Enhancing Learning Environments in Design Education

Dr. Lamiaa Shaheen[1], Dr. Sarah Attia[1], Basma Salama[2], Muda Al Naabi[3], Manal Al Mamari[3]

[1]Assistant Professor, Oman College of Management and Technology, Oman
[2]Lecturer, Oman College of Management and Technology, Oman
[3]Research Associate, Oman College of Management and Technology, Oman
Email: lshaheen@ocmt.edu.om

Abstract

Design education is mainly reliant on studio-based learning, in which collaborative, hands-on activities build both practical and theoretical expertise. The current research looks at different studio classroom layouts and how physical, psychological, and environmental design aspects affect student involvement, satisfaction, and performance. Using historical and modern examples, we investigate flexible and multi-purpose studio layouts, spatial arrangement, ergonomic furniture, air quality, and lighting conditions. Our outcomes highlight the importance of adaptive and well-designed settings in architectural and design education, as they promote creativity, collaborative learning, and skill development. The study demonstrates how purposeful classroom design can improve learning outcomes and provides a paradigm for enhancing studio environments in higher education.

Keywords: Design education, studio-based learning, flexible learning environments, classroom ergonomics, environmental design, student engagement, architectural education, collaborative learning, air quality, lighting in classrooms.

In contrast to lecture classes, where learners' main objective is probably to absorb information that the instructor conveys through detailed teaching, design studios emphasize learners' active learning and practical experiences. In the studio, students' learning doesn't rely on printed materials or hands-on training, and learning objectives are not usually assessed by examinations or tests. Rather, learning outcomes are demonstrated in the level of learners' designs. An assessment of the learning achievements of learner studio projects, for instance, is required to certify an architecture or interior design program (Cho, 2013).

1.1 Historical Evolution of Studio Classroom Models

Three distinct periods may be identified in the history of architecture education. During the initial stage, a master architect provided students with instruction via actual work and hands-on learning. In the second stage, practical instruction in an office took the role of the master. In the third phase, studio classrooms were built within institutions to give learners knowledge from both hands-on and theoretical part sides, integrating practical training within the institution. In building design, studio-based learning has its roots in two of the most well-known creative schools: the Bauhaus and the School of Fine Arts (Ecole des Beaux-Arts) (Wong, 2023).

For almost a century, the design studio has served as a fundamental instructional component in the field of design education. The term "design studio" describes a real, physical location where teachers emphasize "learning by doing" and provide a project-oriented, hands-on educational methodology that involves problem-solving (Eilouti, 2007). The design studio gives learners the chance to demonstrate their abilities without taking "real-world" concerns. The atelier model was replaced by the studio model, which was a reaction to the rise of design learners, the growth of the design sectors, and the requirement for integration in professional practice. The studio model, in contrast, depends on a qualified instructor as the main quality assurance. One of the major advantages of studio integration is that it helps students take on a professional demeanor and gain the abilities and self-confidence necessary to act like designers. Additionally, it enables learners to benefit from the "institution" of a designer's profession, which is the integrated knowledge and experience that is important and worthwhile learning. This is given by the teacher "expert," who is frequently the practitioner, in typical studio settings (Lotz et al., 2015).

Based on Wong (2023) there are six different models of studio classrooms:

1- Studio classroom as an office: The studio setting mimics the real-world constraints of architectural practice by being like a construction office, where actual urban areas, residences, and other constructions are developed, improved, and modified. However, because teaching rather than profit is the main objective, the educational studio is not just a copy of an architectural firm. As a result, even though studio and consultancy offices share certain characteristics, they also diverge (Wong, 2023).

2- Studio classroom as a workshop: The studio is seen by many architects, including Norman Foster, as a workshop for creating original concepts. Rather than just being passive spectators attending design demonstrations in a conference space, the studio classroom functions as a workshop that invites active design engagement from many stakeholders (Wong, 2023).

3- Horizontal and vertical studio classrooms: In horizontal studio classrooms, learners in the same levels learn with one another without interacting with those at different levels. In opposition, pupils from various grade levels and sometimes even fields learn collaboratively in vertical studios (Wong, 2023).

4- Studio classroom without walls: In this case, learning is extended outside the walls of the studio classroom and the school. This rejects the division between theory and practice, education and profession. The studio classroom without walls offers possibilities for learners to interact with a variety of parties involved in the design process, including clients, users, contractors, architects, statutory authorities, engineers, and others, by integrating them into actual projects with society, regional or national organizations (Wong, 2023).

5- Virtual studio classroom: Beyond the regional bounds of actual studios, virtual studio fosters remote communication and permits the exchange of educational materials for architectural education. Additionally, it eliminates regional, ethnic, and cultural barriers to enable actual time global cooperation. Therefore, the virtual studio facilitates constant digital interaction with global partners (Milovanovic & Moreau, 2017).

6- Future studio classroom: Technology is advancing at an impressive rate, which will likely continue in the future studio where architecture is taught. The younger architectural learners are already using information and communication technology (ICT) to facilitate their approach to design. Future studios may use ICT to combine data and promote teamwork for decision-making during the design phase (Wong, 2023).

1.2 Key Characteristics of Effective Studio Classrooms

Obeidat and Al-Share (2012) used a survey to investigate the design studio classroom to

decide whether this design meets students and teachers' expectations and needs. This study focused on exploring the impact of space layout, seating configuration, furniture, lighting, acoustic, and color on educational performance. A purposeful sample of design and architecture educators received a survey that was created and circulated. 500 participants in Jordan took part in the questionnaire, which was conducted online and sent to each participant using their email addresses. Only 94 responses were obtained, and only 86 of these were fully answered. The study findings highlight the importance of having designated design workstations in design studio classrooms. Additionally, this study implies that it is crucial to consider all interior environmental elements that the researchers believe have an impact on the process of learning and instruction in design-studio classrooms. Every characteristic has a varied degree of significance. This study shows that lighting is the most crucial component. It might be true that adequate lighting is necessary for the process of learning design. This study assumes that furnishings, like drawing tables and stools, are needed in a design studio classroom. As a result, this type of furniture ought to be both comfortable and functional. Drafting tables might have enough room for a computer and storage areas. Additionally, stools must be mobile, adjustable, and comfortable (Obeidat & Al-Share, 2012).

Wong (2023) investigated the studio classroom in detail. This study also explores the studio's double character as an actual place and an educational strategy, showcasing the various studio learning models that have emerged. The studio's unique culture, interactive design learning and instruction atmosphere, and function as a design life space are all explored in this article. Wong, in his paper, stated that a studio classroom has four main characters (Wong, 2023).

1- The studio classroom is an interactive place for learning and teaching. Where in this place, architecture students study and experience new language and skills. In addition to that, studio classrooms provide students with a place to be trained to think as architects.

2- The studio classroom is not designed to give information only. Students can spend a long time in the studio, where they can work on a single or multiple projects at the same place.

3- The studio classroom provides a student with a space to live and supports student life. Students can use the studio as a place to meet a friend or even to eat their meals. It is a multifunctional space!

4- One of the main characteristics of the classroom studio is that it provides a high social interaction space. The teachers and learners gather around a table to discuss the current project. Students can leave work in progress rather than having to set up every time, and the area becomes extremely comfortable. Furthermore, teachers and pupils frequently use the studio before and following officially scheduled hours, even on weekends, at night, and even on holidays, as the project deadline approaches.

Importance of Physical Environment in Learning

2.1 Influence of Spatial Arrangement on Learning Outcomes

The actual physical setting of the classroom has a big impact on learning outcomes. The seating configuration is one of the physical settings. The way students sit has a big impact on their behavior, their motivation, and how they interact with teachers and other students. Four goals are achieved by the way that students are seated: accessibility, student-teacher communication, student-student communication, and mobility. In line with this, Hardiansyah et al. examined the effect of seating arrangement on primary school students using observation methods and tests. The results demonstrated that in order for teachers to create appropriate learning environments successfully, they must: (1) be aware of the specific factors that can facilitate the development of optimal circumstances in the process of instruction and learning; (2) be aware of possible issues that

could disturb the learning environment; and (3) be proficient in choosing suitable seating configurations and understand when to use them (Hardiansyah & Rasia, 2022).

Norazman et al. (2019) investigate classroom seating arrangement in terms of the factors that influence the selection of the arrangement and the types of arrangement. The research also uses a literature review to explore the impact of classroom seating configuration on student academic performance. It highlights five factors influencing the selection of seating arrangements: the type of course, learner difficulties, learner behavior, classroom capacity, and learner achievement.

1- Type of course: Previous research shows that the correct selection of seating configuration for each course, based on course requirements and activities, can improve learner academic achievement.

2- Learner difficulties: Certain learners struggle independently, particularly with medical problems like hearing and eyesight, which require attention in the classroom. Choosing the right seat for the pupils can help keep their medical issues from worsening. Additionally, it affects their focus, productivity, and accomplishment.

3- Learner behaviors: According to some research, assigning seats in a classroom should be a key practice since it fosters positive student behavior and attitudes during instruction.

4- Classroom capacity: This can be defined as the total number of learners assigned to a classroom in an educational setting, such as a school. One issue facing developing countries is the large capacity of classrooms, which makes it harder for educators to supervise the kids in the classroom. Additionally, it impacts students' performance, which often requires a comfortable learning environment for efficient instruction and learning processes.

5- Learner achievement: The educator's instructions or the students' own arrangements determine how the pupils are seated, which is typically problematic when choosing seats in a classroom. As it represents learner accomplishment, learners who sit in front of the classroom will profit more than those who consistently sit in the rear. While a student's placement in a classroom is not directly related to their academic performance, it can improve the quality of learning by, for example, decreasing the effectiveness of the teacher-student relationship.

2.2 Impact of Classroom Aesthetics on Student Perception

Studies indicate that excellent interior design enhances an educational environment's functionality, and the comfort of the users involved in the educational process (Obeidat & Al- Share, 2012). Jin and his colleagues (Jin & Peng, 2022) investigated the effects of spatial factors on learner satisfaction using quantitative approaches. In this research, 316 students participated in solving a Likert-based questionnaire. The questionnaire was designed to measure students' perceptions of different classrooms with different styles. Findings show that the way that students perceived space, furnishings, and physical and aesthetic surroundings all had a big impact on their level of satisfaction (Jin & Peng, 2022).

In a standardized attention and concentration test, Lindemann-Matthies et al. (Lindemann-Matthies et al., 2021) looked at relationships between primary students' feelings of satisfaction and the naturalness of window and internal educational settings views and their actual performance. A written questionnaire encompassing learners' comfort and happiness in the classroom, focus and learning capacity, accomplishment satisfaction, feelings of stress, and sense of social belonging was used to measure health. There were controls over social density, room color, and level of classroom interior design. This study involved 785 students from the 4th grade. Results indicated that learners inside a classroom with a window with a natural view have lower stress levels and are more concentrated on their tasks. Furthermore, internal plants did not significantly affect

student's comfort or concentration. However, it was found that students'

connection to the plants (spending time in plant care) positively affected students' comfort and decreased their stress (Lindemann-Matthies et al., 2021).

Psychological Impact of Classroom Design

The educational atmosphere is crucial for gaining knowledge, but it also provides a motivating and nurturing environment for the growth of young people. It makes logical that creating a supportive learning environment in the classroom has been crucial to many school reform initiatives aiming to advance the intellectual and mental health of young people (Wang et al., 2020).

3.1 Role of Environmental Psychology in Education

Wang et al. (2020) explore the existing research that studies the relationship between classroom environment and learner outcomes using the meta-analytic method. The research investigated published papers from 2000 to 21016 and focused on kindergarten to high school students. Findings show that there was no grade-level difference in the relationship between youth outcomes and classroom atmosphere. The findings imply that a supportive learning environment is linked to students' academic and psychological growth during the primary and secondary school years. Additionally, the findings demonstrated that the general classroom environment had minor negative correlations with externalizing attitudes and socioemotional distress and small-to-medium advantageous associations with academic success, enthusiasm and participation, and social competence (Wang et al., 2020).

Berg et al. in a study in (2016) used a monitored, planned design with baseline assessments and follow-ups at two periods to assess the beneficial effects of green walls with living plants in classrooms at two elementary schools. Attentional tests and survey responses were used to examine students' mental functioning, health, and learning environment evaluations (n = 170, age = 7–10) at each evaluation period. The students in the four classrooms with the green walls performed better on a selective attention test than those in the controlled learning environment. However, the green walls did not affect the rate of processing. Student's assessments of the classroom were enhanced by the green wall as well. The two follow-ups yielded excellent overall evaluations of the green walls (Berg et al., 2016).

3.2 Effects of Classroom Atmosphere on Student Well-being

Likewise, Gonzalez-Zamar and his partners conducted a research to study the effect of university classroom atmosphere on maintaining the well-being of the students using a literature review. This investigation aimed to examine global research movements over the preceding 15 years on the influence of academic settings on the management of socio-educational well-being, considering inspiration, socio-perceptual and physical-environmental factors. Findings indicate that interest in this subject increased during the last six years of the studied period. In addition, it was stated that the United States is the main contributor to this field. Moreover, the research shows that the student's well-being is affected by three main factors: the physical environment, socio-perceptual, and motivation (González-Zamar et al., 2020).

To enhance inner living spaces, thermal comfort and indoor air quality have gained importance in the past few years and are the focus of many studies. They are more crucial in educational facilities because poor indoor air quality (IAQ) may harm learners' well-being and academic achievement. Youths stay inside for a large portion of the day. According to most research, unhealthy indoor air quality at educational institutions causes illnesses that cause students to miss class and negatively impact their health, lowering their ability to concentrate in class. In line with this, Ranjbar (2019) investigates the different impacts that distinct ventilation strategies have on indoor air

quality and thermal comfort in design studio environments. Additionally, it investigated the connection between academic achievement and the ventilation type. The research evaluated the experiment room's IAQ and thermal comfort using both quantitative and qualitative metrics over the two seasons (winter and summer) with three different settings. Setting 1 was done by closing all windows, doors, and ventilation systems. Setting 2 was done by using natural ventilation only from doors and windows. Setting 3 was associated with applying mechanical ventilation. In all three settings, students inside the design studio participated in a survey. According to the experimental and assessment data, the mechanical ventilation mode produced the most comfortable interior atmosphere in both seasons and better educational achievement levels (Ranjbar, 2019).

Effective Layouts for Multi-purpose Studios

4.1 Designing Flexible Spaces for Various Learning Activities

- Designing flexible spaces for varied learning activities is critical in current educational contexts, especially in design education, where activities might range from individual study to group projects, lectures, and hands-on experience. Flexible learning spaces can accommodate these multiple activities because they are adjustable, multipurpose, and supportive of various teaching techniques. The goal is to build settings that can be quickly modified to complement various educational techniques while also providing a dynamic and interesting learning experience. There are several criteria for designing flexible learning spaces, as illustrated below.
- Flexibility and reconfiguration:

Spaces should be easily adjustable to accommodate many sorts of activities. Movable furniture, modular walls, and movable electronics are crucial characteristics that enable fast reconfiguration to accommodate different group sizes and activity kinds (Brown and Long, 2006; Oblinger, 2006).

- Technological cooperation

It is vital to include technology in the design. This includes adequate power outlets, Wi-Fi connectivity, and interactive displays. Technology should be smoothly linked to enable digital learning tools and resources, making it simple for students and teachers to use them as required (Radcliffe, 2009).

- Ergonomics and Comfort

The design should consider the comfort and ergonomic demands of both students and teachers. This includes selecting furniture that promotes proper balance, providing enough lighting, and keeping acceptable air quality. Comfortable settings improve concentration and productivity, allowing students to participate in a variety of learning activities (Weinstein, 1979).

- Acoustic and Visual Context

Effective acoustic design is critical for reducing noise disturbances and maintaining clear communication. Visual elements such as natural light and suitable color palettes help to create a welcoming and engaging atmosphere. These factors aid in focus and fatigue reduction over longer periods (Gifford, 2007; Higgins et al., 2005).

- Accessibility and equality.

Flexible learning environments must be accessible to all students, including those who have limitations. This includes both physical accessibility, such as ramps and flexible furniture, and ensuring that digital tools are suitable for everyone. The inclusive design promotes an equal learning environment in which all students may fully engage (Moore & Lackney, 1994).

- Sustainability

It is becoming increasingly vital to include sustainable practices in the design of learning facilities. This involves choosing eco-friendly materials, installing energy-efficient equipment, and planning for natural ventilation and daylighting. Sustainable design not only decreases environmental impact, but also fosters healthier learning environments (Orr, 2002).

- Spatial Arrangement.

The studio's space design should allow for a variety of learning activities. Zoning places for certain tasks such as collaborative work, independent study, and public speaking areas ensures that all activities may be carried out uninterrupted (Radcliffe, 2009).

- Flexibility in Space Use

Multi-purpose studios should allow a variety of instructional techniques and learning styles. Spaces that accommodate classes, workshops, and hands-on activities provide a more holistic educational experience (Brown and Long, 2006).

- Storage Options

A multi-purpose studio requires enough and easily accessible storage. Proper storage solutions provide an ordered and organized environment, which can improve learning and efficiency (Moore & Lackney, 1994).

- Collaborative Spaces

Creating places that encourage student cooperation is critical. These places ought to encourage group discussions, teamwork, and learning from one another, all of which are important aspects of design education (Oblinger, 2006).

- Safety and Security

Ensuring the safety and security of the learning environment is critical. This involves following safety guidelines, providing emergency exits, and ensuring secure access to supplies and devices (Weinstein, 1979).

- Aesthetic Appeal

The visual appeal of the learning environment has a considerable influence on student motivation and participation. Well-designed, visually appealing surroundings can foster creativity and improve the overall learning experience (Gifford, 2007).

4.2 Case Examples of Successful Multi-purpose Studio Layouts

The designing of successful multi-purpose studio layouts is crucial to improving learning environments in educational institutions for designers. Multi-purpose studios provide dynamic environments for architectural and interior design students to participate in a variety of activities such as sketching, model-making, digital fabrication, and collaborative work. These studios not only serve a practical purpose, but they also encourage creativity, cooperation, and flexibility, all of which are necessary for design students' overall growth. Examining excellent examples of multi-purpose studio layouts allows us to see how intelligent spatial arrangements and resource management enhance the teaching experience.

4.2.1 The Cooper Union, New York City:

The Cooper Union's multi-purpose studio has an open-plan layout with moveable dividers that allow for different room configurations. The studio has separate places for solo work, collaborative projects, and digital creation, as well as common areas for evaluations and presentations. Figures 1 and 2 depict the studio's adjustable and dynamic arrangement, which is intended to support both concentrated individual work and collaborative activities (Smith, 2019).

Figure (1): Common areas in The Cooper Union for evaluations and presentations (Smith, 2019 copyrights).

Figure (2): Projects gallery in The Cooper Union (Smith, 2019 copyrights).

This firm handles its multipurpose nature by combining technology and traditional design methods. Workstations with PCs and digital drawing tablets combine with drafting tables and model-making stations. This combination ensures that students may easily shift between digital and physical methods of creation, increasing their skill sets and preparing them for industry expectations (Smith, 2019).

The Cooper Union's studio improves the learning experience by providing a flexible space that supports a variety of design methods. Students benefit from the opportunity to change their workplace based on their project requirements, which encourages adaptation and imaginative thinking. Public areas also promote peer feedback and collaborative learning, which are essential components of design education (Smith, 2019).

4.2.2 Stapaskoli Multi-Purpose Classroom Studio, Reykjanesbaer, Iceland:

The Stapaskoli classroom hall has an open and flexible design that can accommodate a variety of educational activities because of its big classrooms and numerous seating options. Central spherical cores and breakout cells offer a variety of locations for individual or group work, while corridor compartments and open areas expand learning beyond typical classroom limits. This structure facilitates dynamic and interactive learning experiences, which are essential for design education.

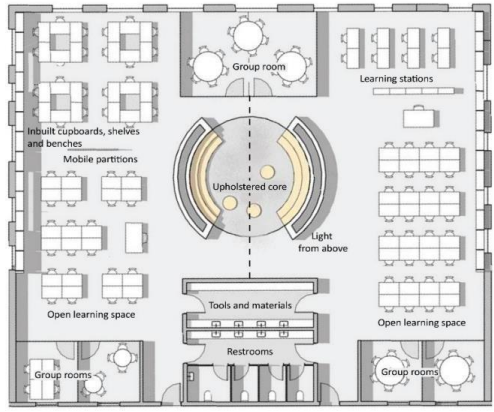

Figure (3): A draft illustration of a classroom by ARKÍS architects (Woolner & Cardellino, 2023 copyrights).

Stapaskoli's layout is a prime example of a multi-purpose studio, where the space can easily be reconfigured to suit different teaching and learning needs. The use of sliding doors, foldable walls, and advanced technology allows the classroom to adapt to various activities, from individual study to large group collaboration, making the space versatile and increasing its utility for diverse educational purposes (Woolner & Cardellino, 2023).

The adjustable design of the Stapaskoli classroom hall is critical to improving the learning environment in design education. The environment enables multiple learning styles while also encouraging creativity and cooperation, which are important parts of architectural and interior design education. The environment's adaptability encourages an inclusive and inventive climate, which is critical for good design learning (Woolner & Cardellino, 2023).

4.2.3 Imagination Lancaster at Lancaster University, UK:

Imagination Lancaster at Lancaster University is an open and flexible studio arrangement within the Lancaster Institute for the Contemporary Arts (LICA), which is intended to stimulate interdisciplinary

cooperation. The room has modular spaces that may be quickly modified to accommodate both solitary and group activity. Shared facilities and specialized labs promote cross-disciplinary integration, resulting in a dynamic environment that supports a wide range of teaching and research activities. Figure 3 illustrates the configuration of the open spaces (Design Council, 2010).

Figure (4): The configurable exhibition and performances spaces in the LICA Studio. (Design Council, 2010 copyrights).

The studio's multi-purpose structure allows for a variety of tasks, including hands-on design work, theoretical study, and collaborative initiatives. This adaptability is achieved using moveable furniture, partition walls, and digital technologies, which allow the space to instantly adapt to changing demands. The design encourages cross-disciplinary interactions, merging ideas and processes, which is key to LICA's educational philosophy (Design Council, 2010).

The multi-purpose studio at Imagination Lancaster improves design education by offering a location for both individual and group work, encouraging creativity and innovation. The studio's multidisciplinary orientation prepares students for professional practice, which requires collaboration across areas. The fluid and adaptive environment reflects the intricacies of real-world design difficulties, preparing students for their future jobs (Design Council, 2010).

Enhancing Air Quality and Lighting Conditions

5.1 Importance of Air Quality in Learning Environments

Air quality is a critical factor that impacts the performance of learning settings. The air quality in educational environments significantly affects the health, cognitive functioning, and general well-being of students and teachers. Poor indoor air quality can cause allergies, respiratory difficulties, and exhaustion, reducing pupils' ability to focus and perform academically (U.S. Environmental Protection Agency, n.d.). Furthermore, research has found that maintaining excellent air quality in learning spaces might improve cognitive function, resulting in higher academic outcomes (Allen et al., 2016). As a result, maintaining adequate air quality is critical for generating an optimal learning atmosphere.

Key Points on the Importance of Air Quality in Learning Environments (Wargocki & Wyon, 2013):

- High CO2 Levels in Classrooms: Studies carried out in several nations, such as Sweden and Denmark, showed that a significant number of schools had CO2 concentrations that were higher than advised. Improper ventilation and poor air quality can have a detrimental effect on the learning environment, as seen by high CO2 levels, which are frequently more than 1000 parts per million during school hours.
- Inadequate Outdoor Air Supply: Poor air quality results from many classrooms' failure to reach the necessary outdoor air supply (OAS) rates. For instance, research revealed that the OAS rate in 50% of classrooms was lower than the ASHRAE guideline of 15 cfm per person. The main cause of the high CO2 levels and poor air quality is this shortage.
- The Effects of Poor Air Quality on Student Health and Performance: High concentrations of pollutants and bio effluents in

the air might cause health problems for pupils. Research demonstrating a positive correlation between increased ventilation rates and better student performance points to the direct impact these health issues can have on students' capacity to concentrate, study, and complete assignments successfully.

• Relation Between Academic Achievement and Air Quality: Academic performance and air quality are positively correlated. Research has indicated that improved ventilation and reduced CO2 levels in classrooms lead to improved student performance in activities including language and math. Furthermore, there is a correlation between reduced absence rates and higher ventilation rates.

• The Benefits of Ventilation for Learning and Pollution Reduction: Enough ventilation improves the overall quality of the air by lowering the quantity of airborne particles and chemicals as well as CO2 levels. This improvement in air quality is essential to establishing an optimal educational setting where students may provide their best efforts without being negatively impacted by low air quality.

• Temperature Control's Significance in Relation to Air Quality: Maintaining suitable interior temperatures is just as important as preserving air quality. High temperatures in classrooms, which are frequently caused by insufficient ventilation, can worsen the consequences of poor air quality. To maximize the learning environment and boost student performance, it is essential to provide proper ventilation and temperature regulation.

 Air Quality's Role in Enhancing Teacher Performance and Satisfaction (Sadrizadeh, Yao, Yuan, Awbi, Bahnfleth ,2022):

• The Financial and Academic Advantages of Better Ventilation

Research by Wargocki et al. has emphasized the advantages of better ventilation in improving classroom air quality (CAQ) from an educational and financial standpoint. Raising the ventilation rate in Danish classrooms from 6 L/s per person to 8.4 L/s per person has the potential to increase GDP by €173 million per year and public spending by €37 million over 20 years. This improvement is linked to higher adult productivity as a result of improved academic achievement and lower absences from work. Better learning environments are facilitated by the increased air quality, and these outcomes include shorter school terms, earlier job market entrance, and fewer sick days for educators.

• Effect on Absences and Productivity of Teachers

Higher CAQ has a direct impact on teacher attendance and productivity. Improving ventilation and air quality also raises employee satisfaction levels by lowering the probability of teacher sick days. Teachers are less likely to suffer from health problems brought on by unfavorable indoor air quality in well-ventilated classrooms, which might otherwise result in more absences and lower productivity. Teachers are better equipped to perform and remain engaged in their responsibilities in a healthier and more pleasant atmosphere, which has a beneficial impact on their overall job satisfaction.

• Cognitive Function and Educational Goals

It is commonly known that CAQ and cognitive function are related. Kids' attention, memory, and focus are all severely impacted by poor air quality, which is defined by low ventilation rates and high CO2 levels. This can have a detrimental effect on kids' academic performance. According to studies, raising ventilation rates to 10 L/s per person considerably enhances learning outcomes for pupils and lowers absences. It is imperative to maintain CO2 concentrations below 900 ppm to sustain good brain function. Improved air quality fosters a more productive learning environment for teachers by helping students perform better on assignments and tests.

• Classroom conditions and thermal comfort

Thermal Teacher performance and satisfaction are significantly impacted by thermal comfort in the classroom. Teachers are impacted by classroom temperature just like students are. Comfortable but unproductive temperatures might lower productivity. Instructors are more prone to change the temperature in the classroom according to their own tastes, which may not always be in line with what the students require. Both instructors and students work better when the classroom is in a comfortable temperature, and research indicates that keeping the air quality and temperature just right can enhance overall classroom performance and happiness.

 Strategies for Improving Indoor Air Quality in Educational Settings (Rawat & Kumar, 2023).

• Technological Interventions: High Efficiency Filters in HVAC Systems

Adding high-efficiency filters to HVAC systems is a crucial tactic for raising indoor air quality (IAQ) in learning environments. These systems, which continually bring in fresh outdoor air and ensure appropriate ventilation, may efficiently regulate the ambient conditions within classrooms. They support a healthy learning environment by assisting in the management of interior air pollutants and preventing the intrusion of outside contaminants. Improvements like continuous fan operation and high- efficiency filters (MERV 13), for example, guarantee that classrooms have enough ventilation, which is essential for lowering respiratory health risks and raising student achievement. However, financial limitations may make it difficult for older schools with existing HVAC systems to upgrade to high-efficiency filters; in these situations, portable air purifiers might be a good substitute.

• Technological Extensions: Air Filters

When it comes to localized air quality problems, air purifiers are a useful tool, especially in schools without sophisticated HVAC systems. These devices remove particulate matter, volatile organic compounds (VOCs), and other air pollutants using a variety of methods, such as mechanical filtration, UV light, and ozone generators. In schools with poor outside air quality or without high-efficiency filters in the current

HVAC systems, air purifiers are extremely helpful. Air purifiers work well when combined with appropriate ventilation techniques since they neither produce fresh air nor lower CO2 levels, despite their effectiveness in enhancing the quality of the air.

• Interventions Behavioral

Behavioral therapies aim to lower exposure to indoor air pollutants by altering both individual and group behaviors. One example of such an intervention is the Environmental Education Program (EEP), which aims to teach parents, teachers, and students about the value of good air quality and ways to reduce exposure to pollution. These initiatives have the potential to significantly lower indoor air pollution by promoting changes in behavior that are informed. For example, integrating real-time air quality monitoring into instructional activities can promote pollution-reduction behaviors and increase public awareness. The total impact of behavioral interventions on indoor air quality can be improved since they are affordable and can be customized to meet the unique requirements of various communities.

• Physical Obstacles: Sustainable Infrastructure

By serving as a physical barrier to pollutants linked to transportation, green infrastructure (GI) offers a naturally occurring way to lower indoor air pollution. Schools may greatly reduce their levels of nitrogen dioxide (NO2) and particle matter (PM10, PM2.5) by installing green walls, trees, and screens around them. Along with improving air quality, GI also has other advantages including lessening the effects of urban heat islands and improving student wellbeing. Educational institutions may develop

learning spaces that are more sustainable and healthful by implementing green infrastructure.

5.2 Best Practices for Lighting Design

Lighting is essential for developing successful learning spaces, especially in design education, where eyesight and comfort are vital. Proper lighting design not only improves the aesthetics of educational environments, but it also has a substantial influence on students' focus, mood, and academic achievement. According to many studies, well-designed classroom lighting systems may increase student engagement, minimize eye strain, and encourage a more productive learning environment. Furthermore, energy-efficient lighting systems may save operating costs while maintaining appropriate lighting conditions, which is becoming increasingly relevant as institutions adopt more sustainable practices (Silvair, n.d.; Lightsearch.com, n.d.).

Several best practices have been developed to ensure that lighting in educational environments is both effective and efficient, with a focus on including natural light, employing energy-saving fixtures, and adapting lighting to different educational tasks. These approaches are critical for developing learning environments that are flexible to the different requirements of students and teachers (Peter Basso Associates, 2022).

 Specifications for Multipurpose Lighting:

• Performance and Efficiency: Multipurpose lighting systems must have excellent luminous effectiveness, exceeding 125 lumens per watt across all CCT levels. They should have full range dimming capabilities (1% to 100%), providing minimum glare and effortless changes between lighting levels. To maximize energy efficiency, the system should reach a lighting power density as low as 0.007 W/ft² by adding sophisticated occupancy and daylight sensors to automatically adjust lighting zones and decrease energy usage (Davis, 2017).

• Tunable White Light (TWL) and Color Quality: The system should provide tunable white light (TWL) and color quality with a continuous color temperature (CCT) range of 2,700 K to 6,500 K, allowing for flexible color adjustment for diverse jobs. Maintaining excellent color quality is critical, thus the system should have a color rendering index (CRI) of 82 or better, with low chromaticity changes, to provide consistent color accuracy and a comfortable visual experience.

• illumination Intensity and Control: Ensure enough illumination for various activities, including reading, testing, performances, and video presentations. It should produce 65-foot candles at reading height, utilizing a combination of fluorescent and incandescent illumination. Dimming switches and rheostat-controlled lights should also be included to allow for intensity adjustments ranging from higher-than- usual brightness to complete darkness (Flanigan 1966).

• Glare Reduction and Visibility: Emphasize glare reduction on boards and visual materials, and provide good sight of letters, numbers, and titles on bookshelves to prevent eye strain. This is critical for ensuring a pleasant and productive learning environment (Flanigan 1966).

• Durability and Longevity: The lighting system shall have a rated duration of more than 50,000 hours and maintain at least 85% of its initial luminous flux. Components should reduce glare and maintain equal illumination distribution, hence increasing the system's durability and dependability for long-term usage in educational settings (Davis, 2017).

• User-Friendly Interface and Safety Controls: Efficient integration of lighting systems in educational environments requires a user-friendly interface with safety controls. The user interface (UI) should be straightforward and simple to use, allowing for fast alterations without interrupting teachers or pupils. The system should also incorporate safety elements such master cut-off valves and switches at the teacher's demonstration desk, which allow for

control of all utilities, including lights, at student workstations (Davis, 2017; Flanigan, 1966).

- Daylighting Integration:

• Importance of Daylighting for Visual Comfort: Daylighting is essential for improving learning performance and attention in educational settings. It is essential for sustaining visual comfort, which has a direct influence on study environment efficiency (Kaymaz, 2018).

• Factors Influencing Daylight Distribution: Season, location, latitude, cloudiness, window size and position, room shape and depth, surface colors, and exterior impediments all have an impact on effective daylight dispersion. These components must be addressed to make the most use of natural light (Kaymaz 2018).

• Integrated Lighting Design and Shading Devices: artificial illumination as possible. This entails employing appropriate glazing and shading mechanisms to prevent glare and direct sunlight, hence assuring energy economy and visual comfort in multifunctional classrooms (Kaymaz 2018).

• Optimization Through Simulation and Retrofitting: Simulation technologies, such as DIALux Evo, are critical for assessing daylight performance and developing appropriate shading solutions. Adjustable horizontal overhangs and vertical louvers controlled by building automation systems can be used to optimise daylight availability, minimize glare, and increase overall visual comfort in properly designed retrofitting situations.

- Impact of Lighting on Health, Well-being and Performance:

• Mood and Alertness: Higher Correlated Color Temperature (CCT) illumination, such as 4200K or 6500K, is linked to improved mood, alertness, and vitality. This style of illumination can improve focus and involvement in tasks that need concentration, such as testing. Blue-enriched illumination increases attentiveness and involvement (Morrow, 2018).

• Calmness and Relaxation: Lower CCT lighting, such as 3000K, encourages calm and relaxation. It generates a relaxing environment ideal for unwinding and preparing for sleep. While a 500K temperature difference does not necessarily have a statistically significant effect on perceived peacefulness, it does alter how restful the area seems (Morrow, 2018).

• Health and Well-being: Lighting quality has a significant impact on health and well- being. Poor illumination, such as flashing fluorescent lights, can cause eye strain and discomfort. Changing the lighting to fit different activities and times of day can improve mood and engagement. Improved illumination levels frequently lead to increased general well-being and performance (Morrow, 2018).

• Visual Comfort and Health Issues: Inadequate lighting, such as glare, flickering, and inadequate illumination, can result in eye strain, headaches, and visual discomfort. These problems have a significant influence on visual performance, creating difficulty with reading and focus as well as potential long-term visual health consequences (ORIBO, 2021).

• Circadian Rhythms and Well-being: Proper illumination is essential for regulating circadian cycles, which impact both sleep quality and general health. Metrics such as equivalent melanopic lux (EML) and circadian stimulus (CS) measure light's impact on various biological processes. Poorly designed lighting can disturb circadian cycles, leading to weariness, impaired mental clarity, and overall poor well-being (Safranek, Collier, Wilkerson, & Davis, 2020; ORIBO, 2021).

• Visual Performance and Academic Achievement: Adequate illumination levels are required for visual occupations like reading and writing. Effective lighting decreases eye strain and enhances attention, which can help with cognitive function and academic achievement. Integrating dynamic lighting systems that change throughout the day meets both visual and non-visual demands, increasing student well-being and academic performance (Safranek, Collier, Wilkerson, & Davis, 2020).

Case Studies and Best Practices

6.1 Analysis of Exemplary Studio Classrooms Worldwide

6.1.1 Case Study 1: University of Miami School of Architecture, USA

Thomas P Murphy Design Studio Building was built in 2018 and has LEED certification. It's an open studio with an area of 13,125 sq. feet. Its adaptable venues may hold lectures, seminars, and evaluation sessions. However, the outcome is not merely an open-plan box: The 20,000-square- foot, low-slung Thomas P. Murphy Design Studio Building is a stunning landmark on the architecture campus and a useful teaching tool for the students who use it. It is primarily constructed of raw concrete. The figure below shows the Thomas P Murphy Design Studio Building (Risen, 2019).

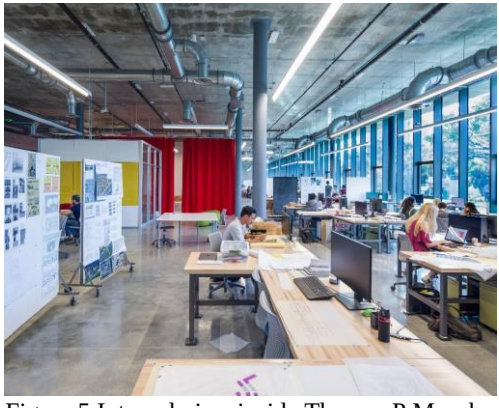

Figure 5 Internal view inside Thomas P Murphy Design Studio Building (Risen, 2019).

Although the studio has an open area, it was designed to accommodate two different groups with a total number of 120 pupils. It features contemporary workstations to facilitate sophisticated digital manufacturing and a cutting-edge fabrication lab. Additional facilities include offices, a computer lab, lecture rooms, review areas, and seating. About 20,000 square feet comprise the building, which has indoor and outdoor jury spaces where students present their final projects to distinguished professors and peers (University of Miami, 2018). Figure 6 shows the components of the studio.

Furthermore, the most cutting-edge glass technology is used in the floor to ceil seamless windows. This provides adequate natural light to the studio during the day. Moreover, the interior features minimum support elements to promote flexible furniture placement and prepare students for modern collaborative workspaces (University of Miami, 2018).

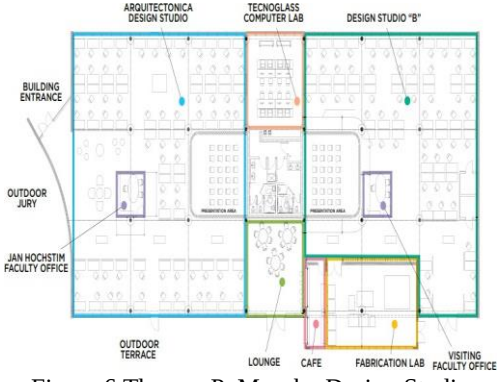

Figure 6 Thomas P. Murphy Design Studio Building Floorplan

Lesson learned from this design:

- The studio classroom gathers architecture students' needs in one place. It makes it easy for the students to achieve their requirements and jobs quickly. Although the studio has a fabrication lab, the noise was minimized using concrete walls around it. Furthermore, having different zones in one place will increase students belonging to the space.
- The design studio accommodates many students, which will increase communication and discussion between them. Consequently, it will improve student work.
- Moving panels for students' work wasn't only increasing student motivation but can be used as partitions to divide the space.

6.1.2 Case Study 2: Nahda University in Beni Suef, Egypt

It is a private university in Egypt which was established in 2006. The university has different

specializations. Architecture engineering is one of those specializations. It consists of several design studios (NUB, 2024). The studied design studio has an area of 80 m2 and accommodates 30 students. Each student has an area of 2.66 m2, and this area is higher than the minimum space needed for each student based on the standard (Chiara et al., 2001; Nabih et al., 2022).

The studio walls were painted white, and the floor was grey color, which is a neutral color that provides a quiet atmosphere. In addition, the studio has large, sealed windows. Those windows are covered with curtains. Because of the bad view and the sun, those curtains cover the windows all the time. The natural light in the studio was replaced with artificial light. The class environment was kept comfortable using air conditioning. Furthermore, although the space of the studio is not large, there was a structural column in the middle of the studio. As a result, this column blocks the view inside the studio, as shown in Figure 7 (Nabih et al., 2022).

The NUB studio has traditional fixed-angled drawing tables. Circular wooden stools were the chairs used in the studio (Nabih et al., 2022). The used stool does not have wheels, which makes it difficult for students to move while drawing. Moreover, electrical sockets for computers are not available in the classroom studio, although architecture students depend a lot on technology. Where it was found that 81% of the student work is presented using the computer (Nabih et al., 2022).

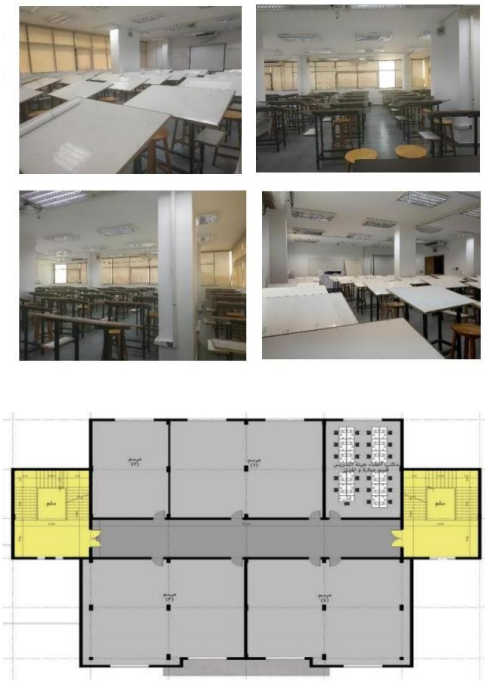

Figure 7 Photos and floor plans of NUB (Nabih et al., 2022).

6.2 Lessons Learned from Leading Design Institutions

In general, visual communication is an important factor that affects the students in the learning process in class. Consequently, it is crucial to pay attention to this factor while designing a classroom. In studio classrooms, this factor is more important because most architecture courses depend on visual communication between students and the instructor.

Fixed and uncomfortable furniture was found to be a reason for health problems in the previous research. It also affects students' performance. Since architecture students spend a long time inside the design studio, ergonomics furniture should be considered.

The world is developing, and technologies have replaced most of the manual work. This fact is also applicable to studying architecture.

Nowadays, most of the architecture works are done based on technology and laptops. As a result, providing electrical sockets should be one of the priorities while designing classroom studio.

Since architecture work and the learning processes are done based on creativity, natural lighting and beautiful views of the outside should be considered in studios.

Conclusion

This research postures that design studios should be more than conventional classroom design, including flexible spatial organization and arrangement, comfortable furniture, and environmentally appropriate design for learning. The investigation finds that layouts with adjustable barriers and mobile equipment accommodate students' learning process while providing them with variations for independent tasks, teamwork, and displays, which is essential for architectural and design professions.

Lighting and especially air quality are very important in facilitating concentration, comfort, and health of students attending that class. The presence of adequate natural light in combination to artificial light allows improving the concentration and mood – the eyes' excessive strain and fatigue. Good quality IAQ is healthy IAQ is achieved when proper accommodation is made to its control such as ventilation control and air purification machinery as it does not only boost up our health aspect but also the well being and our studying or working mind. All these aspects generate a complete context that will accommodate the extended periods students attend studio areas.

However, creating the culture of people's community and social contacts in studio environments for design students is important when it comes to the cultivation of the students' professional selves. Learning environment such as open studio arrangements facilitate for common, casual interactions between the instructors, students and this is especially important as students learn from each other and from the instructors in execution of what is learned in design related fields. These spaces enable learners to participate actively in the cyclical design process by developing self-esteem as well as valuable skills that they practice in their careers.

The outcomes of this research offer insights for designing studio spaces in design education where adaptability, ergonomics, and environmental quality are prerequisites. As such, future research could seek to build on this study by examining advanced uses of digital tools and may also consider using sustainable materials in an effort to improve the performance of the studio as well as a firm's overall sustainability considerations. In this way, through the constant transformation of studio spaces in accordance with current priorities in education and the sphere of professional activity, it is possible to provide design scholars with an opportunity to be prepared for the professional requirements of the field.

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