

The Implications of Sustainable Design Considerations for an Effective
Learning Environment in Industrial Design Studios

by

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Abstract

Design studios are the central part of the learning environment in industrial design schools, and the incorporation of sustainable design considerations are essential for the optimization of the learning spaces for design students in our current times. These studio spaces can play a salient role in facilitating collaboration among students and promoting creativity. Recently, the School of Industrial Design's (SID) studios at Carleton University have been redesigned with an effort to resolve interior design challenges such as Indoor Environmental Quality (IEQ) and sense of space. Through semi-structured interviews and extensive field notes, this study sought to obtain feedback from end-users (students and faculty members) on their overall experience using the new design studios. This study also pinpoints problematic areas that need to be addressed, based on emerging themes. Preliminary directions and guidelines have been proposed that can be implemented in order to improve the studios in the School of Industrial Design. These recommendations include the improvement of IEQ, such as thermal comfort, lighting comfort, acoustic comfort, air quality, and energy consumption, as well as recommendations for other themes including maintenance and waste management and materials storage in relation to learning environments in design education.

keywords: Sustainability, Sustainable Interior Design, Interior Design Elements, Design Studios, Learning Environment, Indoor Environmental Quality

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Thank God, for his manifold blessings, my voyage to Canada is one of them...

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Chapter 1: Introduction

1.1. Background and Intro

Nowadays, sustainability is a big word, and its massive territory is ever-expanding. Consequently, sustainability is defined in many ways. In 1987, The World Commission on Environment and Development (WCED) defined sustainable development as an approach “to meet the needs of the present without compromising the ability of the future generations to meet their own needs” (p. 2).

Similarly, sustainability is defined as “providing equitably for the needs of the present generations is without jeopardizing the needs of future generations” (Stieg, 2006, p. vii). Sustainable design is a highly complementary and comprehensive process; it is defined as “a strategic approach to the design of the built environment which does not diminish the health and productivity of natural systems” (Stieg, 2006, p. viii). Specifically, sustainable interior design is an approach to help improve Indoor Quality (IQ), such as lighting, air quality, acoustic quality and waste management (Abounaga, 2014).

In addition, the term design refers to the methodology for solving problems (Schon, 1987). According to Sanders and Stappers (2012), during the last three decades the design field has incredibly changed, and among such changes is the designer-centred to user-centred approach. There has been a big shift which has led the designer to reframe the design process to put the user in the centre in order to understand the needs of the user while designing or developing their services/products.

Therefore, Margolin (2016) states that based on these shifts in the design activity, the research process required to be incorporated as well by more depth and wider understanding of the people's needs.

In 2018, the School of Industrial Design (SID) at Carleton University expressed interest in moving the undergraduate design studios from Mackenzie building (ME) to a new space on the 4th floor in the Azrieli Pavilion (AP) along with the MDes studio. Previously, the new space had belonged to the Azrieli School of Architecture and Urbanism for graduate studies.

This expression of moving, also referred to *transformation* and *adaptive reuse* of the space to accommodate the new user needs, was the motivation of this research. The SID was involved in this research, through facilitating access to new space and the qualitative and quantitative data collection. The researcher was directly affiliated with the new space and witnessed the transformation period. The research contribution is the development of sustainable design directions and guidelines regarding new spaces to enhance the learning environment and effectively use the space of the new SID design studios. The AP building is located next to Dunton Tower and Tory Building on Library road (Figure 1). It was opened in the fall term 2002 and has a total area of 75,000 SF of four-storey classroom building (Carleton University [CU], n.d.).

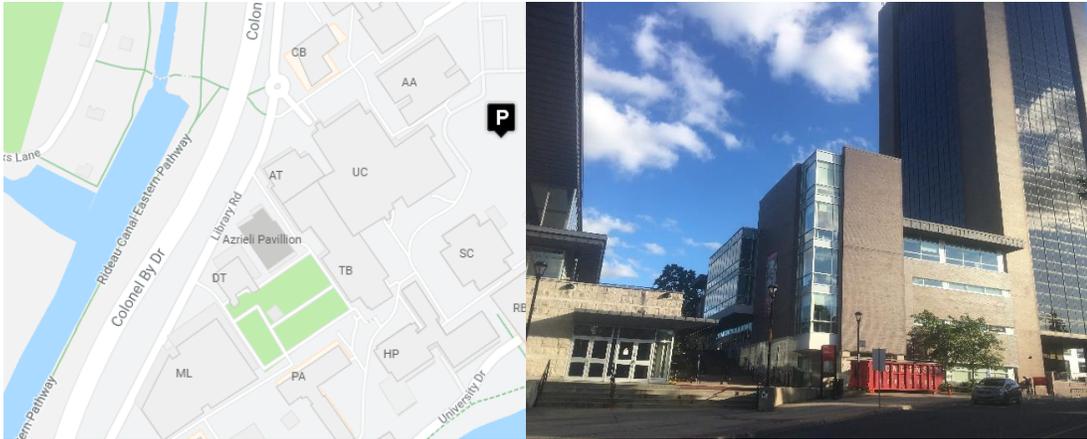


Figure 1: Campus map (Source Carleton university <https://carleton.ca/campus/map/>) and AP (photo taken by the researcher, August 2019).

The left image is the map that indicates the location of AP on campus as described above, and the right image shows exterior facades (Figure 1). Moreover, the images below present the interior space of the 4th-floor plan before affiliated to Azrieli School of Architecture and Urbanism, graduate studios (Figure 2) and after belonging to SID (Figure 3) comparing the *transformation* and *adaptive reuse* of the space.

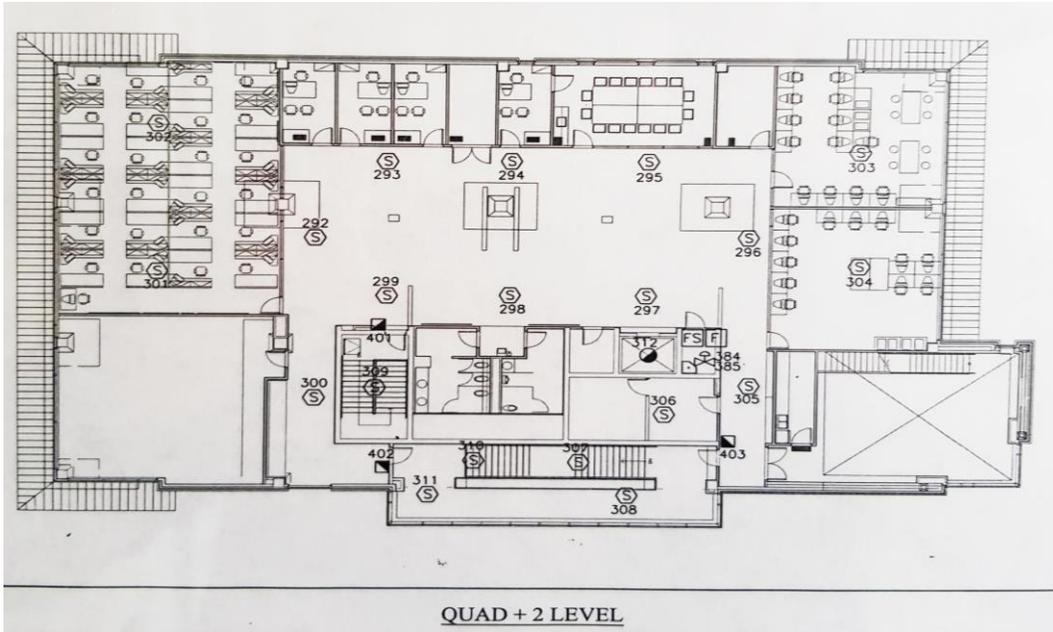


Figure 2: Azrieli School of Architecture and Urbanism fourth floor plan – AP.

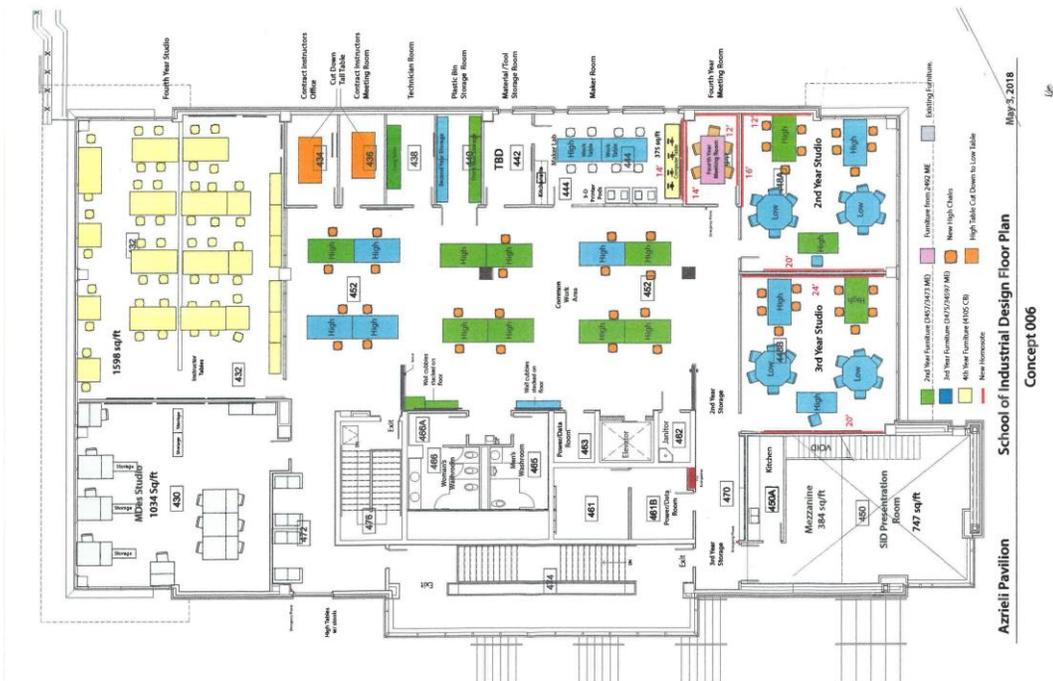


Figure 3: School of Industrial Design fourth floor plan – AP.

The same construction plan (fourth floor – AP); however, the configuration of the interior spaces is evidentially different, if we compare the SID's fourth-floor plan with the Azrieli School of Architecture's one. As space becomes the inheritance of the ID department, it demonstrates the characteristic features of the new SID design studios regarding the "sense of space", as the Industrial Design (ID) students also said during data collection through interviews: "*No one belongs here more than Us*" (Figure 4).

According to Brooks (2012), the learning environment is commonly used as an educational approach, a physical setting or a cultural context in which learning and development take place. Particularly, this research study emphasizes the physical setting of the learning environment, the learning space being the design studio. The physical and social features of learning spaces play a critical role in students' and staff's effectiveness, and through these features, they impact the development and learning processes. (Brooks, 2012). Furthermore, a learning space as design studio has to motivate students and enhance their learning and formal practice, in addition to supporting collaboration. As well, it acts as an inclusive environment which has to be flexible for supporting changing needs.

Considering that our sense of space is one of the main themes in this research study, Morris (2004) defines that as "the basis of all social experience and of perceptual experience in general. Without it, we would have no sense of a world beyond us. But what is the basis of spatial experience, and what does our sense of space tell us about us and our social being?" (vii). Overall, the sense of space rivets space and body together to demonstrate that space is such a concrete environment full of meaning, that represents the unique personality of a human embodiment including expressive, emotional, perceptive and social capabilities.



Figure 4: New signage of SID on the fourth floor in the AP building.

Furthermore, Azrieli design studios - mostly the center space “collaboration/shared space”- confirms how the School has become a more collaborative learning environment rather than a traditional learning setting. However, there are several concerns that have to be considered in order to achieve a high quality of effective learning environment in the new design studios which are discussed in this thesis.

1.2.Purpose of the study

This design research aims towards exploring the transformation of the fourth floor of the Azrieli Pavilion building including the SID 2nd, 3rd and 4th, master's studio, maker space and the collaboration/share space as the main topic of the study to develop sustainable design directions and guidelines for facilitating and enabling this transition in the following years. With this aim in mind, we learn more and more about the changes in the learning environment in relation to the design studio. The main phases of this research are as follow:

- Evaluating the indoor environment quality (IEQ) in the new SID space based on the guidelines & indicators coming from sustainable interior design practices.
- Investigating the potentials of developing a framework through conducting interviews and field notes.
- Analyzing the outcomes of the data, identifying the main problem areas and reflecting on the findings through content analysis.
- Providing recommendations for sustainable design directions and guidelines for the new space of SID.

1.3. Research Questions

This design research aims to explore the implications of sustainable design considerations for interior design principles by adopting more user-oriented research. Particularly, the main focus has been on the new spaces of SID as the learning environment on the fourth floor of the AP building as per the following research question:

What are the implications of sustainability considerations for an effective learning environment focusing on design studios and collaboration/shared spaces?

The literature research showed a number of themes that led to the development of sub-research questions which are:

- What are the Sustainable Interior Design principles?
- What are the implications of sustainability considerations for a learning environment, particularly in design education?
- What are the viewpoints (e.g. needs, expectations, and preferences) of the design

students and staff considering their current work/learning environment in relation to sustainability considerations?

- What are the design directions and suggestions for an effective learning environment in design studios and collaboration/shared spaces?

1.4. Structure of the Thesis

The overview of this thesis and the relation between the chapters can be seen in Figure 5. There are five chapters present in this thesis:

Chapter 1 – Introduction

It presents briefly the background of the research area, the purpose of the study and the research questions.

Chapter 2 – Literature Review

It presents the findings of the literature review. First, it explores the main aspects of sustainability considerations in relation to sustainable interior design. Later, it highlights the issues and barriers toward sustainable design. Following that, it explains the social benefits of applied sustainable interior design principles. The chapter is concluded with guidelines and main themes to achieve the primary research goal.

Chapter 3 - Methodology

It starts with an overall methodology of the research study. Then explains the methods of collection and which is followed by the description of the data analysis and the related research methods for addressing the sub research questions.

Chapter 4 – Results and Findings

It presents the primary research results including findings and insights from interviews, observations and quantitative data on the assessment of the building. Following that, it presents the main findings of the research and how they relate to the research questions.

Chapter 5 – Discussion and Conclusion

The discussion integrates the themes and sub-themes to provide the development of a framework in the form sustainable design guidelines and directions for the new space of the SID, and the last section presents the overall conclusion and related limitations of the study (Figure 5).

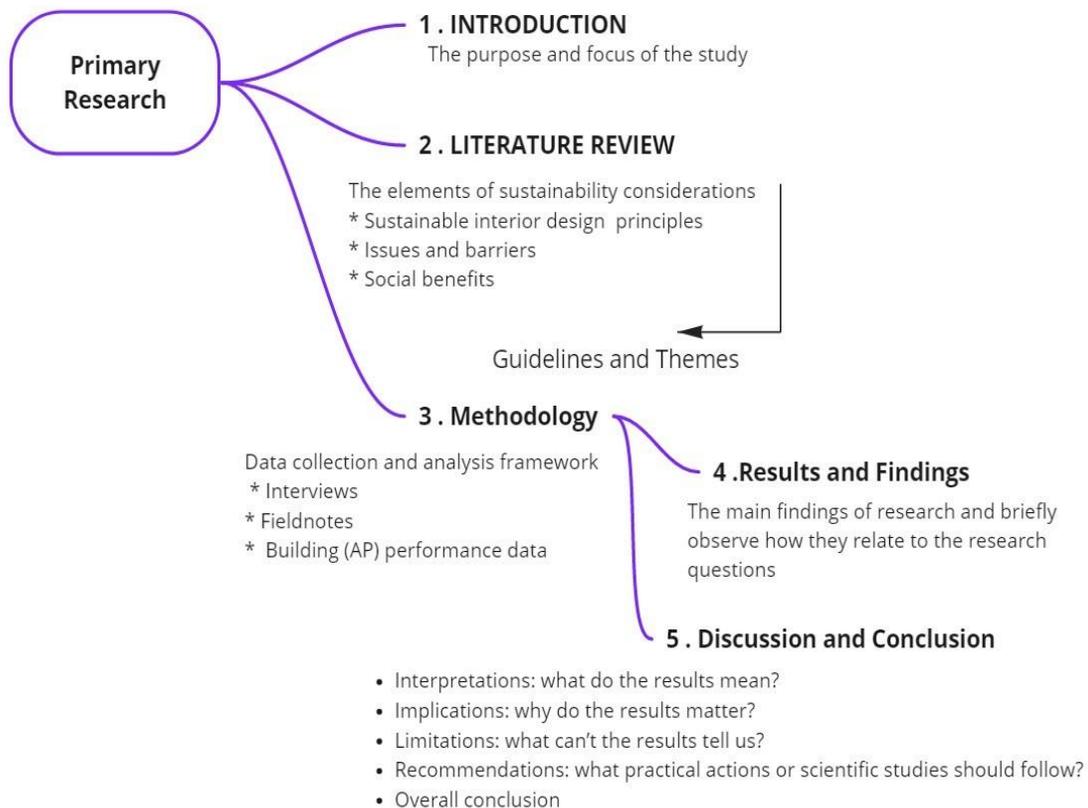


Figure 5: The overall structure of the thesis.

Chapter 2: Literature Review

The literature review summarizes the elements of sustainability considerations for buildings. These include the principles of sustainable interior design and the implications of human behaviour. This literature review also looks at the characteristics of Leadership in Energy & Environmental Design (LEED) rating system and the Indoor Environmental Quality (IEQ), which highlights some of the international measuring methods.

In the current context, the problem that exists relates to improving IEQ, which refers to the combination of lighting, acoustic, thermal comfort and air quality. In particular, the problem is about connecting the IEQ with the type of construction material and building processes to reach sustainable interior design guidelines and framework. This review provides the basis for the major issues and themes that will be explored and scrutinized in the interview and field observations processes later.

Specifically, Gesimondo and Postell's (2011) research, *Materiality and Interior Construction*, and Pelsmakers's (2015) research, *The Environmental Design Pocketbook*, help to form the major sustainable interior design indicators and guidelines by elucidating the characteristics of materials and methods that are used today in construction nowadays.

These reviews highlight various sustainable design indicators to reach a better understanding of the key areas needed to evaluate IEQ. This will be further explored through design research that will examine the new undergraduate design studios of the School of Industrial Design at Carleton University, Ottawa, Canada, based on the reviews and sustainable design considerations which emerged from the literature review.

2.1 Environmental Problems

Interior Designers and Architects have realized that their design techniques, practices, and ideas have a significant impact on environmental and health-related issues. They are responsible for constructing buildings as well as providing solutions for exterior and interior design. However, the existing techniques and practices have also an impact on the surrounding environment, as those intake energy consumption and produce unnecessary waste, which affects not only the current inhabitants in that environment but also the resources of the planet and the health of future generations (Lee, Allen & Kim, 2013).

Lee et al., (2013) highlight that “Interior materials can affect the respiratory system, the digestive system, eyes, and skin with the addition of causing allergies, cancer-related issues and other respiratory problems” (p. 1). The US EPA (Environmental Protection Agency) highlights that “indoor pollutant level may be two to five times higher than the outdoor levels” (Lee et al., 2013, p. 1).

The health complaints that arise in connection to interior spaces are defined as Sick Building Syndrome (SBS), which refers to symptoms that are difficult to medically detect, and that are found in persons when they are inside a building but vanish or contract upon leaving the building. Those symptoms can be extended to include headache, nasal congestion, lethargy and tiredness, and irritated eyes (Roodman & Lenssen, 1995).

According to Lee et al. (2013), the necessity to use the principles of sustainable design indoor environment is no longer an option. Interior designers and architects must determine the proper selection criteria for interior materials, and use more environmentally friendly technologies for energy conservation, air purification, renewable energy and

environmental remediation, which can help preserve the environment through energy-efficient systems and the reduction of harmful waste.

The community has been a core influence for many disciplines for many reasons. Understanding the relationship between society and designing spaces is a must. It is essential to understand the challenges, such as maintaining client expectations and user experience and brand identity that face the interior designer in general, and specifically, sustainable interior design in relation to the development of interior spaces (Poldma, 2013).

In terms of the materials that cause environmental problems, Montgomery (2003) mentions that there are many important and difficult questions, such as how finished materials should be specified. Is it low in Volatile Organic Compounds (VOC)? Is it renewable? Is it eco-friendly? Is it recycled? Further, she questions whether factors including artificial and natural light level, noise level quality, and air quality can be considered to improve comfort for a healthy environment. Montgomery suggests that “these questions arise for the interior designers and architects who are interested in sustainability considerations for buildings” (p. 4). They are responsible for choosing the products and materials used in buildings and how ecologically individuals can relate to their surrounding (Montgomery, 2003). The design research presented here will aim to answer these questions and address potential solutions to the challenges that exist.

2.2 What are the Sustainable Interior Design principles?

The definition of sustainable interior design is “interior design in which all systems and materials are designed with an emphasis on integration into a whole for the purpose of minimizing negative impacts on the environment and occupants and maximizing positive

impacts on environmental, economic and social systems over the life cycle of a building” (Ayalp, 2012, p. 164).

According to Kang and Guerin (2009), sustainable design principles are the foundation of sustainable interior design in term of the building environment. One of the green building standards and rating systems is the Leadership in Energy and Environmental Design (LEED) comprises five environmental categories, such as water and energy efficiency, material and sustainable site development and as well as indoor environmental quality. Indeed, the two categories have a direct relation with interior design, indoor quality and interior material selection put forward human comfort as the main aim (Kang & Guerin, 2009).

Sustainability goals aim to reach a balance by providing people's needs without negatively affecting their health and the environment. Stieg (2006) claims that achieving this balance is complicated, as our society's behaviour towards the environment, product consumption, and significant waste production are beyond our earth's capability to sustain. The Redefining Progress Association states that “we are currently in a state of overshoot” (Stieg, 2006, p. viii). This means that we have already consumed resources that cannot be regenerated.

The principle of sustainable design is known as “5R and 3F”. According to Du (2015), the “5R” principles refer to “revalue”, “renew”, “reduce”, “reuse”, “recycle”, and “3F” refers to “fit for the nature”, “fit for the people” and “fit for the time”. Du has explained the principles as follow:

Revalue: This principle means "revaluation", "rethink" and "recognition” (Du, 2015). It has become a tendency to follow trends blindly using materials related to the

construction such as carpets and artificial light without proper knowledge. Such a practice results in the waste of resources. To prevent this, careful consideration and reevaluation procedures should be used for sustainable design development.

Renew: The Renew principle means "update" and "transformation", means renovating old materials so that they can be reused for the present (Du, 2015). Interior designers and researchers should aim to develop technology and techniques that aim to utilize old materials such as windows, tiles, and doors for contemporary use.

Reduce: Based on the new recycle resource and environment, it should meet the needs of different designs and as well as aim to reduce the yearly demand of the existing built environment (Du, 2015).

Reuse: Establishing "remanufacturing industry" can take wastes as raw materials. This refers to the reuse of old materials including (floors, windows, tiles, doors) to integrate them for the development of furniture for the indoor environment using, for example, steel as a material can be recycled and used for new furniture models (Du, 2015).

Recycle: Recycle is a refining and reusing process that is a little different from the simple "reuse" and "renew" principles as it is combining them together. It refers to salvaging various scarce resources to provide lasting usage and availability (Du, 2015). For example, the sewage water generated within an indoor environment can be recycled through appropriate treatment to be used as water for flushing.

"Fit for nature": This refers to fitting characteristic principles when doing processes including processes design (Du, 2015). Du pointed that "Nature security" means protecting the environment and is the main goal to process-built environment. Due to a disregard for nature, human activities have led to ecological problems like global warming

and increased air pollution levels, attracting the public's attention while increasing awareness of the significance of nature.

"Fit for the people": People are the subjects in the built environment and the designed buildings. Most likely, under the rule of fitting for nature, the people-oriented design additionally assumes an important role. Declared by Jian Wang and Hu Qingming (2011) in the seventh universal Conference on Public Administration (ICPA) Report, "*people-oriented*" theory is unavoidable because it is the regular quest for human society – an unsuitable method to accomplish social sustainability due to rising demands from people.

"Fit for the time": The twenty-first century has its qualities with cutting edge advancement, retrofit, fast improvement and aggressive challenge on innovation.

Designers have to follow these principles further and try to use new resources and find new solutions, such as using renewable resources to preserve natural resources and reduce waste from products. According to Karşlı (2013), it means that the design practice or approach will reduce the negative impact of interior design on the overall environmental space. The successful sustainable design depends not only on the interior designer but also on various stakeholders, including landowners, architects, engineers, policy makers and industry. The sustainable design goal aims to reduce the negative impact on the environment (Karşlı) and to achieve that, there are four main aspects that have to be considered: energy, material, water and health:

Energy: This is the most significant aspect. Energy conservation could be through many ways, for instance, “using natural light, skylight, sky gardens, and lighting control systems” (Karşlı, 2013, p. 1533). Also, using adjustable windows could decrease energy

used for ventilation. Passive energy conservation can reduce cooling and heating energy consumption by keeping the heat inside for more extended times by using solar shading and insulated glass systems and waste heat recovery systems (Karşlı, 2013). There are two measures that energy conservation is based on, which are the “design and selection of energy-efficient equipment” and “use of renewable energy sources” (Karşlı, 2013, p. 1533) like solar and wind.

Material: The second aspect is effective use of materials, which can be achieved by “flexible design,” such as furniture design and interior equipment that have flexible and expandable features. The second measure to reach is the “selection of eco-friendly materials and equipment” which can be done by selecting durable, long-lasting materials from local resources. The third measure is “reducing waste” by using recyclable material such as wood, steel, aluminum and stones (Karşlı, 2013, p. 1533).

Water: The third aspect is the water conservation concept, which can be achieved in interior design by reusing rainwater and water-saving plumbing equipment.

Health: The last aspect is health conservation, which depends on three design measures. “Improving indoor air quality” can be done by avoiding the use of materials, such as radon and formaldehyde, which emit poisons and gases which can cause pollution. The second measure “providing thermal, visual and acoustic comfort” is particularly related to design education and learning environment. Using natural light and a solar shading system will improve visual comfort. Also, sound isolation measures are used for acoustic comfort. The third measure is the “selection of non-harmful material” (Karşlı, 2013, p. 1534). Designers should avoid using a material that emits Volatile Organic

Compounds (VOC's) and that contains pollutant-emitting asbestos fibre in an indoor environment.

In order to look at this, methods are needed to reduce the overall impact on environmental spaces through low energy consumption approaches. However too often we, as a society, have a lack of appropriate knowledge. McDonough and Braungart (2002), in their seminal work *Cradle to Cradle*, speak to the need to consider approaches of sustainability. They present ideas about sustainable thinking with no limitations to be applied in urban environments, buildings, and economic and social systems.

According to Moxon (2012), to accomplish sustainability, it is essential to focus on balancing the social, economic, and environmental aspects, the three converged areas of sustainability (Figure 6). While implementing the environmental standard in a project, the social and economic parts of sustainable design can be effectively acknowledged (Kramer, 2012). Furthermore, Abounaga (2014) emphasizes the importance of adapting environmental solutions into the concept design stage. He describes the overall three categories of benefits that will help the building industry toward sustainable design approach as appears in Figure 6.

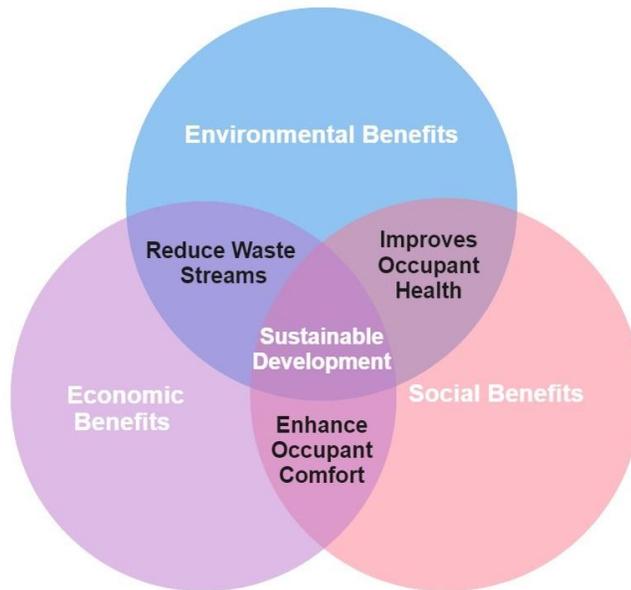


Figure 6: Three dimensions of sustainable design development (adapted from Aboulnaga, 2014).

“Environmental benefits: - Enhance and protect diversity and ecosystems.

- *Improve air and water quality.*

- *Reduce waste streams.*

- *Conserve natural resources*

Economic benefits: - Reduce operating costs.

- *Create and shape makes for green product and services.*

- *Improves occupant health and productivity.*

- *Optimize life-cycle economic performance.*

Social benefits: - Enhance occupant comfort and health.

- *Increase aesthetic qualities.*

- *Minimize strain on local infrastructure*

- *Improve overall quality of life.”* (Aboulnaga, 2014, p. 140)

Focusing on the advantages would help in developing the concept of sustainable development as well as the benefits that would be gained if followed. Therefore, designers have to cautiously consider such knowledge and information to practice design in line with sustainable design development dimensions. Also, they should familiarize themselves with new techniques and get essential training and practices so that they can work accordingly.

2.3 Interior Design's Role in Sustainable Design & Material Selection

Ghani (2012) uses the example of interior architecture to emphasize his point further, as it presents a unique challenge when it comes to incorporating sustainability in concept design. Ghani highlights that “instead of having concern for the traditional aesthetics of massing, proportion, scale, texture, shadow, and light, the facility design team needs to be concerned with the long-term costs: environmental, economic, and human” (p. 22).

Hayles (2015) states that a major problem faced by contemporary Interior Designers while engaging in the practice of Environmentally Sustainable Interior Design (ESID) is the access to and procurement of Green Sustainable and Fair-Trade (GSFT) materials. According to Hayles, "the issue is how these materials are promoted for their green and sustainable credentials and how designers, and the public as a whole, source them" (p. 24). He further adds that “better access to a basic knowledge of sustainability as well as more up-to-date information about sustainable materials will play a critical role in promoting sustainable practice” (p. 24).

Steig (2006) further highlights the significance of the problem by mentioning the fact that despite practitioners being well informed about the principles existing within

Environmentally Sustainable Design (ESID), they lack adequate information regarding the specification of materials and products.

According to Hayles (2015), there is a sense of struggle in locating information about materials usability in environments that could suggest the benefits of using databases for the specification of sustainable materials and products. Though, through the availability of third-party sources, such as environmentally sustainable material selection databases, interior designers can gain significant access to a wide variety of information on materials and products usage. Hayles (2015) states:

Wider use of 'Eco-labels' and 'Green Stickers' for products could promote awareness and support voluntary adoption while increased legislation, regulation and the extension of green building certification schemes to include Internal Architecture would significantly have an impact on the specification and procurement of GSFT products (p. 24-25).

At the same time, realizing the importance of sustainability, the significance for achieving an optimal level of the end result is further endorsed by various rating systems that have been developed to evaluate the sustainable design in different regions in general. These systems understandably address the issue of management of resources and their skillful applications. BREEAM (Building Research Establishment Environmental Assessment Method) and LEED (Leadership in Energy and Environmental Design) are a few examples that rate buildings based on environmental criteria.

The presence of Volatile Organic Compounds (VOCs) is a major concern for Indoor Air Quality (IAQ) in many discussions that take place in relation to indoor sustainable design. The presence of VOC elements primary leads towards long-range

health impact and these elements primary exist within paint categories. VOCs are a class of organic compounds that participates in atmospheric photochemical reactions contributing to the formation of ozone. By definition, VOCs include significant amount of -photochemically reactive compounds such as methane, ethane, and chlorofluorocarbons (CFCs) (Environment Canada, 2010, p. 5).

Gesimondo et al., (2011), in his book, *Materiality and Interior Construction*, discusses interior design construction and the use of each material within the building industry. A major question that aims to be answered in his book is how materials and their properties matter in the design construction process and design intentions. Adding to that, the design concept should involve human factors, health, safety, and welfare as general guidelines to maintain the sustainable approach of today's construction process. "Materiality and Interior Construction" indicates how to consider a sustainable design with general elements and explore further materials with specific properties to preserve the sustainability property of construction in most of the design environments.

One concept that has been discussed is the neutralizing carbon concept, which includes the design process as a means to provide better interior spaces for the individuals occupying them. The use of carbon-free or carbon reduced materials along with the preparation of the space for dwellers is necessary to allow them to reduce their carbon consumption in interior spaces. One example would be the alternative technologies used in preparing and the casting process of concrete that is considered one of the materials that produce carbon most and is largely consumed in the construction industry. As Gesimondo et al. (2011) point out, "the processes of making concrete accounts for more than 5 percent of human-caused, carbon dioxide emissions produced annually" (p. 22).

2.3.1 LEED certification system

U.S. Green Building Council (USGBC) is renowned as the leading authority in the US on sustainable design approaches centred on sustainability in the context of health, environment, and livability. The Leadership in Energy & Environmental Design (LEED) Program developed through USGBC allows this transition to become a reality as the program provides “a framework to create healthy, highly efficient and cost-saving green buildings” (“Green Building Leadership,” 2019). LEED buildings offer high performance in relation to saving energy, conserving resources and protecting health. Furthermore, the program tackles the areas of sustainable sites, water efficiency, energy & atmosphere, materials & resources, and indoor environmental quality (IEQ).

Furthermore, LEED can be one of the main tools to categorize environmental sustainable design that can help to attain improved designs. “These watchdog organizations oversee the processing of materials to ensure that the balance and biodiversity of the ecosystem that some materials come from are maintained and protected” (Gesimondo et al., 2011, p. 22).

Montoya (2011) explains the process to follow in obtaining certifications and specifically LEED certification. According to Montoya (2011):

“Reusing current building stock, choosing building materials that use recycled content, building materials manufactured from renewable resources, recycling waste from construction materials, and resources requires further study” (p. 99-104).

These are some major elements to target to achieve sustainable ventilation systems/air quality for better building indoor environment quality. Buildings have also an

impact on the health and welfare of its occupants through indoor air quality (Fisk & Rosenfeld, 1997).

Interior designers must educate their customers/clients on the importance of choosing materials that will support the intended function of the space in addition to performing well over time. Stadel et al., (2011) reveals how Building Information Modeling (BIM) software can be used by designers and engineers to come up with a 3D model of a structure including the parametric objects to be used such as doors and walls and matching metadata. The information includes the material makeup, cost, and dimensions, etc. which can then be used to carry out an energy audit. The BIM software is beneficial since it is used in determining different variables about the building such as the use of green materials, application of energy consumption standards, and LEED compliance (Stadel et al., 2011). Understanding how our design decisions can affect our physical environment will help to better prepare us for our role as resource managers as we near the 21st century (Bierman-Lytle, 1995).

Designers often use the LEED scorecard to identify if the material is sustainable. Design professionals have a unique opportunity to reduce environmental impact through the specification of appropriate materials. Though LEED standards are efficient in highlighting overall building environment but it is considered outdated in current times and therefore, WELL standards should be consider for current building environments. The WELL Building Standard™ (WELL™) mainly focuses on the elements affecting occupant health and comfort.

2.4 Sustainable Interior Design Issues and Barriers

The literature also thoroughly covers some of the issues and barriers to sustainable interior design. Accordingly, Kramer (2012) claims that in order to achieve sustainability, the interior designer has to be involved in the early stage of design progress to create a balance between environmental, social and economic dimensions. The obstacles that exist in making it difficult to achieve these dimensions are the stakeholders, namely, environmental design involves the input from clients, official authorities, industry, and interior designers.

Moreover, Hankinson et al. (2012) mention that time and cost are the two main barriers that prohibit the client from achieving sustainable solutions. Time and cost have been identified in the literature as two major common obstacles found throughout the study of the client and interior design approaches. Figure 7 below shows some of the preliminary issues which were found in a study on barriers that prohibit achieving environmental interior design by El-Khatib (2017). These are shown in terms of the main stakeholders, namely, interior designers, official authorities, clients and other variables such as knowledge in regard to Canada Green Building Council (CGBC) and Leadership in Energy and Environmental Design (LEED) design requirements.

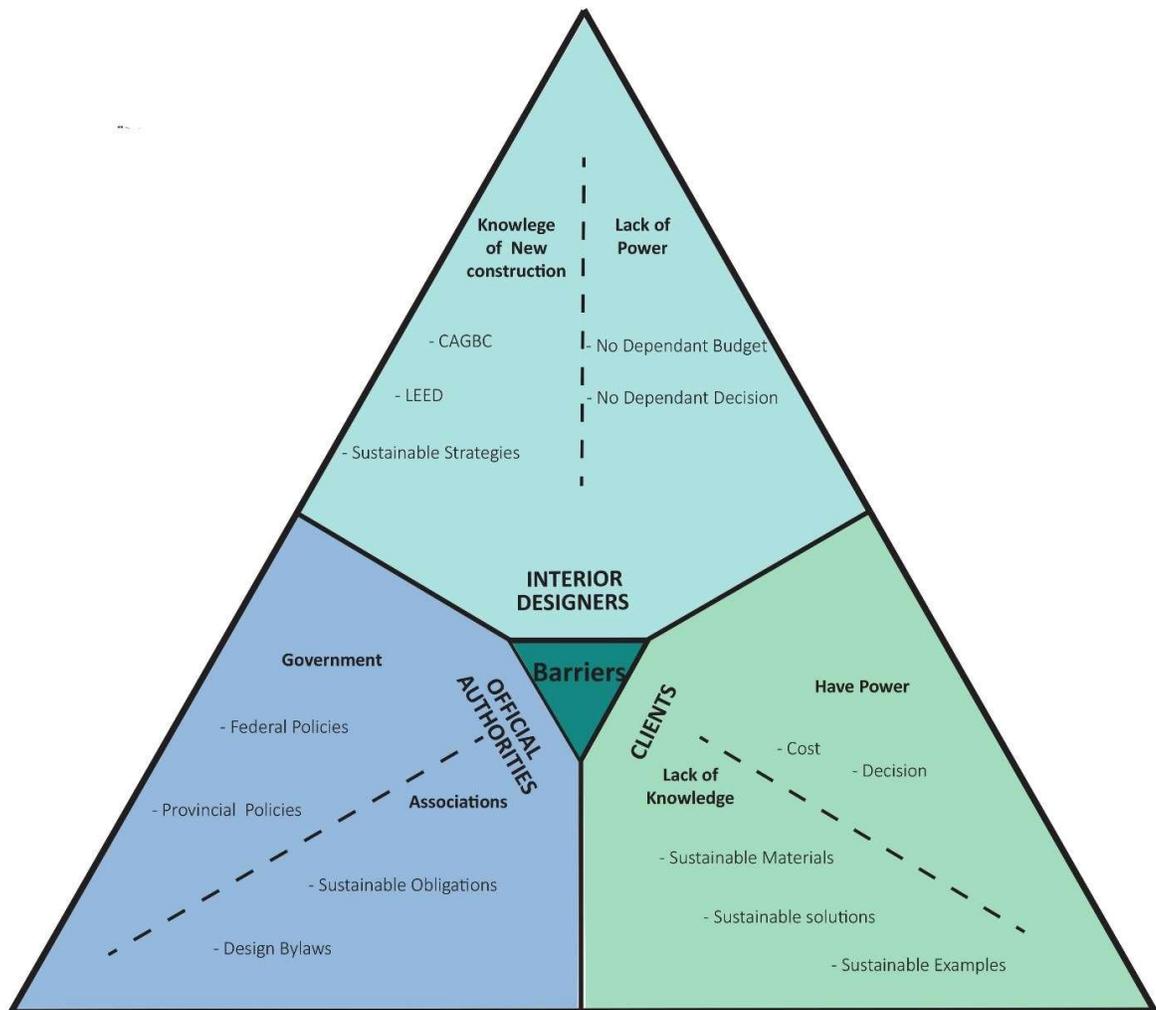


Figure 7: Barriers prohibit achieving an environmental interior design in Canada (adapted from El-Khatib, 2017).

In 2015, Pelsmakers proposes main environmental aspects for interior design spaces in his book entitled, "The internal warmth, light, air, and space environment" (p. 149). Pelsmakers further states two key drivers "are focusing on ways to improve a building's internal environment and the deviating and rising thermal performance of the fabric type that is part of the building" (p. 149). Targeting the interior environment of a

building and in particular, the materials used should be the way to attain a better space understanding by the improvements of warmth, light, and air along with the interior space, which will lead to a better environmental design adaptation.

Pelsmakers (2015) provides a checklist for primarily residential developments. This checklist includes four principal components: space allowance, thermal comfort, flood protection, and interior air quality. As Pelsmakers suggests, "Dwelling space standards: minimum dwelling and room size checklist to better understand the environmental internal space needs" (p. 152-153). He also states, "Thermal mass combined with good summer night-cooling can help keep buildings passively cool in summer and balance winter space heating needs" (p. 172). Targeting thermal mass is a major issue that will improve the thermal adaptation of internal space. Another element is the "pollutants and the indoor environment" (p. 187). Minimizing pollutants found in most of the construction materials will be an important goal to achieve.

The two aspects (thermal comfort and indoor air quality) would go under the health and wellness of the dwellers that will not only improve the dwelling they are utilizing but also will have a significant impact on their health while using the other internal spaces.

2.4.1 Impact of Poor Facilities on Student Health

The Canadian Lung Association (CLA) has determined that having good indoor air quality in schools is more than a "quality" issue: it is necessary for a safe and healthy learning and work environment. Indoor air quality is especially important in schools for two reasons. First, professors and students spend extended periods of time indoors and are potentially exposed to a variety of indoor air pollutants. Second, poor indoor air quality can cause a significant impact on students' health and well-being. Overall, satisfactory

indoor air quality contributes to an effective learning environment for students, as well as productivity for staff and faculty.

Humidity is another factor that relates to the health of a student. An increased level of humidity can cause mould growth in the ceiling, which can trigger allergy symptoms among building occupants (Schneider, 2002). The presence of poor ventilation can also cause carbon dioxide levels to rise, which can lead to high levels of Volatile Organic Compound (VOC) concentration. This can lead to adverse effects, such as headaches, drowsiness, and inability to concentrate (Schneider, 2002).

Through the years, research has been collected highlighting the ways school buildings have had an impact on students' health and learning abilities (Figuro & Rea, 2010; Heschong, 2003; Lackney, 2001). Still, the modern school buildings and systems have failed to adapt and improve; they are in need of repair and replacement to work towards a better environment.

2.4.2 Impact of Facilities on Academic Performance;

A case study completed at Charles Young Elementary School in Washington D.C reported that the attendance records significantly improved from 89% to 93% after a renovation of the school (Berry, 2002). The students' learning abilities, test scores and parent involvement increase as well (Berry, 2002). The changes that were made during the renovation included window replacement, lead paint abatement or reduction, repaired leaks, carpet replacement, updated maintenance training, and major improvements to the heating, ventilation, and air conditioning (HVAC) system. Table 1 illustrates the National Test Results Standard Test before Restoration Post Restoration Observation Results Y1996 and Y2000 for the school.

Table 1: Test Results Standard Test Before Restoration Post Restoration Observation Results (adapted from Berry, 2002).

Standard test results	Before restoration Y1996	Post restoration Y2000	Observation
Math Scores Below Basic	49%	24%	25% of non-performing students have been motivated
Math Scores Basic or Above	51%	76%	Accessible computer technology has enhanced math
Reading Scores Below Basic	41%	25%	Reading improvement suggests better mental concentration
Reading Scores Basic or Above	59%	75%	Open classroom communication comfortable space, noise control, lighting enhance reading skills

2.5 The Sustainable Design and Social Benefits

The social benefits of sustainable design are related to improvements in the quality of life, health, and well-being. The benefits can be divided into three separate levels: the buildings, the community and the society. The buildings level is comprised of sustainable design topics that connect human interaction with the building itself. These topics include health, comfort, and satisfaction. The topic of health is a prioritized issue when it comes to the development of the indoor environment within buildings and the way the spaces are used by the occupants. Comfort and satisfaction are the next topics that come into play based on the connection between health and the indoor environment of buildings. The first section below describes research results indicating positive impacts of sustainable buildings on occupants' health and the second section describes comfort, satisfaction, and well-being.

Looking at the example of school buildings, the use of sustainable building design elements and operations can create a direct impact on the performance of students. These

elements include daylight procedures, thermal comfort, air quality, and acoustics. Studies highlighted by Buckley et al. (2004) show that the presence of better indoor environmental quality within schools' results in healthier students and faculty members. This leads to lower absenteeism and further improves students' overall learning capabilities.

2.5.1 Better Health of Building Occupants

Researches on the health benefits of sustainable design focus on indoor environmental quality (IEQ), particularly air quality (AQ). Health impacts coming about because of natural improvements interrelate with the body's physical systems, particularly respiratory, skin, neural, and visual pathways. Negative health side-effects happen because environmental factors (e.g. synthetic compounds or airborne microbial) influence the activity of the body's physical systems in vulnerable persons.

Numerous researchers have discovered large amounts of air-quality issues and inhabitant diseases in office and commercial buildings (e.g., Brightman and Moss, 2001). Researchers have started to evaluate the causal connections between the building environment and disease side effects in three territories: (1) communicable and respiratory diseases, (2) sick building syndrome (SBS), and (3) asthma and allergies (Heerwagen, 2006).

2.5.2 Improved Satisfaction and Comfort of Building Occupants

The connection of occupant's comfort and satisfaction with building conditions has been evaluated as the primary focus of post-occupancy criteria. Leaman and Bordass (2001) have highlighted that normally an occupant's satisfaction with lighting and air quality is higher as compared to thermal and acoustic satisfaction. There is always a need

for improving comfort and satisfaction as there is a presence of discomfort in relation to learning and working satisfaction and quality of work life.

There have been several studies by Farley and Veitch (2001) that have taken place in relation to the development of building features that show the benefits of daylight strategies, thermal strategies, air quality strategies and the ways these strategies connect with psychological and social benefits. The benefits include reduced stress, improved emotional functioning, increased communication, and an improved sense of belonging.

2.5.3 Satisfaction with daylighting and artificial lighting

The factors that play a critical role in influencing lighting satisfaction are windows, daylight, sense of control over lighting and occupants' location in the indoor space (Farley & Veitch, 2001). A study of seven energy-efficient buildings in the Pacific Northwest found that individuals were more satisfied with having a large amount of natural light in indoor environments as compared to individuals with reduced access to windows (Schumann et al., 2013; U.S. Green Building Council, 2015). Thus, DiLaura et al. (2013) state that the primary objectives of providing daylight are the following:

- Occupants access to daylight,
- Preventing glare and visual discomfort,
- Harvesting daylight to reduce the use of artificial lighting,
- Reaching an acceptable daylight uniformity across the workplace,
- Preventing direct insolation, since it provides visual and thermal discomfort.

2.5.4 Thermal satisfaction

The thermal satisfaction is determined by occupants' responses on the basis of the performance of an activity, clothing level, stress, age, gender, and individual preferences.

Wyon (1996) highlights that the best convenient way to improve thermal comfort is by providing individual control for temperature and ventilation systems.

According to Berry (2002), thermal comfort is an important part of learning environment spaces. There are specific ranges depending on the individual, but it is not realistic to accommodate each student in a shared space that meets their needs. It would be difficult for teaching staff to control according to each individual need (Schneider, 2002).

On the other hand, individuals often prefer windowed areas in indoor environments. The view of nature provides individuals health benefits, such as reducing stress, providing mental relief, improvement in the perception of life and improving emotional functions (Kubba, 2010)

2.5.5 Acoustic satisfaction

Research has shown that student performance is associated with schools that have an indoor higher acoustic comfort level: outside noise causes increased student dissatisfaction with their classrooms, and excessive noise can cause higher stress levels among students (Schneider, 2002). Moreover, Heschong et al., (2004) find that quiet learning spaces are required in order to achieve better student learning and performance. They also state that students with hearing impairment require even more favourable acoustics to facilitate understanding of speech and engagement with the learning environment.

Furthermore, “the ambient noise level in an empty classroom [should] be no greater than 35 dB and the noise level in an occupied classroom should not exceed 40-50 dBA” (SAC, 2019, p. 5). Decibel (dB) units are used to measure the intensity of the sound. Also, acoustic comfort element has a significant impact in workplaces and learning spaces which

can cause a negative influence on worker/end user's (i.e. students, faculty and staff) performance such as distracting, mental stress, irritating and leak of concentration (Della Crociata et al., 2013).

2.5.6 Waste management

Human activities, such as the processing and extraction of the raw materials, create waste that causes direct and indirect negative impacts on human health. However, waste management is deliberated to eliminate the negative impacts of waste on the environment and human health (IFC, 2014). The waste management principles, which categorizes the main management strategies in regard to waste minimization/management, are the "3Rs," reduce, reuse and recycle (Oluwaseyi, 2018).

These principles align with the sustainable interior design principles, or "5Rs," which means that the management of waste is one of the key areas that have a significant impact on environmental efficiency by recycling materials, such as cardboard, plastic and paper (Oluwaseyi, 2018). In other words, the United Nations Environmental Programme (2013) reveals that the development of sustainable design considerations can be beneficial for consistent waste management practices such as:

- Environmental, by reducing the negative impacts on it and eliminating waste resources that help in improved air quality;
- Social, by eliminating negative impacts through following suitable waste management practices can result in creating attractive civic societies and communities;
- Economic, by creating a market that supports recycling materials that follow efficient practices due to valuable materials have been recovered.

Human perception about constructions and the surrounding environment is a major consideration in establishing an approach for the design of the building. The goal of spreading knowledge about sustainability being the main focus leads to the concept of making designs that are readable to the human psyche. Mayerovitch (1996) suggests that we consider buildings to establish whether it can support our physical needs and whether we can gain from what it offers, and to attain this understanding relies on a complex set of faculties, specifically our senses, emotions, and reasoning. Coming up with design ideas for expressing knowledge about the building relies on a greater understanding of design that is manifested via physical, emotional and visual senses (Mayerovitch, 1996).

2.5.7 An example of a heating and cooling system used in Halifax

Through his book *Residential Deep Energy Retrofit in Cold Climates*, Henderson (2014) discusses the construction industry in Halifax, Canada and tries to show the appropriate way to deal with extremely cold conditions. Henderson explains how Canada was one of the first countries to introduce energy-efficient programs through the “National building code of Canada” in 2012 (Henderson, 2014, Chapter 5, p. 113). He also explains how with extreme cold weather comes a number of problems; “horizontal driving rain, repetitive freeze, high flood zones, permafrost, seismic loading, and other structural and safety concerns”, (Henderson, 2014, p. 113). Canada has succeeded to improve its energy efficiency and decrease energy usage to achieve greater thermal efficiency. He suggests different solutions for improving the insulation in renovated buildings, such as adding more insulation to the exterior of the building. As Henderson (2014) points out, “In typical terms of energy efficiency, there is a ‘law of diminishing returns’ in play when increasing insulation levels” (p. 117). Furthermore, he argues, “Controlled (mechanical) ventilation is

required in cold climates as building envelopes get tighter” (p. 119). These Canadian examples of the environmental retrofit process sum up the cold weather environmental design process as an example of extreme climates.

Similarly, the cooling, and heating design-strategy, which bioclimatic architecture and interior designers speak about, consider how to build structures connected with nature. It takes into consideration the climate and different environmental conditions, such as sun, wind, rain, and vegetation. This type of architecture has consistency between design and natural elements, which can help to reduce the energy consumption rate of buildings while achieving the required thermal comfort inside (Chayaamor-Heil & Hannachi-Belkadi, 2017).

The Figure 8 Part (a) illustrates the cooling strategy which allows less humidity as well as promoting refreshing air quality. Part (b) of the figure explains the heating strategy which promotes free heat gains and reduces thermal leakages.

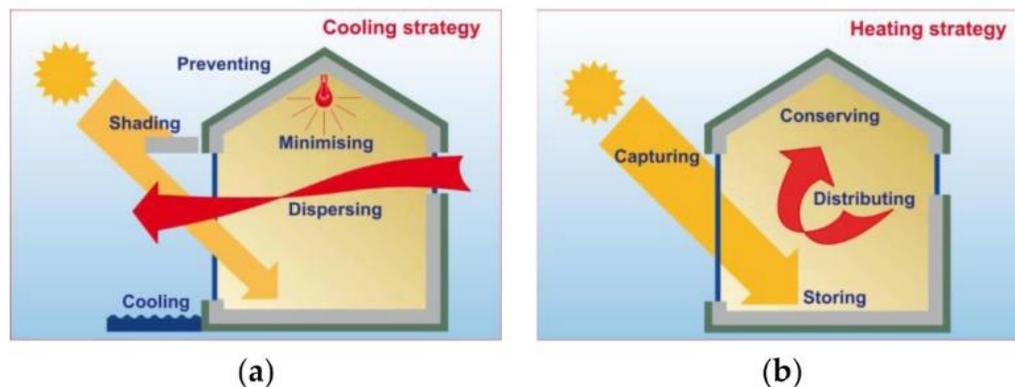


Figure 8: Explanation of thermal comfort (adapted from Chayaamor-Heil and Hannachi-Belkadi, 2017).

While the design community is becoming aware of the rising demands for environmentally conscious design, it is understandable that the construction of buildings is being addressed more carefully in the design process as various organizations have initiated

efforts for environmentally conscious design. Kibert (2005) explains that “sustainable construction may one day become so commonplace that it is unique, distinguishing terminology may be unnecessary” (p. 21). The adoption of sustainable means to reduce the impacts on the environment will help in building a better future as well as will reflect the end-user.

2.6 Analysis: Guidelines and measures perceived

This section explores the existence of emerging themes that aim to provide preliminary means to assess sustainable guidelines & indicators coming from sustainable interior design projects. Referring to some systems and techniques for indicators will be the initial assessment process to evaluate new industrial design studios. One of the major indicators will be the LEED certification checklists that indicate successful sustainable interior design buildings. As a preliminary overview, four themes emerge among the suggested emerging guidelines based on the LEED system to evaluate the sustainable potential of the building.

Overall Guidelines and Dimensions:

1. LEED Guideline; **LEED** v4.1 rating systems for Building Design and Construction C+BC (USGBC, 2019) aims to improve the Indoor Environmental Quality (**IEQ**), particularly the following:
 - Artificial lighting and daylight
 - Thermal comfort
 - Air quality and verification
 - Acoustic performance
 - Waste management

2. The guidelines for environmentally sustainable design considerations provided by Gesimond (2011) in *Materiality and Interior Construction* are the following:
 - Recycled materials – Waste management
 - Natural light and artificial light
 - Acoustics quality
 - Thermal satisfaction
3. The guidelines provided by Pelsmarkers (2015) in *The Environmental Design Pocketbook* are the following:
 - Thermal comfort
 - Daylight and artificial balance
 - Thermal mass and night cooling
 - Natural ventilation and ventilation with heat recovery (VHR)

The literature review has revealed several issues regarding sustainability considerations for buildings. These include the principles of sustainable interior design and the implications of human behaviour. There are several methods that are applicable in improving IEQ such as in the current context, the issue is about linking the IEQ with the building process and nature of construction material to attain sustainable interior design framework and guidelines. This review acts as a basis for the major issues and themes that will be covered in the methodology and results.

Chapter 3: Methodology

The methodology chapter describes the methods incorporated to provide the framework of the research undertaken in responding to the research questions and objectives highlighted in the introduction of the present study. According to Jamshed (2014), research methodology is defined as “a strategy or design by which the researcher maps out an approach to problem-finding or problem-solving” (p 87).

In this research, the methodology chapter starts with the explanation of the research plan carried out by the researcher, which is followed by the first stage of the research referred to as the *Data Collection Stage*. This stage discusses the methods and techniques used to appropriately address the research questions. The second stage is referred to as *Data Analysis Stage* that highlights the methods that were used to analyze the data collected.

3.1 Research Plan

This study will provide a complete description of the research approaches for carrying out the research process, data collection, and data analysis. Additionally, it will include the details for preparing and conducting semi-structured interviews, field observations and the evaluation of quantitative data on energy consumption from the Facilities Management of Carleton University. Finally, through the use of content analysis, further findings and insights will be proposed based on data collected, and these will be presented in the form of design directions and guidelines.

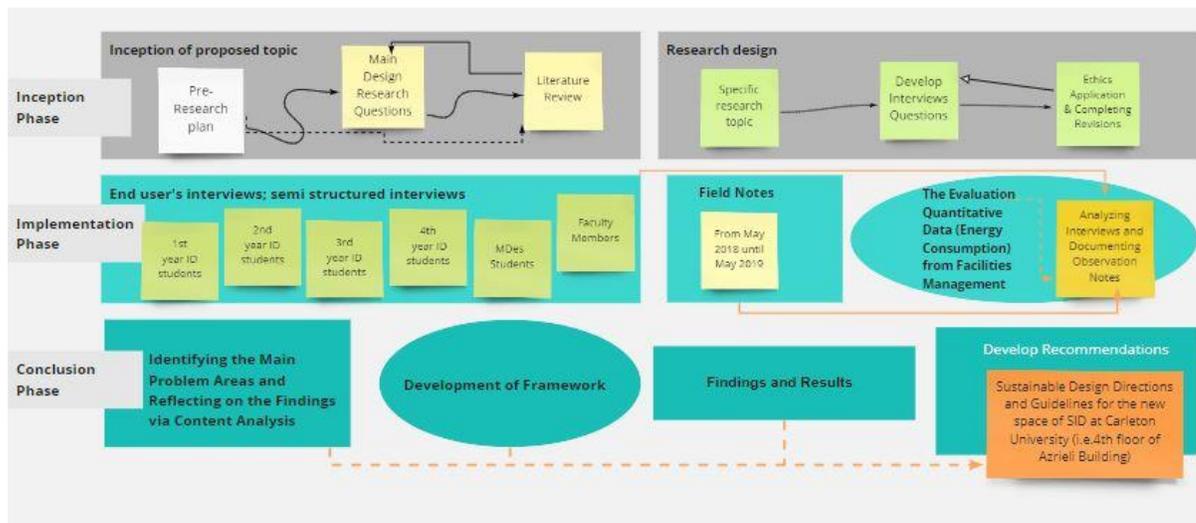


Figure 9: Flow Chart of Methodology.

Figure 9 explains the research phases of the overall thesis and highlights the stages of the research methods. The inception phase highlights the overall research plan which allowed the direction of literature review to develop including main topics of the research. The implementation phase highlights the data collection and analysis stages. The data collection stage involves semi-structured interviews, field observations and the collection of quantitative data on energy consumption from the Carleton Facilities Management. The conclusion phase explains the analysis of data through content analysis.

The research study aims to look at design students', the faculty's and staff's perspectives and behaviours in relation to the use of the new design studios and shared spaces in the School of Industrial Design located in the Azrieli Pavilion (AP) Building. Through the data collection stage, research methods and techniques were used to collect data, which were then analyzed based on the key themes and categories emerging from the data analysis and literature review phases. Key findings and insights were discussed by relating those to the main areas of the literature review and related approaches (e.g. thermal

comfort and lighting).

The data was collected via utilizing various methods and techniques such as semi-structured interviews, field observations and the evaluation of quantitative data (i.e. energy consumption). Through the use of the content, field notes and statistical analysis methods, the data was collected and then analyzed. The data was first collected based on the semi-structured interviews and observations, which were conducted with the end-users of the new design studios on the 4th floor, namely, undergraduate industrial design students (1st, 2nd, 3rd, 4th year), graduate students from the Master of Design program and the faculty members and staff.

3.1.1 Recruitment Strategy

Alshenqeeti (2014) states, “When it comes to dealing with human participants, research projects should rigorously follow ethical considerations” (p. 44). The ethics protocol for this research study was reviewed and approved on March 22nd, 2019, under CURB-B clearance # 110253 by the Carleton University Research Ethics Board which can be found in Appendix E. The process used for each data collection and data analysis stage will be described in the later section of this chapter. To address the research questions, each participant who has been involved in the transformation of the fourth floor of the Azrieli Pavilion (AP) building for the industrial design studios was recruited based on availability sampling. After the approval of ethics, the researcher aimed to recruit the participants through the following ways:

- Online-invitation (Appendix A)
- Email-Invitation (Appendix B)
- Recruitment Poster (Appendix C)

When the researcher had contacted the available participants, they were provided with detailed information regarding the research aim and content through online and/or email invitation. If the participants showed interest, the researcher then contacted each participant to schedule suitable interview times. This enabled the researcher and the participant to proceed with the interview at a convenient time. Prior to the start of the interview, the consent form (Appendix D) was reviewed by the participant, and the researcher recorded the interview with the consent of the participant. Additionally, the participants were given assurance by the researcher that they could withdraw from the research at any time with no reason.

Twenty-two participants agreed to get involved in the interviews:

- One from first-year Industrial Design
- Three from second-year Industrial Design
- Three from third-year Industrial Design
- Four from fourth-year Industrial Design
- Six from the Master of Design program
- Four from Faculty Associates in Industrial Design

As per recruitment each participant was chosen because of his or her involvement in the School of Industrial Design, particularly the new design studios and shared spaces. Through this, the researcher hoped to gain insights into user experiences in exploring the transformation of the new design studios for the School of Industrial Design.

3.1.2 Semi-structured Interviewing stage

In a qualitative research approach, the interview is one of the most common and effective means of data collection. A semi-structured interview adopting a qualitative

approach has two key benefits “(a) it flows naturally, and (b) it is rich in detail” (Dörnyei, 2007, p. 140). Jamshed (2014) states, “Semi-structured interviews are those in-depth interviews where the respondents have to answer pre-set open-ended questions”(p. 87).

The semi-structured interviewing method was applied to this research for two main reasons. First, it aims to reach a middle ground between the standardized responses, which prevents participants from diverting from a set of answers, and completely open-ended questions that sometimes steer away from the purpose of the interview. Second, there is flexibility in preparation, as the interviewer can be prepared before-hand, and this affords participants the freedom to express their opinions and experiences in their own words, especially if there is delicate data being concerned (Jamshed, 2014).

Furthermore, semi-structured interviews are mainly open-ended questions, which provide an exploration of perception and opinions of participants within a specified scope.. Semi-structured interviews have been the primary source for the content analysis through the analysis and interpretation of findings, and as well as better contextual evidence regarding identifying the problem area and the development of a research framework. This process encouraged open discussion with the participants and allowed them to reveal their valued perspectives further.

Between March and May 2019, twenty-two interviews were conducted with ID students, MDes students, and faculty members. Most of the interviews took place through face to face meeting with the researcher at the Master of Design studio on the 4th floor at Azrieli Pavilion at Carleton University, except two interviews that included two participants from the faculty members, and the interviews held at their offices at the

Carleton University. The face to face interviews lasted between 30 and 45 minutes, each participant was asked the same semi-structured interview questions (Appendix F).

The full verbatim transcription of the interviews was imported to the excel sheet for the analysis stage. The main intent of the interviews was to explore the problem area and provide key finding and insights by the content analysis. Also, the main themes (i.e. lighting, thermal and air comfort, acoustic quality, sense of space, maintenance and waste management) developed from the literature review were then applied to the interview transcripts for the analysis phase. Furthermore, in a few interview instances, an additional source of data was recommended from the interviews which were highlighted by the interview participants. For example, during some of the interviews, the participants recommended receiving additional data from Facilities Management and Planning (FMP) at Carleton University. This was possible due to their administration and faculty roles in the School of Industrial Design. The research took place through various steps such as contacting the facility management to collect quantitative data about energy consumption database of the AP building.

3.1.3 Field Observation stage

One of the qualitative research method adopted in this research is observation which was covered with both *field observation* and documentation of the changes on the fourth floor of the building in the field (Jamshed, 2014). Mulhall (2003) emphasizes the importance of unstructured observation in order to determine the problem areas through the field notes. As well as, she states that “The importance of observation: using our eyes

as well as our ears” (p. 2). Thus, this data provides further insights (both verbal and visual) that can be used during the analysis stage.

Over the one year of the research, the researcher interacted with the studio spaces to collect data which was done through field observation, taking notes and documenting images of the fourth floor in the Azrieli Pavilion building. This process started in May 2018 and ended in April 2019. During this timeframe, the researcher collected and documented more than 100 photographs (Figure 10) at different times (e.g. summer 2018, fall 2018 and winter 2019 academic terms) of the space such as shared areas e.g. gallery, collaboration space, maker space, storage area, etc.), and industrial design studios. As a result of this method, various data of different activities and events were gathered including design project presentations, studio work, and the final year exhibit.

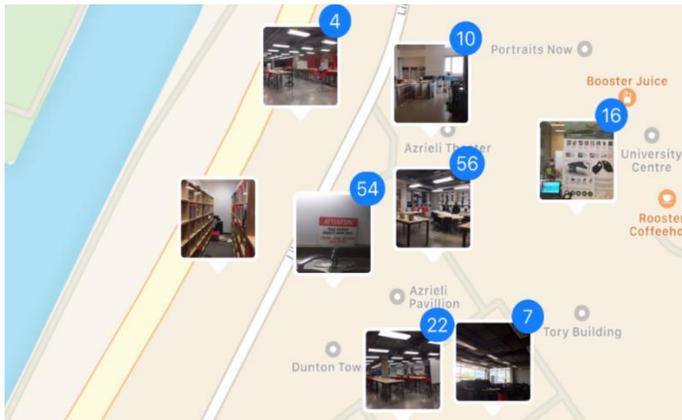


Figure 10: Field observation photos in Azrieli Pavilion on the 4th floor.

Aiming at the above data, these photos have been taken of the space where access was given for the observation of the place and activities to analyze the findings and categorize them based on the themes relevant to the research problem area, for instance (Figure 11) describes the artificial lighting problem.



Figure 11: The artificial lighting problem in the shared/collaboration space.

The Figure 11 highlights that there is a heavy reliance on using artificial lights in the Azrieli studio at the collaboration space as shown, which causes discomfort to the students especially during the presentation due to glares on monitors.

3.1.4 Quantitative Data on Energy Consumption

There can be a number of challenges and limitations facing the researcher in linking quantitative data with the qualitative one. The main challenge for connecting and relating quantitative and qualitative data is “developing the necessary technical competences to deal with data that have different logical principles” (Mason, 2004, p. 107). This data has been collected from the Facilities Management and Planning (FMP) of Carleton University as according to P21 suggestion, the faculty member advised the researcher by emphasizing that “AP building is being monitored by FMP and there is a ready database available” (Table 2).

Table 2: An example of building performance database provided by Facilities Management and Planning of Carleton University.

	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19
AT Elec kWhr	33,245	33,461	38,377	34,242	44,275	46,647	42,144	48,212	36,973	37,124
AT Stm klbs	0	0	63	75	75	124	123	47	47	0
AT DW m3	0	4	2	0	0	2	3	1	1	0
AT CW kbtu	95,396	34,270	0	0	0	0	0	0	1	8,710
AP Elec kWhr	68,218	73,413	72,303	70,339	65,017	65,100	88,652	69,803	69,277	76,427
AP Stm klbs	0	0	63	153	339	211	195	223	139	77
AP DW m3	39	39	39	52	37	44	40	57	41	26
AP CW kbtu	68,805	146,616	531	0	0	0	0	88	5	4,435

Table 2 shows the building performance of Azrieli Theatre (AT) and Azrieli Pavilion (AP) for each feature (e.g. energy consumption, air condition consumption, and heating consumption) in regard to building utility consumption. However, only quantitative data have been examined and analyzed in relation to the aspect of indoor quality and thermal comfort. Particularly, as highlighted above, the electricity (Elce) kilowatt-hour (kWh) is a measure of how much energy the building is using. Furthermore, Carleton Facilities Management provided average hourly consumption rate (total of daily consumption/24 hours from June 2018 to June 2019).

3.2 Data Analysis Stage

Content analysis was used for both the semi-structured interviews and observations. The observations were conducted to support the findings and insights of the semi-structured interviews. In relation to the interviewing method, a qualitative analysis method was used that has been described in the section below.

3.2.1 Content Analysis of Interviews and Observations

Content analysis refers to the techniques used to analyze the content of a sample of text, such as words, images, symbols, ideas, or other forms of transcripts (Macnamara, 2005) defines content analysis as the logical process of identifying differences and similarities that categorize qualitative text data, in order to “identify consistent patterns and relationships between variables or themes” (p. 3). In other words, in qualitative research, the content analysis is required for the researcher to pay attention and read carefully the text because the text may reflect different meanings based on how lengthy the data is (Julien, 2008).

The content analysis was used for the transcripts of the semi-structured interviews. These interviews allowed the researcher to clearly identify the problem area and better evaluate the spaces of the 4th floor in AP. The interviews also provided insights into space and recommendations that are not addressed in the literature review. For instance, the participants recommended that the researcher could benefit from checking additional data that pertain to the building performance. Every statement in the collected data was categorized into themes and sub-themes, which were based on the literature review. The method of analysis comprised of the following five steps:

1- **Preparation of data:** As mentioned previously, the interviews were recorded by using a voice-recorder device. All the interviews were transcribed verbatim at the beginning of the analysis to save time. They were read thoroughly to take notes about the relevant information as presented in Figure 12.

Transcript of P21

- Interviewer's dialogue is in regular font.
- Interviewee's dialogue is in italics.

Do you agree to record this interview?

Sure.

[Intro]

Which spaces do you mainly use as your learning environment on the fourth floor of AP?

I taught fourth year industrial design seminar 4001 in the fourth-year design studio in the fall term. And in the winter term, I taught second year studio in the second-year design studio. You will use mainly but you and I taught research methods in the MDes studio. So, I used those three rooms essentially.

How does artificial light affect your working environment here in Azrieli building, especially on the fourth floor?

I think the immediate thing that comes to mind is the glare on the monitors. So, I'm always asking, should I turn these lights off, so that people if I'm showing anything on the monitors so that they can see them better, they can see right now, right to see the hot spots here. So that comes immediately to mind that there's no adjustability for any kind of monitor screen use. The same would be said, for the industrial design seminar in particular. We had a lot of difficulty with the lighting in the center space in terms of when we were projecting the two seminar events.

Figure 12: The sampling of the transcript of recording P21.

2- **Defining the theme of analysis:** A shared excel sheet was created, which included the themes and sub-themes for analyzing and categorizing the content. Problem and solution areas were identified for each theme based on the main aims of the research (Figure 13).

	A	B	C	D	E	G	H
1	Participant#	Questions	Statements of the participants	Location	Problem Area	Theme	Sub-theme
174	P11 (fourth year ID student)	How does artificial light affect your learning environment	For the studio. There are three sets of lights that are very helpful because and especially from a sustainability standpoint, if there aren't a lot of people in in a certain section of the studio, and you can only turn you can turn one light on and so you don't need to turn the rest of them on, which is nice. Then, it see the artificial light, because there's so many lights and they're all at the same sort of white color. That really brings out the studio fine, if we had yellow, darker lights, it wouldn't be that great. In terms of artificial versus the sun lighting, it's helpful at night. But during the day, there's no point in even leaving them on because there's so many so many windows and the windows that a lot of sun in the light does help with my mood. I'm have more of a positive mood with more lights on.	Azieli Studio	The participant finds that artificial lighting in the Azieli studio is satisfactory. The participant suggests having individuals switches in the studio in order to be more susintable during evening studjng.	Lighting	The feel of artificial lighting

Figure 13: Excel sheet that was created to use as a tool during the content analysis phase.

- 3- **Developing the themes:** Sub-themes were developed based on the approach adopted through the main themes, in order to apply a more interpretive analysis. This allowed the researcher to compare and contrast the various theme and sub-themes.
- 4- **Drawing interpretations based on themes:** all of the themes were compiled in one file and then were examined separately in detail. Once all the transcript data were categorized into main and sub-themes, the key problem areas and insights were highlighted for each analyzed statement.
- 5- **Presentation of results:** The results will be explained and presented in greater detail in the next chapter. Also, these tables are found in the next chapter 4 (Results and Findings) and their relevance to addressing the research questions is discussed in Chapter 5 (Discussion and Conclusion).

The results of the content analysis were initially analyzed using the transcript of the interview with the assistance of an excel sheet. That metadata was helpful for providing a

broad perspective of what ideas were addressed in all of the transcripts, which were then used as evidence that the analysis addresses the research questions.

3.2.2 Field notes Analysis stage

The researcher's familiarity with the AP spaces and the end user's (student, colleagues and faculty members) facilitated observation and exploration by using field notes technique. In this study, the researcher was able to access the space (subject) any time without limitations or obstructs, and to record what he observed. According to Schwandt (2007), the term field notes refers to a kind of qualitative data in the form of notes, images, and media, during the observation of particular themes. These notes were used as evidence that increased the depth of knowledge and provided a better understanding of these themes and sub-themes as categories. Overall, the field notes included two layers of data including descriptive and reflective (Schwandt, 2007).

Moreover, descriptive research is a basic research approach that examines the situation, as it exists in its current state (Leedy & Ormrod, 2001). Reflective information refers to the research being conducted and looks for the reflections of that data including ideas, concerns, and questions that link with the research objective (Schwandt, 2007). The descriptive approach is beneficial to obtain information and highlights the concerns that exist in relation to the current research subject, as it allows to focus on the "what exists" part of the area (Leedy and Ormrod, 2001).

Following steps were applied within the method in order to start the field observation analysis process for field notes:

- Selecting and classifying data gathered (photos);
- Describing and defining each photo;

- Identifying main themes and sub-themes (linked with the literature review and interview themes);
- Listing all the photos for each theme/sub-theme together;
- Discussing and interrogating all the themes;
- Presenting the findings and insights.

3.2.3 Statistical Analysis stage

As mentioned previously in this chapter, qualitative data (interviews and observations) were the main source of data in this research. Nevertheless, the quantitative data on energy consumption aided the results of the content analysis of the semi-structured interviews and field observations. The quantitative data also assisted in highlighting the findings and insights of the semi-structured interviews.

Descriptive statistics are the most common quantitative method that describes and summarizes the benefits of such information. The aim of applied descriptive statistics is to allow the researcher to organize and summarize the collected data in order to characterize the values under the framework (Goos & Meintrup, 2015). Furthermore, due to a large amount of information (i.e. provision of hour by hour energy consumption), that was provided by Carleton Facilities Management, the researcher applied statistical analysis method in order to discover these patterns. The following steps were followed:

- Prepare average hourly consumption rate (total of daily consumption/24 hours)
- Prepare total monthly consumption
- Identify average daily consumption (total monthly consumption/month days)
- Calculate the total daily and monthly consumption during the period (9 AM-5 PM)
- Calculate the total daily and monthly consumption during the period (6 PM-8 AM)

- Calculate the total monthly electricity charges during the period (9 AM-5 PM)
- Calculate the total monthly electricity charges during the period (6 PM-8 AM)
- The cost reflects *Time of Use Pricing* in the province of Ontario for commercial consumers assuming the average price is \$0.125/kWh (from 9 AM - 5 PM) and \$.08/kWh (from 6 PM - 8 AM)

Furthermore, based on the data collected from the interviews, it was highlighted that during the months of February – March the energy consumption was higher due to additional usage of thermal comfort appliances such as portable heaters. This aligns with the data of statistical analysis's results and proves that the content analysis of the qualitative data is directly related to the quantitative one. Therefore, a sense of direction and key findings and insights were supported by the use of the statistical analysis provided by the Facilities Management at Carleton University.

Chapter 4: Results and Findings

4.1 Content Analysis; Sustainable Interior Design Themes

Once the data was collected, it was analyzed for the results and findings. The data collected from the interviews were categorized in the table through the use of excel sheet as explained in the methodology chapter. First, the data was broken down into the themes discussed in the interviews. Tables were created for each theme, and from the findings and insights gained through the interviews, sub-themes were developed. The following tables for each theme categorize and highlight the participants' statements and insights under the section of *problem area* and sub-theme.

4.1.1 Theme: Thermal Comfort – Energy

This section presents the *thermal comfort - energy* theme and the issues related to thermal comfort satisfaction. Sub-themes are also highlighted within this section such as the feel of thermal comfort and recommendation to improve thermal comfort.

Table 3: Thermal comfort – Energy analysis

Participant#	Problem Areas	Sub-themes
P2 (First year)	<ul style="list-style-type: none">• The participant has no issue with the thermal comfort in Mackenzie first-year industrial design studio, except in the evenings.• The participant finds the windows in the design studio are difficult to reach due to where they are placed in that space. The position of the windows; however, does not affect his level of comfort.	The feel of thermal comfort
P1 (2nd year)	<ul style="list-style-type: none">• The participant finds the Azrieli design studio has comfortable room temperature. The students prefer to work in the collaboration space, but	The feel of thermal comfort

	<p>the heating conditions are not suitable for studying.</p> <ul style="list-style-type: none"> • The participant emphasizes the lack of heating and insulation in the collaboration space led to space becomes colder at nighttime, thus affecting late-night studying. • The participant argues that the lack of insulation makes all rooms colder during the winter months, affecting those studying for long hours. Thus, there is a reliance on the building to keep heat within. 	
P5 (2nd year)	<ul style="list-style-type: none"> • The participant finds the Azrieli studio to be uncomfortable during winter and summer months due to the high number of windows and poor insulation within the building structure. He/she argues that there should be no need for heaters, as the building should be insulated. 	The feel of thermal comfort
P9 (2nd year)	<ul style="list-style-type: none"> • The participant finds that the areas by any window in the Azrieli studio are uncomfortably cold and not suitable for studying. The participant finds the entire building to be insufficiently heated. 	The feel of thermal comfort
P9 (2nd year)	<ul style="list-style-type: none"> • The participant argues for a more effective way to heat the building, as the main reliance on heaters consumes excessive energy. 	Recommendation for thermal comfort
P10 (3rd year)	<ul style="list-style-type: none"> • The participant states the gallery space is uncomfortably cold. As a result of poor insulation through the windows, it is not conducive for learning. • The participant finds that most collaboration space on the fourth floor in AP are cold after working for long hours, for example, the collaboration space is usually cold during evenings. 	The feel of thermal comfort

P13 (3rd year)	<ul style="list-style-type: none"> The participant reveals that the Azrieli studio has poor heating, and thus, big areas are harder to keep warm. Room doors are often left open which allows the heat to escape. 	Recommendation for thermal comfort
P11 (4th year)	<ul style="list-style-type: none"> The participant thinks that the Azrieli studio mainly relies on the daylight to warm up. This results in colder working conditions in the evening and on cloudy days. 	The feel of thermal comfort
P17(4th year)	<ul style="list-style-type: none"> The participant finds that the Azrieli studio can be very warm in the mornings due to the windows in the room. The participant finds that as the day goes, space gets colder, and especially in the evenings, the studio is cold enough to wear a jacket. He/she would like to see more room temperature regulation, but they have an overall positive experience with the entire 4th floor in AP, except for the 4th year studio. 	The feel of thermal comfort
P18 (4th year)	<ul style="list-style-type: none"> The participant finds that the Azrieli studio is oftentimes cold and extra clothing is required, this may be due to the large room size and high ceilings. As the participant observed, her/his classmates find that the studios are generally warm; however, they mentioned they would prefer warmer room temperature for having more comfort 	The feel of thermal comfort
P3 (MDes Student)	<ul style="list-style-type: none"> The participant finds that the Azrieli Design studio is cold during winter months due to poor window insulation. The participant complains that heating is used excessively during this time. The participant has no experience being in the Azrieli studio during 	The feel of thermal comfort

	summer months; therefore, he/she has no thermal comfort experiences to reflect on.	
P6 (MDes Student)	<ul style="list-style-type: none"> • The participant finds the Azrieli studio to be generally comfortable in terms of room temp. • The participant mentioned it was very cold in the studio when the semester began, and an instance in the summer when the studio was too hot to work in, although they did not have classes during the summer period, it was experienced during hot days but they did not attend full classes during the period 	The feel of thermal comfort
P7 (MDes Student)	<ul style="list-style-type: none"> • The participant recalls the Azrieli design studio being poorly insulated, which made the working condition uncomfortable during the winter months. The windows allow cold air in and do not insulate the rooms. • The participant finds the design studio to be cold and uncomfortable to study in. • The participant argues that providing the students with heaters is not a long-term solution, and often times there are not enough heaters to keep everyone warm. • The participant also finds the concrete floors to be problematic, as it makes the rooms cold. 	The feel of thermal comfort
P7 (MDes Student)	<ul style="list-style-type: none"> • The usage of carpet in rooms and having the ability to open and close windows. 	Recommendation for thermal comfort
P8 (4th year)	<ul style="list-style-type: none"> • The participant finds the room temperature in the Azrieli design studio and Mackenzie design studio uncomfortable to work in during winter months, and extra clothing is needed to stay warm. This is most likely due to the amount of sun 	The feel of thermal comfort

	received through the windows as well as the lack of enough heating.	
P8 (4th year)	<ul style="list-style-type: none"> • The participant finds that the Azrieli design studio is not adequately insulated, this may be due to the high ceilings and poorly insulated windows and overall structure of the building. The overall temperatures of the studio make the working environment unsuitable for studying. The roof is heated by the sun; therefore, making it warmer when the sun is out as opposed to nighttime when it is colder. • The participant finds the poor insulation within the Azrieli and McKenzie design studio made summer months undesirable for learning to the heat. • The participant recommends working thermostats on-site to adjust room temp. when needed. 	Recommendation for thermal comfort
P12 (Faculty Member)	<ul style="list-style-type: none"> • The participant finds the Azrieli design studio to be uncomfortable during winter and summer months due to poor insulation within the building structure. • The participant believes that the room temp. in the MDes's and second-year Studios of the Azrieli, studio to be problematic due to having exterior walls. He/she argues that the use of space heaters is not enough solution, as these heaters consume energy, and the building should be insulated to ensure effective energy use. 	The feel of thermal comfort
P14 (MDes Student)	<ul style="list-style-type: none"> • The participant has a preference of working in the cooler rooms in general within the Azrieli building, only recalls a few instances when extra clothing was needed. 	The feel of thermal comfort

	<ul style="list-style-type: none"> The participant has no studying experience in any of the Azrieli design studios during summer months as they only had winter-fall classes. 	
P16 (MDes Student)	<ul style="list-style-type: none"> The participant finds the Azrieli design studio to be usually cold due to poor insulation but identifies the space heaters as helpful. 	The feel of thermal comfort
P16 (MDes Student)	<ul style="list-style-type: none"> The participant recommends that there should be better insulation in the building hosting the Azrieli design studios. He/she argues that the windows lack insulation and that must be addressed to be more effective in blocking out cold air. 	Recommendation for thermal comfort
P19 (Faculty Member)	<ul style="list-style-type: none"> The participant identifies the issue of poor thermal comfort as the result of inadequate insulation of the building. He/she recalls the issue going unresolved for time and many resorted to owning space heaters. The participant identifies issues with the overall heating of the building. He/she found the use of curtains helped to insulate studios. It has become warmer; however, in the past the working space was cold, and it did not provide appropriate conditions for working. 	Recommendation for thermal comfort
P20 (Faculty Member)	<ul style="list-style-type: none"> The participant finds that there is a lack of sufficient heating in the winter, and the insulation of the overall building is inadequate, and windows and rooms with exterior walls combined make it colder. The participant notes that the fourth floor is especially cold as the roof is not adequately insulated. Although the students were provided short term solutions with space heaters, some students had to work 	Recommendation for thermal comfort

	elsewhere due to the undesired working climate. The participant also notes that the summer months are not as much of a concern since there are not many students around.	
P21 (Faculty Member)	<ul style="list-style-type: none"> The participant identifies issues the overall structure of the building has poor insulation. The participant recalls the facilities recording the buildings heating performance winter months are poor, due to the lack of roof insulation. The participant cannot comment on summer months, as he/she does not have experience being in the building. 	Recommendation for thermal comfort

The findings illustrated Table 3, there are several problem areas that have been identified by the participants. The main areas that have been identified by the participants are related to the overall structure of the building and the lack of insulation. Most participants found that the thermal comfort was poor in the AP which resulted in an environment that was not considered conducive for learning. The problem areas identified are as following:

- Poorly insulated windows that cannot be opened or closed;
- The lack of insulation in the foundation of the whole building;
- The fourth floor is found to be the coldest floor;
- The absence of ceilings in the studios did not help in keeping the rooms warm;
- Use of space heaters to address the heating issues;
- The studios are too cold to be able to work in.

Among the statements given, there have been several notable comments made by the participants which highlight common issues. These commonalities are worth mentioning as they provide insight as to how to treat these problem areas. Participant 3 and Participant 16 shared common opinions on the windows not being properly insulated. The lack of proper insulation allowed for cold air to enter the room and resulted in making the Azrieli studios colder during winter months. Fewer students are on campus during summer months, and so, it does not affect the majority of students. For those who were on campus, like Participant 6 who found the conditions unsuitable for studying/working.

While these participants found that the poorly insulated windows were the cause of a colder environment, Participant 6 and Participant 11 found that space was kept very warm due to the windows allowing warmth in, particularly in the mornings. Although the windows do provide heat during sunny mornings, many participants found it difficult to do work in the studio during evenings, when the studios became colder due to the lack of heating and the reliance on the warmth from the sun. Participant 1 and 8 all found that the Azrieli studio was too cold in the evening and this affected their studies. Some participants have noted that the fourth floor is particularly colder than the other floors which support the comments made by Participant 20, when they mention that the roof lacks sufficient insulation, suggesting that the fourth floor is subjected to the less insulated roof.

The most common problem area identified by the majority of the participants is that the overall building is poorly insulated, and some participants find the interior of the building is not suitable to maintain a comfortable thermal level for everyone. Participants 5, 16, 19 and 21 commented that the buildings poor insulation made winters very difficult to work through. Participant 8, 20 and 21 commented on the interior of the studios, having

no ceilings contributed to the colder room temperatures. Participant 7 made noteworthy comments on the use of space heaters in the studios. The participant notes that the solution of providing students with space heaters is not an effective long-term solution and consumes too much energy. Participant 12 and 5 commented as well that there should not be a need for space heaters as the building itself should be heated. Participants 14 and 8 mentioned that in order to remedy the discomfort from the cold studio they layer up in order to stay warm. In these comments, it is clear that there are issues with staying warm and comfortable in the Azrieli studios and that the university should implement a more sustainable and long-term solution.

While most participants noted that there are issues with the temperature, there are very few who such as participant 17 and 15, who noted that the room temperature was sufficient. Participant 12 notes that they do not find the temperature in the Azrieli gallery is an issue while Participant 10 finds that the gallery is too cold to be in without a jacket.

4.1.2 Theme: Lighting Quality (Artificial and Natural)

This section presents the *lighting quality* theme and the issues related to artificial and natural lighting. Sub-themes are also highlighted within this section such as the feel of natural light, the feel of artificial lighting and the recommendation for artificial.

Table 4: Lighting quality theme analysis.

Participant#	Problem Areas	Sub-themes
P2(First year)	<ul style="list-style-type: none"> • Having a lot more natural light on the fourth floor of the AP, which looks nicer with a better view. The natural lighting has a positive effect on how space looks and feels like. • The participant finds that the effect of natural light is important in a learning environment. The participant mentions that in general the lighting can be harsh in the Mackenzie studio, but it does not affect him. 	The feel of natural lighting

	<ul style="list-style-type: none"> • The participant finds there is little natural lighting in the Mackenzie studio, he/she states that artificial lighting may be helpful when they are drawing in the Mackenzie studio. 	
P2 (First year)	<ul style="list-style-type: none"> • The participant finds that lighting in the Mackenzie studio can be improved. The participant notes that LED Light replacement is harsher than fluorescent lights. • The participant believes that the Mackenzie studio should have LED lights that produce a warm-toned artificial light would make the space more comfortable. The participant finds the bright white LED lights are too harsh and give the feel of a medical center. 	The feel of artificial lighting
P2 (First year)	<ul style="list-style-type: none"> • The participant believes that using a dimmer switch to control the lights would not be beneficial in the Mackenzie studio. He does not find a use for it while working in the studio. • The participant finds that while they are working in the studio, it is not practical to have some areas dimmer than others, as it may not improve the working environment. The participant notes the lights are not harsh enough to need dimming. • The participant finds it will be disruptive and an annoyance to have a dimmer in the Mackenzie studio, as many people try to control the lights. They find the dimmer unnecessary. 	Recommendation for artificial
P1 (2nd year)	<ul style="list-style-type: none"> • The participant finds the natural lighting in the AP studios makes the space comfortable. The participant mentioned that the overhead light in the studio is strong and may give her headaches or cause dizziness. • The participant finds that natural lighting is much more effective in making the space comfortable for learning. • The participant believes it is more beneficial to have natural light. He mentions he is more active and productive with natural light; He also highlighted the health benefits of natural light. • The participant found that the natural lighting in the AP was better than the lighting in the Mackenzie studio due to the lack of windows. 	The feel of artificial lighting

	The participant experienced that as a positive change to their working environment.	
P1 (2 nd year)	<ul style="list-style-type: none"> The participant notes the AP should offer natural light through the development of skylights. The participant finds that the fourth floor should rely less on artificial lighting and find a way to incorporate more natural light. 	Recommendations for natural lighting
P5 (2 nd year)	<ul style="list-style-type: none"> The participant finds that the Azrieli studio provides sufficient natural lighting as there is no dependence on artificial lighting. The studios do not rely on artificial lighting often and that sets a comfortable and positive work environment. 	The feel of natural lighting
P5 (2 nd year)	<ul style="list-style-type: none"> The participant finds that there is an over-dependence on artificial lighting in the Azrieli Studio. The participant finds that the studio receives enough natural lighting and finding a way to provide light on the tables only as opposed to overhead lighting to provide more lighting comfort. The participant does states that installing a dimmer would be beneficial in the Azrieli studio, but not practical. He/she offers the idea that individual switches may help. 	the recommendation for artificial lighting
P9 (2 nd year)	<ul style="list-style-type: none"> The participant does not find the artificial lighting in the Azrieli design studio is an issue. The participant recalls finding the switches difficult to locate at times. The participant prefers the use of natural lighting over artificial lighting for a better working environment. The participant finds it difficult to focus after spending long periods using artificial lighting in the Azrieli design studio. The participant finds that working during the day is better with the use of natural lighting. 	The feel of artificial lighting
P10 (3 rd year)	<ul style="list-style-type: none"> The participant finds that there is a heavy dependence on the artificial lighting in the AP, especially the breakout rooms. The participant finds that the natural lighting in the general space during the day is sufficient and it creates a positive working environment. The participant believes that certain lighting can induce creativity; thus, suggests the use of 	Recommendation for artificial

	side lamps on the side of the tables during late nights.	
P13 (third year)	<ul style="list-style-type: none"> • The participant believes the students rely on good lighting in the Azrieli design studio, as many students tend to study late night. • The participant prefers working in the Azrieli studio during daylight hours. The participant finds the natural light has improved the working environment. 	The feel of artificial lighting
P15 (3rd year)	<ul style="list-style-type: none"> • The participant finds the natural lighting in the Azrieli building is an improvement from the lighting in the Mackenzie design studio which had no windows in the third year. • The participant finds that the natural lighting in the studio makes it easier to begin early days during winter months. This makes the space more comfortable for working. 	The feel of artificial lighting
P15 (3rd year)	<ul style="list-style-type: none"> • The participant recalls the use of blinds in the Azrieli studio in rare occasions but enjoys the natural lighting more so for studying. 	The feel of natural lighting
P11 (4th year)	<ul style="list-style-type: none"> • The participant finds that artificial lighting in the Azrieli design studio is satisfactory. The participant suggests having individual switches in the studio in order to be more suitable during evening studying. 	The feel of artificial lighting
P11 (4th year)	<ul style="list-style-type: none"> • The participant finds that the natural light in the Azrieli studio provides a more positive working environment. The participant notes the large windows allow for the natural light to come is a positive aspect. 	The feel of natural lighting
P17(4th year)	<ul style="list-style-type: none"> • The participant mentions that they do not use the indoor lighting in the Azrieli studio until it becomes darker outside. The natural light produces enough light for the students to work comfortably. • The participant is more productive working during the day in the Azrieli Studio. • The participant finds a difference in mood when he works under fluorescent lighting. They feel they are more comfortable and more efficient when the room has natural lighting. 	The feel of natural lighting

P18 (4th year)	<ul style="list-style-type: none"> • The participant is satisfied with the lighting in the Azrieli Studio. He/she finds it difficult to get individual lighting when others working in the space prefer to have the lights off. Offering individual lighting options at the table can remedy this. • The participant finds that they prefer to work under natural lighting in the Azrieli Studio. 	Recommendation for artificial
P3 (MDes Student)	<ul style="list-style-type: none"> • The participant finds that artificial lighting is needed within the Azrieli studio because some parts of the studio do not receive full access to the sunlight. • The participant finds that the over-reliance on natural light affects days with poor weather and close tonight, so there is a necessity for good artificial lighting. 	The feel of artificial lighting
P3 (MDes Student)	<ul style="list-style-type: none"> • The participant finds that the layout inside the Azrieli studio does not take full advantage of the natural light it receives. The participant notes most of the activities done in the MDes studio require natural light which is only available in some sections of the studio. Therefore, rearranging the layout of the studio can offer energy-saving solutions. 	Recommendation for artificial light
P4 (MDes Student)	<ul style="list-style-type: none"> • The participant has a preference of working under artificial lighting in the Azrieli Studio. The participant notes that the fluorescent lights help them focus. • The participant notes that unlike natural lighting in the Azrieli studio, artificial lighting provides more consistent lighting. 	The feel of artificial lighting
P6 (MDes Student)	<ul style="list-style-type: none"> • The participant prefers to work during the afternoon in the Azrieli studio, while there is still sunlight remaining. The participant notes that artificial lighting makes them uncomfortable in the working environment. The participant recommends individual lighting to provide light in more areas without causing overcrowding. • The participant recommends being able to bring their own light into the Azrieli studio in order to have better lighting. This, however, may cause issues with trying to conserve energy. 	The feel of artificial lighting

P6 (MDes Student)	<ul style="list-style-type: none"> The participant does not have any issues with the Azrieli studio lighting and feels as though, they have more space than most other graduate students on campus. The participant can only recall the transition from daylight to artificial light being unsettling, thus they prefer not to work at night. 	The feel of natural lighting
P7 (MDes Student)	<ul style="list-style-type: none"> The participant notes that when considering the lighting in the Azrieli studio, we must consider the best methods for energy conservation. The participant can only comment on how sustainable the artificial lighting sources are in the Azrieli Studio. The participant is concerned that the university should make energy conserving choices. The participant notes that the lighting in the Azrieli studio is adequate, based on experience working in many studios. The participant comments on the importance of good lighting in studios, and that it assists students with focusing and thinking. The participant also notes the importance of natural light for working environments. The participant recommends ensuring that the lights used in the Azrieli building are at least sustainable. This, however, can be expensive. 	The feel of artificial lighting
P8 (4th year)	<ul style="list-style-type: none"> The participant comments that the artificial lighting in the Azrieli design studio is often too harsh to work under. The participant finds that natural light proves a better learning and working atmosphere. The participant lists a number of positive health and mood benefits associated with access to sunlight. 	The feel of artificial lighting
8 (4th year)	<ul style="list-style-type: none"> The participant finds the open space and natural light in Azrieli studio is an improvement from the Mackenzie studio. The participant prefers working with access to natural light sources in the Azrieli design studio. 	The feel of natural lighting
P8 (4th year)	<ul style="list-style-type: none"> The participant recommends that the Azrieli design studio use softer lights for when students use the space in the evenings. 	Recommendation for artificial

<p>P12 (Faculty Member)</p>	<ul style="list-style-type: none"> • The participant finds that the natural lighting in the Azrieli design studio is one of the main advantages of the space. The participant also mentions that the middle open space receives artificial lighting in the evening which does not provide the same benefits as the natural lighting for all students. • The participant notes that there are not enough complaints about the artificial lighting in the Azrieli studio, however, this does not mean it is not an issue. The participant notes that it would be useful to research better lighting options. • The participant finds that there is a need for artificial lighting in the Azrieli design studios, regardless if students use them often or not. 	<p>The feel of artificial lighting</p>
<p>P14 (MDes Student)</p>	<ul style="list-style-type: none"> • The participant notes that with their higher sensitivity to light, they found little issues with the artificial light in the Azrieli design studio. • The participant does mention not having enough experience working in the studio but would have liked to be able to use a lamp to improve focusing on detailed work. 	<p>The feel of artificial lighting</p>
<p>P14 (MDes Student)</p>	<ul style="list-style-type: none"> • The participant notes that they would prefer the use of lamps at the working areas in the Azrieli design studio. The participant enjoys the aesthetic appeal to lamps, which set a comfortable environment. 	<p>The feel of natural lighting</p>
<p>P16 (MDes Student)</p>	<ul style="list-style-type: none"> • The participant believes the artificial lighting in the Azrieli studio design studio is adequate. • The participant believes the artificial lighting transitions well from the natural, although he/she enjoys natural lighting as well. Participant finds that working in the evenings is not difficult. • The participant finds that the use of auto sensors in the Azrieli design studio is a more sustainable option. • The participant, however, dislikes the feeling of being reminded that they have been there long enough to have set off the sensor. This general creates an isolated atmosphere. 	<p>The feel of artificial lighting</p>
<p>P16 (MDes Student)</p>	<ul style="list-style-type: none"> • The participant recommends when using the auto sensors, it would not be environmentally beneficial to turn off the sensors. 	<p>Recommendation for artificial</p>

	<ul style="list-style-type: none"> The participant notes it would be effective to find a way to automate the system to not turn the lights off until the person has left the room, rather than based on movement. 	
P19 (Faculty Member)	<ul style="list-style-type: none"> The participant finds that the Azrieli design studio receives a sufficient amount of sunlight, that often the artificial lighting is not used. The participant notes that there is still a reliance on artificial lighting and feels there is a good balance of light in the studio. The participant does not currently have any issues with the artificial lighting in the Azrieli Studio. The participant would like to see the option of turning on only certain lights with individual switches in order to work more effectively. 	The feel of artificial lighting
P19 (Faculty Member)	<ul style="list-style-type: none"> The participant notes that the biggest issue people were having in the Mackenzie studio was that there was not enough natural light. The participant is much happier with the natural lighting in the Azrieli Studio. There are other pros and cons to consider here, the windows caused glares on screens, which disrupted some lectures. 	The feel of natural lighting
P19 (Faculty Member)	<ul style="list-style-type: none"> The participant finds that adding thicker curtains in the Azrieli studio could help keep daylight out due to there being many windows. The participant would prefer more windows if the choice was between space and windows, they would choose to have more windows. 	Recommendation for artificial
P20 (Faculty Member)	<ul style="list-style-type: none"> The participant recalls not having enough natural lighting was a major concern, this is no longer an issue in the Azrieli Studio. The participant has not heard any complaints about the artificial lighting used in the evenings, supposes they can always be improved. The participant recalls the University transitioning into a more energy-efficient plan to develop environmentally friendly lighting systems. The participant is unsure about the knowledge of the research area. 	The feel of artificial lighting

P21 (Faculty Member)	<ul style="list-style-type: none"> • The participant found that the only issues they have with the lighting in the Azrieli studio are when they have too much sunlight causing glares on monitors. The participant suggests having some sort of adjustability in order to prevent this from happening. • The participant notes that the need for comfortable lighting in the Azrieli studio is important during the evenings. • The participant notes the lack of control over the lighting in the Azrieli studio is a negative aspect. The participant notes that new lighting systems provide more control over the lighting systems and therefore would make the learning environment more efficient. • The participant finds that they are much happier with the additional lighting in the Azrieli Studio. The participant points out that it makes the working environment a better experience. • The participant finds that there needs to be some way to control the glare from the natural light in the Azrieli Studio. The participant notes that students lost working space from the walls in order to bring in natural light. The participant suggests finding a way of getting more space for students to work as well as providing enough lighting. 	The feel of natural lighting
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From analyzing Table 4 of participant experience, the problem areas identified with lighting in the studio have proven to have a strong impact on the learning environment for several participants. The problem areas that have been identified into two main concerns, the first being the discomfort that comes from working under the artificial lighting in the Azrieli design studio and the second being an over-reliance on natural lighting, which is not always effective under all climates.

The general response received in regard to the artificial lighting is that it is acceptable but can be improved. Majority of students have noted they are more productive

and have a more comfortable working environment when working during the day with the natural lighting. The participant has mostly provided general feedback on ways to improve the lighting in the studios and it is important to have effective lighting in any working environment.

Participants have noted the level of discomfort they experience when working under the headlights in the studios, which can be uncomfortable. Participant 1 has noted that working under artificial lighting in the studio has caused them dizziness and headaches.

Participants 5, 6, and 10 have expressed the obvious need for artificial lighting, but they find their working experience would be enhanced with better lighting options such as individual table lamps. Participant 7 has mentioned their concern over the sustainability of the lighting in the studio. The participant notes that the university should consider the energy consumption of the lighting provided in the space.

The majority of participants had positive feedback on the amount of natural lighting received in the design studio. Participants 1, 9, 11, 13, 15, 17 and 18 have all noted their preference of the natural lighting in the studio over the artificial lighting. Some participants, such as 1, 13 15 and 17, mentioned that natural lighting has improved the working environment. They expressed how more productive and comfortable they feel when working under natural lighting. Participant 20 mentioned that not having enough natural light was a major concern for many and this has changed for the better in the Azrieli Studio. Participant 19 notes that the problem with natural lighting in the Mackenzie studio was that it did not have many windows. The participant points out that the Azrieli studio has accommodated students by having more windows and more natural lighting. The

participant also mentions the downside of having many windows and natural light, being that it causes glares on computer screens which can be disruptive and that students lose less wall space to use while working on their projects. Another issue identified by Participant 3, is the overdependence on natural light which would pose issues on days when the weather is cloudy, rainy or less sunny.

4.1.3 Theme: Acoustic Quality

This section presents the *acoustic quality* theme and the issues related to acoustic quality in Mackenzie and Azrieli Design studios. Sub-themes are also highlighted within this section such as concerns regarding acoustic quality and recommendations for acoustic quality.

Table 5: Acoustic quality analysis.

Participant #	Problem Areas	Sub-themes
P2(First year)	<ul style="list-style-type: none"> The participant believes that the Mackenzie studio acoustics are sufficient, although it could get loud, brick walls absorb most of it. Unless a loudspeaker is played The participant is satisfied with the acoustic quality in the workshop. The participant recalls instances when neighbouring rooms were disrupted due to noise levels. 	The concerns about acoustic quality
P1 (2nd year)	<ul style="list-style-type: none"> The participant finds the lack of soundproofing walls in the AP space can cause the disruptions of lectures. Often times the lecture has to be stopped in order to stop loud conversations or music played outside the lecture room. The participant complains maker space in AP is often loud. Although the room is relatively small, any conversation at any noise level can be heard externally. 	The concerns about acoustic quality

P1 (2 nd year)	<ul style="list-style-type: none"> • The participant recommends soundproofing the room by installing soundproof panels in the AP. • The participant agrees on a project to soundproof through the ceiling in the AP. 	Recommendations about acoustic quality
P5 (2 nd year)	<ul style="list-style-type: none"> • The participant finds that due to the poor acoustic quality in the Azrieli studio, lectures can be heard by those trying to work in the studio space. This causes problems for those trying to work in the space, as they must be very quiet not to disturb the lecture, or they are unable to work at all. He/she argues lectures should be given elsewhere on campus or room soundproofing. 	The concerns about acoustic quality
P9 (2 nd year)	<ul style="list-style-type: none"> • The participant identifies an issue with noise echoing when there are several people in the Azrieli studio at once. This makes it difficult for students to concentrate on work. 	The concerns about acoustic quality
P9 (2 nd year)	<ul style="list-style-type: none"> • The participant notes that adding acoustic panels in every space within the AP would be expensive to complete. 	Recommendation for acoustic quality
P10 (3 rd year)	<ul style="list-style-type: none"> • The participant finds the exposed walls, concrete and glass in the Azrieli studio causes the sound to reverberate causing echoing. This causes issues between students trying to work, as often people get frustrated with the noise while trying to work. 	The concerns about acoustic quality
P10 (3 rd year)	<ul style="list-style-type: none"> • The participant recommends acoustic diffusers which disperse sound inside a room or acoustic absorbers in the room. • The participant notes that within coming years' noise piracy will develop into an issue and hence looking for soundproofing solutions to suit modern living is needed. • He/she recommends collapsible acoustic panels that cover more surface area but within small packaging. 	Recommendations for acoustic quality
P13 (third year)	<ul style="list-style-type: none"> • The participant identifies an issue with noise echoing when there are several people in the Azrieli studio at once. This makes it difficult for students to concentrate on work. • The participant has been having good experiences with the acoustic quality in Azrieli studio. Although the noise levels do not bother the participant, he/she can recall instances 	The concerns about Acoustic quality

	when more than a few people would be in the space and the noise levels would disrupt others.	
P15 (3rd year)	<ul style="list-style-type: none"> The participant finds that there is good acoustic quality in the Azrieli Studio. He/she identifies issues with the open ceilings which causes a lot of reverb, and music and conversations can be disruptive. The participant mentions the third-year studio play music, so sound insulation could be used as some people prefer the quiet when working for focus. 	The concerns about acoustic quality
P11 (4th year)	<ul style="list-style-type: none"> The participant finds the acoustic quality in the Azrieli studio is poor. The participant complains that there is a lot of echoes in the gallery space making communication difficult. 	The concerns about acoustic quality
P17(4th year)	<ul style="list-style-type: none"> The participant finds there is good acoustic quality for a fourth-year studio. However, they argue it could be better, due to echoing in the common room and even the slight noise travels far. The participant finds the acoustic quality in the Azrieli gallery is poor. 	The concerns about acoustic quality
P17 (4 th year)	<ul style="list-style-type: none"> The participant recommends cork boards and ceiling tiles that would help soundproof for better acoustics. This will also help with space's aesthetic. 	Recommendations for acoustic quality
P18 (4th year)	<ul style="list-style-type: none"> The participant is satisfied with the acoustic quality in the Azrieli studio apart from the gallery and breakout rooms due to echoing noises. 	The concerns about acoustic quality
P3 (MDes Student)	<ul style="list-style-type: none"> The participant finds that the central area in the Azrieli studio is prone to disturbances thereby affecting students from being able to work effectively. The participant feels as though the common space is not suitable for collaboration between students. 	The concerns about acoustic quality
P4 (MDes Student)	<ul style="list-style-type: none"> The participant finds that the acoustic quality is poor in the Azrieli design studio. Since, they find the disruptions affecting their work, having a personal space to study is ideal. 	The concerns about acoustic quality
P6 (MDes Student)	<ul style="list-style-type: none"> The participant does not find issues with the sound quality in the Azrieli Studio. 	The concerns about acoustic quality

P7 (MDes Student)	<ul style="list-style-type: none"> • The participant finds the acoustic quality in the Azrieli design studio is poor. The participant complains that due to the noise disturbances it is difficult to do presentations. • The participant finds that the interior structure of the art gallery space is too long and tall, which echoes noises. 	The concerns about acoustic quality
P7 (MDes Student)	<ul style="list-style-type: none"> • The participant recommends providing soundproofing barriers in the rooms. The participant also notes that reevaluating the Azrieli studio to find gaps in soundproofing can help locate problem areas and how to address them. 	recommendations about acoustic quality
P8 (4th year)	<ul style="list-style-type: none"> • The participant does not find issues with the sound quality in the Azrieli Studio. • The participant finds that the Azrieli gallery has poor acoustic quality and space does not accommodate several people talking in the room as it echoes and can be very disruptive. 	The concerns about acoustic quality
P12 (Faculty Member)	<ul style="list-style-type: none"> • The participant finds the acoustic quality of the Azrieli studio to be poor due to the lack of soundproofing. The participant finds that industrial style of the roof does not allow for proper soundproofing insulation. • The participant notes that poor sound quality issues from the past may have been resolved due to compensating more space for students. The participant also notes that many students wear headphones to help them focus. 	The concerns about acoustic quality
P14 (MDes Student)	<ul style="list-style-type: none"> • The participant did not find any issues with the acoustic quality of the Azrieli studio and found his classes were not disrupted. • The participant mentions that the acoustic quality in the Azrieli studio is fine and they rather enjoyed the sound of other busy at work. 	The concerns about acoustic quality
P16 (MDes Student)	<ul style="list-style-type: none"> • The participant finds that the acoustic quality in the Azrieli studio poor due to the fact that it was difficult to communicate with other large groups around. • The participant finds that although the Azrieli gallery is beautiful, the acoustic quality and sound reverberation were poor and produced echoes. 	The concerns about acoustic quality

	<ul style="list-style-type: none"> • The participant finds that space is ideal for working but the poor sound quality would make working in this space very difficult. 	
P19 (Faculty Member)	<ul style="list-style-type: none"> • The participant finds the Azrieli gallery is a useful space outside of using it for meetings. The participant recommends using the space to archive students work and famous design pieces. • The participant finds that the majority of the acoustic issues in the building are with the Azrieli gallery and the middle space, and the noise levels were too disruptive in these areas for students to concentrate on work or on any presentations given. • He/she finds that the acoustic quality in the second-year room is fair, better than other areas. Due to the small size of the room and the small number of students occupying the space, the acoustics are satisfactory. 	The concerns about acoustic quality
P20 (Faculty Member)	<ul style="list-style-type: none"> • The participant finds that the acoustic quality of the Azrieli design studio was fair and doesn't believe it is a serious issue to address. The participant points out that sound reverberations were due to the concrete interior of the space. • The participant notes that the acoustic quality of the gallery is poor due to the absence of a ceiling and suggests soundproofing panels be installed to reduce the echoes and noise. • The participant notes that noise travels through the glass as glass walls that separate the studios in the Azrieli Studio. The participant points out that adding a layer of glass may reduce noise levels. 	The concerns about acoustic quality
P21 (Faculty Member)	<ul style="list-style-type: none"> • The participant finds the acoustic quality is fair in most spaces in the Azrieli studio beside the gallery and open space area. The participant points out that professional help is being used to address the issue in the gallery which will improve the noise quality. • The participant points out that the open space area in the Azrieli studio should be evaluated for sound quality and should resemble the other studios. 	Recommendation for acoustic quality

- The participant also points out the need for consideration of those with hearing impairments when designing spaces as such.

From Table 5 of data, some problem areas have been identified from the statements made by participants. Majority of the issues can be understood as poor acoustic quality cause disruptions in class and for others working. While some found these acoustic issues disruptive, there still remain a number of students who found no acoustic issues or disruptions. The list of problems consists of:

- A lack of soundproofing in the studios;
- Poor acoustic quality causing disruptions to the working environment;
- Echoing in the Gallery.

Participants 3, 4, 5 and 11 have commented on the poor acoustic quality in the Azrieli studios and some noted that it causes disruptions in their work, making their working environments difficult to focus in.

Participant 3 noted that the central collaboration space in the AP is prone to disturbances thereby affecting students from being able to work effectively and that the common space is not suitable for collaboration between students. It has been noted that due to the lack of soundproofing in the studios, lectures, loud conversations and music can be heard through walls and most people are affected by these noise levels such as Participant 1, 7 and 12 who have all noted the lack of soundproofing. Also, participant 8 makes the statement that they found the acoustic quality in the Azrieli studios fine; however, the acoustics in the Azrieli Gallery is very poor as space produces echoes. Participants 9, 16, 17 and 20 have made similar comments that the sound quality is so poor in the gallery that echoes can be distracting while presentations occur in this space.

The issues of the gallery are similar to the issues noted about the rest of the studio's structure. Participant 19 notes that because the gallery does not have a ceiling, it does not block sound effectively and prevent echoing. Participants 7, 10 and 20 have mentioned the structure of the building does not withstand noise well, thus resulting in poor acoustics. Participant 10 finds the exposed walls, concrete and glass in the Azrieli studio causes sound reverberate causing echoing. This causes issues between students trying to work, as often times people get frustrated with the noise while trying to work. The participant recommends acoustic diffusers which disperse sound inside a room or acoustic absorbers in the room.

This recommendation is similar to other recommendations given by Participants 5, 10 and 15 who suggests more soundproofing. Participant 21 points out that the open space area in the Azrieli studio should be evaluated for sound quality and should resemble the other studios. The participant also points out the need for consideration of those with hearing impairments when designing spaces as such. Participant 7 suggests providing soundproofing barriers in the rooms. The participant also notes that reevaluating the Azrieli studio to find gaps in soundproofing can help locate problem areas and how to address them.

4.1.4 Theme: Air and Ventilation Quality

This section presents the *air and ventilation quality* theme and the issues related to Air and Ventilation in Mackenzie and AP. Sub-themes are also highlighted within this section such as concerns about air quality and ventilation and recommendations for air quality.

Table 6: Ventilation and Air Quality analysis

Participant#	Problem Areas	Sub-themes
P2 (1st year)	<ul style="list-style-type: none"> The participant notes that the Mackenzie studio does tend to get dusty even though masks are worn in the space. The participant points out that the Mackenzie studio gets dusty based on the type of work being done in the room. It, therefore, gets dusty, but it does not affect the quality of air. 	The feel of air quality
P1 (2nd year)	<ul style="list-style-type: none"> The participant finds that the air ventilation in Azrieli general is good only when the windows are open; however, in a closed environment, the studio becomes dustier. 	The concerns about air quality
P5 (2nd year)	<ul style="list-style-type: none"> The participant finds that the air quality outside the Azrieli design studio has declined due to the increased number of people using the space and the types of materials being used. 	The concerns about air quality
P9 (2nd year)	<ul style="list-style-type: none"> The participant does not find issues with the air quality in the Azrieli Studio. 	The concerns about air quality
P10 (3rd year)	<ul style="list-style-type: none"> The participant finds that the air quality in the Azrieli design studio is fine except the area where the 3D printers are located (maker space). The participant finds it stuffy when there are too many people in the room and the fumes from the printers are not safe. The participant suggests more windows being opened in the 3D printer room in order to prevent the fumes from building up. 	The concerns about ventilation
P13 (3rd year)	<ul style="list-style-type: none"> The participant finds that the air quality in the Azrieli studio is satisfactory, as they have experience dealing with very poor air quality in the past. 	The concerns about air quality
P15 (3rd year)	<ul style="list-style-type: none"> The participant is satisfied that the air quality in the Azrieli studio except for the area where the 3D printers are located and the 4th year studio. The participant does not have enough experience in the gallery and Azrieli studio to comment on the air quality. The participant does find that often times studios can get stuffy when there are 20-30 people in the room. 	The concerns about air quality

P11 (4th year)	<ul style="list-style-type: none"> The participant finds that the ventilation in the Azrieli studio is satisfactory. The participant does mention they would like to be able to use windows or fans to add some air circulation. 	The concerns about ventilation
P17(4th year)	<ul style="list-style-type: none"> The participant finds that the ventilation in the 3D printer and computer rooms can get be poor due to the size of the room. The participant notes the room size does not accommodate several people at once and when the computers are in use the fumes can be bothersome. Better ventilation is also proposed for the fourth-year studio, however overall the Azrieli studio has satisfactory air quality. 	The concerns about ventilation
P18 (4th year)	<ul style="list-style-type: none"> The participant complains that the smaller Azrieli studios and the breakroom have no ventilation and thus becomes stuffy. The participant points out that they are unable to open windows due to the colder winter months and windows are hardly open due to winter temperatures. 	The concerns about ventilation
P18 (4 th year)	<ul style="list-style-type: none"> The participant mentions in order to help the air circulation in the Azrieli studios without compromising heated air is to install ventilation that circulated fresh air into the building. 	Recommendations for ventilation
P3 (MDes Student)	<ul style="list-style-type: none"> The participant notes that the Azrieli studio has poor air quality due to the fact that there is little to no air circulation. The participant points out they are unable to open windows, and this also prevents air circulation. The participant finds the air quality in the Azrieli studio is poor; thus, it may pose a concerning health risk to the students. 	The concerns about air quality
P4 (MDes Student)	<ul style="list-style-type: none"> The participant does not usually find any issues with the air quality of the Azrieli Studio. 	The concerns about air quality
P7 (MDes Student)	<ul style="list-style-type: none"> The participant is not satisfied with the air quality in the Azrieli Studio. The participant complains that the lack of fresh air makes the rooms uncomfortable especially when the room is crowded. 	Recommendation for air quality

P8 (4th year)	<ul style="list-style-type: none"> The participant finds the air quality in the Azrieli studio is fair. They believe sometimes odours and smells linger in certain rooms and so perhaps better ventilation in rooms may remedy this. The participant also finds that the inability to open windows hinders the quality of the air as well as student's performance. 	Recommendation for air quality
P12 (Faculty Member)	<ul style="list-style-type: none"> The participant finds the air quality in the Azrieli studio is satisfactory. The participant notes that students are cautious not to use toxic substances and mindful of their space. The participant is concerned about the 3D printer room air quality as the printers emit nanoparticles that are harmful to inhale; thus, large air cleaners were purchased for the room to remedy this. 	Recommendation for air quality
P14 (MDes Student)	<ul style="list-style-type: none"> The participant is satisfied with the air quality in the Azrieli Studio. The participant notes they may not have paid attention to the air quality, as they are too focused on their work. They mention that there is always room for improvement for air quality in the studio. The participant does not recall having any negative experiences with the quality of air in the Azrieli Studio. 	The concerns about air quality
P16 (MDes Student)	<ul style="list-style-type: none"> The participant is satisfied with the quality of air in the Azrieli Studio. 	The concerns about air quality
P19 (Faculty Member)	<ul style="list-style-type: none"> The participant finds that the air quality of the Azrieli studio is satisfactory. He/she believes it would be beneficial to have access to the windows to allow fresh air into the studio. The participant current does not find any issues with the air quality in the Azrieli Studio. He/she mention that in the future when all 3D printers are operating, ventilation should be addressed. 	The concerns about air quality

From Table 6 collection of data, there are many concerns that have been raised by the participants in terms of the air quality, and how it has affected their working environment. Majority of the participants find that there is a lack of ventilation in the Azrieli studios, many take issue with the inability to open windows in the space and many

have expressed concern over the fumes released in the fourth studio where the 3D printers are located. While some students noted they had no issues with the quality of air, they have expressed the space could get stuffy and opening windows would be beneficial. The problem areas identified for air quality are the inability to open windows, gas, and fumes released from 3D printers and stuffiness in the rooms due to overcrowding.

Participants 1 and 11 have both expressed no issues with air quality but would like to be able to open the windows in the studio to allow some air circulation.

Participants 15 and 18 have also commented on the stuffiness in the studio when there are several people working in the studios.

The importance of ventilation in the fourth-year studio has been mentioned by many participants due to the fact that it contains the 3D printers which emit harmful fumes into the small room. Participants 10, 12 and 17 have noted these concerns over those who remain in the room while the 3D printers are in use without adequate ventilation.

Another issue raised is the inability to open windows in the studio in order to circulate more fresh air into the studio and general spaces. Participants 3, 7, 8, 18 and 19 have all expressed concerns over not being able to open the windows of the studio. Participant 7 noted their discomfort in the studio especially when there were several people in the studio at once, due to the lack of fresh air circulating.

4.1.5 Theme: Maintenance and Waste Management

This section presents the *maintenance and waste management* theme and the issues related to Maintenance and Waste Management in Mackenzie and AP. Sub-themes are also highlighted within this section such as concerns regarding maintenance and waste management in addition to recommendations for waste management system.

Table 7: Maintenance and waste management analysis

Participant#	Problem Area	Sub-theme
P2 (First year)	<ul style="list-style-type: none"> The participant finds that there is an issue with cleanliness in the Mackenzie studio. The participant notes that it may be the responsibility of those using the space to keep it clean; however, it does not get maintained the way it should. 	The concerns about maintenance
P2 (First year)	<ul style="list-style-type: none"> The participant notes that there may be a lack of knowledge on the Mackenzie studios disposal system. The participant notes there is no clear direction on what students should do with their waste materials. The participant notes that students should be more educated on the disposal options in the Mackenzie studio in order to keep the space clean. 	The concerns about waste management
P1 (2nd year)	<ul style="list-style-type: none"> The participant notes that the Azrieli studio is regularly maintained and kept clean. The participant notes the use of clay makes it difficult to clean up so there needs to be a better solution to clean. 	The concerns about materials storage
P1 (2nd year)	<ul style="list-style-type: none"> The participant is glad about the building is maintained but argues for changes to include better waste disposal. The participant notes the need for distinguishing plastic and paper recycling bins accessible in the Azrieli general. The participant is supportive of the suggestion of sustainability campaigns on campus to help promote change within the environment. This includes the areas discussed such as reducing noise, cutting down on paper, reducing workload. 	The concerns about waste management
P5 (2nd year)	<ul style="list-style-type: none"> The participant finds that there needs to be better cleanliness in the Azrieli Studio. The participant notes that more student should be aware of their surroundings and cleaning up after themselves. 	The concerns about maintenance
P5 (2nd year)	<ul style="list-style-type: none"> The participant argues that that the Azrieli studio often gets messy with working materials. The participant finds that there are not enough recycling and disposal systems in the studio for the student to use. 	The concerns about waste management

	<ul style="list-style-type: none"> The participant mentions that a revised waste system should include safe disposal methods for materials like clay, cardboard and old projects. 	
P9 (2nd year)	<ul style="list-style-type: none"> The participant notes that the Azrieli studio can get dusty from time to time and as students work on different projects, new materials get introduced into space and new waste is produced. That always makes it difficult to maintain the studio. 	The concerns about maintenance
P10 (3rd year)	<ul style="list-style-type: none"> The participant finds that students using the Azrieli studio are often respectful of others and space. The participant notes that it becomes difficult to focus on cleaning effectively when people are focused on getting their project completed. This becomes more of an issue near the end of the year. The participant finds there is a lack of adequate disposal system in the Azrieli Studio. The participant notes there is no adequate education of the students in terms of what waste they should put in the recycle and the ones for garbage 	The concerns about waste management
P10 (3rd year)	<ul style="list-style-type: none"> The participant finds there is a lack of proper signage for disposal in the Azrieli studio, and this causes issues of misplaced waste. 	Recommendation for waste management
P13 (third year)	<ul style="list-style-type: none"> The participant notes that the Azrieli studios are not receiving proper maintained and is often very dirty by the end of the week. The participant comments that garbage is often left out and the studios become very dusty. 	The concerns about maintenance
P13 (third year)	<ul style="list-style-type: none"> The participant believes the Azrieli studios do not get cleaned by university maintenance and that the common space is the only space that gets cleaned. 	The concerns about maintenance
P13 (third year)	<ul style="list-style-type: none"> The participant suggests scheduling maintenance to clean the floors in the Azrieli studio monthly. The participant notes the lack of cleaning equipment in the studios, and therefore students cannot clean the rooms themselves either. 	Recommendation for maintenance
P15 (3rd year)	<ul style="list-style-type: none"> The participant notes that there may be ways to recycle their project waste more effectively. The participant suggests having space where students can essentially "donate" their waste materials that can still be used by others. 	The concerns about waste management

	Space can be cleaned out at the end of the year and developing a strategic recycling plan would assist with organizing this plan.	
P15 (3rd year)	<ul style="list-style-type: none"> The participant recommends implementing the waste donation plan in both the Azrieli studio and the Mackenzie studio. The participant mentions that all students can benefit from the materials that can be reused, instead of being left for garbage. 	Recommendation for maintenance
P11 (4th year)	<ul style="list-style-type: none"> The participant finds there are no issues with the maintenance of the Azrieli studios. The participant finds there is a mutual understanding between staff and students to not throw out materials and to be respectful not to leave large messes. The participant notes that there is a lack of maintenance for the 3D printers, as they are often out of maintenance. The participant notes that the lack of cleaning equipment in the Azrieli studio prevents students from cleaning their own messes. 	The concerns about maintenance
P17(4th year)	<ul style="list-style-type: none"> The participant finds it is the responsibility of the students who make their own messes to clean them as well. The participant finds the broom that appears from time to time is sufficient for students to use to clean the Azrieli Studio. The participant notes that the students attempted to start an organized recycling system in the Azrieli Studio. Once the students noticed the university maintenance was not recycling properly, the students followed. 	The concerns about waste management
P18 (4th year)	<ul style="list-style-type: none"> The participant finds that the maintenance of the Azrieli studios is not sufficient. The participant finds the bathrooms need more attention. The participant notes that the maintenance is limited in cleaning the space and it is ultimately up to the student to ensure the space is as clean as possible. 	The concerns about maintenance
P18 (4th year)	<ul style="list-style-type: none"> The participant finds there is a sufficient number of recycling bins in the Azrieli studios. The participant finds that there is confusion on which bins are used for what type of recycling in the Azrieli Studio. Signage with a clear 	The concerns about waste management

	division of recycling and garbage materials can remedy this issue.	
P3 (MDes Student)	<ul style="list-style-type: none"> The participant notes that the maintenance in the Azrieli studio is poor due to the fact that staff does not do much aside from replacing garbage bins. The participant finds there is no clarity on where garbage and recyclable waste should be disposed of properly. 	The concerns about maintenance, and waste management
P4 (MDes Student)	<ul style="list-style-type: none"> The participant finds that the Azrieli studio is well maintained. The participant finds that due to the nature of typical studios, space does not need constant maintenance, and if anything, it should be understood if the students accidentally mark or damage the tables. 	The concerns about maintenance
P6 (MDes Student)	<ul style="list-style-type: none"> The participant finds that overall the Azrieli studios are well maintained. The participant finds that there is no clear recycling system, and this adds to the issue of cleanliness. 	The concerns about maintenance and waste management
P6 (MDes Student)	<ul style="list-style-type: none"> The participant is concerned with the level of garbage that gets produced over the weekends when there is no maintenance in the Azrieli studio. 	The concerns about waste management
P8 (4th year)	<ul style="list-style-type: none"> The participant finds that the students using the Azrieli studio should be responsible for maintaining the space. Especially since maintenance cannot dispose of student's work. The participant recalls that the Mackenzie studio had more waste management issues, especially towards the end of the semesters when more students worked in the space and produced more waste. 	The concerns about waste management
P8 (4th year)	<ul style="list-style-type: none"> The participant finds the floor is not well kept in the Azrieli studio, due to a lack of cleaning supplies. The participant believes students are responsible for cleaning the workspace. The participant finds that students often do not dispose of garbage and recycling materials properly in the Azrieli studio. The participant believes it is due to some confusion around how to dispose of waste properly and how much one cares to follow the guidelines. 	The concerns about maintenance and waste management
P14 (MDes Student)	<ul style="list-style-type: none"> The participant finds that there is a need for more bins in the Azrieli studio for the student to dispose of their waste better. The participant suggests having a more organized space with 	The concerns about waste management

	recycled bins and reusable materials for other students to look through.	
P14 (MDes Student)	<ul style="list-style-type: none"> The participant finds that the open recycled material system would benefit the Azrieli Studio. The participant finds that some students can imagine their projects better when touching different materials and objects. 	The concerns about waste management
P16 (MDes Student)	<ul style="list-style-type: none"> The participant finds that without a sink area in the Azrieli studios, space can get messier than normal. The participant finds that the windows are also not kept clean. 	The concerns about maintenance
P19 (Faculty Member)	<ul style="list-style-type: none"> The participant notes that there is a sufficient number of bins in each of the Azrieli studios. The participant does note that students have a problem of leaving behind materials for others to dispose of, and students should take more responsibility for managing the cleanliness of the space. The participant finds there is a lack of storage space in the Azrieli studio for students to keep their projects which contributes to the mess. 	The concerns about waste management
P19 (Faculty Member)	<ul style="list-style-type: none"> The participant finds that there is a lack of proper waste disposal knowledge among the students using the Azrieli studios. The participant notes that if the students could watch a video on the matter and gain more knowledge on how to dispose of materials, especially toxic waste. The participant finds that there is a lack of cleaning supplies and products in the Azrieli studios. The participant notes that it's the responsibility of students using the studios to maintain them, but if the school maintenance is not cleaning, there is no motivation to upkeep the space. 	Recommendation for waste management
P20 (Faculty Member)	<ul style="list-style-type: none"> The participant finds that there is a clear message to all students that they are responsible for cleaning the Azrieli studios after use. The participant points out that students generally do keep the space clean and are respectful of the space. The participant finds the staff does clean the floors and keep the studios general clean. The only time messiness becomes an issue is when group projects occupy the space. 	The concerns about maintenance and waste management

- The participant finds that waste is not disposed of properly in the Azrieli studios, all waste gets dumped into the same bins. The participant notes the school does not undertake good recycling.

From Table 7, participants have identified problem areas concerning maintenance and waste management. Participants have expressed concerns over the ways in which the waste and recycling materials are handled in the Azrieli studio and have suggested ways they find are helpful in dealing with the issues. The problem areas that have been identified are as follows:

- Issues with managing waste appropriately;
- Issues with university staff and their level of maintenance;
- Students not taking enough responsibility in maintaining workspace;
- Students do not have access to cleaning supplies to maintain space;
- And, other issues with the maintenance of the overall studio.

Participants 2, 3, 5, 6, 8, 10 and 14 have all made a similar argument that the Azrieli studio has poor waste management. These participants have noted the lack of clarity on organizing recycling and waste materials, the difficulty of knowing what is waste and now being used by students and what still is being used, and the last being more attention from the maintenance, especially on weekends and to assist in organizing the waste. Participants 2, 8 and 15, have mentioned that students would benefit greatly from receiving more information on waste and recycling management. This would not only educate students, but reduce the amount of waste produced, and help keep the space clean and organized. Participants 2 and 10 mentioned that the materials often used in the studio by students are not common materials that they know how to dispose of. Items such as blue foam and wood

dust can be more difficult to know how to dispose of, and thus they find that it would be helpful to have access to information on how to dispose of such materials.

Participant 14 mentioned that with a better recycling management system, students would reduce the number of reusable materials that are thrown out when they can be used by other students. Participant 10 suggested the use of signage around the studio would help organize the waste and help students know how to manage their own waste.

When it comes to students taking the responsibility of maintaining the studio themselves, many participants noted that they believe it is mostly the responsibility of students who have left materials and waste out, to clean after themselves. Participants 5, 8, 11, 13, 17 and 18 have expressed the concern that students need to take more initiative in maintaining the space. Participant 17 notes that the students attempted to start an organized recycling system in the Azrieli Studio. Once the students noticed the university maintenance was not recycling properly, the students stopped caring and thus the issue they have now with poor waste management. Participant 13 noted that if the students had more consistent access to cleaning supplies, such as a broom, cleaning sprays, etc., then the students may feel more obligated to clean the space more often.

Other issues raised by the participants concern various areas of the studio that they find do not receive enough attention from maintenance. Participant 9 noted how dusty the studio gets based on the type of projects being worked on. Participant 13 notes that the university cleaning staff mostly clean the common area since the staff refrain from throwing out the student's materials/projects. Participant 16 notes they would like to have access to a sink to help keep the space clean and has noticed that the windows are often unclean.

4.1.6 Theme: Materials Storage

This section presents the *materials storage* theme and the issues related to this on the fourth floor in AP. Sub-themes are also highlighted within this section such as concerns regarding materials storage in addition to recommendations for materials storage.

Table 8: Materials storage analysis

Participant#	Problem Areas	Sub-themes
P2 (First year)	<ul style="list-style-type: none"> • The participant finds that there is a shortage of storage space for students in the Mackenzie studio. The participant finds that students often leave unused materials out, leading to overcrowding and messes. • The participant finds that there is the lack of storage in the Mackenzie studio makes it difficult for students who are not able to bring their projects home, they run the risk of having their work damaged if left in the studio. • The participant notes that the large table space in the Mackenzie studio does not get used properly and is often used by students to pile their materials. 	The concerns about materials storage
P1 (2nd year)	<ul style="list-style-type: none"> • The participant found there is a lack of storage space to keep the room tidy, with a lack of waste and recycling disposal services in the Azrieli Studio. He/she notes that there is a need for more storage capacity to avoid overcrowding of materials and messes. • The participant notes that there is a lack of enough materials storage space in the Azrieli studios. The participant notes they carry more safety equipment such as respirator aprons but does not have the space to store them. 	The quality of the materials storage
P1 (2nd year)	<ul style="list-style-type: none"> • The participant suggests a more creative approach to storage space in the AP. There are much space-saving storage solutions that space can accommodate and would be very helpful. He/she notes that the use of knobs to hang items is an example of good storage solutions. 	Recommendation for materials storage

	<ul style="list-style-type: none"> The participant notes that there is a lack of enough storage space in the AP. He/she finds that the bins are not enough to hold materials and projects, and so many run the risk of leaving out projects which may get damaged or stolen. 	
P5 (2nd year)	<ul style="list-style-type: none"> The participant mentions that the Azrieli studio provides students with locked drawers in which they can store their materials. He/she usually works at home, and only leaves materials in storage when they are working on larger projects. The participant notes that there are times students leave projects in the Azrieli studio due to the lack of space that is specifically assigned for projects rather than daily storage. When projects are left out, they are subjected to being moved and or damaged. 	The concerns about materials storage
P5 (2nd year)	<ul style="list-style-type: none"> The participant recommends an easier method to have access to locked storage such as individual lockers. He/she suggests a space for common materials that is more organized and accessible to everyone. Having more organized storage makes space look less messy and less dangerous then if materials are left out. 	Recommendation for materials storage
P9 (2nd year)	<ul style="list-style-type: none"> The participant finds that the Azrieli studio does not have a designated space for materials storage. He/she would like to see more space for flat stock, as they are currently being placed on top of the shops and this leads to blocking light sensors. The participant notes there is not enough space for flat materials, cardboard, foam and card stock. The participant does not feel their belongings were safely secured in the locked cabinets provided in the Azrieli Studio. 	The concerns about materials storage
P9 (2nd year)	<ul style="list-style-type: none"> The participant finds it would be helpful to have more storage bins in the Azrieli Studio. He/she notes that there is a lack of space for projects as well. 	Recommendation for materials storage

P10 (3rd year)	<ul style="list-style-type: none"> The participant finds there is not enough space in the Azrieli studio to store day to day materials. He/she found that the storage assigned to them was not enough and had to find an alternative space to keep their materials. 	The concerns about materials storage
P13 (third year)	<ul style="list-style-type: none"> The participant points out that students would leave their projects in the Azrieli studio, which he/she found this to be an issue. The participant believes that students are utilizing storage bins effectively. 	The concerns about materials storage
P13 (third year)	<ul style="list-style-type: none"> The participant notes that in order to avoid clutter in the Azrieli studio, a second storage room would be helpful. He/she notes that students who used storage bins often left them out which took up working space in the studio 	Recommendation for materials storage
P15 (3rd year)	<ul style="list-style-type: none"> The participant mentions issues of storage for projects in the Azrieli Studio. The participant finds that this leads to overcrowding of projects and materials in the workspace. He/she suggests having more personal space for projects and materials. 	The concerns about materials storage
P11 (fourth year)	<ul style="list-style-type: none"> The participant finds that there is enough storage space for students in the Azrieli studio and finds that students do not maintain the space as often as they should. The participant finds they tend to bring home more and more materials each year. The participant finds that having yearlong storage for tools in the Azrieli studio can give students access to tools all year and would be helpful to have available. 	The concerns about materials storage
P17(4th year)	<ul style="list-style-type: none"> The participant finds that the Azrieli studio had enough storage space, although they did not have to share a working space with other students. 	The concerns about materials storage
P18 (4th year)	<ul style="list-style-type: none"> The participant points out that there is enough storage in the Azrieli studio, as they kept most of their items in bins provided. 	The concerns about materials storage
P3 (MDes Student)	<ul style="list-style-type: none"> The participant finds that there is a lack of organization of material stored in the Azrieli Studio. He/she notes that there are materials left behind from previous students, therefore 	The concerns about materials storage

	<p>it is enforced that students take home their materials.</p> <ul style="list-style-type: none"> • The participant finds that without a clear indication of what materials belong to who and where it is not clear what can be disposed of. He/she finds it useful to have individual storage space and is unsure of the process for the existing system. • The participant finds that there is not enough material waste storage in the Azrieli Studio. He/she found it was difficult to dispose of larger projects. 	
P4 (MDes Student)	<ul style="list-style-type: none"> • The participant found there was no space for them to store their materials in the Azrieli Studio. He/she also finds a lack of enough garbage space compared to recycling space. • The participant finds there are enough recycling bins in the Azrieli Studio. 	The concerns about materials storage
P6 (MDes Student)	<ul style="list-style-type: none"> • The participant notes there was a lack of materials in the Azrieli studio that students could use. He/she finds that when students bring their own materials and are shared, there is a sense of community that derives. • The participant finds that there is a lack of reusable materials in the Azrieli studio or space for reusable materials can exist and be shared with all students. 	The concerns about materials storage
P7 (MDes Student)	<ul style="list-style-type: none"> • The participant notes there is a lack of storage in the Azrieli studio since it is mainly a research studio and not a design studio. Participant finds that there is not a high demand for materials. He/she points out these materials are only needed for projects that are assigned once annually. • The participant finds that there is limited storage in the Azrieli Studio. He/she points out that often times there is limited workspace due to overcrowding of personal belongings and projects. More storage opportunities for students to store personal belongings to make the space more inviting. 	The concerns about materials storage
P8 (4th year)	<ul style="list-style-type: none"> • The participant finds that they personally had enough materials storage space in the Azrieli Studio. He/she notes this may not have been the case for students with larger 	The concerns about materials storage

	<p>assignments and did not find enough space for all their materials. He/she notes this caused overcrowding in the studio and became difficult to work in.</p> <ul style="list-style-type: none"> • He/she has not made use of the big storage area in the Azrieli studio because of the nature of the work they do. • He/she finds that the large storage space is not secure even though space is locked. Space is insecure because all students have to the keys. 	
P12 (Faculty Member)	<ul style="list-style-type: none"> • The participant notes that the disposal of materials, models, and stuff is still a challenge in the Azrieli Studio. He/she notes students should be more proactive in disposing of their projects as the school tries to reclaim more outdoor bin space. 	The concerns about materials storage
P14 (MDes Student)	<ul style="list-style-type: none"> • The participant did not use the materials storage or felt the need to lock their materials. He/she comments that materials do sometimes get misplaced or damaged and individual cubby spaces may remedy this. • The participant finds that individual cubbies with personal locks may be an easy storage solution. 	The concerns about materials storage
P16 (MDes Student)	<ul style="list-style-type: none"> • The participant notes that they did not use the storage bins provided in the Azrieli Studio. He/she found when projects were too large for them to take home, finding space to fit the larger assignment was difficult. • The participant finds that the use of locks on the storage spaces in the Azrieli studio is problematic. 	The concerns about materials storage
P19 (Faculty Member)	<ul style="list-style-type: none"> • The participant notes there is materials storage in the Azrieli studio, but it, however, may not be enough space for all students. He/she notes it may be useful to have more cabinet space for everyday use materials. • The participant cannot suggest any long-term storage solutions for the Azrieli Studio. He/she comments that the studio lacks the capacity to offer more space for storage options. 	The concerns about materials storage

<p>P20 (Faculty Member)</p>	<ul style="list-style-type: none"> • The participant notes that there is limited storage space for students in the Azrieli Studio. He/she notes that the current space seems to not be a problem and students are encouraged to take home unused materials/projects otherwise space can be overcrowded. • The participant does not find there are any issues with the existing storage system in the Azrieli studio, besides when the bins cannot accommodate larger projects. • He/she has no comments about the storage bin, as they note large projects once complete to be taken away from Studio A on Mondays as they don't fit anyway for storage. • He/she raises concerns regarding logistics due to sections of teaching and project work. Where projects are larger, they won't fit in the bins available. There needs to be collaborative working to ensure that these logistics are resolved in the future. 	<p>the concerns for materials storage</p>
<p>P21 (F. Member)</p>	<ul style="list-style-type: none"> • The participant finds that the Azrieli studio has the natural environment of any studio, as studios often get crowded with the number of assignments. He/she notes that improvements can be made in the future where students take more initiative to clean the space independent of university staff. • The participant finds that the disposal bins do not accommodate the level of activity conducted in the Azrieli Studio. • The participant finds that there is a confusing waste disposal system within the Azrieli studio and Mackenzie studio. He/she finds that there are no clear guidelines for the waste organization in the school, which adds to the problem of students disposing of material/projects. 	<p>Recommendation for materials storage</p>

From the collected data, there are several problems area identified that may shape our understanding of the usefulness of the storage space provided to students in the Azrieli

Studio. The problem areas identified by the participants can be categorized into two main areas, first, there being a lack of storage options in various forms and sizes to accommodate the various projects and materials that students use. The second major problem area is the overcrowding that occurs when students leave materials and projects around the studio as the result of an insufficient waste disposal system.

To explore the first problem area, it is evident in statements from Participant 7, who suggests more creative storage options for students to hang coats, bags and other items that can be stored away more efficiently. Participant 14 makes a similar comment suggesting personal cubbies for all students. These small storage ideas can address issues raised about keeping the studio tidy and organized from Participant 1, 5 and 2. Participants 7 and 8, complained about overcrowding in the studio due to the lack of storage for materials.

Among the participants, there is the common suggestion of providing a more general space for storage to remedy the overcrowded and unorganized studio space. Participants 9, 10, 11 and 19 have mentioned a general space for the day to day materials would be helpful in organizing the tools and materials and having them accessible to all students. Participant 6 mentions that they often do not have access to some materials that can be reused and comments that having space for students to dispose of their reusable materials can also help keep the studio clean.

The lack of storage is commented on by Participant 7 who suggests that the Azrieli studio does not accommodate more storage options due to the fact that the nature of the studio is more for research rather than design, much like the Mackenzie studio that does have larger storage space. Participant 19 also comments on the space of the Azrieli studio as not being having the capacity to offer more storage options for students.

4.1.7 Theme: Sense of Space

This section presents the *sense of space* theme and the issues related to Sense of space in Mackenzie and Azrieli Design studios. Sub-themes are also highlighted within this section such as concerns regarding the sense of space, in addition to recommendations to improve the sense of space.

Table 9: Sense of space analysis

Participant#	Problem Areas	Sub-themes
P2 (First year)	<ul style="list-style-type: none"> • The participant notes that there is a sense of personal space in the Mackenzie studio because students can make the space theirs. • He/she notes that this was done by bringing in own couch, and foodstuffs which makes the space more comfortable for the students to be able to bring what they like to space. • The participant mentions that the workshop's sense of space is less due to air quality, but he feels they are allowed to customize the place, yet it is not as comfortable as the studio. 	The concerns about sense of space
P1 (2nd year)	<ul style="list-style-type: none"> • The participant doesn't agree that changing the room to develop more space is easy. He/she would much prefer everyone worked together to make space such as moving chairs and tables and moving things around together to create better space. • The participant mentions that there are no whiteboards to display the work that has been completed or is being worked on so other students are aware of the work being carried out. The lack of space is due to most of the room being covered by windows. • The participant notes the lack of space on the whiteboard as space gets taken up quickly because the whiteboard space needs to be shared. Cannot keep anything on display for extended periods. • The participant states that there is a lack of 	The concerns about sense of space

	<p>a social environment on the fourth floor. Recommends social gatherings or events such as movies. Nobody knows each other personally and is more of a working relationship that everyone seems comfortable with.</p>	
P5 (2nd year)	<ul style="list-style-type: none"> • The participant notes that 2nd-year studio is shared by both undergraduate and MDes students. • The participant notes that he/she needs a dedicated space, but this isn't available. • The participant mentions that moving of furniture in the studio increases the chances of breakage or damages to the materials such as chairs and tables. 	The concerns and recommendations about sense of space and
P10 (3rd year)	<ul style="list-style-type: none"> • The desks in the studios are rigid and cannot be easily moved • The participant notes that there is not the proper orientation in terms of how to use the spaces like the student progress in the studies. 	The concerns about sense of space
P13 (third year)	<ul style="list-style-type: none"> • The participant is comfortable with own space and surrounding. The participant feels comfortable in leaving some of his unused belongings to other people. The participant feels he/she is comfortable during communication with other people in the space. • The participant notes that tables built to promote design. Belongings are usually moved around when presentations or events occur. 	The concerns about sense of space
P15 (3rd year)	<ul style="list-style-type: none"> • The participant notes that better interaction requested for all student years. Chairs are not as strong and need strength to stay in its place in case they are fallen back on. • The participant states that there is a good area of learning for younger people, and they can be social with older people e.g. advice on designs and ideas. Overall, the AP space is acceptable. 	Recommendations about sense of space
P11 (4th year)	<ul style="list-style-type: none"> • The participant mentions that there are a lot of students using the space at the same time, hence some students do not feel the sense of own space. 	The concerns about sense of space

	<ul style="list-style-type: none"> • The gallery has been neglected because students do not prefer to go there. 	
P17(4th year)	<ul style="list-style-type: none"> • The participant notes that he is comfortable with space in the fourth-year studio. He/she feels relaxed and works at a comfortable desk. Workspace feels like a home space or a second home. • He/she recommends keeping the space with this comfort level which would encourage students to spend more time. 	Recommendations about sense of space
P4 (MDes Student)	<ul style="list-style-type: none"> • The participant mentions that he/she is not provided with personal space at the institution hence cannot do her/his work properly • The participant notes that past students left stuff in the spaces; therefore, there are not enough spaces. Having unclear name tags and sometimes duplicate names in the storage spaces bring some sort of confusion. 	The concerns about sense of space
P6 (MDes Student)	<ul style="list-style-type: none"> • The participant notes that unless you are allocated your own space, it is difficult to reconfigure the shared space into customized space to fit your needs • The participant states that bringing in a coffee machine may not be an ideal idea for a learning environment. Besides other students may want to bring their own machines making the space congested. • The participant mentions that unused stuff left behind by other students makes the space to look congested, hence limiting her/his work. 	The concerns and recommendations about sense of space
P7 (MDes Student)	<ul style="list-style-type: none"> • The participant finds that architectural studies require a lot of space, as it involves more drawings and design, which is not available in the studio. 	The concerns about sense of space
P8 (4th year)	<ul style="list-style-type: none"> • The participant notes that sharing of the studio among many students makes it uncomfortable and does not feel like own space. 	The concerns about sense of space

<p>P12 (Faculty Member)</p>	<ul style="list-style-type: none"> • The participant finds that there are accessibility problems to the learning spaces and studio owing to the improper key policies governing access to the rooms. • The participant notes that the studio for second and third-year students is small, hence the students may not have the chance to make sense of the space. 	<p>The concerns about sense of space</p>
<p>P16 (MDes Student)</p>	<ul style="list-style-type: none"> • The participant mentions that frequency determines ownership of space. Everyone has their own space temporarily when occupied. • The participant believes that people should have a dedicated space when working. He/she would prefer a space to work with and leave materials to come back to. 	<p>The concerns and recommendations about sense of space</p>
<p>P21 (Faculty Member)</p>	<ul style="list-style-type: none"> • The participant notes that space is much better, but issues persist with the way building was built. Space and the way it was built was inherited and accepted. • The interior design built to work for all but is much better compared to previous rooms. It provides an advantage of better communication between MDes and undergraduate students. With these changes, it has promoted a better sense of community with more collaborators coming in, and it has presented the opportunity to show what we have. 	<p>The concerns and recommendations about sense of space</p>

From Table 9, while the participants have identified problem areas concerning a lack of a social environment (Participant 1 and 11). This was noted in some spaces where students were not interacting, but with spaces where students from different levels (grad/undergrad) were allowed to interact like workshops, this issue was resolved. Participants note that architectural studies require a lot of space as it involves more drawings and design (Participant 7 and 8), this depends on the nature of the room, some studios require more organization than others depending on the materials and projects worked on, this was only witnessed where rooms were smaller in size relative to number

of students and had the cumbersome feeling especially when instructors teach more than one class.

There was a contrast about sharing spaces and feeling sense of space. Some participants (Participant 8 for example) felt that sharing spaces felt invasive, while others (Participant 5 for example) felt like sharing space was more collaborative that way but too flexible for personal work. There were issues with policies and enforcing them, Participant 12 and Participant 9, for example, feels that more policies that should be in place for moving furniture and for how rooms are used, and the setting is utilized.

4.2 Field notes Analysis; Fourth Floor in AP

Through the analysis of the field-notes, key findings were established in relation to the themes developed in the literature review. First, the field-notes analysis was used to analyze the photos taken through the observation method and then it was used to acquire key data established within the photos. The photos have been analyzed based on the date they were collected, showing a timeline process of the Azrieli Pavilion studio and spaces transformation over the last 2 years started in summer term 2018 until winter term 2019 in relation to the key themes (figure 14, 15 and 16).

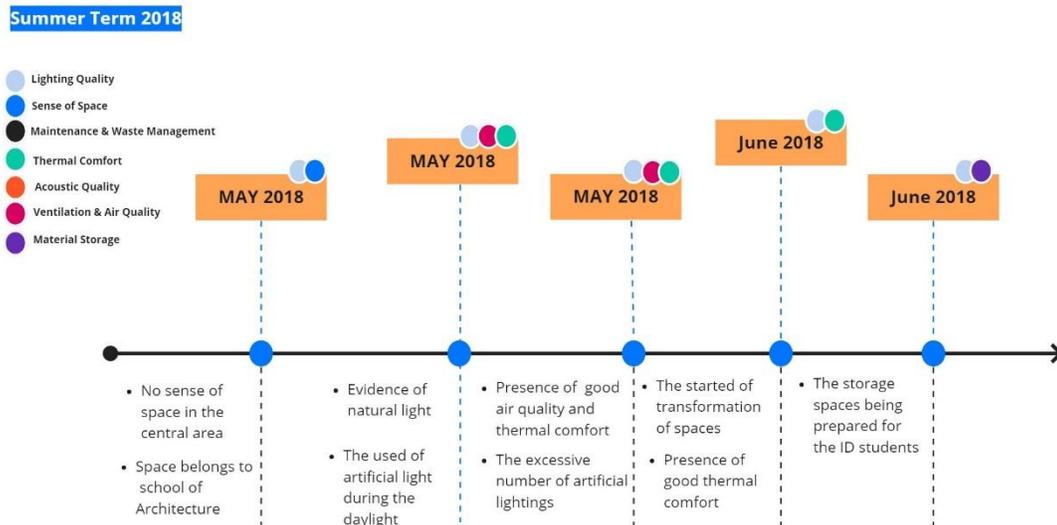


Figure 14: Summer term 2018 AP studios described by field notes along with the timeframe.

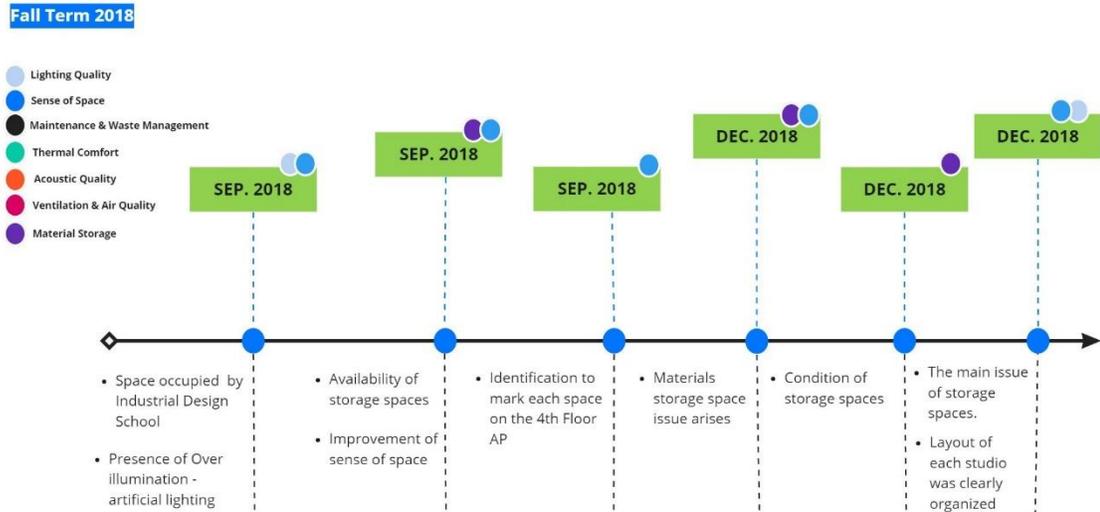


Figure 15: Fall term 2018 AP studios described by field notes along with the timeframe.

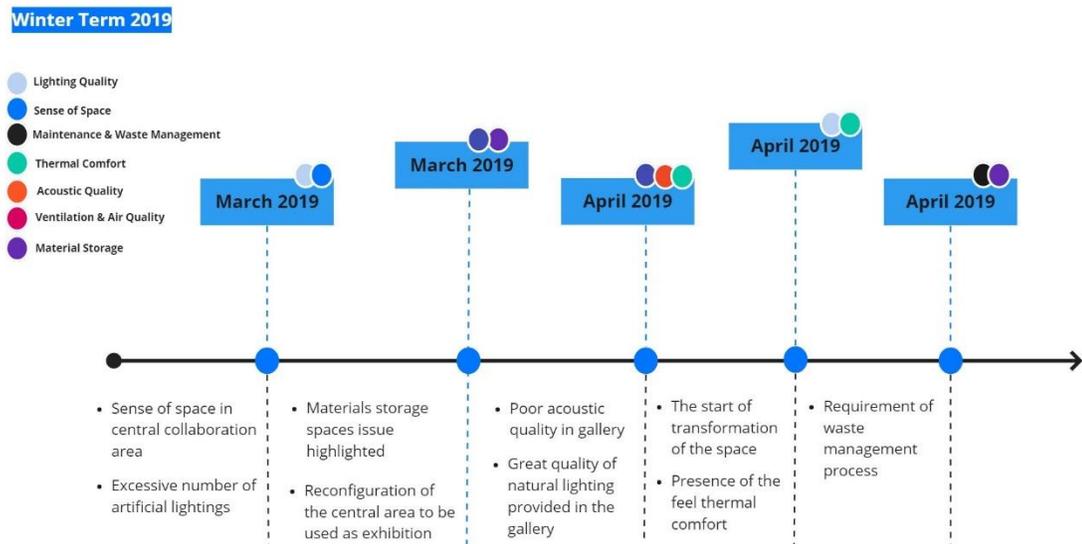


Figure 16: Winter term 2019 AP studios described by field notes along with the timeframe.

4.2.1 Field notes for summer term 2018



Figure 17: Azrieli Pavilion Space in May 2018.

Prior to the 4th floor of Azrieli Pavilion becoming part of the Industrial Design department, it was acquired by the Azrieli School of Architecture and Urbanism (Figure 17). As the school shifted, the first studio to transfer to Azrieli Pavilion was the MDes studio. During that period, there was no sense of space in the central space, corridors and most of the rooms, as they were empty. There was a sense of space to the MDes studio because it was occupied by the MDes students for completing their studies.



Figure 18: Corridor Space – Central Collaboration Space in Azrieli Pavilion May 2018.

Although the spaces were empty, there was ample evidence of natural light through the glazing windows (Figure 18). The artificial lightings were continuously turned on which should be changed to motion sensors, as it results in waste of energy which directly impacts the environment. There were good air and thermal comfort during the periods.



Figure 19: 4th year Studio Space May 2018.

The studio spaces are seen as large in term of size to accommodate a large number of students (Figure 19). Each studio space has a good amount of glazing windows to provide great about natural lighting and at the same time, there is a presence of large artificial lightings to provide light during the evening hours. There was a sense of good air and thermal comfort provided within these spaces.



Figure 20: Azrieli Pavilion, central collaboration space in June 2018.

The transformation of spaces started in the month of June, as it was established that spaces were to be developed as design studios for second, third- and fourth-year ID students (Figure 20). As the furniture and appliances were shifted in the central space of the 4th floor, the sense of space became very congested. As the summer was approaching, thermal comfort was set according to the temperature as well.



Figure 21: Storage space in June 2018.

As shown in Figure 21, the storage spaces were also being prepared for the ID students. There was sufficient lighting present in the storage spaces and simultaneously, the storage spaces felt large enough to accommodate many of the students' work.

4.2.2 Field notes for fall term 2018



Figure 22: Central collaboration space in September 2018.

As the fall semester started, the spaces were all transformed into working studios. The central collaboration space as shown in Figure 22 was the central studio dedicated to all ID students. It was furnished with work tables, chairs, drawing boards and as well as electricity plugs. There was good artificial lighting provided, but the main issue was that these lightings do not have motion sensor and stayed on 24/7. The students were more comfortable with the space as students were fully engaged in and occupying the studio spaces. However, at times colder temperatures as feeling mainly in the central collaboration space as there are no glazing windows to be utilized. As for the studios, having large glazing windows provided great natural lighting but were not operable for opening and closing.



Figure 23: Collaboration space in September 2018.

The studio spaces and the central collaboration space were provided with cabinets and drawers for the storage (Figure 23). Additional storage was also provided, which were highlighted in June 2018 stage. The studio storages felt limited, as they were of small size which could not accommodate all of the student's work, accessories, and materials. There was a good sense of space overall, as the layouts of the studios were well arranged.

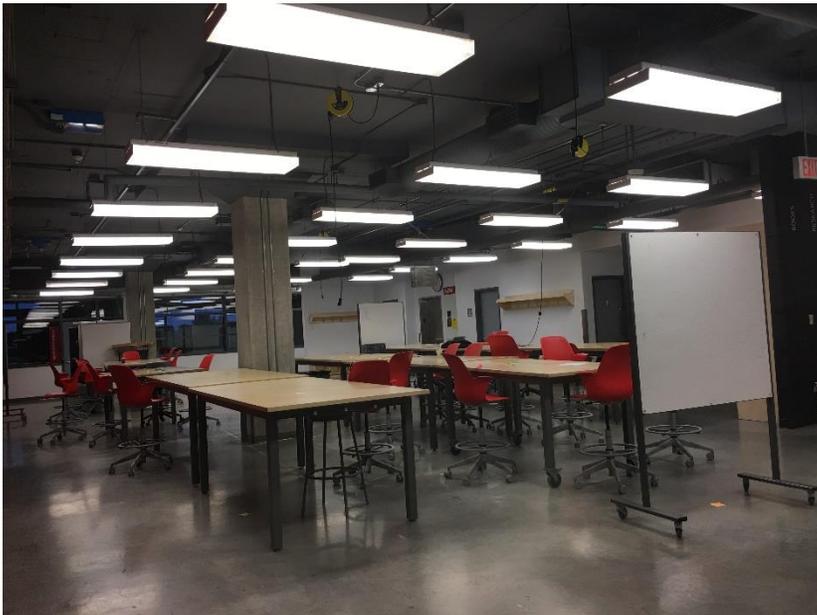


Figure 24: Central collaboration space in September 2018.

Each studio space and shared environment spaces was clearly marked to provide identification of the purpose of the room (i.e label of storage outside the storage space). This further supported the sense of spaces, as well as it allowed the students to be aware of the spaces around them (Figure 24).



Figure 25: Studio space in December 2018.

Deep in the semester, it was noted that there were a lot of materials and equipment laying around the studio spaces. That was due to the lack of proper storage systems provided to the students. The students were unable to store large materials in the cubies or drawers as they were not large enough. Thus, students started placing them around the studio spaces which resulted in congestion of spaces, and as a result students were having difficulties to move around (Figure 25).



Figure 26: Storage space in December 2018.

The above Figure 26 highlights the condition of the storage spaces. It is evident that the storage cubbies provided to students are small in size. This led to the students storing large materials and equipment around the studio space, which directly resulted in misrepresentation in relation to the sense of space.



Figure 27: Studio space in December 2018.

The lack of storage spaces was the main issue in the studio spaces. It was also noted that the artificial lighting systems of the studio spaces were set to motion sensors as compared to the lighting of the central studio space. It was also noted that the blinds were installed on the glazing windows to give the students the flexibility of covering the windows if natural lighting became disturbing. Lastly, the layout of each studio was clearly organized to allow for free movement around the studios. All of these aspects added to the overall sense of space for the studios (Figure 27).

4.2.3 Field notes winter term 2019



Figure 28: Central collaboration space for presentation in March 2019.

The central collaboration studio space also provides great flexibility to the School of Industrial Design overall. The central studio space works as a studio for students, but this has also been utilized as a presentation and exhibition hall (Figure 28). This is due to the provision of great light quality, acoustics quality and thermal comfort of the space. At times, lighting has been considered an issue in the collaboration space, as all the artificial lights are connected to a single switch, and there is no flexibility of turning certain lights. Apart from that issue, the central collaboration space provides a great sense of space to the ID and MDes programs.

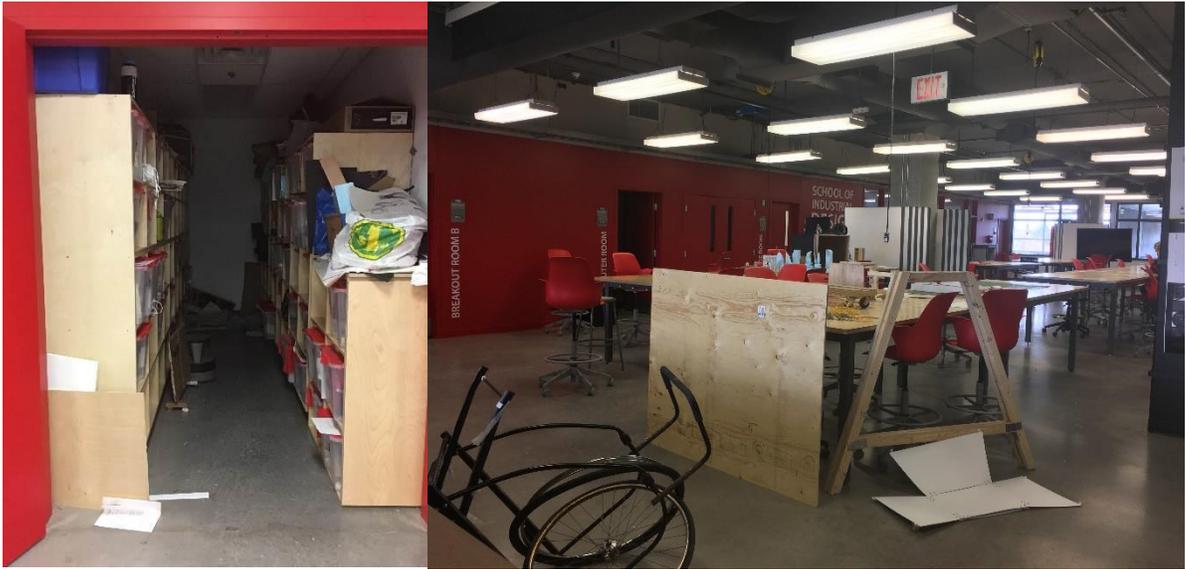


Figure 29: Storage space in March 2019.

Figure 29 further highlights the issues of the storage spaces. Over the school semesters, as the students continuously work on their projects, the storage spaces become over-crowded and congested with their materials, on-going models and related equipment. Additional storage spaces should be provided, and larger storage spaces should be utilized.



Figure 30: Central collaboration space for exhibition in April 2019.

As highlighted in the March 2019 phase, the central collaboration space provided flexibility to be utilized for various purposes (Figure 30).. In April 2019, the central collaboration space was used as the Industrial Design student's final year exhibition. As the central collaboration space has good lighting, acoustic and atmosphere, it acted as the ideal space to be used for the exhibition.



Figure 31: Gallery during the year –end exhibition in April 2019.

The 4th floor of Azrieli Pavilion also provides a gallery space to be used for the exhibitions and presentations (Figure 31). However, the main issue that exists in the gallery space is the acoustic problem. Due to high ceilings, there is an ample amount of echo in the space. The sound quality becomes distorted, and it becomes difficult to hear the speaker. As of currently, the space is only being utilized as the exhibition space, but in order to be used as presentation space, the acoustic needs to be thoroughly investigated. This can be done by installing sound-absorbing materials in the walls, adding carpet to the flooring, install acoustic panels, cover the windows and as well as furniture in the space. Despite the issue of acoustic quality, the gallery space provides good quality of natural lighting and ventilation.



Figure 32: 4th year design studio during final project in April 2019.

During different stages of students' project, it was noted that there was a constant presence of waste of materials and equipment. The studio spaces and central collaboration space should contain large bins, so the students are able to sort them in order to support recycling and reusing rather than throwing those away.

4.3 Statistical Analysis; Energy Consumption

Analyzing energy consumption of Azrieli building over a year (Jun 2018 – Jun 2019) shows a steadily increasing rate. From the consumption chart below, we can depict the consumption of the month of February is much higher (almost twice as much) compared to other months (Figure 33).

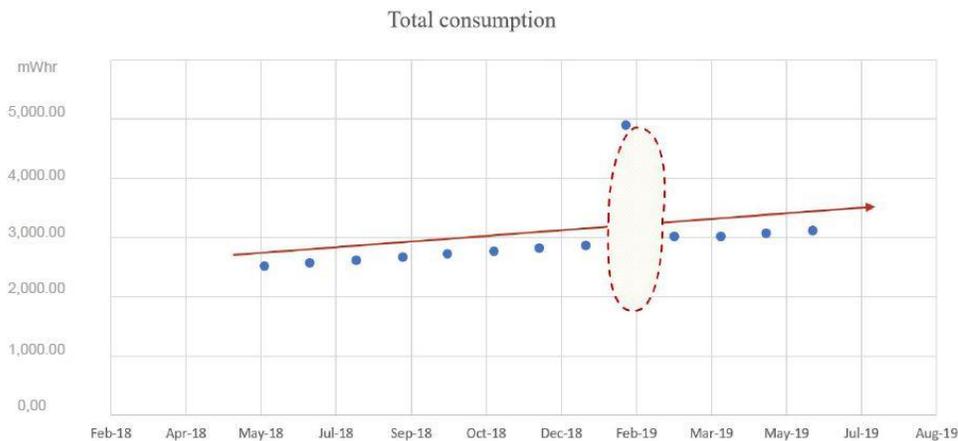


Figure 33: Monthly consumption for Azrieli building (May 2018 until June 2019).

Based on the interviews conducted, it was found out that the students bring portable heaters during the month of February because it is unbearably cold that month. It proves that the insulations aren't good and need to be improved in order to reduce energy waste. Also, the chart shows a slight difference in energy consumption daily or even monthly rates. There wasn't an expectation of much differences in the energy consumptions over the year due to many factors:

- Outside temperatures: Heating and cooling use high electricity consumption, the Canadian weather has extreme weather. The colder outside temperature simply means more heating is required and in turn higher electricity consumption. Similarly, hotter summer days mean more cooling is required and higher electricity

consumption in turn. Utility companies actually increase their rates when the temperatures drop dramatically.

- The number of students inside the building: The room temperature gets warmer as the number of students increases; however, it depends on the student behaviour as well. It means less heating is required in winter during the daytime and more heating is required in the evening and overnight.
- Types of lighting, heating, cooling systems, etc.: Fluorescent lights and older heating and cooling systems are energy inefficient. On the other hand, LED lights consume much less electricity and the same for energy-efficient systems.

Commercial Hydro customers (high electricity consumption level) are being charged variable rates according to the hourly market prices per kilowatt-hour, that make hydro bills for those customers are unpredictable. At night the rates are lower than daily rates due to the nature of lower demand in the evening and overnight compared to daytime hours. Commercial businesses represent the majority of energy consumption everywhere; therefore, the demand of energy reaches its maximum level during the daytime and its minimum overnight.

After analyzing the hourly electricity consumption of AP building and observing the lighting, heating and cooling systems, below some of the solutions are presented to reduce the energy consumption and the hydro bills without any compromise. In order to reduce the hydro bills, it required to:

- reduce the actual energy consumption by switching to new technologies (such as LED lights, room temperature, and lighting sensors and replace the older system with energy-efficient ones);
- change the energy consumption behaviour, by minimizing the usage during high demand (where the prices per kilowatt-hour are high) and;
- maximize the usage during the low demand (where the prices per kilowatt-hour are the lowest). Such as behavioural change can happen by storing energy in batteries overnight (lower demand and lower prices), then the stored energy in these batteries becomes the new source of electricity to provide the required energy needs during daytime (high demand and higher prices).

Chapter 5: Discussion and Conclusion

5.1 Overall Findings; Sustainable Interior Design Themes

These research study findings could be considered when renovating and constructing a design studio to integrate sustainable design features in order to enhance the Indoor Environmental Quality (IEQ). While, LEED green building certification aims to address sustainability issues based on the specific standards, such as material, construction, and maintenance, the WELL Building Standard™ (WELL™) focuses on the elements affecting occupant comfort and health. LEED does not incorporate the guidelines that put forward health and wellness, nourishment, fitness and comfort. New standards that have been established within the context of WELL can be beneficial for future research in learning environments (Appendix G, H, I).

This chapter summarizes the research findings in terms of developing directions and guidelines based on the interview and design research process results, as highlighted below.

5.1.1 Theme: Thermal comfort –Insights

The feel of *thermal comfort* insights as follow:

- The entire AP building lacks sufficient insulation; thus, many found that the Azrieli design studio, the Mackenzie design studio and the fourth floor in AP were often too cold to work in or there was the need for additional clothing (e.g. sweaters, gloves, coats, etc.).
- There was a reliance on the sun for heating the building, and thus problem areas arise during the evening and cloudy days and different weather conditions.

- The fourth floor is found to be the coldest during winter months due to the inadequate roofing insulation.
- Fewer students are on Carleton campus during the summer term, and so, it does not affect the majority of students. For those who were on campus found the conditions unsuitable for studying/working due to the lack of air conditioning and not available individual thermal control such as thermostats and/or operable windows.
- Some students did not have any thermal comfort complaints and preferred working in cooler environments. Some did not find any issue with the use of additional clothing.

The recommendation to improve *thermal comfort* as follows:

- The entire building, including the roof, lacks enough insulation. This makes the studying and working conditions inadequate for students; thus, there is a need for evaluating the building's internal insulation system.
- Sealing the windows had positive results in making the rooms warmer during winter months. Therefore, ensuring all windows on each floor are properly sealed and generally maintained by staff.
- It is suggested that individual thermal comfort controls for occupant space and group thermal comfort controls for all shared multipurpose spaces should be provided (USGBC, 2019).
- The concrete floor has notably made the space cooler; and thus, looking into alternatives such as sustainable flooring options in working spaces. Carpets should be avoided due to the cost of cleaning and potential health concerns (e.g. dust and dirt). However, the highly recommended floor tile is Bio-flooring (PVC free and

inspired by nature) for commercial spaces. The floor tile brings heavy-duty function and concrete look together with high performance.

- Having access to thermostats on each floor may give students the opportunity to adjust the heat. Regulations must be applied to ensure proper use of thermostats. (USGBC, 2019).
- Both window insulation and maintenance are the key factors for reliable Heating Ventilation and Air Conditioning (HVAC) system. The HVAC system requires good window insulation to minimize air leakage which makes it runs less. Thus, it leads to an increase in service life by less energy consumption, and also a decrease in maintenance cost (Wei, Kusiak, Tang, & Zeng, 2015).
- Portable space heaters are not an effective long-term solution and should be avoided in the future. They are costly and consume more energy. Therefore, it is best to address the root of the heating and thermal comfort issues.

5.1.2 Theme: Lighting Quality (Artificial and Daylight) - Insights

The majority of the participant are more satisfied with about the daylight at the new design studios in AP. However, the main concerns about artificial lighting the most participants claim that they are having lighting issues (i.e. flicker, glare and poorly distributed light) to be considered, as well as they required better lighting during evenings, especially during the winter term.

According to the website noao.edu, the performance standard dimensions for indoor artificial light level ranged from 100 - 300 lux for normal activities in the past. Nowadays, the artificial light level is an average of 500 - 1000 lux depending on the activity taking place. For detailed and precise works, the light level can even reach 1500 - 2000 lux

as presented in Table 10. (“Recommended light levels (Illuminance) for outdoor and indoor venues”, n.d.)

Table 10: Guide for recommended artificial light levels in different workspaces (adapted from “Recommended light levels (Illuminance) for outdoor and indoor venues”, n.d.).

Activity	Illumination (lux, lumen/m ²)
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, Homes, Theaters, Archives	150
Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000
Detailed Drawing Work, Very Detailed Mechanical Works	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000
Performance of very prolonged and exacting visual tasks	5000 - 10000
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000

Overall, there are several factors that affect the effectiveness of illumination, such as quality and quantity of light, amount of flicker, and glare and shadows, as well as contrast considering WELL building standard. In addition, lighting fixture standards serve to tackle the increase of other issues related to design, positioning, installation and minimum power requirements and the effective distribution of lighting, also other related factors including effectiveness, cost and maintenance (“Recommended light levels (Illuminance) for outdoor and indoor venues”, n.d.)

On the other hand, WELL™ promotes lighting fixtures designed to increase alertness, enhance experience and visual comfort (Appendix G) as follows:

- To minimize glare, luminaires more than 53° above the center of view (degrees above horizontal) must have luminance’s less than 8,000 cd/m.

- The average light intensity the ambient lighting system should be able to maintain 215 lux (20 fc).
- If ambient light is below 300 lux (28 fc), task lights providing 300 to 500 lux (28 to 46 fc) at the work surface are recommended.

The recommendation to improve the artificial *lighting quality* as follows:

- Different sources of light should be considered, with different hues and colours (bright white/warm) as having different shades of light would help in making the room more comfortable depending on the time of the day.
- Reflective surfaces could also be incorporated to give a sense of brightness and improve lighting and adding few mirrors in the room could be beneficial.
- For at least 90% of an individual occupant, spaces should provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences, with at least three lighting levels or scenes (on, off, midlevel) (USGBC, 2019).
- Studios should be provided with a lighting system that operates in at least 2 modes: general illumination and A/V (USGBC, 2019).
- Shared multipurpose space such as Gallery and central collaboration space should provide lighting system controls for all in order to enable adjustments that meet group needs and individual preferences (USGBC, 2019).
- For the entire space, it is recommended to use light sources with a Certificate Revocation List (CRL) of 80 or higher. Exceptions would include lamps or fixtures specially designed to provide coloured lighting for effect, site lighting or other special use (USGBC, 2019).

- It is recommended to use direct-only overhead lighting fixtures for 25% or less for all regularly occupied spaces (USGBC, 2019).
- All transparent glazing in design studios should be provided glare control devices regardless of whether the glazing receives direct sunlight or weather reflection artificial light. The glare control devices would include interior windows blinds, interior shades, curtains and movable screens (USGBC, 2019).
- Provision of satisfactory daylighting and glare control devices ease the need for artificial light by the incorporation of daylight materials such as sensors and dimmers that would reduce the lighting energy consumption of the space and build overall.

5.1.3 Theme: Acoustic Quality - Insights

There are many concerns in regard to *acoustic quality*, as participants find acoustic quality of Azrieli design studio poor due to the lack of soundproofing; industrial concept of the ceiling (i.e. open ceiling) does not allow for proper soundproofing insulation. Use of ceiling tiles and gypsum board with acoustic high performance (e.g. Acoustic Panels Canada [APC]) would improve the acoustic quality of space. They are constructed of high-density 6lb per cubic foot and glass wool to Control echoes & reverberations. Poor acoustic quality causes disruptions to the working and learning environment at the space (USGBC, 2019).

On the other hand, the WELL™ promotes comfort acoustic quality designed to facilitate productivity, collaboration and distraction-free spaces (Appendix H) as follows:

- The average sound pressure level not to be exceeded from outside noise intrusion 50 dBA.

- The higher Noise Insulation Class (NIC) value, the better sound insulation, for example, more effective sound cancellation between spaces.
- The larger the Noise Reduction Coefficient (NRC) value, the better the material is at absorbing sound under standardized conditions (WELL, 2019).

Furthermore, The WELL™ standard provides the guideline for background noise levels that do not exceed the thresholds shown in Table 11.

Table 11: Guide for recommended minimum background noise levels (adapted from WELL, 2019).

Sound Pressure Level (SPL)		Open Workspaces, Dining Areas	Enclosed Offices, Residential Living & Sleeping Areas (Daytime)	Conference Rooms, Classrooms, Residential Sleeping Areas (Nighttime)	Points
Average SPL (L _{eq})	dBA	45	40	35	3
	dBC	70	65	60	
Max SPL (L _{max})	dBA	55	50	45	
	dBC	80	75	70	
Average SPL (L _{eq})	dBA	50	45	40	2
	dBC	75	70	65	
Max SPL (L _{max})	dBA	60	55	50	
	dBC	85	80	75	
Average SPL (L _{eq})	dBA	55	50	45	1
	dBC	80	75	70	

Controlling levels of background noise is one of the main considerations to ensure acoustical comfort across the variety of spaces in a building. Once the exposure to noise is reduced, occupants are less susceptible to distraction, general potential health risk and stress (WELL, 2019).

The recommendations to improve acoustic quality are the following:

- HVAC background noise levels from the air conditioning and ventilating systems

should be determined by the facilities management and planning at Carleton due to it requires calculation and measurement of a sound level to find a proper solution based on the analysis of the background noise level result (USGBC, 2019).

- The collaboration space in the AP should be evaluated for sound quality. This will reveal what could be done to make improvements while also revealing the cause of poor acoustic quality.
- A down drop ceiling in the Azrieli gallery can address the poor acoustic quality issue and reduce echoing. That solution would provide a surface that absorbs sound rather than forcing it to bounce off leading to an echo (Marinova, et al., 2017).
- Sound transmission could be controlled by adding a sound barrier mass inside the walls within the stud cavity which absorbs sound before it reaches the other side. Resilient channels can also be used as furring strips on one side of the partition (Marinova, et al., 2017).

5.1.4 Theme: Air Quality- Insights

The concerns about *air quality* are mainly presented here. The participants had many issues with *air quality* for example, Azrieli studio gets dusty based on the type of work being done. Also, the ventilation in the 3D printer and computer rooms can be poor due to the size of the room. The participants also added that the smaller Azrieli design studios and the breakout room have no ventilation system. To improve the air quality recommendation based on the issues experienced by the students and the faculty members in different areas could be resolved by:

- Limiting the number of people in the room as this affects the air quality;
- Using mobile air purifiers in the areas with low ventilation;

- Cleaning all vents and filters regularly;
- Adding some indoor plants would help with air quality in addition to enhancing aesthetics;
- Providing adequate mechanical ventilation system for occupant comfort would support air quality in study areas (i.e. stuffy/stale air, cleanliness, odours, etc.);
- Providing the maintenance of the studios regularly;
- Using toxin-free materials in walls, floors, ceiling, floors, etc.

Improving indoor air quality requires multi-disciplinary coordination and collaboration through the design and construction stages. Moreover, it must involve mechanical engineers, architects and interior designers in order to reach maximum air quality. The WELL™ promotes different strategies to reduce or minimize the sources of indoor air pollution, and it highlights the important standards related to air quality (Appendix I) as follows:

- National Institute of Building Sciences (NIBS) - (Building)
- ASHRAE 62 (Design)
- ASHRAE 0-2005 (Envelope Commissioning)
- AHERA (Asbestos)

For example, WELL building standards highlights that testing and evaluating air leakage has to be achieved after substantial completion and prior to occupancy permit in order to ensure that the building/space is airtight

5.1.5 Theme: Maintenance and Waste Management

The maintenance along with waste management was one of the major issues pointed out by the participants involved in this research due to the lack of knowledge on how the disposal systems work. Besides some material (e.g. clay) are more difficult to clean than others and might need special tools or devices for cleaning. However, there is no cleaning equipment or tool provided and available at the studios. As well as, responsibilities are not highlighted properly about who should clean spaces, whether the students or the cleaning staff. Also, there are so many specific materials mainly used in the Industrial design studios including (e.g. Styrofoam in various colours, paper-based materials) which are mainly thrown away, as a result of ineffective use of those materials or not properly sorting out and/or labelling them. It is usually unclear whether these materials are in use or not, or whether those can be reused or recycled.

The recommendations for improve maintenance and waste management quality involve:

- At the beginning of the year, recycling awareness campaigns (Waste Minimization and Recycling at SID studios) might be effective in educating/encouraging students.
- Posters can be prepared that show how to recycle properly and those can be communicated all over the studios.
- On flyers/posters, different methods can be highlighted to reduce waste and reuse materials that could be used even if it is reused in a different way. An example would be reusing leftover materials or inefficiently used materials in projects (Olanrewaju & Abdul-Aziz, 2015).

- Materials and waste should be sorted out effectively so that they can easily be recycled. For example, glass, plastics, paper, Styrofoam (Blue Board) and biodegradable materials should be indifferent bins (Olanrewaju & Abdul-Aziz, 2015).



Figure 34: Recycling, trash, and compost colour code.

- Change in the applications and policy at the university, particularly the Azrieli School of Architecture and Urbanism, should be proactively promoted . This will have a long-term positive effect since it leads to an organizational culture that would support waste management (Olanrewaju & Abdul-Aziz, 2015).

5.1.6 Theme: Materials storage

A common issue with materials storage is lack of personal storage space in Azrieli studios, and safety equipment and materials do not have a designated space to store. Overall, there are no long-term storage spaces.

The recommendations for better materials storage include:

- Installing vertical shelves and adding more vertical space can be suggested, as it creates more space for storage while minimizing costs that could arise from building an extra storage room or facility.
- The students can be asked to recycle or reuse of unneeded items (i.e. materials for constructing prototypes and models) rather than keeping them in storage. It prevents waste and also makes sure the storage is available for other items particularly for on-going projects in studios. It also prevents waste, since some items could be placed in storage for a long time without being used.
- Lockers can be installed in areas with a high need for storage area with an expiry date, so the students are forced to remove the items. It frees up storage quickly while also ensuring that space is used efficiently (Smith System, 2016).
- Movable storage cabinets can be proposed that could be used depending on needed areas. They can be moved conveniently and stored when not in use, and then brought out when needed.
- A central or department store with shared items (safety items, reusable materials, etc.) can be installed. This prevents the use of extra space and also ensures the storage space is used to capacity (Smith System, 2016).

5.1.7 Theme: Sense of space

After the transformation have been completed and the whole floor has reflected the identity of SID. There is a general concern that there is a lack of personal/individual space, especially since the students are in the studio all at the same time. One solution that easily comes to mind is the possibility of moving furniture and other equipment to create more space, but this can lead to a higher risk of damaging the furniture and as well as the studio space itself and thus, should not be considered. The recommendations to improve the sense of space can include:

- Space should be more secure and comfortable, which increases the comfort level while allowing students to spend more time. A comfortable environment will be more conducive to learning, and this also includes the appropriate light and noise conditions (Karrholm, 2016) as discussed before.
- Students should be allocated with their own space so that they can reconfigure or personalize it to fit their own needs. The dedicated studio space for each student will reduce confusion and while also encouraging collaboration among students (Karrholm, 2016).
- There should be dedicated spaces and studios for students where they can spend more time than the library, especially MDes students who invest a lot of time and effort in their research projects. Having studios dedicated and personalized for the MDes would empower them with the tools they need to advance in their journey, as well as save their time in searching for rooms in the library that are usually booked a long time in advance. The students will be accustomed to a specific place and it will also improve the sense of space (Karrholm, 2016).

5.2 Field notes Discussions

Based on the evaluation of the photographs taken, main discussion points were developed highlighting the researcher's perspective of the themes utilized and used in the studios and spaces of the fourth floor in Azrieli Pavilion (AP) building.

Thermal Comfort: Although not properly highlighted through the photographs, the thermal issue was observed by the researcher. During the winter days, thermal is not adjusted to the proper level and in such cases, the students have to request or bring their own heaters. During the summer days, at times the air-conditioners are on a high level which results in the students bringing their jackets as well.

Lighting Quality: As the lighting quality is divided into two areas which include artificial and natural lighting, the photographs were able to highlight the areas in detail. In terms of the artificial lighting, the studios and collaboration areas, gallery, maker space provide good artificial lighting as the students are able to work comfortably in days and nights with the presence of good lighting systems. The major concern that has been noted is that in a few spaces the lighting is not set on motion sensor and this results in waste of energy. In terms of the natural lighting, each studio has large glazing windows which result in great natural lighting and provides good sunlight as well. However, it would be beneficial for the students if the windows could be opened to allow natural air as well.

Acoustic Quality: Similar to air quality, acoustic quality has not been adequately defined through the photos, but the interview participants have clearly talked about them within the interview phases. Exploring the 4th floor studios and spaces, it can be interpreted that there is an overall good sound quality within all the spaces except for the gallery space and that

is due to reasons of a high ceiling, the emptiness of space and the lack of sound absorption materials.

Air Quality: Although air quality is difficult to describe through the photographs taken in the Azrieli Pavilion 4th floor spaces and studios, the interview participants clearly identified the air quality around the spaces and studios. The researcher also believes that there is good air quality around the high and open spaces as good ventilation is provided.

Maintenance and Waste Management: It can be noted through the photos that no appropriate measures have been taken to address the maintenance and waste management in the spaces. The students' material wastes masses in the studios and there is no availability of large bins to throw away the waste.

Materials storage: It is evidential through the photos that there is a lack of storage spaces on the 4th floor. The student requires large spaces for storage due to the large scale of materials, models, and equipment they have in possession. Further to add, the storage spaces that are provided in the storage rooms, and as well as cupboards and cubbies in the main central space are less to hold the student's belongings.

Sense of Space: There is a good understanding of the sense of space on the 4th floor of AP. There is a clear plan of the spaces and the configuration of the spaces further add to a good sense of space overall.

5.3 Statistical Discussion

Based on the analysis of the quantitative data provided by Facilities Management and Planning (FMP) at Carleton university, the discussion is as follow:

- The building is centrally heated and cooled, and not temperature adjustable. Some floors are colder or warmer than others, depending on the time of the year whether

it is winter trimester, summer or fall. In general, the number of students is much less in the summer.

- The systems used aren't energy efficient, such as fluorescent lights and high energy spotlights.
- The energy consumption isn't the only problem, also the cost of it as utilities charge different rates per kilowatt (the daily rate is always higher than night rates).

From the above, the suggestions are as follow:

- Install better insulations for the building in order to minimize energy waste;
- Install digital thermostats in each section in every floor to control the environment inside the building by temperature, instead of the central thermostat;
- Replace lighting bulbs (florescent and spotlights) with LED for better luminance (less energy consumption and less heat emission); and
- Reduce energy costs by applying a nightly rate (cheaper) instead of the daily rate.

Performing quantitative data analysis on AP building hourly energy consumption, for simplicity the average daily rate is calculated at (\$0.0125/kwh), compared to nightly rate (\$0.08/kwh). Figure 33 shows the different energy pricing rates over two periods of time (9 AM to 5 PM and 5 PM to 9 AM the next day). The results highlight that while the consumption is almost 67% higher from 5 PM to 9 AM, the cost is less than 7% higher than the cost from 9 AM to 5 PM. The suggested solution is developed by the Ottawa based new start-up. The solution is based on storing electricity in a battery while it is cheaper to supply the energy needs instead of a utility company.

5.4 Overall summary

This chapter discusses the findings and insights emerged from the thesis study that intends to understand how the undergraduate and graduate students and faculty members in the School of Industrial Design were using learning/working environment on the fourth floor in AP. The researcher identified seven themes that can describe the satisfaction with a given space. These themes reflect directly on the convenience, and comfort of a given space based on the design research approach. This research study found that indoor environmental quality (IEQ) and the sense of space play a significant role in the overall satisfaction with space. Although not discussed in this research, the function of the using the new SID design studios (i.e. computer lab, maker space, group meetings, seminar room, gallery, etc.) plays a significant role towards all-purpose satisfaction with space.

This study incorporated design research methods by using both quantitative data from the FMP Carleton University and qualitative data (i.e. field notes and semi-structured interviews). The new orientation and planning of the design spaces are valuable for the SID and have an integral role in encouraging creativity and supporting collaboration among the students. This thesis provides a framework to develop sustainable design directions and guidelines to enhance the learning and working environment (Figure 35). Given that, there can be a number of recommendations based on preferences, spaces can be renovated and fit-up to meet the needs of faculty members and students in the School of Industrial Design.

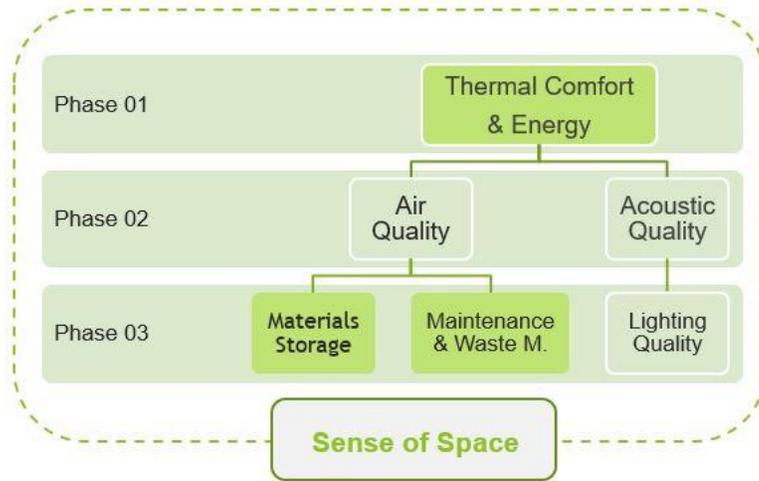


Figure 35: Framework to develop sustainable design directions.

In order to conclude and implement the design directions presented in this thesis, the researcher suggests a hierarchy of action plan (Figure 35), which may be classified in three separate phases, based on the problem areas that were identified. The first phase focuses on improving thermal comfort and energy in the studios and shared environments, as it is the most important theme illustrated in the findings and insights from the participants' statements. Following that, the second phase emphasizes two themes, air quality and acoustic quality. Finally, the third phase resolves issues emerging from materials storage, maintenance, and waste management and lighting quality themes. Thus, these phases will benefit the users of the AP design studios to feel more comfortable and productive, and that will reflect on the increasing satisfaction of the sense of the space. Finally, future attempts to explore new directions for design studio education can benefit from this research study and target to use design research methods of the data collection.

5.4.1 Limitations

The fact that only design studios and spaces of the School of Industrial Design were examined in this research which can be extended to other design education environments

or schools to explore these themes in depth. In addition, the LEED standard rating system has many different classifications to improve sustainable building performance. Only, the themes scrutinized and evaluated here are the ones directly related to students' effective learning environment including thermal comfort, lighting, acoustic quality, and air quality.

This study has some limitations including:

- This limitation occurred as a result of delays in obtaining ethics clearance.
- The findings and insights from this study were based on the participants' knowledge of Sustainable Design (SD) and the Sustainable Development Goal (SDGs) at the time they were interviewed. Further participation of the School of Industrial Design (faculty members and students) in future research may provide additional insights.
- Quantitative data could be improved by adding surveys to the study to have a better understanding of students' needs regarding their learning environment.
- Another improvement that could have been implemented was interviewing professional experts in order to develop more design-oriented specific directions and guidelines for each theme.
- The time scale of the research study was limited.

5.4.2 Future Studies - What's Next?

Future research could include more participants from different years of the School of Industrial Design to make the study more inclusive. An additional path to explore is a comparative study with other industrial design schools or departments that implement sustainable interior design approach to gather more information about methods towards enhancing the design studios. Future research could also focus on more detail upon major problem areas or themes. For example, thermal comfort or lighting quality were the main

issues that would benefit from in-depth research. Involving experts in the design research process through using generative tools and methods and more participatory methods could also be applied for developing and adopting research through design approach for future studies.

Appendices

Appendix A : Online Invitation

Appendix A



Online Invitation

To be posted on Facebook and distributed through the school of Industrial design

Volunteers needed for an interview

We are looking for volunteers to participate in a 30 - 45 minutes interview, either online, or in-person. This project is concerning the implications of sustainable design considerations for the effective learning environment in industrial design studios, under supervision of Prof. Cagla Dogan. The study aims Gain insights into user experiences in exploring the transformation of the fourth floor of the Azrieli Pavillion (AP) building for the industrial design studios (2nd, 3rd and 4th), master's studio, maker space and the pit area as the main topic of case study to develop design directions and guidelines for facilitating this transformation in the following years.

To be eligible, you must be English-speaking, Students or Faculty members from the School of Industrial Design and at least 18 years old.

There is no compensation for participation in this study. If you are interested,

Please email **Mohamed Matbouly** at Mohamedmatbouly@mail.carleton.ca for more details on participating.

The ethics protocol for this research has been reviewed and approved under CURB-B clearance # 110253 by the Carleton University Research Ethics Board

Sincerely,
Mohamed Matbouly
School of Industrial Design
Carleton University

Appendix B : Email-Invitation



Subject: Invitation to participate in a research project on the implications of sustainable design considerations for the effective learning environment in industrial design studios.

Dear Sir / Madam,

My name is Mohamed Matbouly and I am a master's student in the School of Industrial Design at Carleton University. I am working on a research project under the supervision of Prof. Çağla Doğan.

I am writing to you today to invite you to participate in a study entitled "The implications of sustainable design considerations for the effective learning environment in industrial design studios". The study aims to gain insights into user experiences in exploring the transformation of the fourth floor of the Azrieli Pavillion (AP) building for the industrial design studios (2nd, 3rd and 4th), master's studio, maker space and the pit area as the main topic of case study to develop design directions and guidelines for facilitating this transformation in the following years.

This study involves one 30 - 45 minutes interview that will take place in a mutually convenient, safe location. With your consent, interviews will be audio-recorded. Once the recording has been transcribed, the audio-recording will be destroyed.

You will have the right to end your participation in the study at any time, for any reason. If you choose to withdraw, all the information you have provided will be destroyed.

All research data, including audio-recordings and any notes will be encrypted. Any hard copies of data (including any handwritten notes or USB keys) will be kept in a locked cabinet at Carleton University. Research data will only be accessible by the researcher and the research supervisor.

The ethics protocol for this project has been reviewed and approved under CURB-B clearance # 110253 by the Carleton University Research Ethics Board. (Clearance expires on: 30/09/2019).

There is no compensation for participation in this study.

If you would like to participate in this research project, or have any questions, please contact me at Mohamedmatbouly@mail.carleton.ca

Sincerely,
Mohamed Matbouly
School of Industrial Design
Carleton University

Appendix C : Recruitment Poster



Volunteers Needed for an Interview

The Implications of Sustainable Design Considerations for the Effective Learning Environment in Industrial Design Studios.

To participate in this study, you must be:

- ✓ Students or Faculty members from the School of Industrial Design.
- ✓ At least 18 years old
- ✓ Comfortable in the English language

This is a 30- 45 minutes study. You will be asked to explain and answer questions about your experience regarding the New ID Studios, in order to develop design guidelines and design directions that could help improve the learning environment.

This project is under supervision of Prof. Cagla Dogan in the School of Industrial Design. The ethics protocol for this project has been reviewed and approved under CURB-B clearance # 110253 by the Carleton University Research Ethics Board.

Please contact the researcher, Mohamed Matbouly, for more details on this study at Mohamedmatbouly@cmail.carleton.ca.

Mohamd Matbouly									
Mohamed matbouly@cmail.carleton.ca									

Appendix D : Consent form



Research Consent Form

MDES Research Topic:

The implications of sustainable design considerations for the effective learning environment in industrial design studios.

Carleton University Project Clearance

Clearance number: #110253

Date of clearance: TBC by REB

Ethics Clearance for the collection of Data Expires : September 30, 2019

I _____, choose to participate in this research study on the research topic of: What is the implications of sustainable design considerations for the effective learning environment in industrial design studios? The researcher for this study is Mohamed Matbouly under the supervision of Professor Çağla Doğan at School of Industrial Design, Carleton University.

You are invited to take part in a research project about sustainable learning environment for design studio. The information in this form is intended to help you understand what we are asking of you so that you can decide whether you agree to participate in this study. Your participation in this study is voluntary. As you read this form, and decide whether to participate, please ask all the questions you might have, take whatever time you need, and consult with others as you wish.

The study aims gain insights into user experiences in exploring the transformation of the fourth floor of the Azrieli Pavillion (AP) building for the industrial design studios (2nd, 3rd and 4th), master's studio, maker space and the pit area as the main topic of case study to develop design directions and guidelines for facilitating this transformation in the following years.

We do not anticipate any risks to participating in this study. As well as, by signing this form, you are not waiving any rights or releasing the researchers from any liability.

You will not be paid or compensated for your participation in this study.

If you withdraw your consent during the course of the study, all information collected from you before your withdrawal will be discarded or will still be used, unless you request that it be removed from the study data. You can withdraw by phoning or emailing the researcher or the research supervisor. All data will be stored on protected computer with secured folders. All hard

**This document has been printed on both sides of a single sheet of paper.
Please retain a copy of this document for your records.**

copies will be in a secure cabinet. Once the research study is completed, the data will be destroyed on October 31, 2019.

If you would like a copy of the finished research project, you are invited to contact the researcher to request an electronic copy, which will be provided to you.

The ethics protocol for this project was reviewed by the Carleton University Research Ethics Board - B, which provided clearance to carry out the research. Should you have any ethical concerns with the study, please contact Dr. Bernadette Campbell, Chair, Carleton University Research Ethics Board-B (by phone: 613-520-2600 ext. 4085 or by email: ethics@carleton.ca). For all other questions about the study, please contact the researcher.

Researcher Contact Information:

Mohamed Matbouilly
School of Industrial Design
Carleton University
Email: Mohamedmatbouilly@cmail.carleton.ca

Supervisor Contact Information:

Çağla Doğan
School of Industrial Design
Carleton University
Email: Cagla.Dogan@carleton.ca

I voluntarily agree to participate in this study.
I agree to be (audio/video recorded/photographed)

Yes No
 Yes No

Signature of participant

Date

Signature of participant

Date

**This document has been printed on both sides of a single sheet of paper.
Please retain a copy of this document for your records.**

Appendix E : CURB-B clearance



Office of Research Ethics
503 Robertson Hall | 1125 Colonel By Drive
Ottawa, Ontario K1S 5B6
613-520-2600 Ext: 4085
ethics@carleton.ca

CERTIFICATION OF INSTITUTIONAL ETHICS CLEARANCE

The Carleton University Research Ethics Board-B (CUREB-B) has granted ethics clearance for the research project described below and research may now proceed. CUREB-B is constituted and operates in compliance with the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (TCPS2).

Ethics Protocol Clearance ID: Project #110253

Research Team: Mr. Mohamed Matbouly (Primary Investigator)

Dr. Cagla Dogan (Research Supervisor)

Project Title: The Implications of Sustainable Design Considerations for the Effective Learning Environment in Industrial Design Studios

Funding Source (if applicable):

Effective: **March 22, 2019**

Expires: **March 31, 2020**.

Please ensure the study clearance number is prominently placed in all recruitment and consent materials: CUREB-B Clearance # 110253.

Restrictions:

This certification is subject to the following conditions:

1. Clearance is granted only for the research and purposes described in the application.
2. Any modification to the approved research must be submitted to CUREB-B via a Change to Protocol Form. All changes must be cleared prior to the continuance of the research.
3. An Annual Status Report for the renewal of ethics clearance must be submitted and cleared by the renewal date listed above. Failure to submit the Annual Status Report will result in the closure of the file. If funding is associated, funds will be frozen.
4. A closure request must be sent to CUREB-B when the research is complete or terminated.
5. During the course of the study, if you encounter an adverse event, material incidental finding, protocol deviation or other unanticipated problem, you must complete and submit a Report of Adverse Events and Unanticipated Problems Form, found here: <https://carleton.ca/researchethics/forms-and-templates/>

Failure to conduct the research in accordance with the principles of the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans 2nd edition* and the *Carleton University Policies and Procedures for the Ethical Conduct of Research* may result in the suspension or termination of the research project.

Upon reasonable request, it is the policy of CUREB, for cleared protocols, to release the name of the PI, the title of the project, and the date of clearance and any renewal(s).

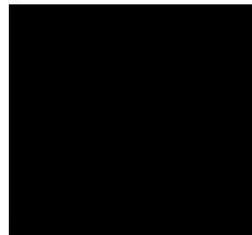
Please contact the Research Compliance Coordinators, at ethics@carleton.ca, if you have any questions.

CLEARED BY:

Date: March 22, 2019



Bernadette Campbell, PhD, Chair, CUREB-B



Natasha Artemeva, PhD, Vice-Chair, CUREB-B

Appendix F : Semi-Structured Interview Questions



Canada's Capital University

Semi-structured interview script

For all participants (Students and Faculty members)

Title: The implications of sustainable design considerations for the effective learning environment in industrial design studios.

Hello,

I'm briefly going to go over a few points before we begin the session.

I'm a master's student at Carleton University, my thesis entitled "The implications Of Design Considerations for Effective Learning Environment on the fourth floor of AP dedicated for industrial design education".

I'm working under the supervision of Professor Çağla Doğan in the School of Industrial Design. Through this study, we would like to understand your experiences and insights regarding your Working/learning environment to develop design considerations for enhancing your/ Students design education process here on the fourth floor of AP building.

This study will take 30 - 45 minutes; during that time, I will ask you some questions about your experiences. With your consent, this session will be audio recorded.

All responses will be kept confidential and your name will be removed from the data; for example, you may be referred to as participant 1. The ethics protocol for this project has been reviewed and approved under CURB-B clearance # 110253 by the Carleton University Research Ethics Board.

General Questions

What is your profession? Can you tell me a bit about yourself? (professional approach)

- Faculty member
- MDes Student
- 4th year Student
- 3rd year Student
- 2nd year Student
- Other

1. Which spaces do you mainly use as your learning environment on the fourth floor of AP? Studio, pit area, etc.?
2. How would you evaluate the following aspects in your learning environment? What do you think about using lighting - daylighting? How do these aspects affect your learning and interaction experience in design education?

(How does [artificial lighting] affect your learning environment? Positive negative experiences in relation of specific context - studio, pit area, fab lab? Suggestions?)

- a. Lighting - Artificial lighting and Daylighting
 - b. Material storage - sharing model making materials – waste and recycling of paper-based materials?
 - c. Energy - Thermal comfort
 - d. Maintenance and or cleaning of space - waste management - separate and recycle
 - e. Air quality - ventilation
 - f. Acoustic quality
 - g. Sense of place - personalization of the space?
 1. Can they reconfiguration any furniture in the space?
 2. How do they own the space?
 3. What qualities of that space would allow them to change in the space?
 4. How do they change the space?
 5. what do you want to change in the environment? how?
 - h. Other factors affecting learning environment?
3. What do you think about these aspects - in relation to the working/learning environment?
 4. Would you give examples of your positive/negative experiences in relation to the aspects?
 5. What are the ways to improve your current experiences regarding each aspect?
 6. Please describe any shortcomings of your existing space? (through the previous questions they will already talk about that.)
 7. How would you compare two spaces - past and current? Why do they think in that way?
 8. What would be your suggestions to improve your current learning environment?

Thank you for your time, really appreciate it.

Appendix G : Infographic Light - WELL Building Standard™

WELL Building Standard Concepts Facts & Figures

LIGHT

WELL promotes lighting systems designed to increase alertness, enhance experience, and promote sleep.

CIRCADIAN LIGHTING DESIGN

Intent: To support circadian health by setting a minimum threshold for daytime light intensity.



Light models or light calculations should show at least one of the following:

1

At 75% or more of workstations, at least 200 EML is present and simulates the view of the occupant. This light level may incorporate daylight if it is present for at least the hours between 9:00 AM and 1:00 PM for every day of the year.

2

For all workstations, electric lights provide maintained illuminance on the vertical plane facing forward of 150 EML or greater.

RIGHT TO LIGHT

Intent: To promote exposure to daylight and views of varying distances by limiting the distance workstations can be from a window or atrium.



WINDOW access

Buildings should utilize daylight as a primary source of lighting to the greatest extent possible.

95% of all workstations must be within 12.5 m (41 ft) of an atrium or a window with views to the exterior. And, 75% of all workstations must be within 7.5 m (25 ft) of an atrium or a window with views to the exterior.

LEASE depth

75% of the area of all regularly occupied spaces must be within 7.5 m (25 ft) of view windows.

SURFACE DESIGN

Intent: To increase overall room brightness through reflected light from room surfaces and avoiding glare.

LIGHT exposure

mainly occurs via two ways:



directly from luminous sources



indirectly from reflected surfaces

Light Reflectance Values (LRVs)

Surfaces with lower LRVs absorb light from the source and result in lower overall light intensity. Surfaces with higher LRVs reflect more light from the source, resulting in maximum light intensity and promoting alertness and activity. Choose surfaces with higher LRVs to ensure a sufficient amount of light reaches the eye without increasing energy consumption or glare.

Equivalent Melanopic Lux (EML)

An alternate metric for the biological effects of light on humans.

Unlike the traditional lux metric (the measurement of light intensity for visual acuity), EML is weighted to the ipRGCs instead of to the cones.

Content sourced from the International WELL Building Institute

LIGHT

WELL promotes lighting systems designed to increase alertness, enhance experience, and promote sleep.

50-70 MILLION
U.S. adults have a **CHRONIC SLEEP OR WAKEFULNESS DISORDER**

Such disorders and chronic sleep deprivation are associated with increased risk of certain morbidities, including

- Diabetes
- Obesity
- Depression
- Heart Attack
- Hypertension
- Stroke

GLARE CONTROL

Intent: To minimize direct and overhead glare by setting limits on the luminous intensity of luminaires.

To minimize glare, luminaires more than **53° above the center of view** (degrees above horizontal) must have luminances less than 8,000 cd/m.



Light fixtures of greater luminous intensity require a greater **shielding angle** to reduce the likelihood of creating direct glare for occupants.



215 lux (20 fc)

The **average light intensity** the ambient lighting system should be able to maintain.



If **ambient light is below 300 lux (28 fc)**, task lights providing **300 to 500 lux (28 to 46 fc)** at the work surface are recommended.

Content sourced from the International WELL Building Institute.

DAYLIGHT MODELING

Intent: To support circadian and psychological health by setting thresholds for indoor sunlight exposure.

sDA

Spatial Daylight Autonomy (sDA) is the percentage of floor area that **receives adequate sunlight**.

sDA300,50%

At least 55% of the space must receive at least **300 lux (28 fc)** of sunlight for at least **50%** of operating hours each year.

ASE

Annual Sunlight Exposure (ASE) measures the percentage of floor area that receive too much direct sunlight and places a cap on inappropriately high levels of sunlight.

ASE1000,250

No more than **10%** of the area can receive more than **1,000 lux (93 fc)** for **250 hours** each year.

Appendix H : Infographic Acoustic- WELL Building Standard™

WELL Building Standard Concepts Facts & Figures



ACOUSTIC

ACOUSTIC problems

are a leading source of dissatisfaction within the environmental conditions of an office.

Studies show that individuals exposed to **traffic noise** have a higher risk for diabetes, stroke and heart attack, and those exposed to **road traffic** and **aircraft noises** have a higher risk for hypertension.

RT60

Reverberation time is the time it takes for sound to decay. The most commonly used reverberation time is RT60: the time it takes for the sound level to decrease **60 decibels**.



Important Values Related to Comfort

The larger the **Noise Reduction Coefficient (NRC)** value, the better the material is at **absorbing sound** under standardized conditions.

The higher **Noise Insulation Class (NIC)** value, the better **sound insulation** – i.e. more effective sound cancellation between spaces.

50 dBA The average sound pressure level not to be exceeded from outside noise intrusion.

MAXIMUM reverberation time (RT60) for:

Conference rooms: 0.6 seconds

Open workspaces: 0.5 seconds



Content sourced from the International WELL Building Institute.

ERGONOMIC

ERGONOMICS AND universal design

play a significant role in mitigating physical and mental stress.



Most of the adverse health effects related to ergonomics are seen in the **MUSCULOSKELETAL** and **NERVOUS SYSTEMS** of the human body.

31 million Americans affected by **LOW BACK PAIN**



380,600 DAYS

of work were missed in 2013 because of musculoskeletal disorders, accounting for one third of the total number of days away from work.

NEARLY **7%** (MORE THAN 169 MILLION)

of all *disability-adjusted life years (DALYs)* resulted from musculoskeletal disorders worldwide in 2010.

Appendix I : Infographic Air Quality- WELL Building Standard™

WELL Building Standard Concepts Facts & Figures



15,000 liters
Amount of air we breathe every day

Air pollution is the number one environmental cause of premature mortality.

50,000
PREMATURE DEATHS annually in the United States

7 million
PREMATURE DEATHS annually worldwide

Content sourced from the International WELL Building Institute

In the U.S., the Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards (NAAQS).

Important Standards Related to Air Quality

ASHRAE 62
(Design)

NIBS
(Building)

ASHRAE 0-2005
(Envelope Commissioning)

AHERA
(Asbestos)



Indoor air quality can be degraded by outdoor sources, as well as by off-gassing from building materials, indoor combustion sources and water leaks.

6 MAJOR air pollutants

- Carbon monoxide (CO)
- Lead (Pb)
- Nitrogen dioxide (NO₂)
- Ozone (O₃)
- Particulate matter (PM₁₀ and PM_{2.5})
- Sulfur dioxide (SO₂)

POOR VENTILATION PRACTICES can fail to address outdoor sources, off-gassing by building materials and indoor combustion sources exposing us to **volatile organic compounds (VOCs)**, **polycyclic aromatic hydrocarbons (PAHs)** and **microbial pathogens**.



Air quality issues can **diminish work productivity** and lead to **sick building syndrome (SBS)**. SBS symptoms include eye, skin and airway irritation, as well as headache and fatigue.



Concentration of the contaminant, the rate of intake, and the duration of exposure determines the reactions people have to air pollutants.

Pollution source avoidance, proper ventilation and air filtration are some of the most effective means of achieving high indoor air quality. ✓

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