 females, 3 males) answered the electronic questionnaire.

Thorough description of data collection is mentioned in chapter 5.

## 8. Potential source of error

Potential source of error in the study can be categorized into two main areas;

### 1) Errors from subjects:

The study focuses on one of the most complex and sensitive individuals in the society. Although the selection criteria of the study focused on individuals with developmental disabilities, where subjects are able to communicate their feedback and expression towards the environment. Nonetheless, the researcher must consider that routine and repetition is significant asset in special needs education, hence, subjects could perceive their poorly conditioned learning space as acceptable. Moreover, subjects might not be aware about these environmental stimuli.

As explained in the selected research method, to insure gathering the most accurate data from the subject, the researcher relied on observation as well as specialists/ therapists to get better understanding of students reaction towards the study variables (Light and acoustics).

### 2) Recorded measurements

In monitoring phase, devices will be placed at different locations depending on where the activity will occur. Subject's behavior as well as curiosity towards the measuring devices could affect the readings. For example; the

microphone attached to the acoustic device could be tempting for the subjects to touch or shout at, which will affect the final readings.

Also, the selected case studies had different opening hours, where two of the case studies followed school opening hours and one case study open hours extended till evening. As a result, the recorded lighting features differed for spaces with daylight access . Hence, the visual comfort related to natural light will vary.

## Chapter 4

## Chapter 4: Case Study

### 1. Overview

Following up on the previous information provided, this chapter will discuss the situation further through in-depth case studies, forming a milestone towards the purpose and aim of this paper. The impact of light and sound quality on the occupants with disabilities will be examined in three different types of building structure (schools, Centers and clinics).

The reason behind selecting these three specific facilities lies in their common occurrence. In other words, the types of educational centers/ institutions, presented in these case studies, are the only available for this category of individuals in the society.

It is more common in the UAE to find special needs centers in villas and apartments than specified built facilities for them. Moreover, it is worth mentioning/ taking note that the majority of these centers are non-profit institutes that rely mainly on sponsorship and supporters to facilitate their services. Consequently, the administration and decision makers of these centers face many obstacles to create the optimum services/ environment for their students.

Special education requires special consideration, and a safe environment is the priority in any institute that embrace individuals with disability. This makes space the first hurdle or challenge; to allocate therapy rooms in a restricted environment, decision makers are bound to compromise and work with the available (given/provided) space(s), which are often not convenient.

Allocating/ planning dedicated zones for classrooms and therapy rooms, scores second as a byproduct of the limited availability of space, leaving preparation and capability of providing the necessary needed equipment for different therapy classrooms or activity type, determined by the occupants and their ability, a more inevitable challenge.

Hence, aside from the fact that these schools/ facilities put a lot of consideration for the occupants, their needs and what tools they require to rehabilitate and learn, i.e. the physical environment in the special education, there is yet a serious lack of knowledge towards the area of environmental parameters that is embodied in every classroom.

There has been little research published regarding the impact of indoor environment in special education facilities. Researchers often tackle sensory or specific types of activity in a controlled environment. Sometimes the studies were conducted in a comparison/comparative setting; i.e. comparing between children with disability and children who don't suffer from any impairments.

One of the reasons that could justify this lies in the difficulty in the selection of the subject of the research. It is easier to have a confined/controlled study that focuses on one type of setting, than looking holistically at the impact of the

environment on the occupants. Another factor manifests itself is the difficulty to evaluate individuals with disability; as so many considerations are needed to be taken while evaluating their cases and how they perceive the environment around them. Hence, it is crucial to look at the overall big picture than a narrow focused pin hole.

## 2. Case Study

The studies highlight three building structures, where the age of these buildings is put into consideration. Moreover, each case study represents a different category of institutions, existing in the following types:

1) *Purpose built school* for children with disability. The objective of this selection is to study the ideal built environment that has been designed/ built/ accustomed to the needs of the occupants.

2) *Residential villa*. The objective of this selection is to study a form of facilities that the majority of the special needs centers facilitate through villas. This is perhaps due to the accessibility and possibilities to facilitate a special needs center in house held environment. Yet there are limitations to consider.

3) *Commercial and residential apartments*. The objective of this selection is to look into a very restricted environment, which has a massive influence on the structure of the classrooms, zoning and even the number/ age/ type of disabilities of children who can attend the institute.

Each Case study represents a category of institute dedicated for special education and therapy for children with disability.

The *purpose built* case study represents main-stream school for children with disabilities, the *villa* case study represents recreational centers, where the center's educational system differ from main stream school. The case study located in a *commercial and residential apartment* is a support group center type, where they support children with disability from underprivileged families.

Moreover, the eligibility criteria for the selected case studies were the occupants' disability conditions or type. As mentioned earlier in chapter three, the study focuses on individuals with development disabilities; hence institutes that solely work with other type of disability such as Autism were eliminated from this study.

Other criteria that were looked into are the age of the building; this will give a good indication on the conditions of the indoor environment.

The institute's financial state and budget were also considered. Since the majority of special needs centers in the UAE are non-profit institutes, the study looks into understanding the extent of the impact of having budget on the quality of classroom indoor environment.

### **3. Weather Data in UAE**

The weather conditions during the data collection phase of this research were in February to March 2017. The Winter/ Spring season in the UAE falls in the months of December 21<sup>st</sup> to June 21<sup>st</sup> (Source: Weather data). In the Mid-winter season, the weather Profile is considered very pleasant, with average temperature of 25° C / 77° C.

### **4. Selected Case studies**

#### **4.1. Special Needs Future (SNF) Development Center**

SNF is a support group that aims to provide training programs for young adults with disabilities. The institute majorly focuses on students at the age of 18 and above. The center was created to fulfil the gap/ problem of students who graduate at the age of 18 from special needs schools and can no longer continue at the school. This is due them reaching the age limit of these schools, regardless of the fact that they are qualified or not. It's worth mentioning that all special needs centers in Dubai graduate students at the age of 18. This age limit of school policy puts the students in a critical position, hindering their naturally slow progress and results in them staying at home.

SNF was opened to give young adults with disability and adults who require extensive attention a full-fledged training center, which provides therapy and vocational training that students require in order to develop/ progress as they grow older. The given program is a continuation of the previous program they already had learned, but more tailored to their age/ ability range.

Furthermore, the center provides support for underprivileged children with disabilities who come from low income families who do not have the financial support to take their children to a specialized main stream school for disabilities.

The difference between main-stream school for children with disabilities and SNF is their educational system. Unlike main-stream system, where each department works separately, such as speech therapy and physiotherapy, the units in SNF are interlinked where the program is created/ designed collectively by the teachers/ specialists in all the departments. Following this system formed a holistic learning program that helps students' performance and fast progress.

However, this study investigates to what extent students are able to benefit from such tailored program where the environment is limited by the building structure.

The center is located in an urbanised area in Dubai, formally the city center of Dubai. Residential buildings and commercial buildings surround the area and the front side of the building is on the/ a main road. The building consists of 4 floors: the ground floor has shops, while the other floors are a mixture of residential apartments, offices, and educational institutes.





Figure 4.1: Special Needs Future (SNF) Development Center Location  
(Google earth ,2017)

## 4.2. Tender Hearts Arena

Tender Hearts is a therapeutic recreation center located in Dubai, recently opened in April 2015. It is considered one of the few of its kind in the UAE and gulf region. Moreover, Tender Hearts' philosophy in choosing the villa type as a suitable venue to run recreation center, is because of the ideology that considers the effectiveness of home-like environment for individual with disability which is very important to maintain the consistency of what is being taught and where the individual will practice. Home-like environment is more comfortable and recognizable for individuals with disability than any other (box-like) confined environment. More elaboration will be presented in the Discussion chapter.

Another advantage of the flexible program is that it helps low income families to enroll their children in educational institute where it's more affordable than special needs school.

It is worth mentioning the choice of the villa setting was considered deliberately by the founders of the center to fit into their goals and mission. Their main goal is to make the school give a welcoming environment which will give the children with disabilities more comfort to learn and be more open to learn.

As described earlier, the nature of therapeutic recreation center is a multidisciplinary system divided based on activity type rather than assigning programs based on therapy. Therefore, specialised therapy rooms for certain children requirements (such as speech and language specified classrooms and occupational therapy rooms) are not available nor provided in this center. Instead, three activity classes were selected that has similar approach/ set up of these therapy rooms.

This research will evaluate three different sets of activity classrooms that are essential in the educational syllabus of children with disabilities. Each one of these classrooms would require different visual and acoustic features. Speech and language therapy focuses on the sense of hearing and articulation, while Occupational therapy focuses on performance skills in three main areas; 1) Motor skills 2) Process skills 3) Social interaction skills.

The academic classrooms contain a variety of group work and one to one sessions with each student.

Since therapeutic recreation center run an unconventional system in education. The selected classes/ activity for this study will have similar goals and objectives as Speech & language therapy and occupational therapy. The common factors are:

- 1) Goals obtained/ taught to the students.
- 2) The work area, where the students in all the three case studies are using the same settings.

The Center is located in a residential area in Jumeirah, Dubai. Residential villas and other institutes that are facilitated in villas, such as nursery and health clinics, surround the center. The center is far from any main highway or main road; hence the area is generally quite. The primary sources of noise to the center are the construction work at the compound in the opposite side, and the construction work of a two-story villa behind the center.

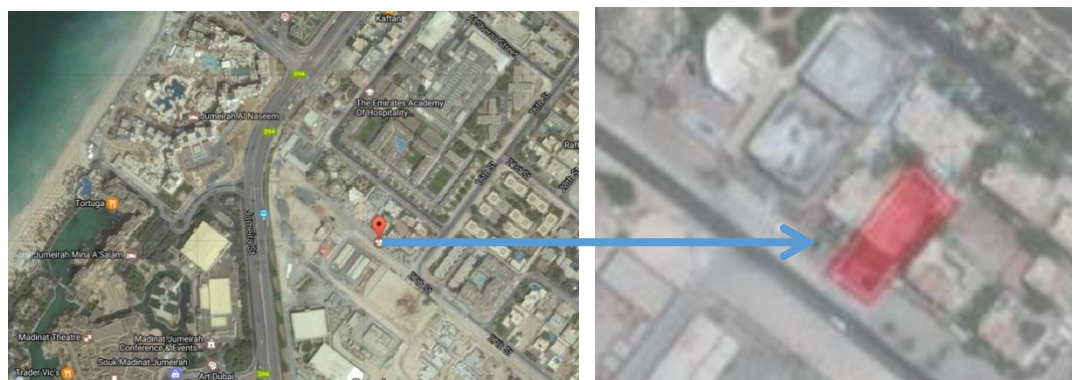


Figure 4.2: Tender Hearts Arena Center (Google earth, 2017)

### 4.3. Future Center: Rehabilitation Center

Future Center is a school based center for children with disability. The school runs special education program and therapy program for children who suffer from different types of disabilities.

Initially, it opened in 2000 in a villa setting, and in 2011 the school relocated in their own purpose-built facility that accommodates bigger number of students and larger facilities to operate advanced therapy services.

Students are grouped based on their age group and abilities into academic classrooms. Each classroom have weekly schedule, where the schedule vary between group sessions and individualized educational session. The school provides special education services and therapy services.

For the sake of the study, the selected zones include speech and language therapy room, occupational therapy and academic classroom.

Future Center is located in the capital Abu Dhabi, Al Musaffah area. Al Musaffa is considered a new area recently got urbanized with residential villas and educational facilities such as schools and universities.

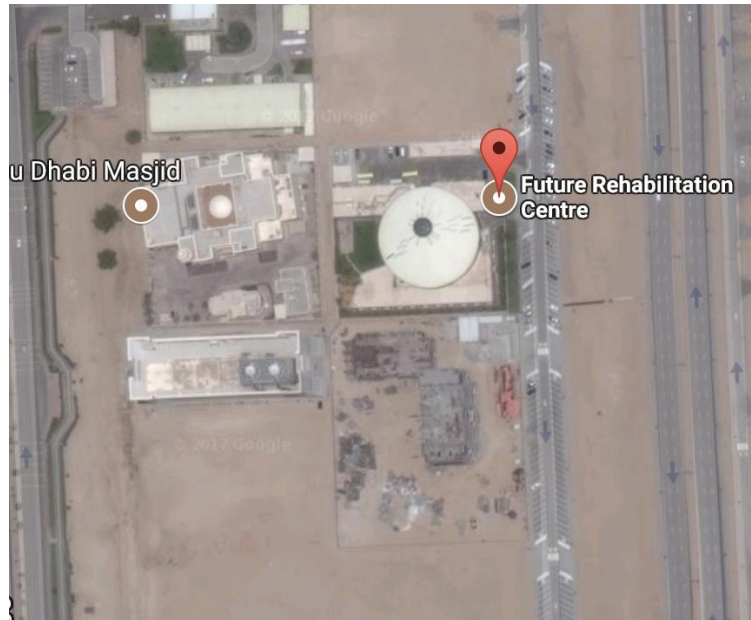


Figure 4.3: Future Center Location (Google earth, 2017)

Summary of all the three case studies:

Table 4.1: Case Studies Summery (2017)

Name	Special Needs Development Center	Future Tender Hearts	Future Center
<b>Building structure</b>	Commercial / Residential apartment	Residential Villa	Purpose built school
<b>Building Age</b>	20 Years	7 Years	5 Years
<b>Category of institute</b>	Support group	Therapeutic recreational center	School

While each of the case study may differ in the approach of their education system, yet there are similar in their goal such as:

- 1) What they provide may differ in system and approach but it's all the same in different levels as per the ability and/ or limitation of the center.
- 2) Relevant education and programs and rehabilitation services to students with Special Needs.
- 3) Behaviour al and academic goals.
- 4) The Individualized Education Program (IEP).

## Chapter 5

## Chapter5: Observation, Results and Discussion

### 1. Overview

This research is dedicated to run an extensive investigation on the subject of the impact the indoor environment quality, specifically light and acoustic parameters, has on children with developmental disabilities in special educational environments in the U.A.E.

The investigation examined three case studies with three different building structures. Case studies were objectively selected to differ in their built structure, size, location, surrounded built environment as well as the condition of the building. On the other hand all the selected centers had the same category of occupants (individuals with developmental disabilities).

The reason behind the later choices was to have a critical overview on the existing facilities dedicated for the population of special needs in the UAE. To properly asses and evaluate the IEQ, as well as highlighting on environmental problems found in special educational centers due to lack of knowledge and/ or improper practice.

Referring to chapter 3, this research investigation requires three stages before presenting solutions for the identified problems, the later process is illustrated in figure 5.1. This section presents findings of the research investigation.

Findings of each case study will be presented separately first, followed by a thorough comparison between the three case studies.

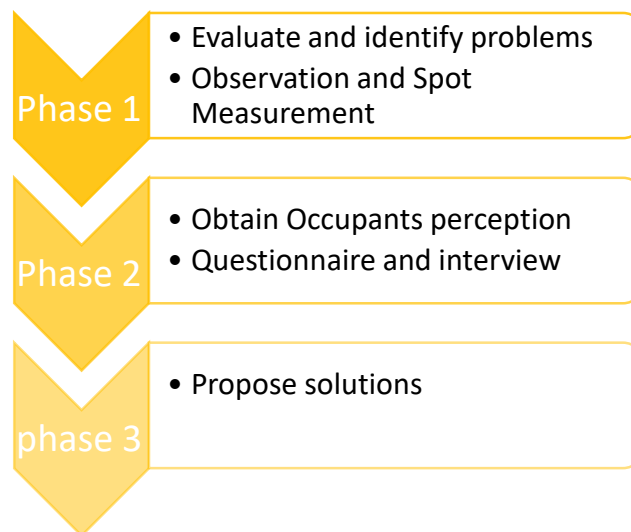


Figure 9.1: Research Process (2017)

It is important to note that the investigation was completed during week-days in school hours in order to validate that the collected data as an accurate representation of the existing IEQ of the center/ school during the occupancy hours.

The investigated study zones in all the three case studies are;

- 1) Occupational Therapy room.
- 2) Speech and Language Therapy room.

These therapy rooms were purposely chosen for multiple reasons. First, occupation and speech therapy are considered one of the essential programs in any facility dedicated for individuals with disabilities. Hence, the researcher aimed to investigate the most important unit in these facilities, in order to provide solutions in enhancing the learning outcome and possible long term positive impact on the progress of the students. Moreover, due to the expertise of the author in the special education. The author observed that facility administration and decision makers did not have the awareness of the impact of IEQ on the school/ center occupants. Furthermore, the author noticed that these administrations gave more attention was for equipment and devices for students, while neglecting upgrading the indoor environment elements of the facility. Hence it is necessary to conduct a study to verify that students are vulnerable to the environmental factors, and that these factors are stressors that has a direct impact of student's behaviour and level of progress.

Lukas (2012) discusses the challenges and strategies of inclusive education in the Czech Republic. "*The aim of inclusive education is to ensure equal access and opportunities for typically children and children with special educational needs*" (Lazarová, Pol, 2002). The findings of Lukas study indicated the importance of altering the classroom setting to correspond with the needs of individual students, as well as the requirements of classrooms to support the students with SEN in their learning process.

Similarly, a study by Bendová and Fialová (2015), found that one of reasons of poor IEQ in inclusive education is because teachers had minimal knowledge that classroom indoor environment such as temperature, air quality and lighting environment act like environmental stressors for pupils with SEN. Furthermore, teachers had minimal knowledge on what triggers anxiety on students. Survey results showed that teachers generally assumed that student's reactive behaviour is due to their condition.

Coming back to this study, the evaluation period of each case study required two to three days to complete data collection phase. One full day was dedicated to collect data for each selected zone in each case study, this included observation, spot measurement, survey and interview. The investigation was conducted during the months of February and March. This period of time was selected as it the weather is pleasant in these months. Weather condition has a strong impact on the overall mood and behaviour of individuals with disabilities. For example, during the harsh summer weather in the UAE, the uncomfortable weather triggers maladaptive behaviour. Hence, individuals with disabilities find coping with the weather difficult. Therefore, the author selected a suitable timing to eliminates an important factor that affects the participants of the study.

Furthermore, the selected months are the middle of academic year, this means that students have adapted to the school environment, and another factor that effects the comfort of participants is eliminated.

Pleasant weather of an average temperature of 20 °C, average high temperature of 25 °C, average low temperature of 14 °C in February and average temperature of 23 °C, average high temperature of 29 °C, average low temperature of 17 °C in March. See figure 5.2.

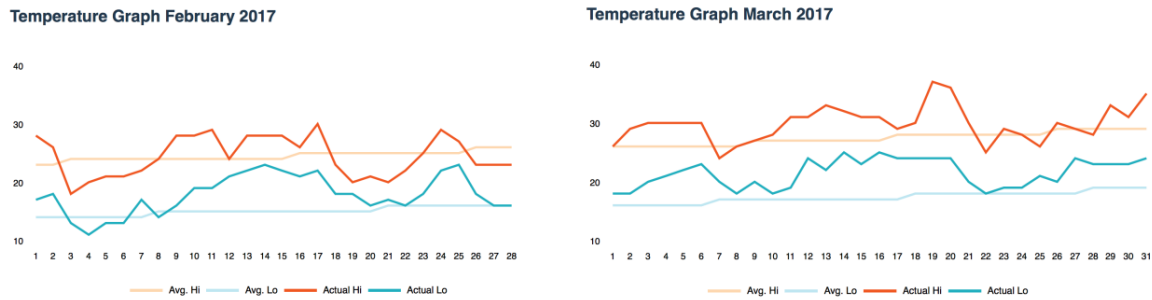


Figure 5.2: UAE Temperature Graph February, March 2017 (AccuWeather, 2017)

## 2. Findings

The structure of chapter 5 is as follows, each case study will first present observation of the authors from walkthrough into the center/ school and from the selected zone that will be evaluated (Therapy classrooms). Followed by findings from spot measurement, then results from questionnaire and interview will be presented and discussed. Finally, discussion, comparison between the three case studies and solutions for every case study will be given at the end of the chapter.

It is important to highlight that the author is eligible to take observations on behaviour of children with disabilities for this research, as she have a career in the special education field, and have been working closely with this category of children for 5 years. Henceforward, the observation and behaviour analysis are carefully analyzed considering the subject's abilities, mental functioning and suitability to be part of this study.



Figure 5.3: Structure of Results (2017)



Special education program relies on individualized education program; most assigned classrooms are taught on a one to one basis, where each therapy program is facilitated in one room and students rotate between the therapy rooms. Occasionally, some centers allocate two functions (therapy) in one space due to space limitations. This fact was taken into consideration, and highlighted, since as a result of this, the investigated classrooms in this research are two to three classrooms per case study. The study evaluated a total of 7 therapy room and participation of 44 students. Although a total of 7 classrooms may be seen as insufficient in IEQ study, literature on population with disability normally all run investigations on specified and selective areas as well as small number of participants. This is due to the complexity of cases and authors are cautious when it comes to this sensitive category of individuals and the special considerations taken towards them.

In Shapiro's IEQ evaluation study (2007), sixteen children with developmental disabilities participated in the study. The study was conducted in two dental rooms; the first room setting was regular dental environment, while the second dental room was transformed to a sensory adapted environment (SAE). Alternation in the second dental room included sensory stimuli of: Light, Sound, Sensory and tactile. The study aimed to find the impact of SAE on anxiety adaptation of the participants.

Another pioneer researchers on the category of individuals with developmental disabilities Hall and Case-Smith (2007). Conducted a study with a small sample size of 10 children. The study focused on evaluating the impact of sound based therapy program on children with developmental disabilities. For this study children with ASD and visual impairments were selected.

## **2.1. Case Study (A) Special Needs Future (SNF) Development Center**

### **2.1.1. Case Study (A) Building/ facility Observation**

The center is located in a commercial building in a highly urbanized area in Dubai. The building is located on the main road near an intersection leading to the highway; hence external noise levels are high.

This commercial building was constructed in 2002. From the initial walkthrough observation in the building, it was evident that the building was poorly maintained. Different factors to poor indoor environmental quality in the building were observed. Stiffness in the air and a mixture of intense odors in the hallways and elevator was present as well as signs of dirty HVAC systems in the supply/ return grill indicating a lack of maintenance. Wide dark spots of mold and yellow stains were visible on the ceiling tiles. Moreover, the hallways in the floor had few windows that were either locked or sealed; therefore there was lack of natural ventilation causing air tightness and CO<sub>2</sub> condensation to increase. Low visual clarity was experienced when walking through the corridor. The corridor ceiling had multiple flickering florescent lights and some burnt lighting bulbs. Finally, it was noted that there were no floor zone arrangements separating residential apartments to office and educational facilities.



The overall observation indicated serious problems in the IEQ of the building which needed to be addressed to ensure the health, safety and well-being of the occupants of this building.

SNF development center utilized and merged three apartments to facilitate their program and operate 9 units of activities. As a support developmental center, the vision of the center is to train and rehabilitate young adult with disabilities. SNF accepts both mental, physical and developmental disabilities with the exception of individuals who need more clinical supervision.

Currently, the center accommodates 40 students, 16 teachers/ specialists and 10 staff. As a result, spaces are adjacent resulting in a cramped space.

Walking through the center, the first impression from the environment was the feel of tightness, both in the air quality, visual comfort, as well as space. Although the center had three entrances, only one main entrance was used for entering and exiting the center while the other doors were for emergency exit. As a result, one main path of circulation between the departments is available for students and staff.

The center is divided into four main divisions, see figure 5.4:

- A. Entrance and Administration.
- B. Classrooms.
- C. Daily living skills department.
- D. Production Unit.

Reception desk, administration offices and meeting room is located at the entrance of the center. This is a good consideration for children's safety and it also separates the facilities and units from the administration department and avoids any possible disturbance to student's classrooms from visitors. Near the administration is a multi-functioning hall used for different purposes. As the apartment is originally designed for residential use, room sizes and arrangements differ from the expected known classroom size. Corridors and spaces between the rooms were tight and limiting for children with disabilities, with 1.8 meter and 1.2 meters in width. As seen in the floor plan (Figure 5.4), only two main corridors are found in the two apartments. Since these two apartments are joined, navigation/circulation between departments is through classrooms. Most classrooms are either open to each other with no doors, or the door is open all the time for students and staff move between units.

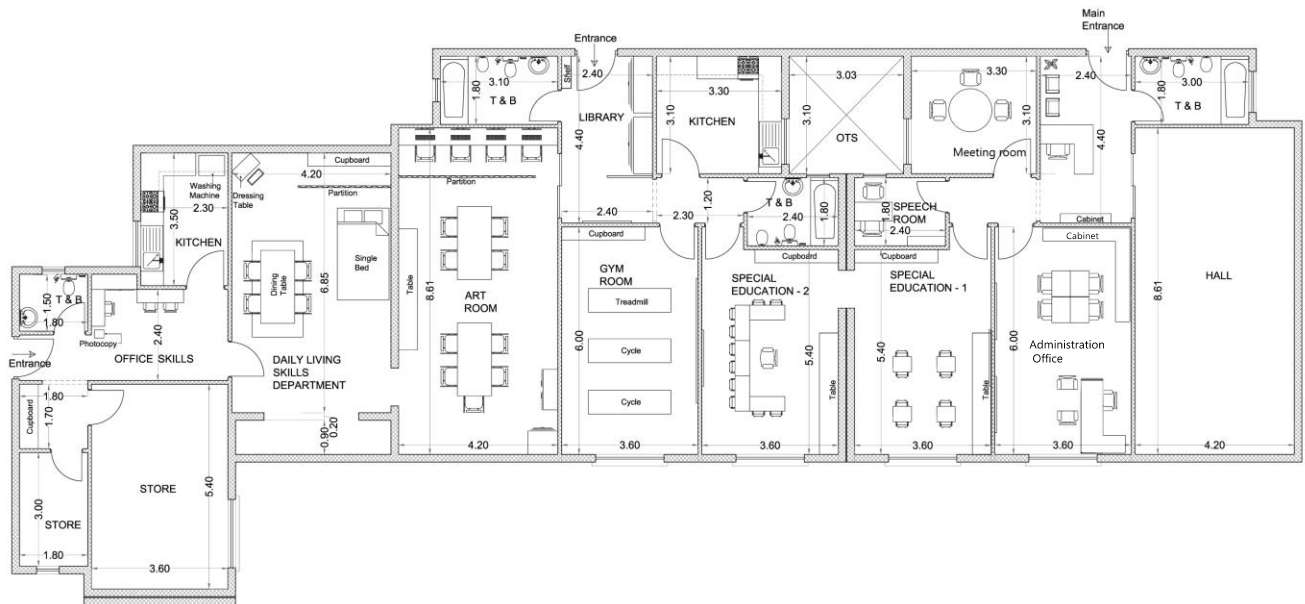


Figure 5.4: Special Needs Future (SNF) Floor Plan (2017)

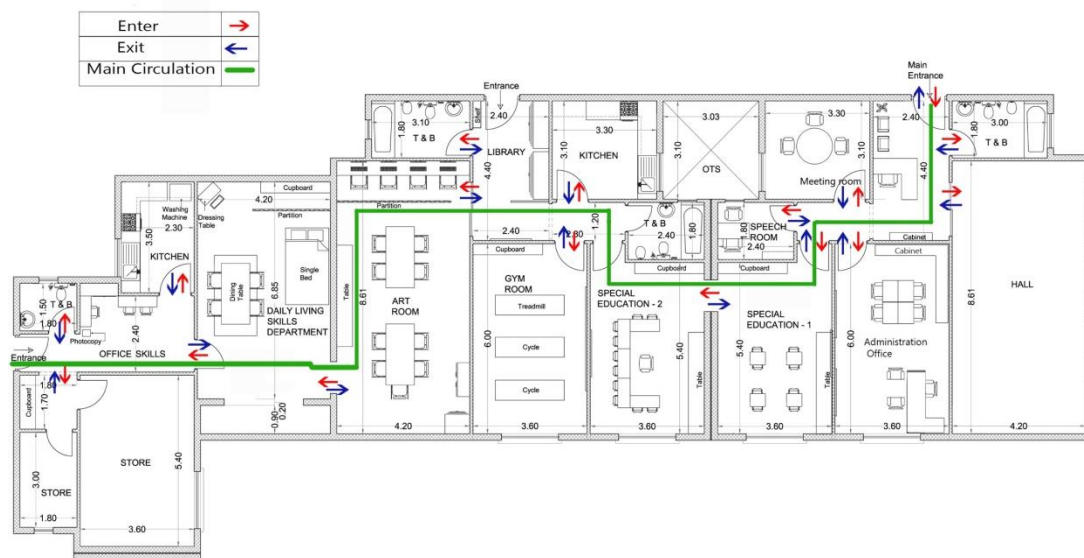
For air conditioning, split system units were installed in every classroom, fans were also used in common areas. It is noticeable, that even though classrooms are supported with air conditioning units, stuffiness in the air is strongly sensed once you enter the space.

Adjacent spaces have massive impact on the air quality. The rise in temperature, condensed air, increase in CO<sub>2</sub> levels and mixture of intense odor - especially during lunch time, odors from the gym room, consequently cause discomfort, nausea, anxiety and sickness. All of this while keeping in mind that the students are at an age where their bodies produce more sweat and get affected with change in temperature.

While taking measurements of luminance and sound level of this center, the author also took measurements of CO<sub>2</sub> levels in the space to get an indication of the overall indoor air quality. High CO<sub>2</sub> readings was observed, although the feel of tightness and stuffiness was sensed as one enters the space, the actual reading was surprising. The average CO<sub>2</sub> reading in speech and language therapy room was 3322.25 PPM, minimum of 2157 PPM, maximum of 4482 PPM. The average CO<sub>2</sub> reading in occupational therapy room was 2304 PPM, minimum of 2130 PPM, maximum of 2460 PPM. The accumulating impact of poor indoor environmental quality has a direct correlation to the performance of children with impairments. As mentioned in chapter 2, factors such as discomfort, inadequate temperature, and odor can lead individuals with impairments to be reactive and cause increase in maladaptive behaviours such as tantrums, and other intense behaviours like screaming.

Recent study by Gaihre et. al. (2014), investigated the relations between CO<sub>2</sub> concentration and student's educational performance and attendance. Findings of the study showed that inadequate ventilation is the primary reason in the increase of CO<sub>2</sub> concentration in classrooms to be above 1000 PPM. Students reported feeling drowsiness and inability to concentrate. ASHRAE guidelines recommend CO<sub>2</sub> levels for school

classrooms to not exceed 1000 PPM. Occupants will experience health symptoms such as fatigue and poor performance as a consequence of poor IAQ.



#### 2.1.1.1. Observation in Speech and Language Therapy Room SLT

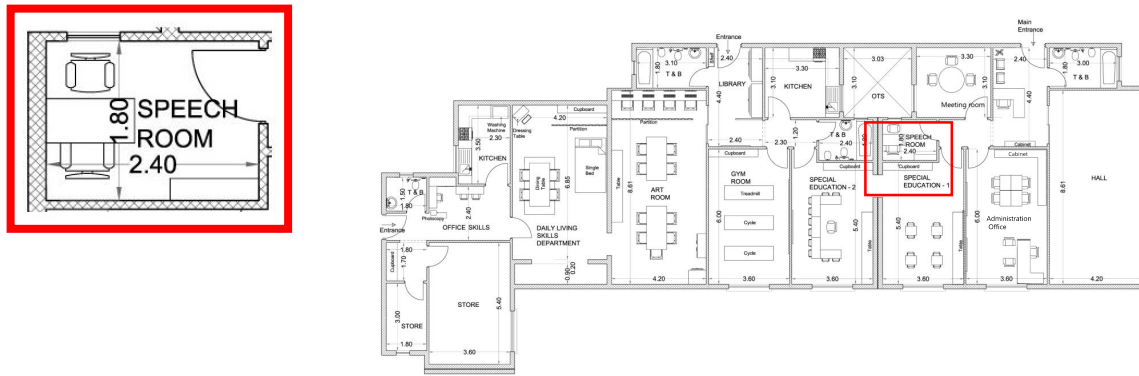


Figure 5.6: Case Study (A) SLT Floor Plan (2017)

Four sessions are conducted throughout the day. Depending on the profile of the student, the specialist conducts a one on one session with the student or can have two students together in one session. Each session takes 45 minutes. The door remains closed during the session.

The following observation was taken during field measurement. The researcher's presence in the therapy room did not interrupt the flow of the given therapy.

- Since the room had no windows, the luminance level remained constant at the level of 195 Lux.
- As the room was relatively small, the uniformity and light distribution was very good. Working in a well-lit therapy room had a positive effect on the student. Observations showed that lighting helped students being alert and focused during the therapy session. Different tasks were given during the session including writing, acting, using tablets and physical interaction with the therapist. Luminance level was suitable for all the given tasks.

On the other hand, the main barrier/ distraction observed in the therapy room was the noise coming from outside the room. Since the SL therapy room is located near the center entrance; on one side the classroom was attached to the meeting room, on the other side, it was attached to classroom one, where all the circulation to other departments goes from that door.



Figure 5.7: Case Study (A) SLT Room (2017)

#### **2.1.1.2. Observation in Occupational Therapy Room OT**

Moving forward with observation to occupational therapy classroom. The classroom located at the midpoint of the center, connecting the administration/ entrance to different departments/ classrooms. Room area of 19.44 m<sup>2</sup>. On one side of the room, there is a wide opening that leads to the other merged apartment and other facilities. Classroom fixtures (table and chair) were positioned facing the window, which is a good approach to sustain the students focus to the teacher and minimize the visual distraction. Portable furniture has been used in this classroom, giving flexibility for specialists to adjust the tables and classroom setting as preferred and most comfortable for the student. Walls are painted in the colour of light and dark yellow. The selected colours have a positive impact on the psychology of students as well as it reflects light and supports the vision. The room was ventilated by split unit HVAC system and fan. Adequate amount of daylight was sourced from the window, even though the window was facing another adjacent building. Although there was no direct sunlight accessing to the classroom, the room is well lit by natural light. The room had two linear florescent lights.

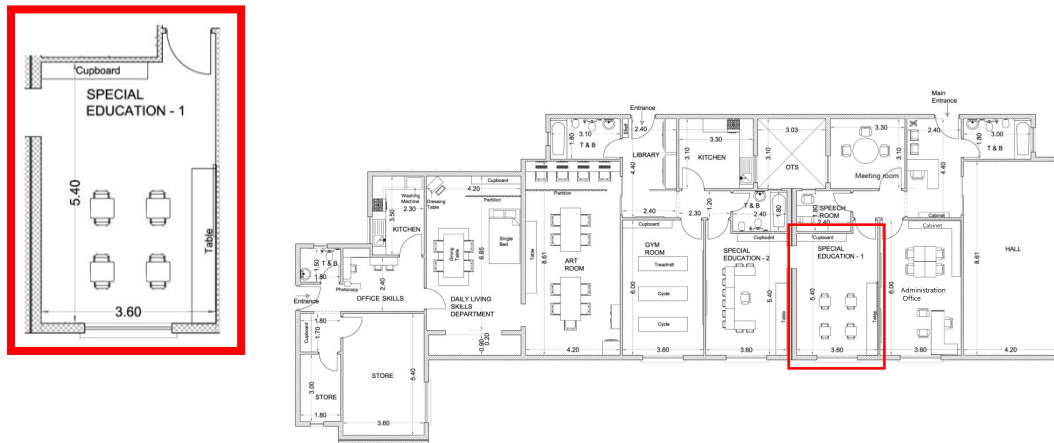


Figure 5.8: Case Study (A) OT Floor Plan (2017)

One major disadvantage observed in the classroom, was the opening between the classrooms and the location of the classroom; constant disturbance from people moving between the departments, and background noise continuously intensified as sound transfer from the classroom next door due to the opening in the wall. Also noise from moving fixtures within the classroom itself (Chair, table) in addition to sound of cars and traffic from the window.

Interestingly, a different observation was taken in each session; as the students' abilities differed, their activity type and reaction to the therapists also differed therefore some observations were taken on how students reacted differently with the surrounding environment.

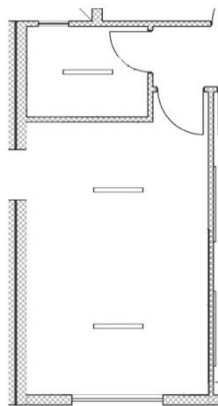


Figure 5.9: Case Study (A) Lighting Layout of Selected Zones (2017)





Figure 5.10: Case Study (A) OT Room (2017)

It was evident that students in SL classroom were distracted and more attentive to background noise. The therapists also were struggling to sustain the student's attention to the given task. Noise was mostly challenging for students who had visual impairments as they tend to depend on their hearing sense to follow the therapist's instruction.

- Every session had 4 to 5 students, students were relatively around same functioning level. Although the session had a group of students, however each student had a different activity task to work with. It is observed that the IEP (individualized education program) is applied even in a grouped classroom.
- Class 1: observed that some students are visually impaired, using thick magnifying glass. In order for the students to complete the given task, they had to lean forward, bringing the object very close to their sight in order to see what they need to do.
- Class 2: Student had speech difficulties; difficulty to express verbally

- Activity type: Writing, motor skills, identifying visual tasks, building tube PVC pipe, puzzles construction. Eye- hand coordination.
- Student who are visually impaired rely on their sensory skills to identify objects, and they are sensitive to the sound.
- For visually impaired students, task light is preferred as it helps their sight
- Some other students with visual impairments are sensitive to direct light; their immediate reaction to light is directly avoiding window and task light. Hence, flexibility is the key to create comfortable learning environment for this variety of levels. Specialist can alter/ change/ customize the intensity/ hue and colour of light.

### 2.1.2. Spot Measurements

SNF center has one SLT and one OT room. Each room holds 4 sessions a day. Occupancy level vary for each room depending on the profile of the students. Speech and Language therapy require one on one practice with the exception of a small group. On the other hand, occupational therapy at SNF is considered a group classroom, where 4 to 5 students work simultaneously. Two therapists are assigned in Occupational classroom. A total of 7 sessions were evaluated on lighting and acoustic parameter. Table 5.1 present the readings of spot measurements in the selected zones.

Table 5.1: Case Study (A) Light and Sound readings in SLT and OT

Parameters	Speech & Language Room				Occupational Therapy		
	Location 1	Location 2	Location 3	Location 4	Location 1	Location 2	Location 3
Light (Lux)	189	195	186	194	120	136	133
Sound (dB)	56 - 76	58 - 61	70 - 79	70 - 81	74 - 76	65 - 69	65 - 68
Time	9:15 AM	10:15 AM	11:15 AM	11:50 AM	10:15 AM	11:15 AM	11:50 AM

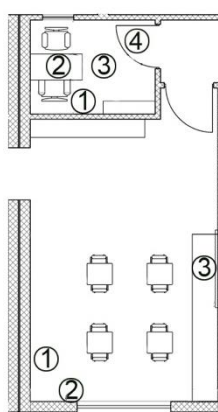


Figure 5.11: Case Study (A) Spot Measurement Location (2017)

Data was collected from SLT room on February 15th 2017. All devices were placed at desk level, where activities were taken place. Since SLT classroom utilized one small table, measuring devices recorded in one spot. Luminance remained constant as there was one source of light and no windows to have external natural light or fluctuation in the



light uniformity. Luminance remained constant, at an average of 195 Lux; this is because the classroom had one source of light.

Data collected from OT room on February 27<sup>th</sup> 2017. OT classroom utilized 4 working desk tables, where students were facing the window. Measuring devices were relocated in every session to have different readings. The average time it took for each reading was 15 minutes. As presented in the previous section, window blinds were put down as it causes distraction for students. Lux levels in OT classroom were at the average of 130 Lux. Although indirect daylight was available in OT room, it was observed that the specialist avoided direct daylight and preferred to pull the blinds. This strategy could be aimed to support the students by preventing all possible sources of distraction. Also, it was noticed that the activity type in this class was all at desk level obliging students to be attentive on the given task as mentioned in the previous section. Furthermore, it was noticed that students in OT classes were moderately on the same intellectual level nonetheless their disabilities varied, as mentioned in the previous section. Hence, daylight could potentially have less significance compared to the artificial lighting in the classroom.

Table 5.1 presents, measurements recorded from SLT and OT. Lux levels in each location gives the average reading registered. Sound levels in each location gives the maximum and minimum dB recorded. Similar measurement configuration for case study 2 and 3 is presented in Table 5.3, Table 5.4 and Table 5.5.

What stands out in the table 5.1 is that luminance readings in both classrooms are way below the international guidelines for SEN. Guidelines designed for pupils with special educational needs and for SEN schools such as Building Bulletin 77 and 87 recommend Lux levels of minimum 350 to 500 Lux. Measurements were also found below guidelines in learning environments for typically students. CIBSE, IESNA, BREEM require a minimum of 300 Lux.

Referring to the table 5.1 it is noticed that Lux readings in SLT were close in the range, while Lux readings in OT were slightly varied. This is because SLT classroom is much smaller in size, with one source of light and no windows to have a daylight factor changing the light intensity. Also, all activities took place on one table. On the other hand, in OT classroom, the room area is bigger. Multiple light units were installed in the room, in addition to daylight factor coming from the window. Finally, readings were taken in different locations in the room.

Sound measurements presented similar readings. Both luminance and sound features were not in the recommended ranges of international guidelines (an average of 70 dB and maximum reading is 79 dB). From observations, it was evident that the causes of high readings in each therapy room were different.

In SLT the advantages of utilizing small room is good in having minimum reverberation time. Sound levels were relatively high as the device was situated between the teacher and the student. Most sounds were generated by the occupants because of the activity rather than background sounds. Student's curiosity about the measuring devices that was placed on their working desk. Students tend to touch the microphone and occasionally come very close to the microphone and speak in a louder volume to observe the change in numbers on the device screen. Whereas, in OT room, background noise of other

students and staff circulation was more dominating than the sounds generated from activities taken in the class and students.

According to (Building Bulletin 87, ASHA American Speech Language Hearing Association, NSI/ ASA American National Standard Acoustical/ Acoustical Society of America S12 .60-2010, ASHAREA EN 15251) sound levels in teaching spaces in a facility must be 35 dB and noise level to not exceed 60 dB (Reference all the guidelines).

### 2.1.3 Questionnaire, Interview and Discussion

An electronic visual questionnaire was given to the students at the end of each session to get their feedback on the indoor environment quality. Questions were simple and clear. Questions format on comfort indicator was in the form of (*How do you feel right now? How do you feel about light in this room?*) – a sample of the questionnaire is provided in the appendix. As explained in methodology chapter, the structure of the questionnaire is intended to reflect student's comfort/ discomfort about lighting and acoustic features in the room, as well as to get an indication if the student has the awareness and can identify these stimuli. Keeping in mind that the cognitive skill of each student may vary, this must be taken into consideration.

A total of 15 students answered the electronic questionnaire; 5 students (4 females, 1 male) from SLT room and 10 students (5 females, 5 males) from OT room.

The overall perception of the classrooms is as follows:

- SLT classroom; 3 students answered *Happy*, 1 answered *Tired* and answered 1 *Sad*.
- OT classroom; 6 students answered *Happy*, 3 answered *Relaxed* and 1 answered *Tired*.

Answers with regards to the student's impression towards the lighting environment:

- SLT classroom; 2 answered *Happy*, 1 *Relaxed*, 2 *Tired*.
- OT classroom; 2 students answered *Happy*, 3 answered *Relaxed*, 3 answered *Tired*, 1 answered *Sad* and 1 answered *Irritated*.

Differences in answers indicate that students have different perception in experiencing / reflecting the light and sound quality of their classroom. Answers for the OT room suggest that lighting properties is not suitable for the type of function as different lighting intensity is required for different types and levels of children attending the class.

As mentioned in observation section (5.2.1.1.2) Solutions for this room must consider flexibility in lighting character to suite the different light requirement for different conditions of visually impaired students.

When asked about what type of lighting makes the student feel happy, two options were given;

- Light from window (Indicating natural light).
- Light from Ceiling (Indicating artificial light).

8 out of 15 students preferred natural light. This indicates students' preference to soft light.

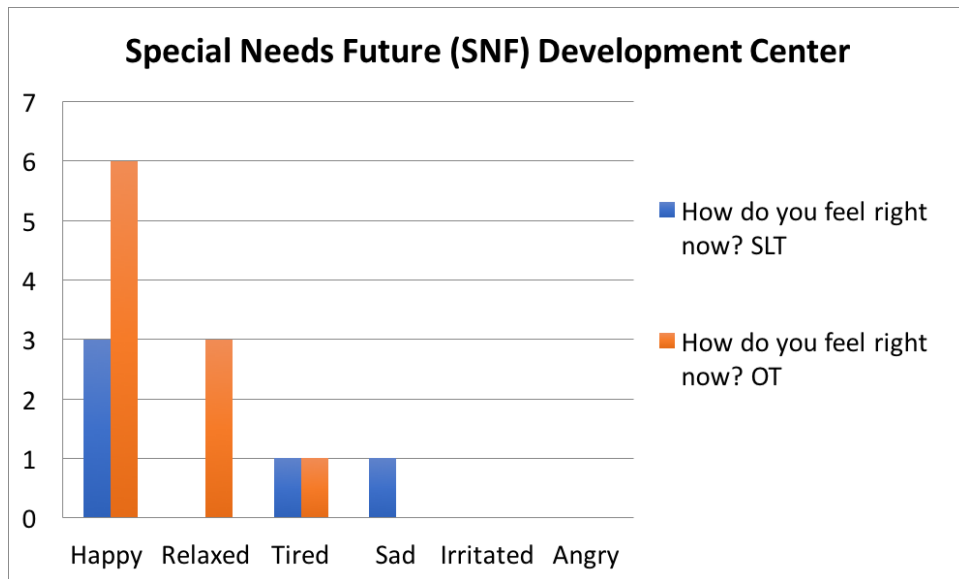


Figure 5.12: Case study (A) Comfort/ Discomfort Level of Classroom IE (2017)

Answers on the students' impression towards the acoustic environment;

- SLT classroom; 1 answered *Tired*, 2 answered *Sad*, and 1 answered *Angry*.
- OT classroom; 3 answered *Tired*, 1 answered *Sad*, 3 answered *Irritated* and 3 answered *Angry*.

The third set of questions focused on sound/ acoustics in the room. It is apparent from Figure 5.13 and 5.14 that students were highly affected by the noise in both classrooms. This shows that both rooms had poor acoustic features. As seen in the observation, students in both classrooms were uncomfortable as their anxiety levels increase with the increase of background noise. Acoustic solutions must be looked into to promote comfort and assist students in performing better.

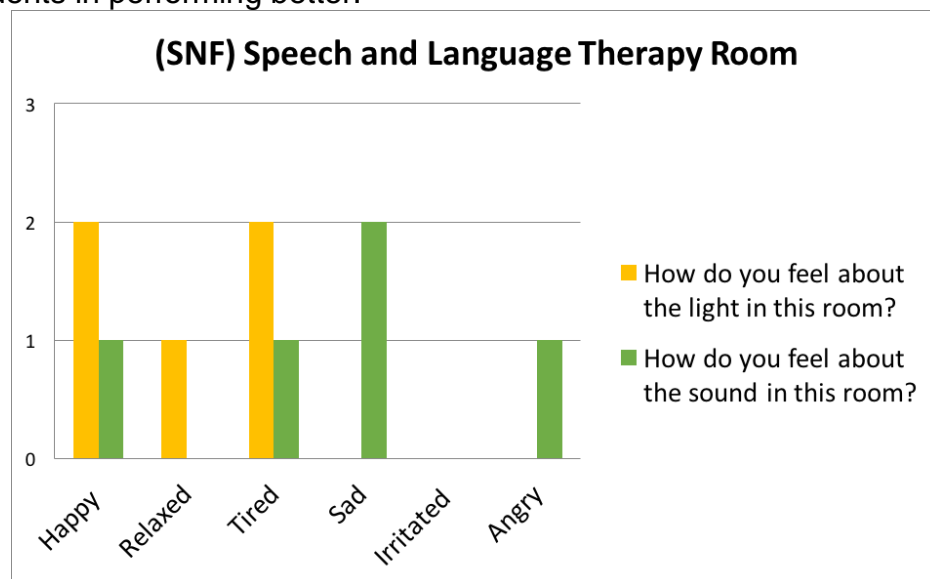


Figure 5.13: Case study (A) Comfort/ Discomfort Level of SLT Room (2017)

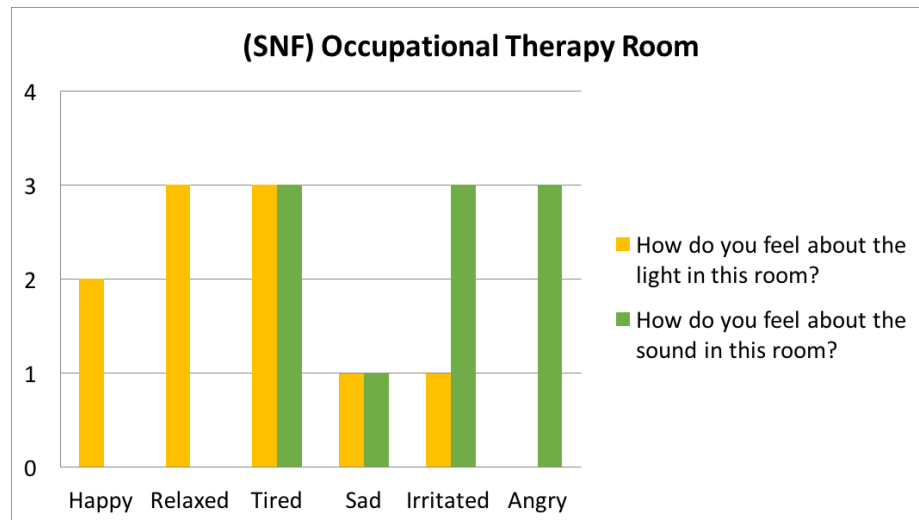


Figure 5.14: Case study (A) Comfort/ Discomfort Level of OT Room (2017)

All students who attended OT class suffered from visual impairment and different levels of speech impairment. This means students had difficulties to express their thoughts. Their means of communication was mainly from visual charts, and hand gestures. Some students were able to speak words but they had to put a lot of effort to pronounce them. Hence this section answers were taken from students with the assistance of the therapists.

Source of noise listed by students in OT are:

- People moving through the classroom from the entrance to other departments
- Sounds from classes taking place from the class next door
- Sounds of cars, machines from the window

It was noted that two students in OT were both sensitive towards light and sound; with every sudden loud noise they immediately covered their ears and were going through anxiety. All the above suggests that the acoustical features are poor in this room and the students' sensitivity towards these environmental stressors were causing them not to perform well.

Solutions must consider the sensitivity of students attending this class as light and sound are major stressors to their wellbeing and reflects on their performance.

Interviews with therapists and teachers of both SLT and OT were made, and since they are also occupants of the space, their perspective on IEQ is as important as they have better insight on students' behaviour and what triggers it.

All therapists have had direct interaction with students. Two sets of questions were asked. The below are the findings from the interview:

**Lighting:**

- Therapists in SLT found lighting environment as acceptable. While therapists in OT found lighting environment not sufficient to suite the different needs of students.
- Therapists have no control on lighting characteristics; the only control is to switch on/ off.
- Students' behaviour towards lighting: in SLT some students get distracted by staring at the light fixture. In OT most students are reactive towards light, either avoid light or stare at daylight from the window.

**Acoustic:**

- All therapists found acoustic environment to be poor. High levels of distraction was mentioned due to the space arrangement, people moving through the classroom to get to other departments and sounds from other classrooms.
- Therapists have no effective solutions to minimize noise distraction.
- All therapists agree that noise level affects students' performances and triggers anxiety and maladaptive behaviour.

It is clear from the initial space observation that building structure and limitations are the cause of poor indoor environmental quality of the center. Although the gross area of the combined three apartments provides what seems as a sufficient space, however the net area in which occupants have access to and use is not efficient for the type of therapy and activity required for students of special needs.

It is important to highlight that a big part of special education environments rely on flexibility in teaching methods/ tools and space; as the nature of the programs are based on individuals rather than grouped students. Hence space limitations has lead decision maker at SNF to turn to other solutions. As a result, the biggest hindrance for occupants and cause of discomfort is noise generated from improper circulation pathway for occupants in the three-merged apartment.

In SLT room, the relatively small size of the classroom had the advantage in having a good luminance level. Another advantage helped in the satisfaction of students was the activity type, luminance level was good for desk level activities. On the other hand, students showed more sensitivity towards the background noise. Sound insulation and sound absorbent furniture is recommended to minimize the transferred noise.

In OT classroom, both light and acoustics were found to cause discomfort for students. The IE conditions were more limiting to students' abilities. Solutions to enhance the indoor environment are necessary for the well-being of students.

Results from students' questionnaires did not correlate with the results from therapist's interview, nor did the findings from the measurements. Surprisingly, only a minority of respondents' answers reflected on the poor IEQ.

While classrooms environmental measurements, well as therapist's answers, clearly indicate that the lighting environment and noise levels in classrooms had a direct impact on the anxiety and low performance of the students. This could be for couple of reasons:

- Students' inability to express their satisfaction toward the environment, despite of /regardless of the observation, spot measurement and therapist's answers combined.
- Students are adaptable to the surrounding environment where they are not aware of the poor IEQ.

Therapists in both classes expressed their interest in the topic of the research, it was noticed that therapists were also not aware about the extent of the physical indoor environment parameters in the well-being and performance of children with developmental disabilities. Therapists were more aware/ observant about student's sensitivity towards light and sound during field trips. Where students showed extreme behaviour patterns in environments with different types of lighting. Therapists related these behaviours to being in new environment where students require time to adapt to the place, as the author was explaining the research hypothesis and topic, therapists started to see similar behaviour patterns of students within the classroom. This means that therapists rely on student's to adapt to the classroom environments even when the classroom conditions is not at the ideal set up. Keeping in mind that therapists also were un aware of student's vulnerabilities towards the classroom setting.

Furthermore, therapists empathized on the impact of noise on student's concentration, as well as their ability to effectively work with students. Main source of distraction from therapists point of view was from frequent interruption by staff and students crossing the classroom.

Proposed solutions are:

- Sound insulation to be installed on the walls.
- Working desk to have adjustable side partitions; this allows students to visually focus on the task given. Partitions with fabric materials can increase the sound isolation, making background noise less stressful.
- Lighting fixtures with different intensity, hue, temperature, colour levels to be controlled by the therapist depending on the sight endurance of the students.

## **2.2. Case Study (B) Tender Hearts Arena**

### **2.2.1. Case Study (B) Building/ Facility Observation**

The center is located in a villa in a residency neighbourhood in Dubai. The villa consists of two floors; first floor consists of a reception, one administration office, kitchen, multi-purpose hall, and a yoga room. The second floor has a sharing hall which is converted to resting area and library. The hall connects four classrooms; the art classroom, Martial-art classroom, Music room and Communication skills room.

Observation from first floor was; two water feature/ sculpture under the staircase gave the environment a pleasant background, minimizing disruptive screaming sounds from students as well as minimizing echo in the space. It was observed that the overall space was well maintained and clean. Natural lighting in all classrooms was very good as each room had a large window.

Figure 5.15 presents the layout floor plan of the 1<sup>st</sup> floor.

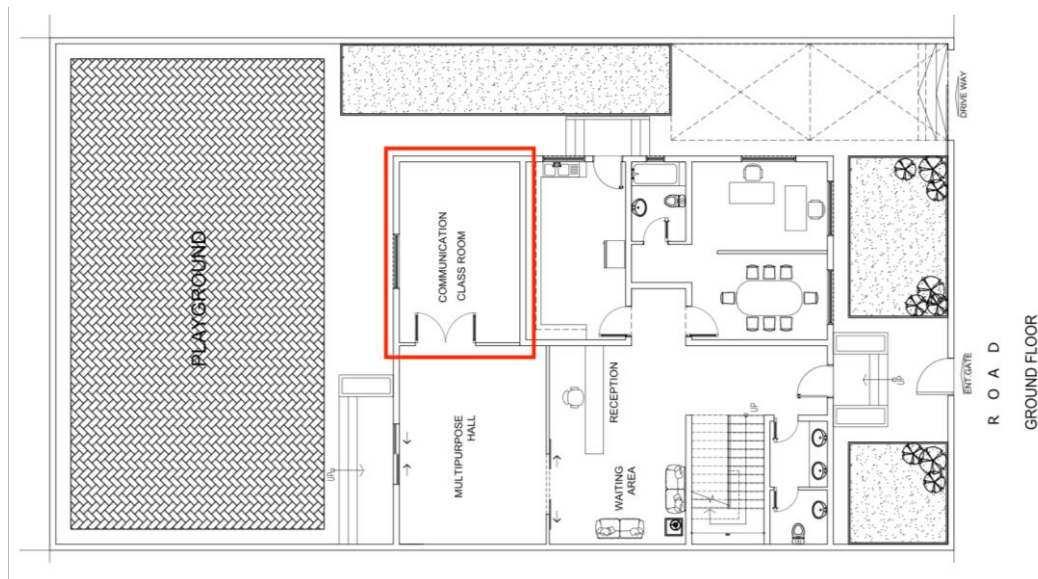


Figure 5.15: Tender Hearts Arena Ground Floor Layout

Since the purpose of the research is to highlight types of existing facilities dedicated for the population of disabled individuals, the presented case studies were deliberately selected to be different in structure and represent different practices, where occupants are the common element between the three facilities.

While the first case study was a support center, the second case study represents recreational center for individuals with disability. Referring to Chapter 4, the selected zones for this case study are classrooms that have the most resemblance to activities and objectives taken in Speech and language therapy and Occupational therapy rooms. Accordingly, Communication skills classroom and the Art classroom were selected. During the period measurements were taken for this study, Communication skills classroom used two rooms, observations and readings for both rooms are included in the research.

#### **2.2.1.1. Observation in Communication Skills Classroom**

Occupants of the class room were students, the teacher and volunteers. It was noted that the center emphasizes on evolving community in the recreational program. The ideology behind this is that the integration of children with disabilities with the outer community in daily activity session will support the child and help their learning process and personal development. Although the support of volunteers is sought to have a positive impact, on the other hand more sound is generated within the classroom which causes increase in sound level and discomfort in which consequently leads to discomfort. The type of activities conducted in this classroom are reading, listening, recreating scenario, and acting scene. Students and volunteers were seated on the floor, on comfortable bean bags.

Sound level in the classroom where relatively high, this is due to the activity type where the teacher had to elaborate the scene and scenarios in different sound pitch impersonating different people. Moreover, the sound from volunteers repeating

instructions to children increased the overall sound generated in the classroom. Although sounds in classroom were high, the author observed that students were not distracted by sounds.

**Classroom 1:** Located on the first floor. Duration of the class was one hour. Walls were cladded with stuffed material with height of 1.8 meters for safety purposes, while the floor was covered with vinyl sheets for safety purposes as well. Daylight was sourced from one window. Other observation of the room setting was the suspended false ceiling. Artificial lighting from the ceiling observed were; direct light, spot light and indirect light, few of the lightbulbs were burnt. Although good amount of lighting was visible in the room, the lighting was off. Main source of light was from the window, which made the room feels dull.

**Classroom 2:** Located on the second floor. Vinyl sheets were used for flooring. The room seems more spacious as it was kept empty with no furniture in addition to the big balcony that provided daylight into the room. Students in this class room were performing better than students in classroom 1. Activity in this room included more physical movement and acting; the teacher tend to have faster pace in giving instructions and deliberately changing the activity type to test the endurance and quick mental response/active thinking. Balcony window had an advantage in creating a comfortable learning environment as it kept temperature in the room warm.

First, it is necessary to mention that students attending communication skills classes were between moderate to high functioning students, whereas students from art class were moderate to low functioning. An important note that communication skills classrooms had group of students working together for one hour, while art class was more of a one on one class (or two students) and class duration was shorter.

Multi-disciplinary room facilitated different kinds of classes including dance class and yoga. Furthermore, since the connecting door is glass door, the given activity in the multi-disciplinary room was vividly visible which effected the overall attention span. The activity types in communication skills class were generally very interactive between the teacher and students. Physical activities such as acting and improvising scenarios were practiced. Since volunteers had presence in the classroom, they were active as well encouraging students. This added another loud source of sound in the classrooms.

However, it was observed that despite the loud noises in the classroom, students were attentive and alerted, as well as focused. This is due the type of the activity and high interactive as students changed location. On the other hand, it was observed that students in the second classroom were distracted by the view from the window. Students were distracted at the movement of the tree from the balcony view. No signs of discomfort were observed.

### **2.2.1.2. Observation in Art Classroom**

The settings in this room were tables and foldable chairs. Vinyl flooring sheets covered the floor of the room. All activities were conducted on desk level. Unlike the communication skills classroom, this classroom is calmer. As art activity is mostly visual, the teacher dose not necessary require to give a thorough explanation. Duration of class was 30 minutes. Students worked independently. Noise was heard from construction working behind the



villa, muffed background sounds from the neighbouring classroom, and feeling of vibration from the martial activities from other neighbouring classroom. Most distraction was from other students randomly and suddenly walking into the classroom coming in and out.

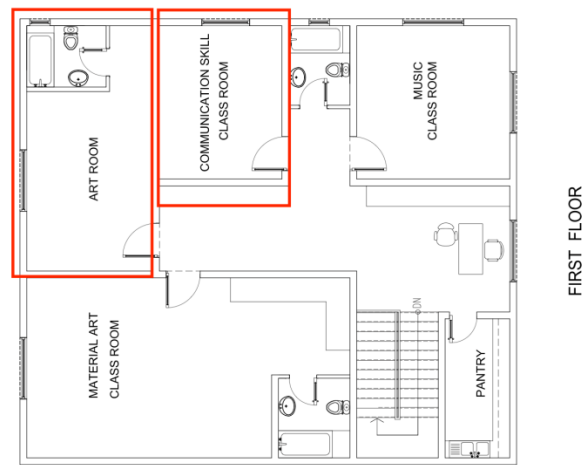


Figure 5.16: Tender Hearts Arena First Floor Layout



Figure 5.17: Case Study (B) Art Room (2017)

Noise levels increased once few students got reactive and started to scream and get in an unsettling mode. Maladaptive behaviour was in the form of repeating the same words in high vocal sounds, as well as hitting the table. This behaviour caused distraction and annoyance to the other students in the classroom, to the extent that they stopped working on the given task. The teacher remained calm working cautiously with those students, giving them space to release their irritation and calm down on their own pace.

In the second session, two students joined the class. One was none verbal, yet mentally he was healthy. The other student suffered from mental development delays, also was none verbal, however the later student was more interactive using sounds and hum. Suddenly during the session the second student heard noise of screaming students from the hallway, his reaction was to imitate that sound with a very high pitch. The first student could not tolerate the noise made by his colleague so he left the classroom. After the end of the session the teacher explained the reason behind the behaviour of the student.

Another observation was from another none verbal student whom when entering the classroom, he examined the light switches and made sure to switched on all the lights in the room, and selected to sit next to the closest table to the window. The teacher later explained that light environment, specifically natural light has a positive impact on his mood and performance.

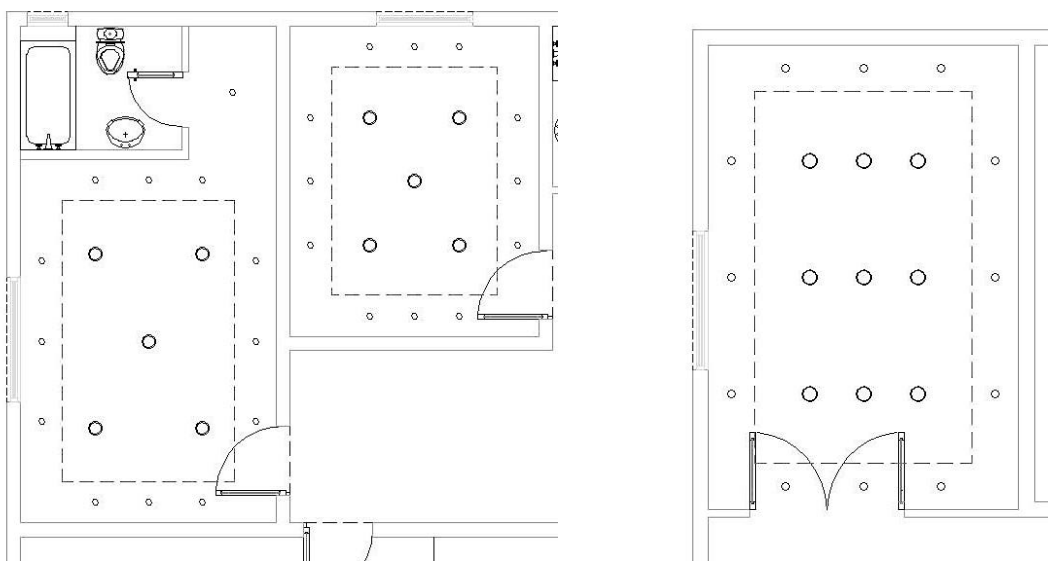


Figure 5.18: Case Study (B) Lighting Layout of Selected Zones (2017)

### 2.2.2. Spot measurements

Readings have been recorded in three classrooms. Differences between communication skills and art class are shown in Table 5.2.

Table 5.2: CS Classes and Art Classes Difference (2017)

	<b>Communication Skills class</b>	<b>Art class</b>
<b>Duration</b>	60 min / session	30 min/ session
<b>Occupants</b>	Teacher, Students, Volunteers	Teacher, Students
<b>Students competence</b>	Moderate to high functioning	Moderate to low functioning
<b>Activity type</b>	Reading, Acting, Movement	Desk- level

Spot measurements in communication skills sessions were taken in different locations, mostly on the floor as students were seated on the floor, whereas, spot measurements in the art classrooms were taken on a working desk level.

Occupancy level in the communication skills classroom was relatively higher than the art classroom with the presence of volunteers as well as the number of students (as they were all between moderate to high functioning level, they were able to effectively work as a group). Data was collected from Communication skills classroom 1 on March 26th 2017. Data was collected from Communication skills classroom 2 on March 23rd 2017. Data was collected from art classroom on February 16th 2017.

Table 5.3: Case Study (B) Light and Sound Readings in The Selected Zones (2017)

Parameters	Communication Skills- Room 1			Communication Skills- Room 2			Art		
	Location 1	Location 2	Location 3	Location 1	Location 2	Location 3	Location 1	Location 2	Location 3
Light (Lux)	50	76	73	202	190	70	194	147	171
Sound (dB)	75 - 62	80 - 55	82 - 66	76 - 88	75 - 90	63 - 77	60 - 68	50 - 79	67 - 80
Time	12: 45 PM	1: 30 PM	12: 45 PM	1 PM	1: 30 PM	1: 45 PM	11 AM	1:15 PM	3 PM

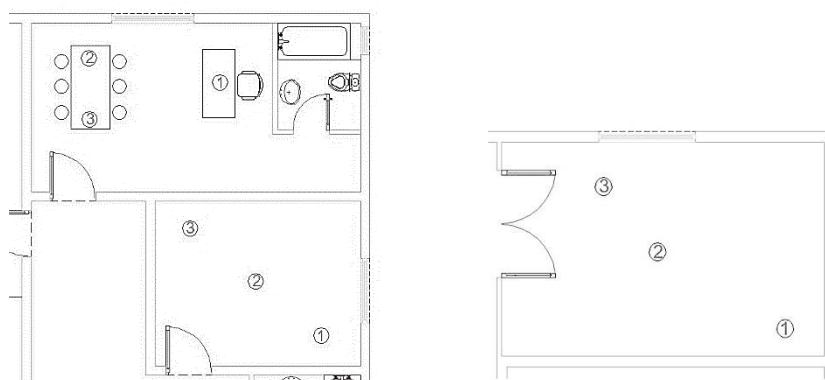


Figure 5.19: Case Study (B) Spot Measurement Location (2017)

In Communication rooms 1, lights were off relying only on daylight. Room 2 had higher readings recorded due to access of more daylight even though the lights were closed.

Similarly, in the art room more light was coming from the balcony. As a result, lighting in the room were dim and insufficient, however, it was noted that students were not bothered with the lack of lighting.

Readings in communication skills room 2 is different due to the location of the devices. The average Lux level in CS-room 1 is 66 Lux, 154 Lux in CS- room 2 and an average of 170 Lux in the art room. Luminance level in all the rooms are below the standard requirements, hence the visual quality is considered low, however in such conditions, students may experience difficulties in performing/ completing or even understanding the given instructions.

The first thing noticed in Table 5.3 is the variety of measurements I the three classrooms. In communication skills room 1, Lux measurements are found to be the lowest compared to the other two rooms. The teacher kept the room light closed, conducted the sessions relying on daylight factor only. During the interview with the teacher, this observation was asked and the justification for this was that students preferred the daylight more than lighting in the classroom. However, contrary to the expectations, questionnaire findings from this room showed the opposite. As seen in Figure 5.21. two of five students found lighting in the room tiring and irritating. This means that some students require more uniformity and lit environment and that not all students have the same tendency to feel comfortable with daylight.

Measurements in communication skills room 2, have the highest lux reading among the three rooms. As mentioned before, this is due to the large wall window in the room location on the north east. Lux levels in the art room was also below the recommended range. Although the room had large wall window. Less direct daylight had access to the room because of the window was on the north west of the building.

These findings suggest that daylight in the classrooms are not sufficient, leading to a poor light environment. According to these data, we can infer that better lighting environment can be achieved if both daylight and artificial light were utilized together. However, during the observation phase, it was noted that students were well engaged in the learning activities despite the poor lighting environment.

Sound features were also above the recommended international guideline. From the observations: CS- room 1 & 2, due to the activity type as well as the occupancy level and interaction between the occupants, the sound level was high. Table 5.3. shows that communication room 1 had the highest readings, this is resulted from the presence of volunteers. The table also shows that in art room relatively had lower dB readings except for reading in location (3). This is because the student in that session was screaming from anxiety attack. The average dB level in CS-room 1 is 70 dB, in 78 dB CS- room 2 and an average of 66 dB in the art room.

### 2.2.3. Questionnaire and Interview

A total of 18 students from this case study answered the questionnaire. 5 students (male) from Communication skills room-1, 8 students (4 females, 4 males) from Communication skills room-2, and 5 students (2 females, 3 males) responded from Art room.

The overall perception of the classrooms are as follows:

- CS- 1 classroom; 3 answered *Relaxed* and 2 answered *Tired*.
- CS- 2 classroom; 5 students answered *Happy* and 3 answered *Relaxed*.
- Art classroom; 1 student answered *Happy* and 2 answered *Relaxed* and 2 answered *Tired*.
- 

Answers on students' impression towards the lighting environment;

- CS- 1 classroom; 1 student answered *Happy*, 2 answered *Relaxed*, 1 answered *Tired* and 1 answered *Sad*.
- CS- 2 classroom; 1 student answered *Happy* and 7 answered *Relaxed*.
- Art classroom; 2 students answered *Happy*, 2 answered *Relaxed* and 1 answered *Tired*.
- 15 out of 18 students preferred natural light.

Answers on students' impression towards the acoustic environment;

- CS- 1 classroom; 2 answered *Happy* 1 answered *Irritated* and 2 answered *Angry*.
- CS- 2 classroom; 1 student answered *Happy*, 1 answered *Sad* and 5 answered *Irritated*.
- Art classroom; 1 student answered *Happy*, 2 answered *Tired* and 2 answered *Angry*.

From these data, it is noticeable that in the first question on the over-all classroom environment, the majority of students' answers indicated satisfaction, where most answers ranged between *Happy- Relaxed- Tiring*. See Figure 5.20. On the other hand, when asked on the light and sound quality separately; answers indicated that students felt discomfort. Answers for lighting environment, indicate that students in CS-1 and art class found the lighting environment tiring. While all students in CS-2 found the lighting environment to be comfortable. See Figure 5.21, Figure 5.22 and Figure 5.23. Interestingly, 7 out of 8 students answered (*Relaxed*), this could be due to the window balcony in the room. Furthermore, most students found the acoustic environment disturbing. Responses varied between *Sad, Irritated, Angry*.

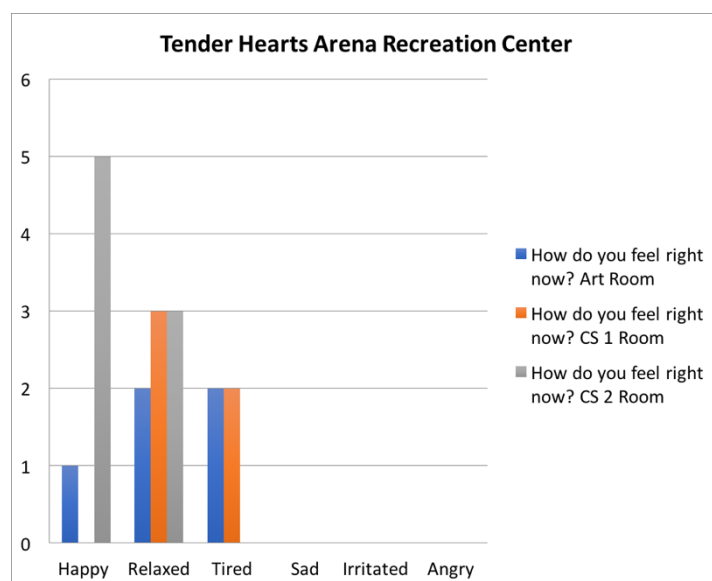


Figure 5.20: Case Study (B) Comfort/ Discomfort Level of Classroom IE (2017)

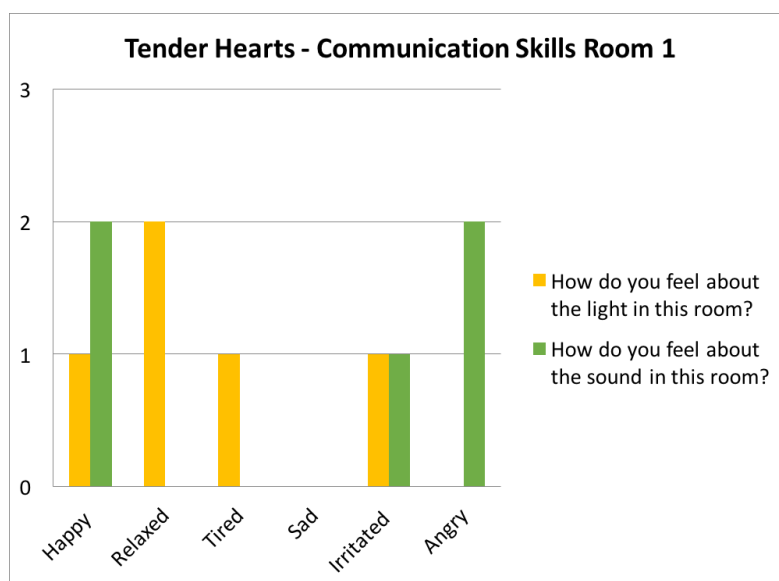


Figure 5.21: Case Study (B) Comfort/ Discomfort Level of Communication Skills Room-1 (2017)

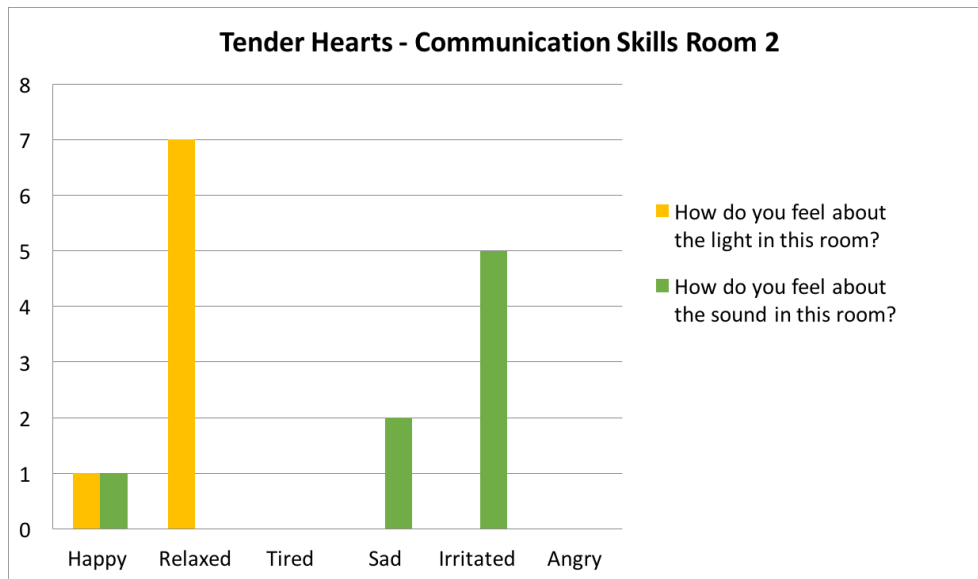


Figure 5.22: Case Study (B) Comfort/ Discomfort Level of Communication Skills Room-2 (2017)

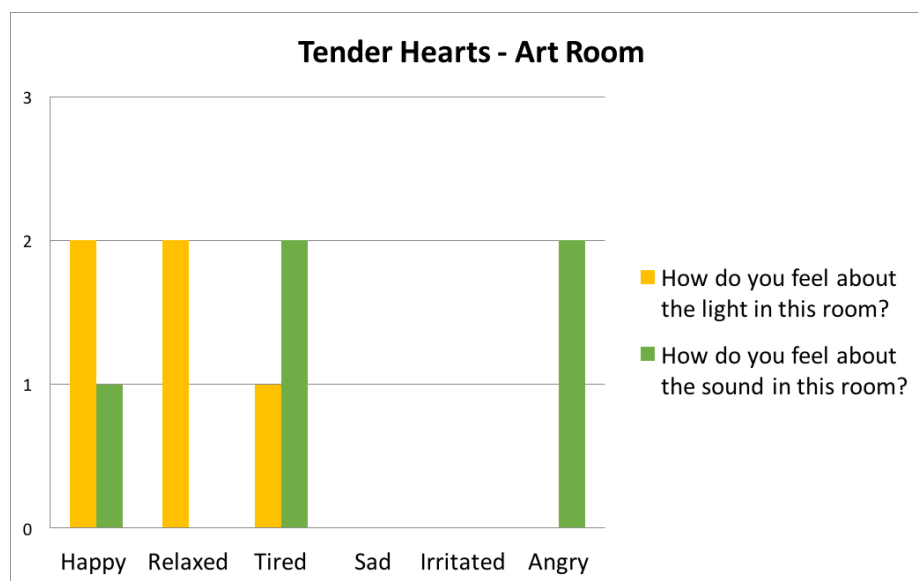


Figure 5.23: Case Study (B) Comfort/ Discomfort Level of Art Room (2017)

Results from interview with teachers are as follows:

- All teachers conducted group sessions with 2 to 9 students per session.

#### Lighting:

- All teachers found the lighting environment as acceptable.
- Therapists have no control on lighting characteristics; only control is to switch on/ off.

- Students' behaviour towards lighting: in both classrooms students' performed better in natural lit environment. This is with the exception of few students whom were reactive towards direct light.

#### **Acoustics:**

- All teachers found the acoustic environment as acceptable. This is with the exception to the noise coming from students who are low functioning and tend to communicate through reactive behaviour such as screaming and generating sounds. Other source of sound is from classroom activities such as *Martial-Art room and Music room*.
- Solutions to minimize the noise were to isolate students whom are at distress because of the noise.
- All teachers agree that noise affects students' performance and triggers anxiety and maladaptive behaviour.

Although the visual quality of the classrooms was low, neither the students nor the teacher showed signs of discomfort. This finding is interesting as it highlights how special education is different than the regular/ normal education. Here not only is the demand different, the teaching approach is different, as well as the way the students perceive instructions are different. In other words, it could happen that the environmental features may not be at a high, or acceptable, international standards, but teachers find a way to cope with the space limitations.

In the art room, it was observed that students preferred working near the window, this indicates how sensitive students are towards lighting; the need to have a good lighting environment specially lighting that mimics natural daylight such as circadian lighting.

Conflicting results were found from measurements, answers from students and teachers. Figure 5.21, Figure 5.22, Figure 5. 23. Show different answers on comfort and discomfort levels. Answers from teachers shows that teachers had minimal knowledge on the contribution of classroom environment to the comfort of the students. Teachers were found to observe student's sensitivity towards lighting type. Teachers were mostly considerate to the condition of the child and their limitations rather than having an extra consideration on what can support or disrupt their abilities from the classroom environment. As a result, they were also unaware about what is the accepted range that can support the students to adjust the room setting and physical parameters to suit the students.

These results provide further support for the hypothesis that special education indoor environments are a complex environment which requires careful consideration of the occupants classifications as well as environmental parameters.

### **2.3. Case Study (C) Future Center; Rehabilitation Center**

The school based center is located in the capital of United Arab Emirates, Abu Dhabi. Situated in an industrial area called Al Mussafah, 30 Km from the center of the city. In the past few years, the industrial area has grown to be a suburban area with a growing educational community where many schools, such as the Future Center, have relocated to Al Mussafah. The center provides both special education as well as therapy based program. Future center is one of the largest schools for children with disabilities, hosting over 300 students.



The purpose-built school consists of two floors. The first observation made once entering the building is the internal structure. The core of the building has a big atrium made of glass bringing the maximum daylight into the body of the building. The atrium is located at the center of the building with a circular staircase. The building has a spacious hall way, the wide corridors, pathways to different departments (the division of departments), and a wide circulation path helped with accessibility for students

As shown in the floor plan Figure 5.25, the atrium divided the building into two halves. The First floor consists of administration offices, while the opposite side of the building consists of intervention room, occupational and physio therapy, assessment, autism department and an indoor swimming pool. The Second floor is dedicated to the higher functioning classrooms, functional skills, auditorium, and music room.

The impact of having atrium as a core structure on the indoor environment quality:

- Allow maximum daylight light entering the building.
- Friendly environment.
- Use of plantation underneath the atrium, adding visual element.
- Increase in wellbeing of occupants.
- Encourage students to use the staircase underneath the atrium rather than the elevator.

Department zone arrangements were designed to provide maximum support for the students. Visual guidelines such as floor and ceiling designs, colour coding and imagery posters were utilized. Corridors had handrails for support for students with physical limitations. Advantages of good zone arrangements and spacious environment were observed. Easy accessible environment successfully empowered students of different disabilities and physical conditions to find their way in the school with minimal assistance needed. Students were observed to be walking in the school campus with confidence.

Air quality was sensible, no orders in the air. Overall temperature was convenient in all the spaces and therapy rooms even with the vertical window walls.

The selected zones in this study are located in the first floor.



Figure 5.24: Future Center (2017)

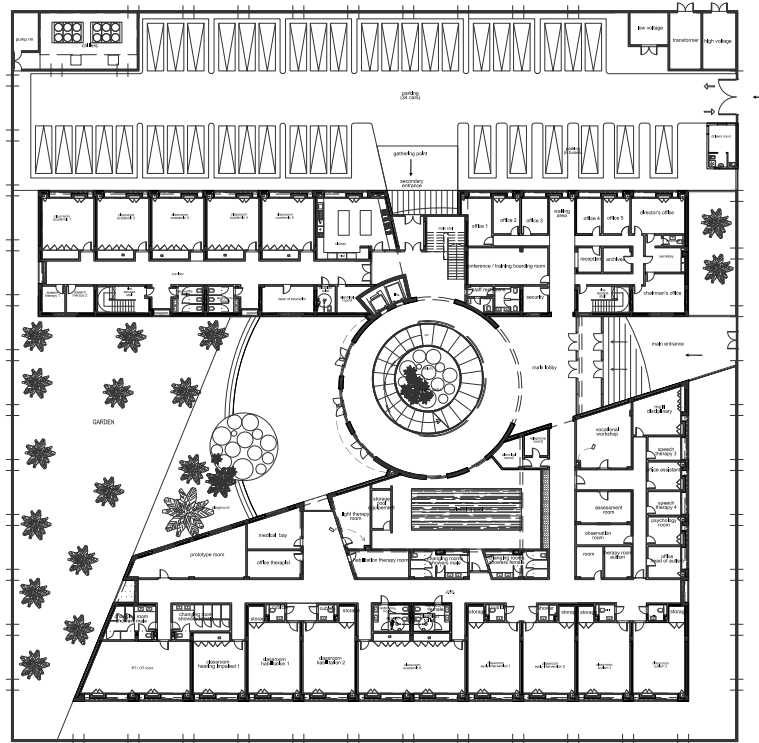


Figure 5.25: Future Center Ground Floor Layout (2017)

### 2.3.1. Observation in Speech and Language therapy room SLT

Relatively small classroom, net area of 11.16 m<sup>2</sup>. The classroom was located near the Autism department and assessment room. Minimal classroom furniture included teacher's table, computer, cupboard and table for the/a student. All sessions were conducted on a one on one basis. Duration of the session was 30 minutes. The room had vertical wall window which got access to daylight. Activity type was mostly reading and writing. Source of noise in the room was mainly the teacher and student. The highlight of the classroom was the vertical window. Although the window is narrow, yet the visual feature it adds to the room enhances the overall environmental quality. As seen in the Figure 5.27. The use of blinds to avoid direct sunlight generates a soft diffused light that gives soothing effect for the users of the space.

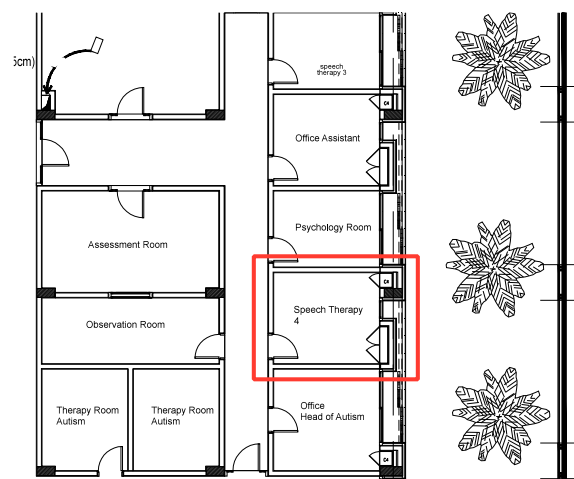


Figure 5.26: Case Study (C) SLT Floor Plan (2017)



Figure 5.27: Case Study (C) SLT Room (2017)

## Observation from Students

The first observation on students is that they were the source of sound in the room. As most activities focused on pronunciation, students were imitating and repeating the therapist. One student had hearing impairments, as it was challenging for her to follow the therapist instruction, so the therapist relied on vibration from her vocal cord. It was observed that environmental stressors could not cause this student discomfort. Another student was attentive and suffering from hyper tension, where noise from the nearby department was distracting him. The therapist had to use electronic devices and short writing tasks to keep him engaged. Observed behavioural patterns of this student was tapping on the table, repetition of rhythmic sounds once distracted with background noise, as background sounds were sounds of screaming children, it was noted that adaptation methods of this student was to create noise when feeling disturbed or scared. Other student's reaction to disturbing background noise was to throw objects on the table, so the therapist reaction to this behaviour was to give the student time to regain focus and continue with the given tasks.

### 2.3.1.2. Observation in Occupational Therapy Room OT

The occupational therapy room, articulation classroom and the gym are located at the very end of the school. The advantage of this zone arrangement is that by keeping the classrooms that generates loud sounds and possible noise for other departments helps in mitigating the overall noise level. Observation on the space, the room was relatively large in size. As the main purpose of occupational therapy is improve, motor skills, eye- hand coordination, concentration and social skills. Different types of physical and mental activities takes place in this department. Devices and tools used in this department vary in size, tool, and usage. OT classroom in this case study was separated into three area. The classroom consists of three areas; **area-A** has all the tools and machines used for physical and motor skills activities whereas **area-B** has 5 tables with partitions mainly used for activities at desk level such as writing and building blocks, while **area-C** has the multi-sensory space, see figure 5.28.

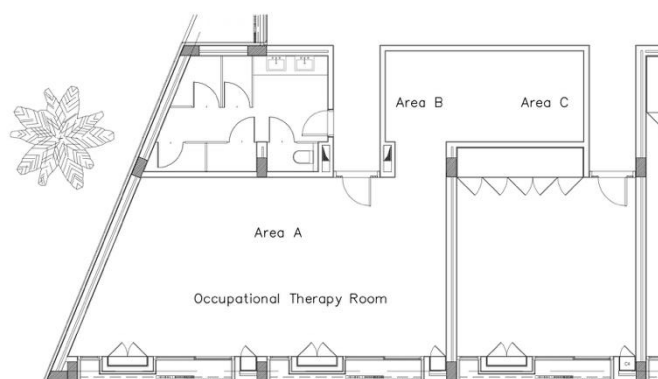


Figure 5.28: Case Study (C) OT Floor Plan (Area A, B, C) (2017)

Equipment in area-A were all covered with durable vinyl cover material, most gymnastic equipment were stuffed with polyethylene foam core. The none-slippery surface added another safety feature to the comfortable and durable material. Other observation of the area was the sanitation of the OT room, the staff were cautious on the hygiene of the equipment and room. Figure 5.29.



Figure 5.29: Case Study (C) Equipment's and Tools Used in Area- A OT (2017)

Regarding the lighting environment, it was very good. A great advantage of having full height large windows (glazing) covering a big portion of the room is that it allows maximum daylight to access the classroom, add up to the uniformity of the space as well as keep room temperature warm. On the other hand, excess of light can cause glare for the users of the space. Figure 5.30, shows the light uniformity in area-A with the artificial light on and off. Although the window was a great source of lighting in the room, there was an external activity happening outside the school: construction work-in-progress to which students tend to get distracted by the movements. Furthermore, study observations were taken in the winter season, where movements of the outside tree from window were also



distracting. Similarly, the mural on the wall with the different colours and shapes was a source of distraction.



Figure 5.30: Case Study (C) Lighting Environment in Area-A OT (2017)

Area-B was specified for activities that take place on desk level, few tables were facing the wall while one table was next to the window. Tables that were facing the wall had desk partitions. Advantages of using the partition was to have better isolation work area for the student. Students were observed to perform better and more efficiently when they were located at desks with side partitions and facing the wall compared to students who were working on tables facing the window. The later students were distracted and took more time in completing the given tasks. These students were distracted by the courtyard view, noise made from activities in Area-A as the table was closer to the equipment of area-A and finally, distraction from moving trees and brides in their vision (Window pane). Figure 5.31.



Figure 5.31: Case Study (C) Tables Facing the Wall and Partitions Area-B OT (2017)

Observation in area-C starts with the setting. This area is designed as a multi-sensory room for students. As shown in Figure 5. 31, area-C separated from area-A, and B. For further isolation and privacy, curtains of thick fabric material was used. Comfortable bean bags, vinyl floor mats used as movable furniture. All activities were performed at floor level.

Source of light in this area was colourful disco lighting and soft light projector. In the corner of the space, a continuous strip of mirror was installed at low height. Other items found in the area was a small cabinet with fish tank, see Figure 5.32. The dim moving lighting and the reflection of light from the mirror gave the space a soothing ambient. The mirror was used as a teaching method to enhance the visual participation of the students. The impact of soft lighting and lava lamp, with the movement of fish in fish tank helped to release tension and anxiety and improve performance in the given tasks. It was noted that specialists use low voice tones. It is interesting to mention that although the space is divided with fabric curtains, users of the space were in a calm status. The overall ambient of the sensory area (Area-C) was peaceful. Depending on the needs and mood of the students therapists determine the duration where students need to spend in the sensory area.



Figure 5. 32: Case Study (C) Area-C OT (2017)

The single most striking observation to emerge from OT classroom was that the room was shared with 7 therapists conducting one on one sessions with students at the same time. Therapists utilized different areas in the OT room simultaneously while other therapists were conducting their therapy activities. Consequently, sounds generate in the classroom was higher/ more than background noise. Another factor that added to the high sound level was the sounds generating from the use of tools and devices. In some cases, the therapists were giving instructions in higher sound level due to the hearing impairments of the students.

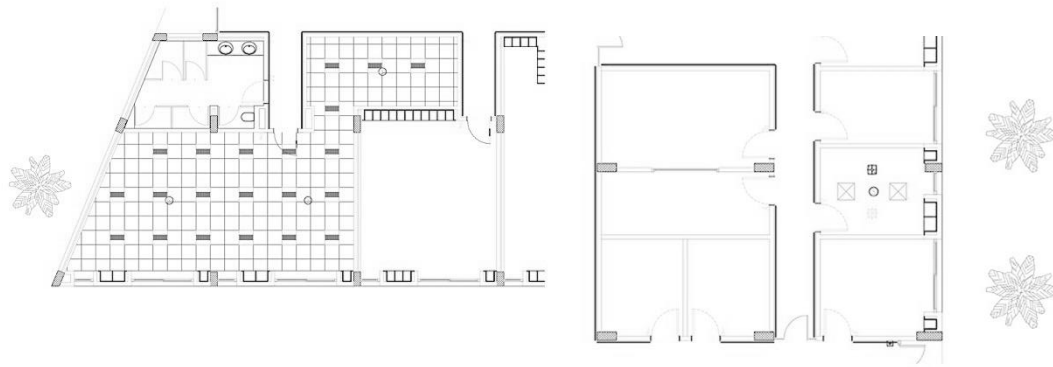


Figure 5.33: Case Study (C) Lighting Layout of Selected Zones (2017)

### 2.3.2. Spot Measurements

Data was collected from OT room on March 5th 2017, while data collected from SLT room was on March 9th 2017. Devices in SLT were all measured on a desk level, whereas in OT room devices were placed in different heights as activities were conducted in different height levels between desk level, floor level, 50 cm above the ground. A total of 13 readings were gathered in this center. SLT had a total of 7 sessions during the day, 30 minutes to 45 minutes sessions depending on the level of the students. OT classroom conducted 7 sessions during the day, 30 minutes per session. OT classroom was being shared between 4 therapists at the same time. All sessions were conducted on a one on one basis in both the therapy rooms.

Due to the different range of used tool and activities in OT for this case study the author took inconsideration the peak level where activity is taken place. Figure 5.34 shows the position and location of the devices are on the classroom floor, as the activity is occurring on the ground level. On the other hand, most activities held in the SLT is on working desk level, hence devices record lighting and sound level from the same desk height.

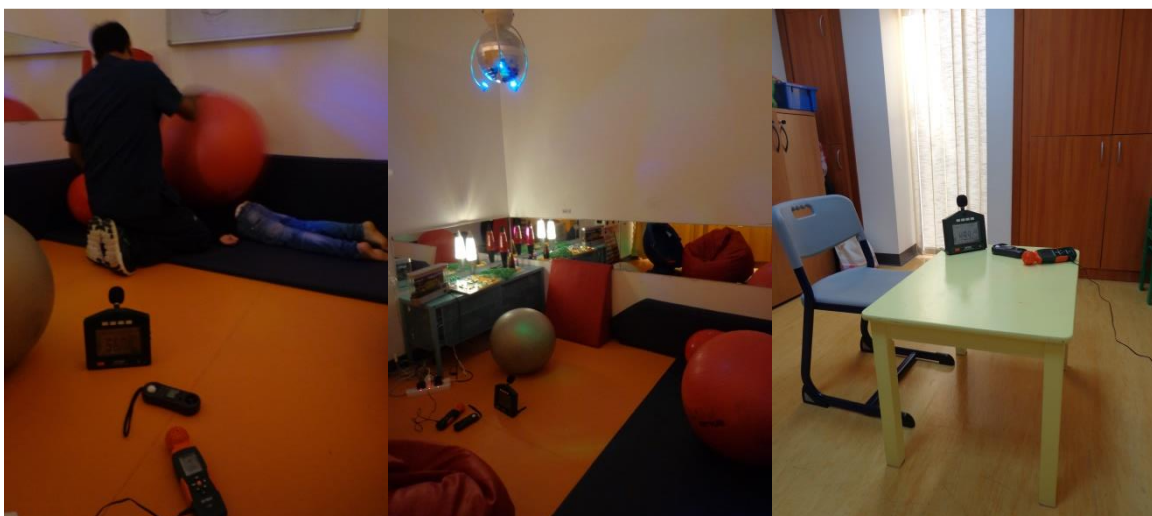


Figure 5.34: Case Study (C) Positions Measuring Devices in OT and SLT (2017)



Table 5.4: Case Study (C) Light and Sound readings in SLT (2017)

Parameters	Speech & Language Therapy					
	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6
Light (Lux)	605	410	418	335	303	300
Sound (dB)	65 - 71	62 - 72	60 - 66	48 - 59	65 - 53	69 - 75
Time	8:05 AM	9 AM	9:30 AM	11:18 AM	12 PM	12:50 PM

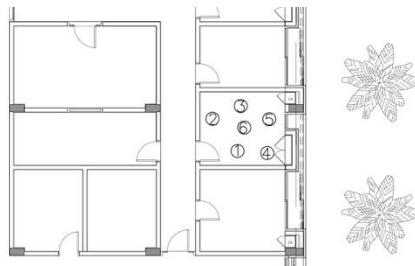


Figure 5.35: Case Study (C) Spot Measurement Location STL (2017)

Table 5.5: Case Study (C) Light and Sound readings in OT (2017)

Parameters	Occupation Therapy						
	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7
Light (Lux)	634	854	27	1838	1831	840	477
Sound (dB)	51 - 55	55 - 65	45 - 50	66 - 71	60 - 68	47 - 52	47 - 51
Time	10 AM	10:30 AM	11 AM	11:30 AM	12 PM	12:30 PM	1 PM

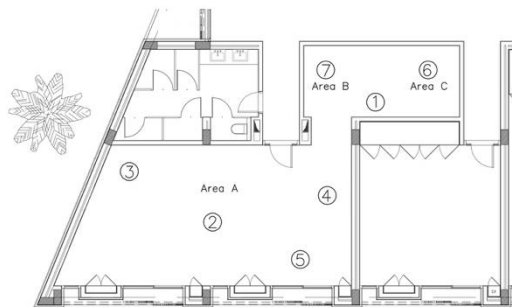


Figure 5.36: Case Study (C) Spot Measurement Location OT (2017)

This table is quite revealing in several ways. First, unlike the other case studies, measurements of the luminance environment in both therapy rooms were within the standard international guidelines. The average luminance level recorded in SLT was 383 Lux. The average luminance recorded level in OT was 1004 Lux.

This means, students had sufficient lighting to efficiently work on the given tasks. As there was no flickering lighting observed in both therapy rooms. Lux measurements in the OT room were found to be within standard range. This is due to the vertical window wall (curtain wall glazing) that had a positive impact in the supporting artificial light. It was observed that students showed more interest in working in areas near the window, this indicated that natural light has a positive impact of the performance of children with disability.

Second, luminance readings from *Location 3* in OT room have no coherence/ consistency with readings in other location in the room, this is because location 3 represents reading taken from area-C the multi-sensory room. By the nature of the environment, low soft lighting is required to stimulate the sense of relaxation and calmness for students.

Third, another reason for having a good lighting environment in classrooms is related to the lighting arrangements of the classrooms, which gave a uniform efficient and sufficient lighting to light the whole space.

Fourth, readings for sound level were found to be on the borderline of exceeding the recommended levels, where the standard level is 35 dB and maximum level of 60 dB. The average recorded dB level in SLT was 62. The average dB level in OT was 56. None the less, readings in this case study were the closest to the standard compared to the other two case studies. Table 5.5 shows that 4 out of 7 locations recorded dB levels in the acceptable range, with minimum of 48 dB in area-C Multi- sensory room, once again, this is due to the nature of activity taken in that area, the therapist conducted the exercises/ activities with minimal verbal instructions. Reading in SLT room shows 2 out of 6 locations recorded dB levels were in acceptable range. One supporting factor for having better sound levels is the Vinyl flooring of the rooms. Vinyl flooring is considered a good choice for sound reduction. The flexible surface is cushioned with a layer of foam that reduces sound waves. Sound source in SLT room is sourced from outside the classroom. While in OT room, the majority of sound was sourced from area-A, where all the gymnastic equipment and tools are used.

### **2.3.3. Questionnaire and Interview**

A total of 11 students from this case study answered the questionnaire. 5 students (5 females) from SLT room and 6 students (3 females, 3 males) responded from OT room.

The overall perception of the classrooms are as follows:

- SLT classroom; 3 answered *Happy* and 2 answered *Tired*.
- OT classroom; 1 student answered *Happy*, 3 answered *Relaxed*, 1 answered *Tired* and 1 sad.

Answers on student's impression towards the lighting environment;

- SLT classroom; 2 answered *Happy* and 3 answered *Relaxed*.
- OT classroom; 1 student answered *Happy*, 1 answered *Relaxed*, 3 answered *Tired* and 1 answered *sad*.
- 7 out of 11 students preferred natural light.

Answers in the SLT room where found to vary between extreme comfort and extreme discomfort. This means that students' perception towards each element separately is different. As some found lighting in classroom convenient, others found sound irritating and causes anger. Flexibility in lighting is required as well as solutions for sound quality. See Figure 5.31.

Answers on students' impression towards the acoustic environment;

- SLT classroom; 1 student *Happy* 1 answered, 3 answered *Irritated* and 1 answered *Angry*.
- OT classroom; 2 answered *Relaxed*, 2 answered *Tired* and 2 answered *Irritated*.

On the other hand, answers from OT room had more coherency between light and sound. Also, the range was not in both extremes, correlations between light and sound responses means that students have the awareness on both environmental factors together.

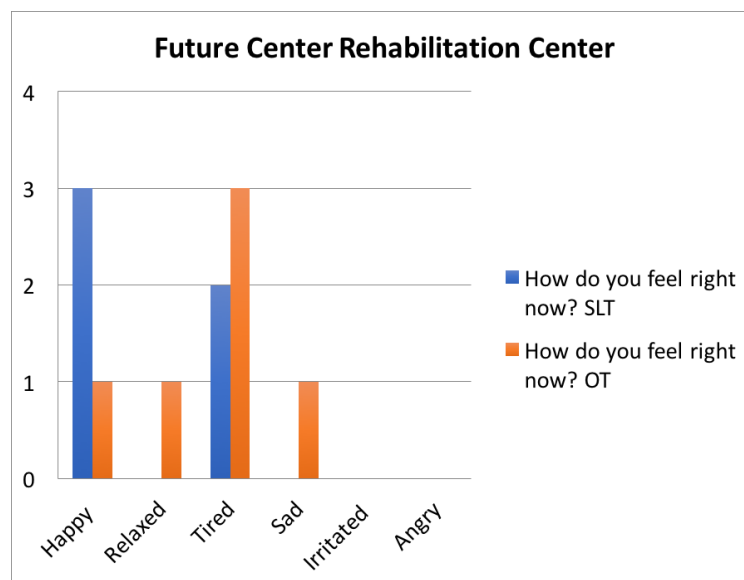


Figure 5.37: Case Study (C) Comfort/ Discomfort Level of Classroom IE (2017)

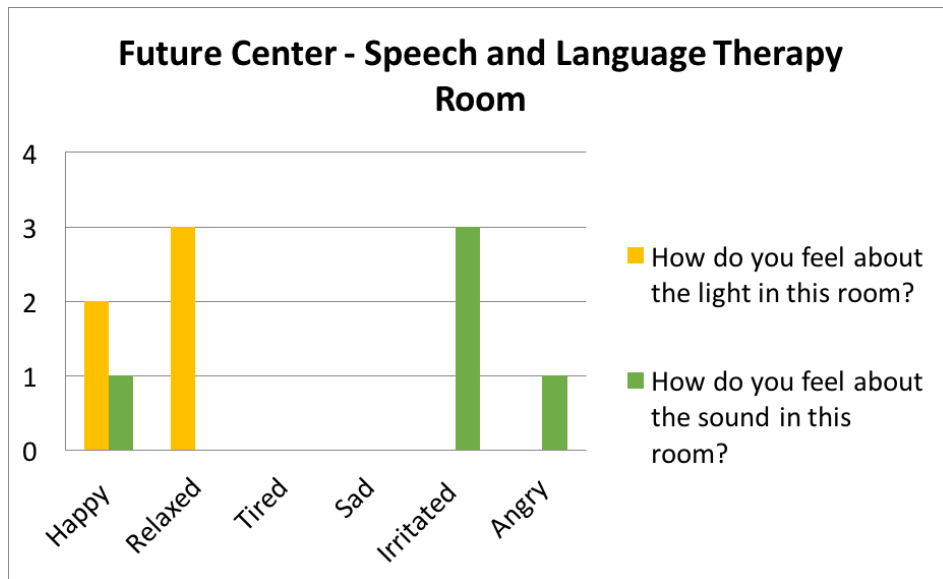


Figure 5.38: Case Study (C) Comfort/ Discomfort Level of SLT Room (2017)

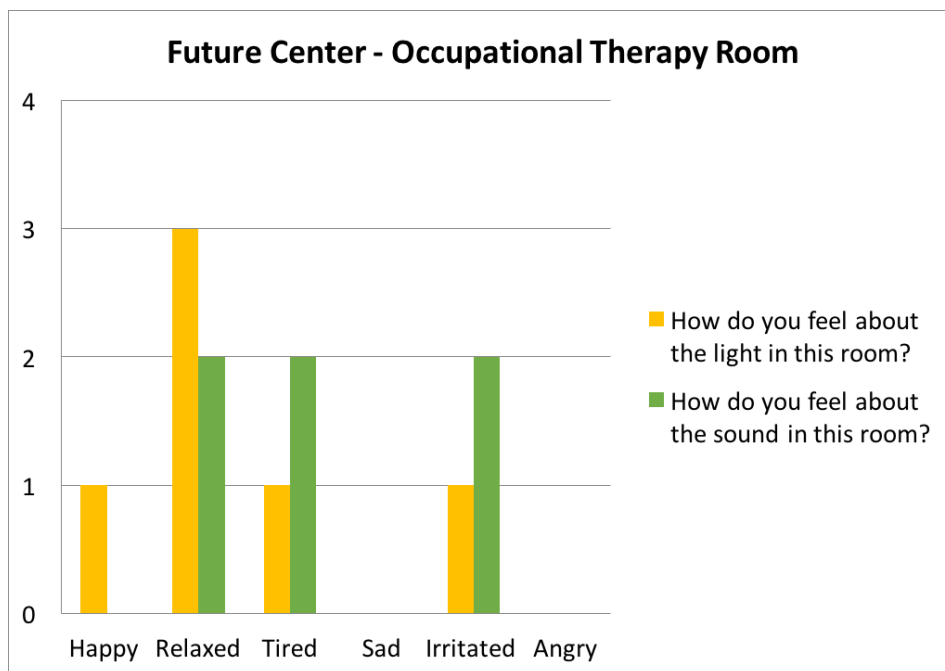


Figure 5.39: Case Study (C) Comfort/ Discomfort Level of OT Room (2017)

Figure 5. 37. Shows that students in SLT was equally divided between comfort and discomfort, while answers of OT room had a more reasonable transmission. Similarly, to other case studies, answers differed when asked about the light and sound parameters separately. Figure 5. 38. Showed that students are satisfied with lighting environment in SLT. On the other hand, answered in OT varied. Acoustic features, figure 5. 39. Showed that in both rooms students were dissatisfied. In SLT, only one student felt comfortable, while others felt irritated and angry.

Results from interview with the therapists are in the below list:

- Therapists in OT room conduct one on one session with students, in a space shared with 7 other therapists working at the same time.

#### **Lighting:**

- Therapists found the lighting environment ideal, as they have good lighting in their classroom. Most therapists did not see the significance of having daylight in their class, especially in the OT room, as comments on the vertical window wall was that it raises the temperature of the classroom, which can cause discomfort to students.
- Therapists have no control on lighting characteristics; only control is to switch on/ off. In Multi- Sensory room, the therapist had the control to use different light sources, for example: lava lamp, disco wall, LED lights.
- Students' behaviour towards lighting: in SLT therapists mentioned that most students are limited in their capability to identify causes of their discomfort, this is due to the neurological dysfunction. Therapists in OT room emphasized on the importance of integrating more lighting levels for the multi-sensory area in OT.

#### **Acoustic:**

- Therapists in SLT found acoustic environment good. While therapists in OT found acoustics in the room to be poor, as noise generated inside the classroom or from external sources plays role in the performance of students, specifically their room which determine how well they progress in the class.
- Therapists faced difficulties to find solutions for the sounds in OT room, as the main barrier was the sharing sessions and time given to conduct the therapy.
- All therapists agree that noise level affects students' performance and triggers anxiety and maladaptive behaviour . Some students find echo in the room disturbing and it's difficult for them to understand the cause of it as a result their immediate reaction is anxiety and fear.

### **3. Discussion**

The purpose of the study is to evaluate the IEQ (light and sound quality) conditions in three different built facilities for individuals with developmental disabilities, to find to what extent does light and acoustic environment have an impact on subjects in these facilities. This chapter presented findings, results of the evaluation. There was a significant positive correlation between classroom light and acoustic quality and occupants comfort and performance.

44 students participated to answer the questionnaire, 23 females and 21 male students. Combined answers from the participants regarding lighting were mostly acceptable, comfort scale was as follows:

21 answered *Relaxed*, 11 *Happy*, 8 *Tired*, 3 *Irritated*, 1 *Sad*.

While reviews on the sound/ noise levels showed different levels of discomfort. Answers are; 14 *Irritated*, 9 *Angry*, 8 *Tired*, 6 *Happy*, 5 *Sad* and only 2 students answered *Relaxed*.

This is a strong indication that the acoustic environment is more tangible and sensed by children with developmental disabilities than light quality in the classroom. Furthermore, the referred sounds were perceived as the noise the students experienced that causes them discomfort and anxiety.

In addition, findings from the interviews with the therapists also showed that subjects are less tolerant towards noise and noise is one of the sources that lead to maladaptive behaviour.

The below table is a summary of key findings of the evaluation.

Table 5.6: Key Results of this Evaluation (2017)

SNF			Tender Hearts			Future development center	
	SLT	OT	Cs-1	Cs-2	Art	SLT	OT
Activity type	-Desk level	-Desk level	-Floor level	-Floor level	-Desk level	-Desk level	-Desk level -Use of equipment -Floor level
Occupancy level	-One to one - 1 to 2 student per session - Therapist	- 4 students - 2 Therapists	-5 students - Volunteers - Teacher	-8 students - volunteers - Teacher	-One to one - 1 to 2 student per session - Therapist	-One to one - Therapist	-One to one - Shared room, 7 sessions in the same time. - Therapist
Source of light	- Artificial ceiling fixture	-Artificial ceiling fixture -Window	- Artificial ceiling fixture - Window	- Artificial ceiling fixture - Window	-Artificial ceiling fixture -Window	-Artificial ceiling fixture -Window	-Artificial ceiling fixture -Window
Light quality	195 Lux	130 Lux	66 Lux	154 Lux	170 Lux	383 Lux	1004 Lux

<b>Identified problems</b>	Below standard	Below standard	Below standard	Below standard	Below standard	standard range	standard range
<b>Source of sound</b>	Internal (therapist/ student dialogue)	External background noise	Internal (therapist/ student/ volunteers dialogue)	Internal (therapist/ student/ volunteers dialogue)	Internal (therapist / student dialogue) External background noise	Internal (therapist / student dialogue) External background noise	Internal (therapist / student dialogue) External background noise
<b>Acoustic quality</b>	70 dB	79 dB	70 dB	78 dB	66 dB	62 dB	56 dB
<b>Identified problems</b>	Above standard	Above standard	Above standard	Above standard	Above standard	Above standard	standard range

Findings indicate that case study-1, facilitated in a commercial apartment has the worst IEQ. From the internal structure, the limitations from the building created poor environment that affected the performance of the staff equally as the students to give the maximum of their power.

Both light and acoustic levels were found to be disruptive by students and therapists. Qualitative data also showed that light and acoustic environment were out of the recommended standards.

Moreover, in case study-2, villa recreational facility had limitations of background noise from other classrooms as well as noise generating from students and activity held in the classroom. Similarly, light and acoustic quality was not in the recommended range. Advantage of all classrooms in this facility was the efficient access of daylight, in which from observations and students' questionnaire, it had a positive impact on the productivity of students.

The third case study was evaluated to be the best case scenario among the three case studies. Classrooms were designed to fulfill the need of all the taken activities in both SLT and OT. One major disadvantage in this case was that the room was running 7 sessions at the same time; 7 therapists working with 7 students on a one on one basis. This created an enormous amount of noise, where all students were affected by it.

After identifying problems in the case studies, and carefully observing subjects' behaviour in the classrooms, a proposal of ways to improve the light and acoustical environment in the three case studies is given below.

Table 5.7 presents the identified problems and proposed solutions.

Table 5.7: Identified Problems and Proposed Solutions (2017)

		Identified problems	Proposed solutions	
<b>SNF</b>	SL T/O T	Disturbance from Background noise	Minimize sound transmission by reducing reverberation and reflection of sounds.	Changing in the physical environment: -Suspended Ceiling of sound absorbing material/ tile -Carpet flooring - Wall installation of cork, flannel bulletin, felt board.
	SL T/ OT	Disturbance from main circulation going through classrooms.	Change zone arrangement of the center	-Create main path for circulation such as connected corridor between the three apartments.
	OT	Insufficient Light quality	Installed of more florescent lighting units	
	OT	Subject's different visual impairments that require different lighting settings	Installation of lighting system with a variety of features	Therapist to adjust the lighting system based on the subject's limitation
		Subjects with high sensitivity towards noise distraction and insufficient light	-Install adjustable desk partitions with imbedded fabric, felt board. -Install task light on each table.	-Effectively reduce distraction. -Subject and/ or therapist can adjust the direct task light on working surface.
	SL T/ OT	Subject who are effected with environmental stressors (poor IEQ) and are reactive towards	Dedicate a classroom/ area in the center as a multi-sensory room.	Multi-sensory supports students to effectively reduces anxiety and encourage concentration suing environmental factors such as light, music, sensory tool
<b>Tender Hearts</b>	CS	Noise from equipment's used in class and/ or Classroom activity	Locate classroom that is expected to generate loud sounds in a remote corner of the building.	Arrangement of zones to have classrooms/ areas that require maximum of sound insulation close to classrooms/ area that are quite. Group



<b>Future development center</b>				classrooms with activities that generate sound close to each other.
	CS/ Art	Insufficient Light quality	Installed of more florescent lighting units	
	OT	Noise from equipment's used in class and/ or Classroom activity	Locate classroom that is expected to generate loud sounds in a remote corner of the building.	Arrangement of zones to have classrooms/ areas that require maximum of sound insulation close to classrooms/ area that are quite. Group classrooms with activities that generate sound close to each other.
		Shared OT room among multiple therapists	Divide the gross area of the OT room into the three main functions utilized by therapists	Divide spaces using portable partitions for better flexibility. Partitions to have sound absorbent installation on both sides to prevent the transition of sound between area.

Based on the observation taken from the three case studies, combined with environmental measurements and based on findings of subjects' questionnaires and interviews with therapists/ teachers, all evidences show that lighting and acoustic environments in the selected case studies are far from having good IEQ that supports the wellbeing, productivity and performance of the subjects.

Findings show that:

- Measurements are either below or above the recommended international guidelines.
- There are no existing guidelines dedicated for special needs facilities that includes detailed specifications of IEQ or ways to achieve a healthy environment.
- Due to the complexity of different disabilities and individuality of occupants, it is difficult to assign one set of guidelines that could provide comfort for all occupants, instead, IEQ must be adjustable to provide different ranges of environmental characteristics.

- Environmental stressors such as flickering light can cause individuals with disability setback as they these stimuli could be intensely sensed, causing maladaptive behaviour.

Another finding of the study is that students are distinctive from each other in the way they see, sense and understand the way they view light and sound and these two elements together as well as other environmental factors.

This has a massive impact on the way they perceive a comfortable environment.

The complexity of neurological dysfunction of the subject must be considered in studies that evaluate the connection between IEQ and the perceived comfort or discomfort of individuals with developmental disabilities.

This study was set to understand the connection between the quality of light and acoustic in SEN environment and the perception of its occupants. Subject's behaviour and reaction in classroom was the main guide to know their satisfaction and comfort in the space. Subjects were found to be sensitive towards different levels of lighting quality depending on their condition.

The most significant finding was that subjects' answers from the questionnaires were contradicting with the findings of measurements and feedback from therapists' interview. Subjects' answers did not reflect the poor conditions of the classrooms environment which leads to multiple conclusions:

- Subjects' adaptability to the environment, as explained in the above section.
- Subject's inability to understand what causes their discomfort.
- Subject's inability to link environmental stimuli (light and sound) to their feeling of discomfort.
- Subject's inability to positively communicate the mental state of being discomfort.
- Types of the activities conducted/ practiced could possibly be what trigger their behaviour initially. Hence cause of discomfort could not be solely based on one factor rather collectively caused by multiple factors.
- Subjects' inability to verbally express their discomfort hence, their aggressive reaction could be sources due to this.
- Subjects have different coping techniques to deal with what causes them stress
- Subjects may react to anxiety in a different way. So, their reaction towards to light may differ. As seen in case study one.

## Chapter 6

## **Chapter 6: Conclusion**

### **1. Overview**

Having explored the relationship between light and sound, individually and coexistent, on the developmental progress of children with disabilities, especially children with cognitive disabilities, also known as intellectual disabilities, this study sought to obtain field data to aid in addressing these barriers and limitations.

Furthermore, through conductive and deductive analysis, it was clear that the population with disabilities is more vulnerable towards the physical environment compared to the general population; as their neurological deficiencies cause them to perceive the physical environment in an intensified manner. Therefore, to create an environment that supports their development, it is necessary to understand the environmental health issues that is caused by poor IEQ in order to find solutions that helps/or adds on to their quality of life.

In this study solutions were put forth to enhance the indoor environment. Solutions aimed to help subject's in their learning journey to be independent, understand themselves and their surroundings.

This research was carried out in the UAE, where the majority of special needs centers are facilitated in villas, some in commercial buildings and few in purpose built buildings. The three case studies that were selected represented each building type, looking closely into the limitations in these built environments. Educational practices were examined to see how practitioners, school management and staff cope with limitations in these facilities.

In this study, the occupant's characteristics and conditions were the main concern, hence, through a comprehensive literature review about the disability, special education, enabling environment, lighting and acoustic features in educational facilities was provided. In addition to an overview of the international standards related to special needs educational environment and UAE vision for disability.

The study evaluated IEQ in two therapy rooms:

1. Speech and Language Therapy.
2. Occupational Therapy.

### **2. Research Findings**

The explanatory method was utilized in this research, through qualitative data of spot measurements in the selected areas, recorded in (Lux) and (dB), followed by quantitative data collection of questionnaires and interviews answered by the students as well as therapists.

The study has identified that occupants in each case study were facing different types of limitations caused by five factors:

1. The building structure.
2. Therapy practice and methods (Tool used, approach).
3. Lighting and Daylight factor in classroom.
4. Source of noise.
5. Student level of cognition (Level of sensitivity towards the environmental factor)..

These factors were found to have direct connection to the comfort level of students with disabilities.

Moreover, this study has raised important highlights about the nature of schools for children with developmental disabilities. Adaptability and flexibility of the environment for everyday use is crucial to meet the need of students. In order to meet the needs of different types of abilities, SEN must be adaptable and flexible for its occupants; adjusting the environment of the class to suit the needs of the student, in addition to promoting the well-being and comfort for occupants by providing good thermal, lighting, acoustical and air quality.

Common solutions proposed for the three types of SEN building facilities are:

1. Building structure:

- Zone arrangement. Separating departments that require calm ambiance from busy and loud departments.
- Accessible open area.

2. Lighting in classroom:

- Upgrade lighting system to standard range.
- Promote daylight access to classroom (With acceptable uniformity ratio).
- Provide controllable lighting.
- Consideration of glare-free lighting.
- Promote visual contrast and texture.

3. Acoustic in classroom:

- Install sound absorbing material to balance sound level to standard range.
- Mitigate background noise and white noise.
- Furniture and fixture with less reflective surfaces and short reverberation time.
- Install fabric wall panels.
- Use sound field- systems.
- Acoustic ceiling tiles.
- Sound proof interior doors.
- Echo eliminator for noise control made from recycled cotton.

Solutions as per each case study are:

In *case study 1 (SNF Support Center)*: Results suggest that SEN centers located in commercial buildings require major changes in order to sustain a good environment quality suitable for its occupants.

These solutions include:

1. Building structure:

- Responding to the surrounding environmental of the building. Being part of a commercial building in a busy urbanized area, requires additional precautions to minimize the noise sourced from outside.

- Changing space zoning, where zoning is outlined as per the most active department as well as circulation route. This will drastically enhance acoustic conditions.
  - Substitute intersecting circulation routs between departments with one main pathway.
2. Lighting in classroom:
- Introducing dynamic lighting systems to provide different variation compatible with different needs of students.
3. Acoustic in classroom:
- Closing the wall opening between the OT room and the classroom next door to mitigate sounds transferring between classes.
  - Upgrading classrooms with noise control tools, such as vinyl flooring and acoustical panels.
  - Scheduling time for circulation between departments to minimize interruption

*In case study 2 (Tender Hearts recreational center):* Recommendations were addressed to the following areas as follows:

1. Acoustic in Classroom
- Introducing music therapy (Alpha-music) to the classes to divert the occupants attention to sounds into a rhythmic music in which it will supports the learning process.
  - Separating students who have higher potentials to have maladaptive behaviour than those who are sound sensitive

*However, in case study 3 (Future Rehabilitation Center):* Recommendations focused on the lighting and the acoustics as the building structure was already purposely built for children with disabilities, and hence optimized to meet their needs in terms of structure and circulation. These are summarized as follows:

1. Lighting in classroom
- Utilising window blinds to decrease heat in peak hours, glare and distraction
  - Introducing lighting sensors to detect un-occupied area in OT room
2. Acoustic in Classroom
- Utilising less reflective surfaces for furniture in OT room
  - Separating OT room as per activity with sound proofing panels
  - Introducing sound field system in OT area-1
  - Schedule less sessions operating at the same time

### **3. The Human Factor**

It is worth mentioning that findings of the used methodology in this study were significant. Students' answers in the given questionnaires did not match the findings of the observations, measurements and answers from the interviews.

In terms of lighting for example, general findings showed that students made no significant preference to electrical light on that of natural lighting. Perhaps it is because due to the

agitate features of light that makes electrical light less favorable, such as, flickering light of a light bulb or colour temperature that could cause irritation to the student (similar to the incidents observed in CS2, refer to chapter 5). However, all students were found drawn to the natural light, where therapists confirmed that students perform better when they are located near the window.

Another example is in the findings from students who answered “acceptable” to the light and sound quality questions even when registered measurements were above the standard requirement. This gives the indication that children with developmental disabilities can adapt to the environment condition when they are constantly spending long time in the space.

Also, the results found that:

1. Students’ interpretation of the physical environment was conflicting with the classroom environmental conditions.
2. Some students’ inability to differentiate between the two environmental stimuli’s (Light and sound)
3. Some students found communication and expressing their emotions and ideas difficult due to their condition. Expressing their desire could be difficult for them as well as for the receptive individual to understand.

All of the above shows that in studies that involves individuals with disability, other methods are necessary to back up the findings from the occupants, hence in this current study, qualitative data and quantitative data from therapists as well as the observation of students’ reaction towards the light and acoustic feature was necessary to understand the relation between the indoor parameters and students’ perception, and most importantly, to understand the cause and effect of the quality of IEQ in student’s reactive behaviour which indicates the student’s comfort and discomfort levels, which highlights the vulnerability of children with developmental disabilities the indoor environmental parameters (light, sound...etc.)

#### **4. Implications for the Field of Knowledge**

Globally, few studies were found on IEQ assessment on special educational environments. Similarly, very few studies were found in this region to investigate solely, discuss and evaluate the connection of the indoor environment quality to the well-being of occupants with disability. Therefore, this study is considered to be first of its kind in the UAE connecting / or brings together the environmental science and occupants from population with disabilities.

#### **5. Contribution of the Study**

Since there aren’t many thorough studies on the role of the IEQ in special education facilities; giving less attention to the environmental stimuli that affect the perception of children with disabilities residing in them, this study explores the built conditions of special needs schools; looking into the weaknesses and strengths of the buildings’ structures, and most importantly, provide sustainable ways to improve the learning experience of the occupants.

Taken together, these findings suggest a role for good light and acoustic quality in promoting well-being and productivity of children with developmental disabilities. Findings of this investigation complement those of earlier studies of IEQ in educational environments.

The findings bring an important contribution to the field of special education, on a specific level and in general to the educational sector as well. It will help schools, targeting the inclusion of students with disabilities, to take further considerations towards the sensitivity of the students and create a healthy environment for all of its students by presenting a school environment that promotes productivity as well as mental wellbeing. Finally, this study supports UAE 's vision of "Accessibility for all".

## **6. Limitations of the Study**

The study is limited by the lack of literature on SEN environments. Most found literature was focusing on autism spectrum disorder. Furthermore, studies regarding individuals with disabilities in learning environment found to be focused on the integration aspect of how to help individuals adapt to the environment. Hence, less studies connecting the environmental impact in SEN was scarce.

A limitation of this study is difficulties to get approvals from school administrations, as most schools in the UAE are conservative in participating in research that include pupil.

Limitation from sensitivity of the children, the study had to be careful to not change classroom conditions that could jeopardise student's comfort.

The author was given selective dates to conduct the research. As a result, the author did not have the chance to select high functioning students who have better abilities to respond and understand the questionnaire.

## **7. Recommendations for Further Research**

Further investigation and experimentation into special needs educational environments is strongly recommended. Experiment studies in multiple room settings will help better identifying the IEQ ranges for different types of disabilities. There is, therefore, a definite need for more research dedicated to the population of individuals with disability is necessary for a better understanding of environmental health and well-being of this vulnerable individuals. More in-depth studies are encouraged to look into the health hazards on poor IEQ for this population, seeking strategies to improve their life quality. Future studies are highly recommended to select participants with high functioning skills who can effectively express their opinion. Future studies must look into several ways to support findings of the study, especially when pupils are involved. A further study could assess the long-term effects of light and sound quality in SEN. Long term field study is recommended. Lastly, further research in evaluating the indoor air quality in special needs facilities is recommended.



### **7.1. Decision Makers**

There are a number of essential changes which needs to be made to enhance the IEQ in the SEN educational spaces. These are:

- Appropriate considerations in zone arrangement, particularly in isolating departments that require quiet and calm ambience.
- Get consultant expertise in SEN involved from design stages.
- Input from light specialist is recommended.
- Input from audiologists specializing in SEN is recommended.

### **7.2. Policy Makers**

- Government authorities to be responsible for regulating standards of indoor environmental quality for any facilities that has occupants of this populations.
- Governments to encourage SEN centers to consultant experts when designing and equipping classrooms.

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## Appendix

### Questionnaire Samples

The British University in Dubai- Mahbooba Karima- 2013117045

#### STUDENTS QUESTIONNAIRE

##### Privacy Statement

This survey is being conducted to determine the possible impact of light and acoustics on the development of children with disabilities. The information gathered may be used by the researcher to make informed choices about lighting/acoustic, and to improve the state of knowledge about special needs response towards these two indoor environment factors.

1. What is the name of your school?

Future Rehabilitation Center  
Special Needs Future Development Center  
Tender Hearts Arena

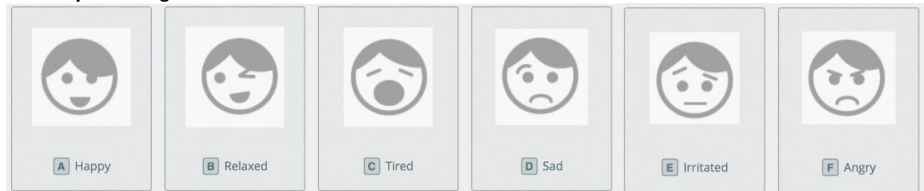
2. Gender



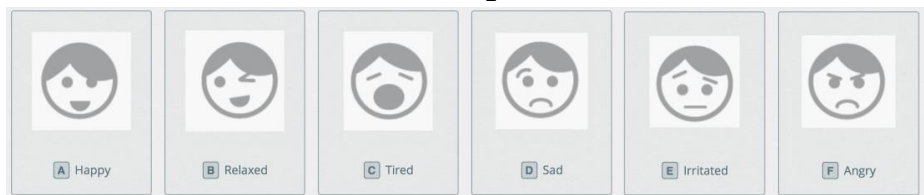
3. How old are you?

>= 8  
8-10  
11-15  
15-18  
<18

4. How do you feel right now?



5. How do you feel about the light in this room?



6. What type of light makes you feel happy?

Light coming from the window  
Light coming from the ceiling

7. Do you like to watch through the window?





☐ YES ☐ NO

**8. Do you hear the noise/sounds in the class?**

☐ YES

☐ NO

**9. How do you feel about the noise in this classroom?**

 <b>A</b> Happy	 <b>B</b> Relaxed	 <b>C</b> Tired	 <b>D</b> Sad	 <b>E</b> Irritated	 <b>F</b> Angry
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**10. Can you identify the source of the noise?**

☐ YES

☐ No

If yes, please mention it -----

**Thank you for taking time to answer the questions**

\* Students will answer the questions using a tablet given by the researcher. To see the format of the question, please go to:  
<https://mahboubakarimaa.typeform.com/to/mP5Dir>



## THERAPISTS QUESTIONNAIRE

### Privacy Statement

This survey is being conducted to determine the possible impact of light and acoustics on the development of the students. The information gathered may be used by the researcher to make determine the relation of lighting/ acoustic and student's performance, moreover, to improve the state of knowledge about special needs response towards these two indoor environment factors. The researcher will share all the collected data and the result of the study to the participated centers.

### Responses are anonymous

This ensures that your specific responses will not be mentioned in the research nor does the entity/ organization that you are representing. Your responses will only be available as aggregated group information. The purpose of this survey is to extract background and field experience from your professional life and observation of the category of children with special needs. The study aims to evaluate the current statues of existing centers of special needs in order to find strategies and opportunities to improve the indoor environment of special needs educational organizations.

School: \_\_\_\_\_

### Background

**1. Profession**

\_\_\_\_\_

**2. How long have you been working in this field with children of disabilities?**

\_\_\_\_\_

**3. How long have you been teaching in this institute?**

- ☐ ≥ 1 year  
☐ 2 – 3 years  
☐ ≤ 3 years

**4. What is the level of your interaction with students?**

- ☐ Direct interaction with students  
☐ Observing, follow up from teachers  
☐ No interaction

**5. How many sessions do you handle in a day?**

- ☐ ≤ 3  
☐ 3 - 6 sessions  
☐ ≥ 6

**6. How many students do you work with per day?**

- ☐ ≤ 5  
☐ 5 - 10 sessions  
☐ ≥ 10

**7. What is the nature of your sessions?**

- ☐ Group session  
☐ Teaching one to one

**8. On the average, how long do you stand inside the classroom when teaching?**

- ☐ 10 %  
☐ 25%  
☐

50%

☐ 75%

☐ 100%

**9. Do you share classrooms with other teachers?**

- ☐ YES ☐ NO

**10. Do you share classrooms with other grade/year levels?**

- ☐ YES ☐ NO

### Lighting

**11. Overall, is the lighting comfortable in your classroom?**

- ☐ YES ☐ NO

**12. To what extent you can control the classroom lighting?**

- ☐ On/ Off switch  
☐ Dimming option  
☐ Fixed lighting  
☐ Window shutter

**13. Do you think natural light has a positive impact on the students?**

- ☐ YES ☐ NO

**14. Would you prefer the classroom to solely rely on natural light? Why?**

- ☐ YES ☐ No

### Student's behavior towards lighting

15. How do students respond to different levels of lighting?

---

---

16. Do students tend to stare or avoid at source of light?

- ☐ Stare  
☐ Avoid

17. Are students sensitive towards natural light and/ or artificial light?

- ☐ Natural  
☐ Artificial  
☐ Both

18. Does the color of light/ lighting have different impact on students?

- ☐ YES ☐ NO

19. Do you have a window in your classroom with a view?

- ☐ YES ☐ NO

20. Do students tend to watch through the window?

- ☐ YES ☐ NO

21. To what extent do you think light has an impact on students? Please elaborate.

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22. Do you think light is a dynamic factor that can be a barrier and/ or effective tool for the students learning process? Please elaborate.

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## **Noise**

23. Overall, is the noise in your classroom tolerable?

- ☐ YES ☐ NO

24. To what extent you can control the classroom noise/ sound?

- I don't notice any noise  
To some extent  
I can effectively reduce noise  
I don't have control on noise

25. Can you allocate the source of noise?

- ☐ YES ☐ NO

Mention\_\_\_\_\_

26. How do you manage distraction in your class?

---

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27. If yes, do you think that it bothers/distracts the students?

- ☐ YES ☐ NO

28. Do you think there are noise sources from the classroom setting that causes discomfort to students? Please select;

- ☐ YES ☐ NO  
AC noise  
Squeaky door  
Echo within classroom  
Other\_\_\_\_\_

29. What is the primary cause of distraction and disturbance in your classroom while teaching?

- ☐ Poor lighting  
☐ Noise outside the classroom  
☐ Lack of ventilation  
☐ Odor inside the classroom

30. Do you use any of the following teaching tool? if yes, please select

- ☐ Over Head Projectors  
☐ LCD Projectors  
☐ Audio-Visual Presentations  
☐ Powerpoint Presentations  
☐ Other\_\_\_\_\_

31. Do you think noise from the teaching tools could cause discomfort for students?

- ☐ YES ☐ NO

32. Do you think that the current environment of your classroom contributes to the reason why some students don't have the motivation to go to school everyday?

- ☐ YES ☐ NO

## **Student's behavior towards acoustics**

33. How do students respond to different volumes of noise?

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34. To what extent do you think acoustic has an impact on student's performance? Please elaborate.

\_\_\_\_\_

\_\_\_\_\_

35. Do you think light is a dynamic factor that can be a barrier and/ or effective tool for the students learning process? Please elaborate.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Thank you for taking time to answer the questions**

\* Teachers/ specialists will answer the questions using a tablet given by the researcher. To see the format of the question, please go to:  
<https://mahboubakarimaa.typeform.com/to/GUGjOb>