Exploring the Built Environment and Student's Productivity in School of Architecture

Comparative Analysis of selected case studies in Cairo, Egypt

A Thesis submitted in the Partial Fulfilment for the Requirement of the Degree of Master of Science in Integrated Urbanism and Sustainable Design

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Sherry A. Eskarous

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Abstract

In the age of the knowledge economy, the need for knowledge productivity, in which one must combine and interpret information and knowledge to find creative solutions for new problems they encounter in their daily life keeps on increasing. Architects too, as a profession which relies heavily on creativity, it is key to find a balance between one's creative energy and productivity, starting early on from their university days. Despite the presence of different arrangements and designed productive spaces, students face the struggle of a knowledge worker towards being productive. This research aims to understand and investigate the productivity of architecture students and its relationship with the built environment. Understanding how different factors of the built environment could affect productivity, and to what end is the magnitude of this influence. Focusing on users' satisfaction with the built environment and their perceived productivity as well as the objective environmental quality measurements.

The research focus on the productive spaces presents in faculties of architecture, of two case studies of Ain Shams University and Misr International University in Cairo, Egypt. Using a mixed method of approach in studying the correlation between the built environment and perceived productivity.

The study discloses certain phenomena and issues that possibly affect Architecture students' perceived productivity. Both tangible and intangible, those factors are tied to the built environment of their working place and the students' perception of said environment. Through those findings, further research towards improved consideration may help improve the students' productivity.

While there have been multiple efforts in researching knowledge productivity, there is still a gap in the literature concerning focused specialized professions as well as cross-cases analysis. This research focuses on Architecture students in Cairo as a specific case study.

Keywords:

Architecture, Architecture School, Environmental Behaviour, Environmental Psychology, Built Environment, Perceived Productivity, Knowledge Productivity, Environmental Quality, IEQ, Sensory Experience, Cairo

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List of Abbreviations

AIA; American Institute of Architects

ASHREA; The American Society of Heating, Refrigerating and Air-Conditioning Engineers

BUS; Building Use Studies

CECSA; Consortium of East Coast Schools of Architecture

CIBSE; Chartered Institution of Building Services Engineers

EQ; Environmental Quality

HVAC; Heating, ventilation, and air conditioning

IEQ; Indoor Environmental Qualities

IAQ; Indoor Air Quality

KP; Knowledge Productivity

KWP; Knowledge Worker Productivity

PMV; Predicted Mean Vote index

PPD; Predicted Percentage of Dissatisfied

PP; Perceived productivity.

UNSDG; United Nations Sustainable Development Goals

1. Introduction

Designing the designer's space! You've probably never thought about how architecture students should design their study spaces to help them learn efficiently. The key to long-term success lies in a physical space. There are specific things that can help architecture students do their job better.

"There seems to be a virtuous circle linking health, sustainability, and environmental quality. Better building performance is likely to lead to better human performance...Our surroundings can influence our mood, and our concentration, and enhance or detract from our basic motivation to work." –Derek Clements-Croome

In the context of the global "Knowledge Economy", being able to generate novel solutions in a timely manner is becoming an increasingly important and essential skill. Supported by the United Nations Sustainable Development Goals (UNSDG), which aim towards ones' ability to supply and determine the standard of living. By increasing said productive skill, individuals are able to obtain what they desire in a shorter length of time or obtain a greater quantity in the same amount of time.

With regard to Architects, finding a happy medium between one's creative energy and one's ability to get work done is essential. Especially, if one works in a field that places a high premium on originality. However, the problem lies with the clear challenges architect's face with productivity, just as other professions face similar challenge (Teicholz, 2013). This problem is not only noticeable at the professional level; rather, it emerges at a much earlier stage, throughout one's time in university.

Issues with built environment satisfaction and perceived productivity is being researched and studied for the past decade and half, and the research is still not done yet. While studies of knowledge productivity are extensive and thorough in general; it is the specified studies that are still lacking. As knowledge workers work nature differ across professions and cultures, there is a need in the science

to dive into those needs and focus more on specialised knowledge fields and their productivity.

For this the research aims to Exploring the extent environmental quality (EQ) affects knowledge productivity, within schools of Architecture. Exploring its correlation to knowledge productivity and the interconnected factors among it and the building's physical components. Through understanding the productive work nature of an architecture student and its relation to the building spaces, while studying the different productive spaces across universities and understanding their EQ properties. Moreover, understanding different factors alongside EQ and their relation to enhancing productivity. Seeking to build and understand the correlations between the spaces' EQ and the student's productivity across the case studies.

Through this research, the study delivers those objectives through answering the following questions:

Q1. What is the work nature of an architecture student in term productivity?

Q2. What are the physical qualities of the productive spaces in architecture schools?

Q3. What is the definition of knowledge productivity and factors affecting it?

Q4. What are the intangible and tangible elements affecting one's productivity in an architecture productive space?

Q5. To what degree do the Universities of Architecture built environment affect and relate to the students' perceived productivity?

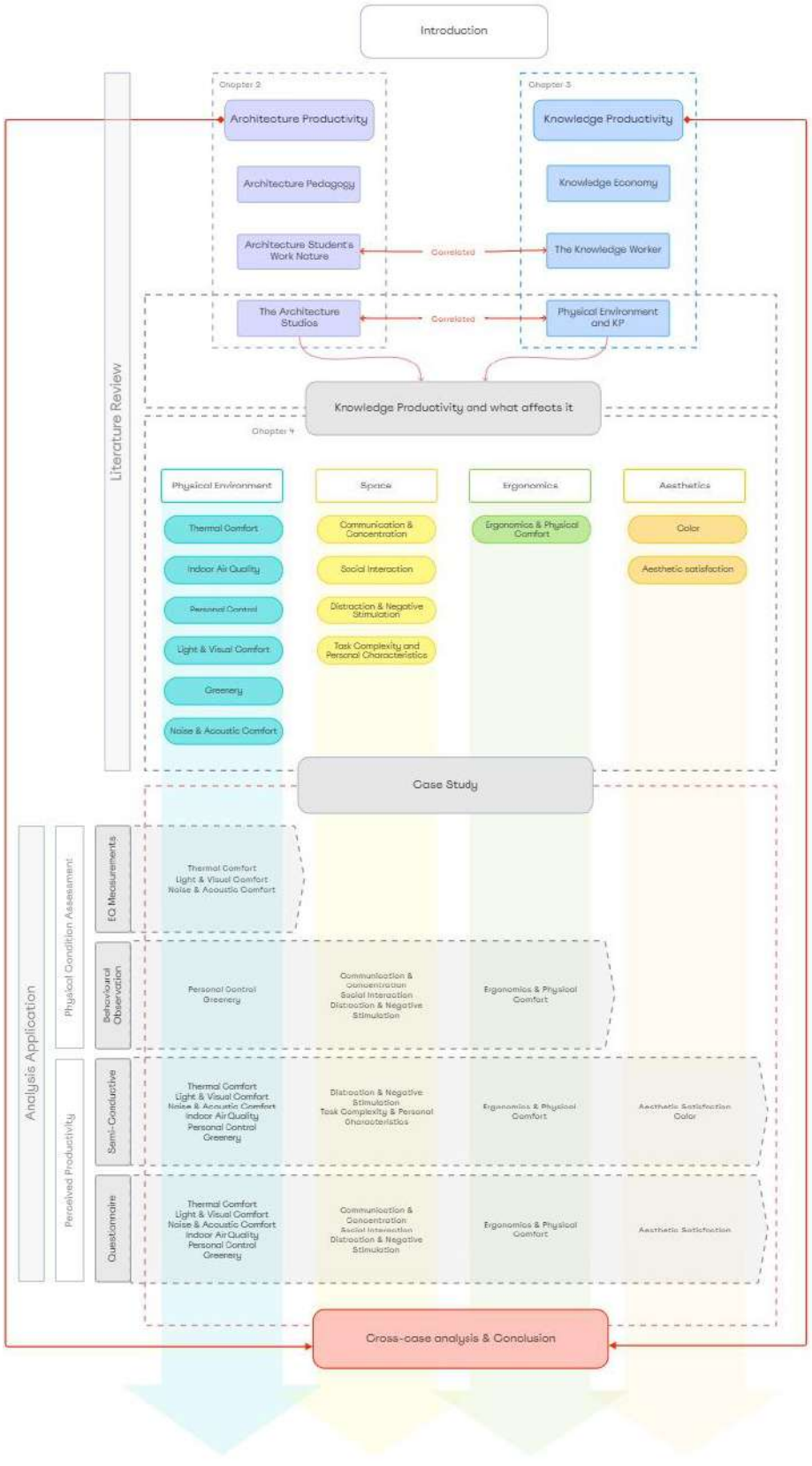
In the past 30 years, the field of architecture has gone through a number of big changes. This is because society's needs for the built environment have changed because of things like population growth, more people living in cities, technological advances, the rise of ageing societies, and concerns about the environment. Several different pieces of research have talked about this change

(Doxiades, 1963) (Sanoff, l975) (Prak, 1986) (Gutman, 1988) (Cuff, 1991). In 1968, Sanoff, Goates, and Moffett wrote a book called "Response to Environment" in which they said that architecture used to be about making specific works of art on specific sites. The only way to solve the design problem was through intuition, and a lot of weight was put on the knowledge, judgement, and natural skill of each designer. Even though this method of architecture has led to some of the most long-lasting and important works of the past, the profession is currently facing serious problems that threaten the way it has always worked. The most recent research Salama, O'Reilly, and Noschis (2002) backs up this point of view and suggests that architectural education and practise need to become more flexible to keep up with the constantly changing industry standards. (Habraken, 2006) (Salama, 2008). It is not just the learning experience rather also the knowledge practice within Architecture education and the productive output that keeps on being challenged. The literature explains how the environment can affect productivity, yet how does that fare with reality within the schools of Architecture in Cairo, the study aims to explore that notion further.

With the economy shifting to a knowledge economy, organisations, companies, and even governments gain a competitive edge by using knowledge and its resources to their advantage. According to the Oxford English Dictionary, a "Knowledge Economy" is *"an economy in which growth depends more on the amount, quality, and availability of information than on the means of production."* With this change comes a new factor of production: more knowledge (Stam C., 2007). If you look up the word "productivity" in the Oxford English Dictionary, it means *"the effectiveness of productive effort, especially in industry, as measured by the rate of output."* But it's not that simple when it comes to the productivity of knowledge. Knowledge productivity is defined by Kessels (2001) and Poell (2004) as *"the process of signalling, identifying, gathering, absorbing, and interpreting relevant information, using this information to develop new capabilities, and using these capabilities to improve operating procedures, products, and services in small ways or in big ways."* The

main source of production for a knowledge worker is not only their knowledge, but also their brain, which is the main tool of production (Stam C., 2007).

Through this research the notion of knowledge productivity is revised and its correlation with the environment is explored. Focusing on Architecture schools in Cairo, Egypt, and the students' perceived productivity (PP). The research is divided on two parts; the first goes over the literature of the work nature of an Architecture student and architecture pedagogy, Knowledge productivity (KP), and factors that affect KP in regards of environmental qualities. Second, focus on the local case studies in Cairo, which are Ain Shams University (ASU) and Misr International University (MIU), and analysing the status quo of the environmental qualities on campus as well as students' perceived productivity. Aiming through the study to explore the extent environmental quality (EQ) affects knowledge productivity, within schools of Architecture. Exploring the interconnected factors among it and the building physical, attitudinal, and social components.



Q1. What is the work nature of an architecture student in terms of productivity?

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2. Architecture Productivity; Student Work Nature.

Architecture is a profession that relies heavily on creativity and coming up with novel ideas. Innovation is a key element of an architect's skill and work nature, however without productivity this creative energy can be rendered fruitless. The challenge between creativity and productivity is ongoing for the architect ever since they are faced with their first design project starting from school days. In the following section of the research the process of architecture pedagogy and the studio process will be explained and further understood, hinting at how it relates to knowledge productivity, as it will be discussed throughout the literature.

Architecture pedagogy is a mix between learning, exploring, and doing. The learning environment changes out of the traditional space we know of, and it rather becomes a space for mixed use. The term "learning environment" refers to the diverse range of settings, both geographically and culturally, in which students are expected to acquire knowledge (Thamarasseri, 2017). Students are expected to acquire knowledge; thus, the objective is to design a learning environment that makes the most of their potential to absorb information (Afoma & Christy, 2014). Learning can take place in a variety of contexts, and the situations in which it takes place can be either unstructured or structured. Learners in the modern day are entitled to learning environments that cater not just to their individual requirements but also to the requirements of the group as a whole. (Adewale, et al., 2021)

When analysing a learning environment, factors such as ambience, mood, atmosphere, ecology, and scene are taken into consideration. As a result, a learning environment is also sometimes referred to as a classroom climate. Ibem, Alagbe, and Owoseni (2017) state that the learning environment is made up of both the psychological and physical characteristics of its immediate surroundings. The psychological aspect is concerned with how people act, think, and feel in relation to their immediate surroundings, whereas the physical aspect is concerned with the effect that behaviour, thought, and emotion have on one another as a result of the interaction (Ibem, et al., 2017). However, according to Mick Zais (2011), a learning environment is defined as the degree to which a

place of learning promotes the health and safety of the people who use it. The surroundings or rooms in which students are instructed throughout their time at the educational institution make up the learning environment. The spaces that students study in at educational institutions ought to be inviting and relaxing. The architectural design studio serves as the major learning setting for those who are studying architecture. Architecture student typically gain knowledge relevant to architecture while working in what is known as a design studio. According to Oluwatayo, Aderonmu, and Aduwo (2015), the studio is the learning place in which students spend the majority of their time acquiring instructions, networking with professors, and interacting with fellow students. A studio is a space where students may engage in a variety of activities and network with one another, which helps to organise their educational experience. However, the students' educational opportunities may not be limited to the confines of the studio (Oluwatayo, et al., 2015).

2.1. Architecture Pedagogy

During the past three decades, the field of architecture has been subjected to a number of significant shifts in order to accommodate the shifting demands placed on the built environment by society as a whole as a consequence of factors such as population growth, increased urbanisation, technological advancements, the emergence of ageing societies, and concerns regarding the environment. This shift has been cited in a few different research. (Doxiades, 1963) (Sanoff, et al., 1968) (Sanoff, 1975) (Prak, 1986) (Gutman, 1988) (Cuff, 1991) The most recent research suggests that architectural education and practise need to become more adaptable in order to keep up with the ever-evolving industry standards (Salama, et al., 2002) (Habraken, 2006) (Salama, 2008).

Over the course of the last few decades, a number of studies have pointed to the profound shifts that have occurred within the profession (Doxiades, 1963) (Bolman, 1981) (Balfour, 1987) (Gutman, 1988). It is now usual practise to note that significant shifts are taking place in the fields of building, architecture, and urbanisation. According to the opinions of a great number of educators, (CECSA,

1981) these developments will significantly open up new channels for responsibilities that architects and planners could play, which may result in a shift in the traditional role of the architect.

It would appear that we are currently living in an age in which no single discipline can have strong claims any longer over its own path, concerns, and areas of knowledge in isolation from what is happening in other disciplines (Rockeach, 1973). This is because we are living in an age in which all disciplines are becoming increasingly intertwined. This necessitates rethinking architecture such that it is ultimately a social act as well as a subject of study and practise that transcends disciplinary boundaries. In this light, architecture need to be considered a socially responsible and axiological form of art (Burgess, 1983). Furthermore, it is essential for the existing theory and practise of architectural and urban education to examine the fundamental values that are reflected in the design process. This will lead, consequently, to the students of architecture being exposed to alternative societal roles.

According to Salama (2021) it is important for the studio to place an emphasis on the various architect role models that are related with the social and ethical commitment towards current cultures. If one dissects the architectural studio into its three component parts—the content, the process, and the teaching style—one will discover that none of these parts expose students to any other architect role models than the egoist role, and in some cases, the pragmatist role. This is the case regardless of which part of the architectural studio one examines. In relation to this issue, Jakobson (1970) asserts that one must possess three fundamental capabilities in order to have a better comprehension of society. The art of thinking, the art of judging, and the art of speculating are the three arts that make up this discipline. As a result, the study of these three arts ought to turn into the focus of each and every design course offered in the field of architecture. Ledewitz (1983) has defined four intentions, in terms of learning objectives that should be implemented in the studio; these might be summarised as follows: In response to the dominance of the egoist role model:

- Students need to be made aware of the significance of the function that values play in the design process. They ought to be aware of the fact that discrepancies in the solutions to design problems are related to disparities in the values.
- Students need to realise that the values they hold may not be the same as the values held by the people for whom they are designing.
- It is important for students to be able to differentiate between design actions that are based on their own personal values and those that are based on the values of others.
- Students need to be able to articulate their personal beliefs and principles more cogently.

"Students seeking to become architects must first be made aware of the negative effects of current architectural education, juxtaposing this awareness with the values of real engagement with the world," Salingaros and Masden (2007) wrote in a recent eloquent argument on architectural education. One could see how such an argument discerns the ills of architectural education and the architect roles it emphasises while at the same time offering a panacea for those ills. In other words, the argument identifies the problems with architectural education and the architect roles it emphasises. (Salama, 2021)

The fundamental concept of education in architecture that this approach is based on is that it should be based upon a comprehensive understanding of the values, needs, and desires of all members of the design team. (Cross, 1972) (Cross, 1990) (Sanoff, 1978) (Sanoff, 1988) (Sanoff, 2003) (Stohr & Sinclair, 2006) This is the striking observation in which this approach works, and it is the reason it is effective. In this context, the design team is comprised of all of the individuals who would be directly influenced by the created design solution as well as the individuals who have an influence upon the implementation of the design project.

Salama (2021) discussed in response to the various perspectives that have been held in the past on architecture, four distinct types of architectural education have come into existence: the academic, the craft, the technological, and the sociological. The study of compositional theory and the classical principle of formal design is regarded as the most important component of an architect's education by the educational establishments that provide this training. Schools and academies, where teachers are well-versed in the most effective architectural design principles, as exemplified in great buildings from the past or in historical manuscripts of architecture, are widely regarded as the best places for students to acquire these fundamentals of architectural design.

It was anticipated that architecture schools would begin placing a greater emphasis on pragmatic principles as a result of the impact of the newly developed fields of sociology and social science. As a result, they placed an emphasis on social function in structures, as well as the correct link of these characteristics to the social and physical surroundings, and as a consequence, they paid attention to planning and designing for all people living in cities and towns. As a result of changes in the environmental needs of society brought about by factors such as population growth, advances in technology, and increased urbanisation, the practice of environmental design, also known as urbanism, has become extremely influential over the course of the past three decades.

2.2. Work nature of an Architecture student

Clips Sturgis (1914) published one of the earliest publications discussing the evolving function of the architect at the very beginning of the 20th century. In this work, Sturgis argued that architects ought to have a variety of skills in order to produce architecture of a higher quality. He made the following statement: *"Architecture is not just an art. It is also an area of industry and scientific study. It calls for a wide variety of skills and abilities. Architects that focus primarily on one of these competencies are only partially competent, and as a result, they provide subpar services to their clients. It is essential for architecture to be a collaborative effort"*. Salama (2007a) have presented an argument regarding the

perspectives held by the vast majority of architects, which begins at such an early one. "Architects continue to hold the belief that they have the right to use the process of building, which results in structures that are ultimately utilised by other people, as a medium for their own personal investigation and expression. They are constructing architecture that has very little to do with anything else and is driven entirely by their creative instincts."

Through his extensive studies on Architecture Pedagogy and practice Salama discussed that in the same way that other forms of education do, design education in architecture and urban design conveys, preserves, and transmits the values that are held by the profession as well as by society as a whole. Design education is the embodiment of the ability to conceptualise, coordinate, and execute the notion of building anchored in the tradition of humanism. This is because the creation of architecture and the general urban environment occurs in a field of conflict between reason, emotion, and intuition. Architectural and urban design is a broadly based activity that touches everything from identifying problems to specifying methods for dealing with these problems in order to achieve responsive solutions.

Given that the design studio serves as the nerve centre of architectural education, much of the criticism has focused on contrasting the contents and processes that characterise the way in which architecture is approached in the design studio with the way architecture is actually practised in the real world. The various architects who have served as role models should each be given the same amount of attention while teaching architectural design (Boys, 2010) (Brandt, et al., 2013). Within the context of the design studio's instructional procedure, ideas like programming, post-occupancy evaluation, and user interaction ought to be seen as fundamental components of the whole curriculum. Students will have the chance to be researchers and designers in this area of study because they will be able to tackle design problems by critically analysing previous iterations of projects that are conceptually comparable to the ones, they will be working on (Kurt, 2009). They are able to work with customers and users in a process that is

collaborative to determine the customers' and users' values, needs, and the limits of the problem. (Salama, 2021)

The critical discussion has pointed out the fact that the understanding of design has expanded from a view of design as an intuitive experience to a view of design as a process of investigating, reasoning, and testing (Boys, 2010) (Salama, 2021). The traditional method of instructing design is based on pedagogical practises that are in total contrast to the way design is really done in the real world. Methods such as "the written programme," "the Charrette," "the concept development," "the sketch design," and "the finished presentation" have very little to do with actions taken by professionals who are committed to their work. An important aspect of the service that an architect renders to society consists in determining and articulating the requirements of his or her individual clients. In its most basic form, this procedure entails the identification of problems and the formulation of those problems in a manner that makes them solvable and identifies specific goals (Brandt, et al., 2013). In the meantime, what actually occurs in the design studio is that the student produces a solution without investigating, recognising, or even understanding the problem that needs to be solved. This is because the student is tasked with solving the problem on their own (Kurt, 2009) (Brandt, et al., 2013). Procedures that are followed in the studio are very different from those that are followed while really designing something, therefore there is a big difference between the two. (Salama, 2021)

Students majoring in architecture are required to study a wide number of classes, some of which include building history, building science, building materials and structures, and building design. In order for them to be able to practise, they are necessary to study, comprehend, and succeed in these classes (Oluwatayo, et al., 2015). In the field of research, the terms academic performance and academic outcomes are frequently used interchangeably. The performance of a person in an educational setting is referred to as their academic performance. Academic success is a phenomenon that combines academic performance with the outcome of learning goals, perseverance, the acquisition of desired competencies and

abilities, satisfaction, and performance after college (York, et al., 2015). According to Opoko, Oluwatayo, and Ezema (2016), academic performance of students is a measurement of the degree to which a student has been able to reach the educational set-goal. This was stated in the previous sentence. Having academic success is absolutely necessary in order to accomplish one's learning goals and acquire one's desired level of knowledge. As a result, it is necessary to get an understanding of the numerous contextual factors that have an impact on the academic performance (and consequently, the academic success) of architecture students. The environment of the classroom is made up of a variety of components, including the time factor, the acoustic factor, the visual factor, the spatial factor, the thermal factor, and the facilities. According to York, Gibson, and Rankin (2015), the spatial factor, which includes the classroom arrangement, seating positions, and space management in general, has a more significant impact on the students' level of understanding, and as a consequence, their academic performance, because it affects the fundamental component of teaching and learning, which is communication. As a result of this, it is recommended that the atmosphere of the classroom should be one that is well-organized, equipped, and facilitated. The performance of students is also significantly impacted by the spatial and ambient characteristics of the classroom, which in turn are shaped by the planning, management, and, finally, upkeep of the same (Zheng, et al., 2013).

2.3. The Architecture Studio Process

The process of design is broken up into two separate stages through the use of the analysis-synthesis approach. During the phase known as analysis, information that is pertinent to the problem is gathered and then examined in order to provide a deeper knowledge of the problem. In contrast to the typically unstructured nature of the synthesis phase, this phase has been thoroughly mapped out. The first stage, analysis, is a logical stage, and the second stage, synthesis, is an intuitive and creative stage that comes after analysis. The primary criticism levelled against this methodology is that the conclusions of the analysis phase are

typically ponderous statements of the blindingly obvious (Archer, 1969), and that the design situation is handled within a fragmented linear sequence. In the field of education, students frequently lack the ability to successfully apply the findings of the initial phase of analysis toward the development of a plan (Ledewitz, 1985) (Salama, 2007b). When using this method, the student is typically led to believe that an optimal solution will signify the end of the design process. It is assumed that a creative leap will translate the programme into the design solution (Brandt, et al., 2013). Consequently, the student is led to believe that an optimal solution will signify the end of the design process. Therefore, students continue to look for this leap, and as a result, they frequently find themselves unable to finish their ideas within the allotted period of time.

The approach is organised in the form of a series of consecutive procedures, each of which leads to the next, and ultimately results in a comparative study. These procedures include:

1. Identifying the models.
2. Establishing a format for description, which consists of a) the conception of architectural design, b) the design process, and c) the teaching style.
3. Summarising the description.
4. Identifying the underlying issues for comparison, and
5. Conducting a concluding content analysis.

Identifying the models is the first step in the process. The results of the study, which are comprised of a diagram summarising each model and three comparison analysis matrices, were addressed to the authors of those models for the purposes of receiving comments and verifying the findings of the study. Every author received the opportunity to make changes to his or her model based on the comments and suggestions made by readers. Both the matrices and the diagram have been altered in accordance with their responses. While this section provides analytical descriptions, the following section provides a discourse as

well as reflective comparisons that highlight the most important characteristics of the models. (Kurt, 2009) (Brandt, et al., 2013) (Salama, 2021)

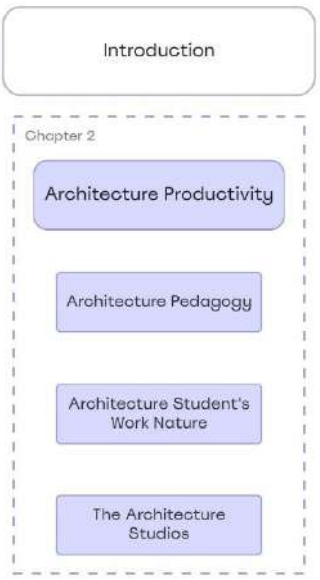
Herbert Simon argues that the act of design is a sort of problem solving in his book titled The Sciences of the Artificial, which was published in 1976. He considers creating in its most fundamental form to be an optimization process, and he ignores contentious, uncertain, and one-of-a-kind circumstances as a result. On the other hand, the design literature (Schon, 1988) argues that the act of design, in its broadest sense, entails the creation of representations of things that are intended to be materialised. This is due to the fact that designer's piece together existing elements to produce new artefacts. Therefore, it is envisaged that the design process will function on the basis of rigorous reasoning, logical treatment, and intuition. According to Schon (1988) a design process is a reflective conversation taking place between the materials of a given design situation. This is an insightful interpretation of the nature of the design process. In this regard, one may claim that it is a process that involves phases of analytical comprehension, critical thinking, and creative decision making. This is due to the fact that: However, design does not take place in a linear fashion; rather, it requires integrated thinking, and there is ongoing interaction between the stages as the design progresses (Salama, 2005).

While students' design actions continue to be tacit and internalised, conventional teaching practises suggest that typically studio teaching adopts a product-based approach. In this type of teaching, the emphasis is often placed upon exploring solutions and the development of form manipulation skills (Salama, 1999)There are two basic project kinds. The first is hypothetical when design aspects are not genuine but simulated. The second scenario takes place in "real life," in which a genuine client and an actual issue are present and play an essential role in the process of finding a solution. Both have the same two primary characteristics: deciding what to design and how to create it (Kurt, 2009). What to design is about beginnings and endings, whereas how to create is about ways. What should be designed is constrained by the project programme in both its broadest and most

particular aspects (Mann, 1992). It distinguishes itself by putting up ideas for human activities that are suitable for particular kinds of forms or settings (Salama, 1995). In essence, what to design must answer to the institutions of society, to society's cultural dictates, and to the overall lexicons of construction. The process of learning how to design is centred on methods, which is a term that gives the impression that design is a collection of steps and routines that a design student does on purpose. Design in this sense may be researched, tested, and most significantly, it can be taught. To design something means to carry out a sequence of actions that culminate in the production of the intended outcomes.

2.4. Conclusion

Throughout this chapter, we understand the work nature of an Architecture student and how architecture pedagogy works. For an architecture student to perform well in class, they are required to be able to analyse information they are exposed to and come up with creative solutions. Similarly, the work nature of an architect student can be considered fairly similar to that of a knowledge worker. While knowledge worker aims to come up with novel solutions to old problems, an architecture student needs to come up with creative designs for existing building typologies. In this regard as well we start realising that architecture students' productivity is a form of knowledge productivity. In the following chapters, the terms knowledge productivity and knowledge workers are further understood and elaborated as well as the factors affecting them within the built environment.



3. Knowledge Productivity; an economy shift

Following our understanding to architecture students' work nature and how their productivity is linked to knowledge productivity. It is interesting to notice that the economic shift also affected the architecture practice, inside and out. Both in terms of the working spaces design and the practice of architecture design. This section of the research goes deeper towards understanding the term knowledge productivity and knowledge economy and how it resulted from the economical shift. That shift redefined productivity and the workplace.

As the change in economy turn from industrial economy to knowledge economy, there comes a competitive advantage of the organizations, companies, and even governments in exploiting knowledge and its resources to their favor. According to oxford dictionary, Knowledge Economy is "*an economy in which growth is dependent on the quantity, quality, and accessibility of the information available, rather than the means of production*". With that change comes a new production factor which is an increase in knowledge (Stam, 2007).

According to Stewart (2002) and Drucker (1999), one can summarise knowledge economy in three attributes; first being the knowledge economy as a product, the second is the intellectual capital (IC), and the third is the knowledge productivity (KP). Knowledge productivity comes as the biggest challenge when it comes to the knowledge economy.

Looking up the meaning of productivity in the Oxford English Dictionary, productivity means the effectiveness of productive effort, especially in industry, as measured in terms of the rate of output. However, for knowledge productivity it isn't that simple. Kessels (2001) (Kessels & Poell, 2004) define Knowledge productivity as *"a process that entails signalling, identifying, gathering, absorbing, and interpreting relevant information, using this information to develop new capabilities and to apply these capabilities to incremental improvement and radical innovation of operating procedures, products, and services".* According to Drucker (1993) the knowledge worker productivity is one of the biggest challenges within the 21st century. Knowledge worker is not only the main source of production, which is knowledge, rather they also own the main

tool of production, which is their brain (Stam, 2007). Therefore, to make way for a healthy knowledge economy, a productive work environment is of great importance. As the physical environment influence people, it can also affect their productivity (Kastelein, 2014).

3.1. What is Productivity & Knowledge Productivity

By the start of the second millennia, the economic world saw a change toward knowledge economy. According to Drucker, while the most important contribution to the 20th century management was the productivity of the manual worker, the 21st century similarly focus on the productivity of knowledge workers. Naming knowledge worker and their productivity as the most valuable asset of age (Drucker, 1999).

With that change towards the knowledge economy, organizations competitive advantages come from their ability in exploiting knowledge. Leading to an increased importance of knowledge as an economic resource (Stam, 2007) (Harris, 2019). Routine work is being replaced by knowledge work, one in which workers need to understand and interpret information and knowledge to come up with innovative solutions (Kessels & Keursten, 2002).

Productivity is not just of importance to cooperate organizations, rather it is of importance to the individual as well, especially with how fast the world moves toward development and innovation these days. However, while manual productivity concerns physical input and output, it is not the case with knowledge workers. According to Drucker (1993) six major features could be linked to the productivity of a knowledge worker and how said productivity is realized.

Quoted from Management Challenges for the 21st Century, Ch. 5 (Drucker, 1999)

- Knowledge worker productivity demands that we ask the question: "What is the task?"
- It demands that we impose the responsibility for their productivity on the individual knowledge workers themselves. Knowledge workers have to manage themselves. They have to have autonomy.
- Continuing innovation has to be part of the work, the task and the responsibility of knowledge workers.
- Knowledge work requires continuous learning on the part of the knowledge worker, but equally continuous teaching on the part of the knowledge worker.
- Productivity of the knowledge worker is not—at least not primarily—a matter of the quantity of output. Quality is at least as important.
- Finally, knowledge-worker productivity requires that the knowledge worker is both seen and treated as an "asset" rather than a "cost." It requires that knowledge workers want to work for the organization in preference to all other opportunities.

Starting off comes the need to understand the task at hand. Depending on the field of work concerning the knowledge worker, tasks differ, and the required skills and knowledge differ. Hence it is important for increasing knowledge-worker productivity (KWP) to ask the questions to define the task, what to be done and to be expected, what aids it and what hinders the task to be eliminated (Drucker, 1999) (Harris, 2019).

Clements-Croome (2006) identified the relation between extraneous factors and knowledge productivity. He indicated a link between environmental quality, health, and sustainability. He outlined how complex the relation between the surrounding environment and its effect to one's mood, concentration, and their work motivation.

3.1.a. Evolution of the productive workspace

Since the early 1900s, there has been constant attention put towards understanding the impact the workplace has over workers productivity. Starting by Fredrick Taylor and his seminal *Principles of Scientific Management*, highlighting the importance of a supportive and co-operative management to employee's productivity (Taylor, 1911). Following that in 1920s and 1930s, the Hawthorne Experiments started building correlation between the surrounding environment and workers productivity. In addition, factors that rely on social interactions like work groups and others that focus on personal control over workplace environment and working methods were highlighted to have positive impact on productivity (Harris, 2019).

Comes the post-war globalization movement in the 1960s which led to business complexes and layered unchanging organizations. All those changes led to devising open plans for multiple office complexes. During the 1970s, and the growing complexity of office work, in addition to the increased number of office workers created a demand towards offices efficiency and raised concern toward employee's productivity (Thompson & Kay, 2008). With that comes Herman Miller and the "Action Office" open plan system to solve the increase demand on offices efficiency and productivity. While the open plan system was though to improve social interactions and communication between office employees (Bedoir, 1979) (Brunia & Hartjes-Gosselink, 2009) (Ives & Ferdinands, 1974) (Sundstrøm, 1986) and are more efficient in term of increasing occupants' density, and easier when it comes to layout changes, they come with what we now call productivity cost (Harris, 2019). The discussion over the pros and cons of open offices plan is still ongoing till date, and 60 years later, they have been a stable approach in workplace design.

With the rise of technology and communication, it was key to introduce it to office designs. Organization management then started utilizing both the physical layout and communication to achieve their objectives (Stone & Luchetti, 1985). Said objectives focused on exchanges between employees both formal and informal,

providing them with specialized equipment, attracting employees with talent and increasing productivity (Harris, 2019). Stone and Luchetti (1985) a new approach towards the workflow proposed by which focused on a holistic flow of information and people enabling a richer experience in an activity setting workplace. It was unorthodox at time and viewed technology as an enabler in the workplace.

Around the mid-1990s the implications of workplace design and its changes had a growing library of materials to reference (Duffy & Powell, 1996) (Duffy & Tanis, 1993) (Duffy, et al., 1993) (Raymond & Cunliffe, 1997) (Worthington, 1997). With the shift to knowledge economy, work was starting to be about empowering employees and knowledge workers to interact and collaborate. Consequently, the workplace had to adopt and provide to the evolving work nature, by providing a more prosperous and dynamic work setting to accommodate both individual and group work needs.

The turn of the new millennia witness what was called *"the rise of the agile working",* highlighting how work is becoming more mobile, and how less a fixed workplace is needed to perform the task at hand. Hence workplaces will witness a transformation from a place of task completion and more a place of social interaction, collaboration, and networking. Workplaces are changing into hubs where employees learn, communicate, network, and do more work-related social activities than actual tasks (Cairncross, 1997). This stems from the knowledge worker need of continuous learning and innovation to be productive (Drucker, 1999). With further technological advancement and development in mobile phones, laptops and internet, work is turning more into an activity and less a place. Instead of a fixed place for work, workplaces are becoming a resource for empowering knowledge workers and improving their well-being and their productivity, as they are the most valuable asset to the business.

3.1.b. The shift towards knowledge productivity

With today's work nature, the workplace is changing to be a place of learning and a source of knowledge. Thus, the basic relation between work and knowledge is changing, instead of knowledge being seen as preparing for work it is now turning to be the actual work at hand. Knowledge work is one where the worker needs to be able to receive information and knowledge while interpreting them to find innovative solutions (Kessels & Keursten, 2002). In such work nature, workers would be unable to perform their job without learning, here comes the need to create an environment where working and learning are considered as one. Such environment needs to trigger knowledge workers and stimulate them in a way that is attractive to them and their intellectual needs.

One of the main differences that stand clear in knowledge economy is the major value added by knowledge (Drucker, 1993) (Castells, 1998) (Kessels & Keursten, 2002). The productive process of a knowledge worker requires the intellectual ability to filter through knowledge and information and identifying the relevant information needed. Then utilizing said information towards the development of new skills which is then put towards creating innovative solutions, whether procedures, products or services (Kessels & Keursten, 2002). Since knowledge productivity entails mental skills of analysing information, it is linked to the individuals assigned and concerned with the task at hand. It is important to realize is that knowledge is defined as a personal ability, resulting in a personal link between said knowledge and the personal interpretation (Stam, 2007). While there are methods of acquiring knowledge through the knowledge of others, that does not lead to the same knowledge for each person. Hence, knowledge should be clearly divided into information, experience and skill (Stam, 2007). As mentioned earlier, Drucker highlighted that knowledge productivity, constant innovation, and learning are the base of knowledge work. Rather than applying rules in a tradition matter to solve a problem, the knowledge worker is required

to keep improving what is currently known of solutions and devising new models and analysing new situations besides solving issues at hand. Subsequently,

knowledge productivity happens when there is constant improvement, and radical innovations resulting from knowledge are acquired and applied. The true asset is not the actual innovation rather the ability to come up and generate new ideas and solutions, for that, the ability to learn is closely linked to the ability to innovate within knowledge productivity

3.2. The Knowledge Worker Productivity and How to Measure it

Three of the most sought-after goals in any workplace are increasing productivity, stimulating knowledge sharing, and satisfying employees. The process of knowledge productivity is a very complex process with multiple stimulants and factors affecting said productivity. Extrinsic factors lie in the surrounding environment, both physical and managerial, while intrinsic factors can be pointed to personal capabilities and general well-being (Maarleveld & De Been, 2011) (Been, et al., 2016) (Greenhill, et al., 2017).

3.2.a. The Knowledge worker

Previously was mentioned the six factors determining the KWP discussed by Drucker (1993), identifying the knowledge worker as a capital asset instead of a cost. Drucker discuss that understanding the work nature of the knowledge worker is key in improving KWP, for it is understanding the task and what it should be which could double or triple the KWP. Knowledge worker here becomes the owner of the mean of production, their mental power is the factory for knowledge work and hence they are an asset. That entails that it is of high value attracting high producing knowledge workers and improving their performance. A change in the basic attitude of both the individual and organization is due in order to make way for the knowledge worker to be productive (Drucker, 1999).

Part of the knowledge worker productivity lies in the knowledge worker understanding of their productivity means as well, as in what makes them individually productive. Here the work environment needs to help facilitate such means to understanding one's productivity, concentrating on their needs,

strength and improving those strength (Drucker, 1999). Second to understanding how knowledge worker performs comes the need to understand how they learn (Drucker, 1999) (Kessels & Keursten, 2002). Knowledge is the main mean of production for a knowledge economy. Said knowledge is acquired by the knowledge worker through extensive education and practical experience (Kessels & Keursten, 2002). Knowledge workers don't only own the knowledge they know the mean to make knowledge productive, turning knowledge into an act instead of a product only. Learning then becomes a critical gear in the machine of is knowledge creating and processing.

3.2.b. Physical Environment and Knowledge productivity

In regards of influencing knowledge productivity, the physical environment is arguably one of the major tools and factors used for it (Maarleveld & De Been, 2011). Many publications discussed the effect of temperature (Lan, et al., 2010) (Niemela, et al., 2002), lighting, technology, noise, and personal control (Hameed & Amjad, 2009) on knowledge productivity, both negative and positive. Hameed and Amjad (2009) study highlighted lighting to be the most influential factor over productivity, followed by spatial arrangement. Another study by Block and Stoke (Block & Stokes, 1989) found a relation between office layout and occupants' perceived productivity, with the type of work being done relating to how influential the relation is.

While communication does not equate with productivity, many organizations link them together with an assumption that the former could promote the latter. Spatial arrangement that favours interactions, especially spontaneous ones were found to be very important to productivity, followed rightly by the ability to work individually (Brill & Weidemann, 2001) (Maarleveld & De Been, 2011). Barry Haynes discussed those factors even more in his publications; stating how perceived and self-assessed productivity is impacted by interaction and distraction the most (Haynes, 2007). Furthermore, in a following study environmental factors such as comfort, office layout, interaction and distraction were examined in regards of their effect on productivity (Haynes, 2008a)

(Haynes, 2008b) (Haynes, 2008c). However, while various studies have examined how particular environmental factors influence employee productivity, there is still little understanding of how much their effects are interrelated, especially with specific work nature and needs.

3.2.c. Features towards measuring knowledge productivity

In the research done by the British council for offices (Greenhill, et al., 2017) the physical design and management of offices correlation with knowledge workers productivity was examined. In addition to an understanding of productive workplaces with their relation towards improving productivity.

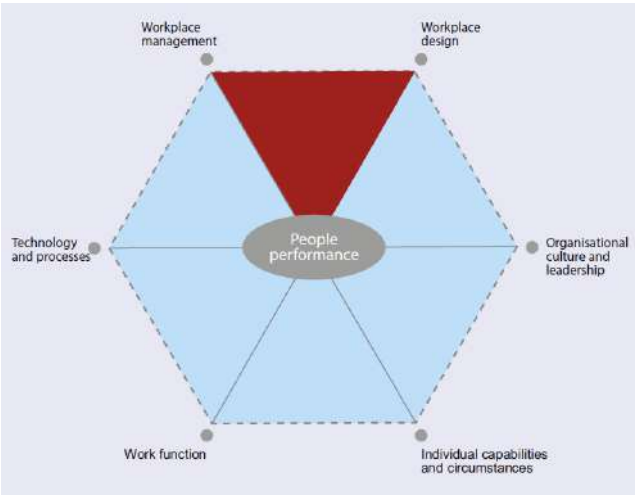


Figure 1 *shows the numerous interconnected influences on an individual's productivity (Greenhill, et al., 2017)*

Being able to support occupant's wellbeing as well as enabling them to perform better in term of efficiency and effectiveness should be a given goal in offices and workplace design. Thus, productivity should be a holistic consideration in design and not only in few elements or spaces. In this regard, a productive workplace would hence enable individuals and teams alike in performing better within their work environment (Greenhill, et al., 2017) (Harris, 2019). In doing so, the workplace would aim towards four conditions to improve productivity: healthy, effective, efficient, and engaging (Greenhill, et al., 2017). Hence the design should be leading to an environment that support and improve well-being with minimum waste of space and time to enable occupants to do perform their job optimally. In addition, it should be a destination that is attractive and desirable to work at.

It is required from offices and workplaces of the current time to provide an environment that is heathy and supportive of occupant's well-being. Moreover, an added advancement comes from using the spaces efficiently, which in its way facilitates achieving the best results. Thus, it is important to consider the effect of the workplace on productivity that could result in its decline. It is also important for the work environment to enable both effective and efficient, supporting both individual and team tasks to their best abilities (Greenhill, et al., 2017). Figure 2 discusses dimensions of workplace productivity and how tangible and intangible factors impact each other in influencing users' productivity.

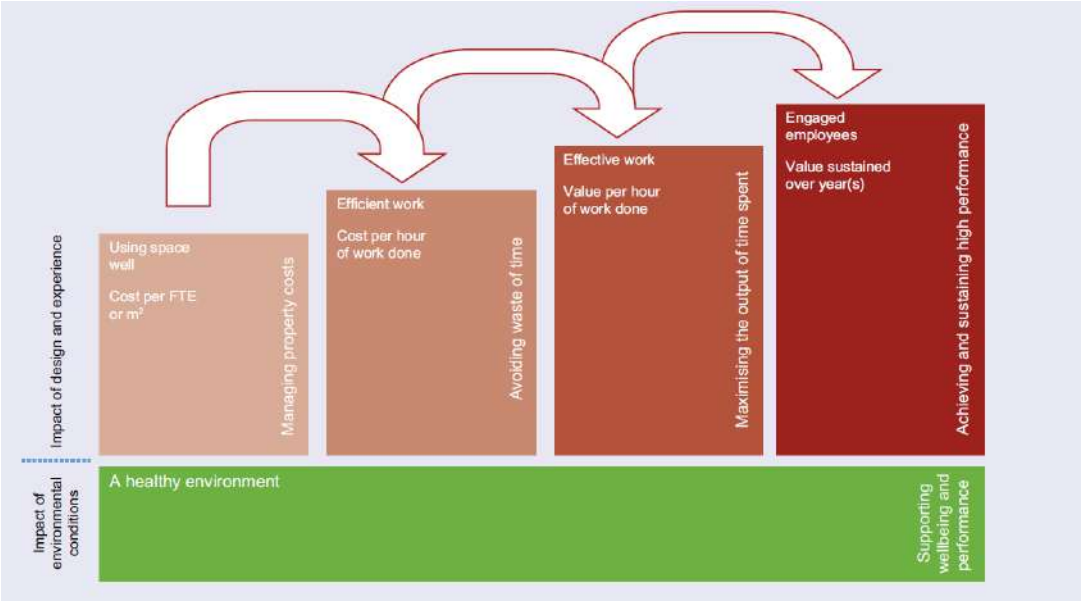
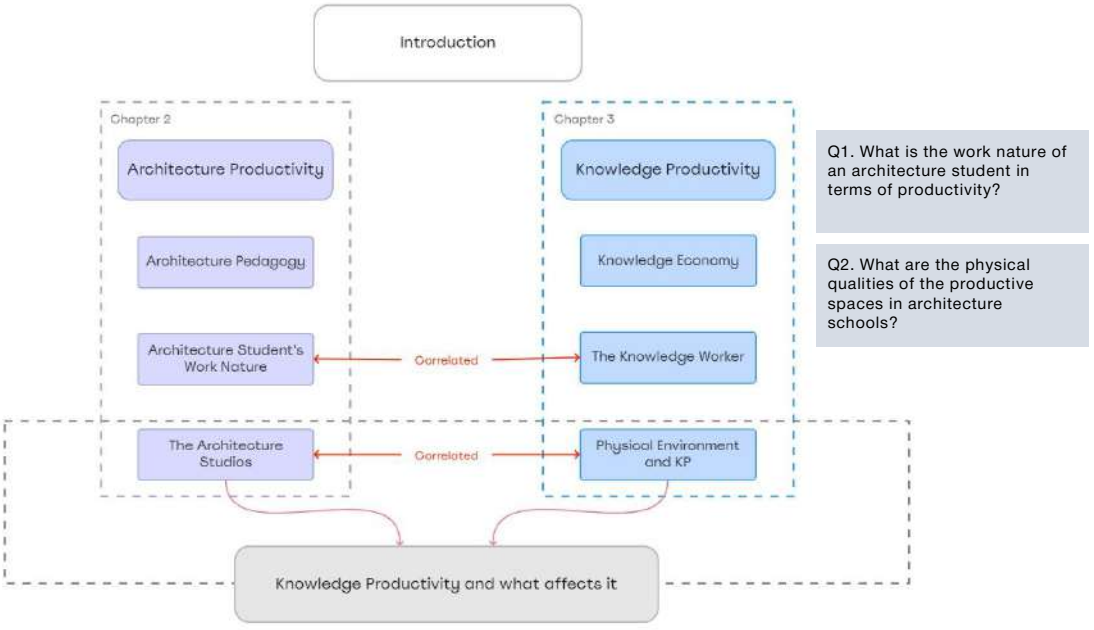


Figure 2 *Dimensions of workplace productivity (Greenhill, et al., 2017)*

3.3 Conclusion

In this chapter, further understanding of the term knowledge productivity create connections relating to the change in productive workplaces. Furthermore, elaborates on the similarities between the nature of the work done by knowledge worker and an architecture student. Increasing productivity, boosting knowledge exchange, and pleasing employees are three of the most sought-after goals in any business. The process of knowledge productivity is an extremely complex one, with several stimuli and elements influencing it. Extrinsic variables include the physical and managerial environment, whereas intrinsic factors include personal capabilities and overall well-being. In order to understand the effect of those extrinsic and some intrinsic factors on knowledge productivity, the following chapter specifies each factor discussed in the research.



4. Knowledge Productivity and What Affects It.

As priorly discussed in the earlier chapters, knowledge productivity is such a complex task. It is heavily related to the knowledge worker and subjective in regards of their perceived productivity results. For that, measuring and exploring the factors affecting them is not an easy task. Some tangible and other intangible, even within the physical environment. Focusing on the built environment, in this chapter of the research, categorizing those factors and understanding their relation and effect over KP is explored and elaborated.

4.1 What Influences knowledge productivity

Many literatures developed models in aim to understand the assumed impact and influence of various variables on productivity. The majority of those models confirm that many variables may have an influence over productivity, distinguishing physical environment, work process, personal characteristics, organizational characteristics, and external and social context (Clements Croome, 2006) (Van der Voordt, 2003) (Kessels, 2001) (Haynes, 2007). In regards of personal factors, intrinsic motivation, attitude, and personal skills are considered. Organizational aspects concern structure, culture, organization strategy, and leadership style (Bakker, 2014). Social atmosphere, peers' interactions, social cohesion, and communication are all social aspects influencing productivity. In addition, within the physical environment, physical conditions like indoor climate, space, ergonomics, and aesthetics influence occupants' satisfaction with the environment, on motivation and the job satisfaction which leads to it influencing productivity and performance (Bakker, 2014) (De Been, et al., 2016).

Figure 3 *Example to intrinsic drives of knowledge worker*

Attaining personal objectives and having facilities that fit with personal needs are important factors to attain for a knowledge worker and to ensure optimal productivity and happiness (Bakker, 2014). Low self-esteem, low morale, an

inefficient work organization, a poor social atmosphere, or environmental factors such as excessive heat or noise can all contribute to lower productivity in the short term, the medium term, and the long term (Clements Croome, 2006). For that the physical environment needs to correspond to those needs by facilitating different job activities, whether it is communication or concentration, or informal or formal meetings. Along with different moods, being calm and relaxed or being stressed, it is key that the environment is providing adequate conditions for such needs. Lethargy, headaches, and other bodily illnesses are examples of factors that might impair productivity by diverting our attention and making it more difficult to concentrate on a task (Clements Croome, 2006). Defining the relative importance of external conditions is a rather difficult fact due to the difference in variables. However, there has been multiple studies that provided empirical data confirming the assumed relation between the external environmental conditions and productivity (Bakker, 2014).

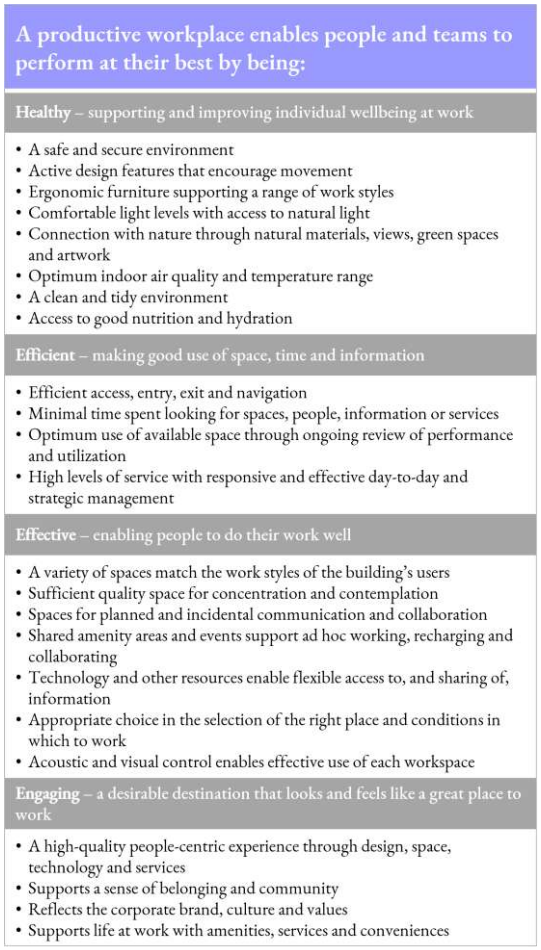


Figure 4 *A definition of a productive workplace*
Source: (Greenhill, et al., 2017)

4.2. Healthy, Efficient, Effective, and Engaging

In a study done by the British Council for offices in 2017, according to the findings of this study, the concept of a productive workplace should incorporate four different aspects that are all interconnected with one another. When addressed collectively, these characteristics have the potential to remove barriers to productivity, which in turn can

assist people, teams, and organisations in better achieving their objectives. Within those four aspects lies all the previews factors priorly discussed individually and highlighting how they work highly correlating to each other.

A workplace that is productive enables individuals and teams to achieve to their full potential by being:

- Healthy, which means supporting and promoting individual wellness while at work.
- Effective, meaning that it makes appropriate use of the available resources (time, space, and information)
- Efficient, in that it enables individuals to perform their jobs effectively.
- Engaging, in the sense that it is both a desirable destination and appears to be an excellent place to work.

4.3. The Physical Environment

When experiencing a space, an environment, people tend to experience it as a whole and not divided into characteristics. In general, peoples are not aware of the characteristics of the environment that lead to their felt experience (Bakker, 2014). The way people experience the environment is not solely based on their senses and sensory stimulants, rather their own individual personal characteristics play a role in said experience (Vonk, 2003) (Bakker, 2014) (Clements Croome, 2006) (Haynes, 2007). Our reaction to the environment is psychological, physical, and cognitive, and they all influence one another. How our brain process light and temperature affect our process of thinking and energy levels and so on. Our responses to the environment around us are heavily influenced by the experiences we've had in the past (Clements Croome, 2006) (Been, et al., 2016) (Haynes, 2008a). This system is triggered by the stimuli that come from the outside world, which then awakens our consciousness to varying degrees of focus. Information is processed by the human perceptual sensory systems based on feelings of sight, hearing, touch, smell, and taste respectively. Our environment provides us with a sensory experience, and as a result, it must

have some influence on the way we go about our work. Conditions that are external to the body have the potential to disturb these systems (Clements Croome, 2006).

Clemente Croome (2006) in his study about productive spaces and our cognition, highlighted the lack of consistency in the level of understanding regarding environmental issues. To claim that a high level of understanding exists about the ways in which heat, light, and sound affect our thermal, visual, or aural reactions is probably an accurate statement. There is far less information regarding how we react to combinations of these stimuli and about their effect on the sensory system. The fact that human responses are both physiological and partly psychological adds an extra layer of complexity to the situation. The reception of information from different senses, such as visual images, music or voice, odours, or touch, all interact with one another, which is still another source of complexity. In addition to the eyes, ears, nose, mouth, and skin, the sense organs also include the vestibular organs, which are responsible for orientation, posture, and movement, as well as a variety of respiratory and thermos-receptors, which respond to air quality, pressure, and temperature. The skin also plays a role in the sense of touch. There are many different levels on which we react to the environment that is around us. According to Chalmers (1996) it is conceivable to use other people's accounts of their own experiences. There have been other studies that have investigated productivity by employing methods of self-assessment. This is an acceptable method provided that the individual doing it tries to objectively structure the information that is output.

The CIBSE model divides the physical environment into extrinsic and intrinsic factors that facilitate a productive environment (Oseland, 1999). Ones regarding the physical environment are physical condition, space, ergonomics, and aesthetics, especially are highlighted.

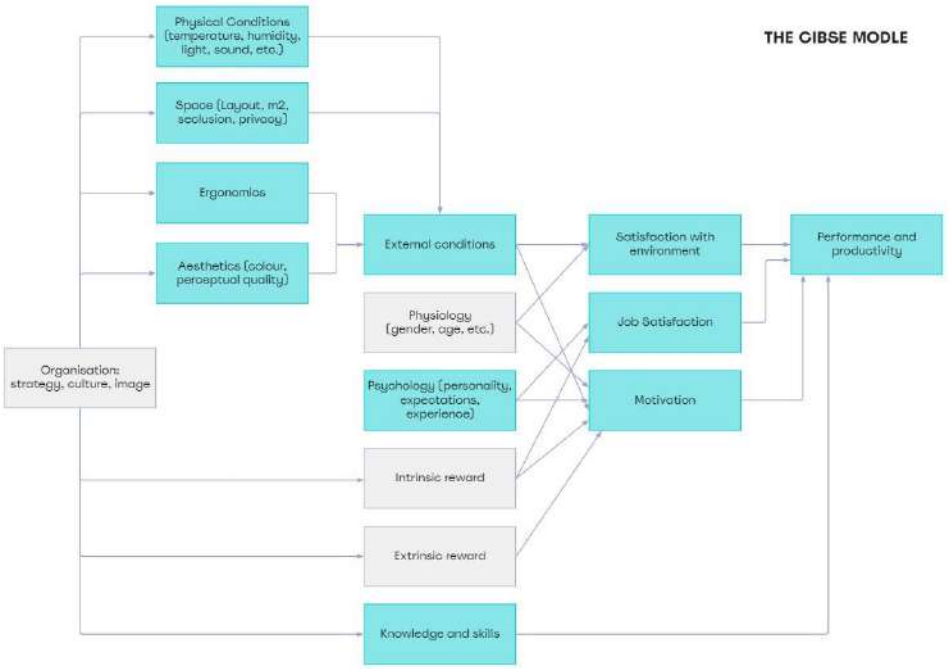


Figure 5 *Impact of various variables on performance and productivity (Mawson, 2002) (CIBSE, 1999)*

4.4. Experiencing the Environment

William James, a well-known psychologist, thought that consciousness wasn't a thing, but rather a process of thought that required attention and short-term memory. From a brief awareness, the brain builds a representation that is centred on the view, and the visual inputs wake up a higher level of attention. In the process of designing a productive workplace, an effort is being made to create settings that will enable certain information to be swiftly detected and conveyed by the human perceptual sensory system (Chalmers, 1996) (Clements Croome, 2006).

In regards of the sense and architecture, Juhani Pallasma (1996) in her book *The Eyes of the Skin: Architecture and the senses* explained on this point very eloquently. During the Renaissance, people thought that the five senses formed a hierarchy, with vision at the top and touch at the bottom. This fits with the image of the universe in which sight is linked to fire and light, hearing to air, smell to vapor, taste to water, touch to earth, and so on. Most of what we learn about

the world around us comes from what we see and hear. But you shouldn't underestimate the importance of the other senses, like how a meal smells or how flowers smell, or how you react to the temperature. All of these things give us a bank of sensory experiences that shape our thoughts and expectations about the environment. The senses not only give information to the mind so it can make decisions, but they also spark the imagination. This part of thought and experience through the senses, which triggers the body and mind, is triggered by the environment and the people around us. However, when we are inside a building, the architecture of the space shapes the way we react. Quoting Merleau-Ponty *"The task of Architecture is to make visible how the world touches us"*.

The interaction of one's senses helps to both reinforce and articulate one's perception of the world as it actually is. Architecture is an extension of nature into the realm of built things. It gives the ground for perception and the horizon to experience, both of which are necessary for one to understand the world. In addition to acting as a filter for the flow of light, air, and sound between the interior and exterior spaces of a building, buildings are also capable of indicating the passage of time through the views and shadows they provide for the people who live there (Pallasmaa, 1996) (Clements Croome, 2006).

That total cognitive experience of the physical environment effects many of our daily activities, productivity being one of them. Myers and Diener (1997) have been conducting a series of systematic research with communities to investigate levels of awareness and levels of contentment with life. Subjective well-being is a term that psychologists frequently use to refer to this. It seems that happy people often have a satisfying degree of personal control over their lives, whether at work or at home. This is true regardless of the setting. It is probably safe to conclude that it is more likely that a person's work production will be high if they have a high level of happiness and satisfaction in their life (Clements Croome, 2006). The state of one's wellbeing reflects how they feel about themselves in relation to the world. According to Warr (1998) a view of well-being should include three scales: one for pleasure, one for comfort, and one for enthusiasm and depression.

There are aspects of one's profession as well as aspects of their life outside of work that can characterize their level of well-being at any given moment, and these aspects can overlap with one another. The state of one's well-being is simply one component of mental health; other aspects of mental health include personal feelings about one's level of competence, aspirations, and the degree to which one exercises personal control. Absenteeism, arriving late or departing early, taking excessively lengthy lunch breaks, careless blunders, overwork, boredom, and discontent with the management and the environment are just some of the ways that a lack of productivity can manifest itself. The constructed environment provides both a physical and social atmosphere, both of which influence a person's level of motivation. The ability to thrive can be enabled by creating conditions in which the individual has control, and the environment is healthy. By allowing the option for task execution, facilities such as communications systems, restaurants, and other comforts contribute to an individual's level of motivation and ability (Warr, 1998). In order for us to have a holistic perspective on the world around us, the word "environment" must have a wide range of connotations. This includes the way in which the organization functions and how the staff is managed; the physical factors such as lighting, noise, and the quality of the air indoors; the spatial planning and layout; the economic factors; the general aesthetics; the conveniences, facilities, and support systems that are provided by the organization; and the social atmosphere (CIBSE, 1999). In the following section, some of those factors will be delved into more to understand their correlation to productivity referencing Been, Der Voordt, & Haynes (2016), Celement-Croome (2006), and Igor Mujan (2019) in regards of the IEQ.

4.4.a. Thermal Comfort & Indoor Climate

The term "thermal comfort" refers to a person's level of mental contentment with the surrounding temperature conditions and is evaluated based on the individual's own perceptions (Mujan, et al., 2019) (ASHRAE, 2017a). It is the IEQ parameter that has been studied for the longest and is of utmost significance. A person will experience cognitive processes that connect physical, physiological,

and psychological components in order to accomplish the goal of achieving this mood (ASHRAE, 2017b). Productivity is directly correlated to thermal comfort; therefore, maintaining a consistent temperature range of 21–25 degrees Celsius creates the optimal conditions for working and remaining inside the premises. According and Seppanen and Fisk (2006) and Chartered Institution of Building Services Engineers (2013), if this upper limit is exceeded, productivity will drop by 2% for every additional 1C° that is present in the air. The dry bulb air temperature, relative humidity of the air, air velocity, mean radiant temperature, human metabolism, and clothing level are the primary factors that determine thermal comfort (Mujan, et al., 2019) (ASHRAE, 2017a) (ASHRAE, 2017b). There are a number of secondary elements that can also have an effect on thermal comfort, including environmental nonuniformity, the climate of the outdoors, age, and gender, as well as visual stimulation (Mujan, et al., 2019) (ASHRAE, 2017a) (ASHRAE, 2017b).

Multiple studies found that an uncomfortable interior climate, regardless of whether it is warm or cold, can have a detrimental impact on employee productivity (Lan, et al., 2009) (Niemelä, et al., 2002) . When a task is carried out for a longer period of time, the level of influence and authenticity of the effect both increases. Other factors, such as the local climate, social and cultural norms (for example, regarding clothing) (Kurvers & Leijten, 2013), and organizational factors such as managing expectations, explaining and visualizing the use of the installation, and responding equitably to complaints all have an impact on the evaluation of the indoor climate (Pols, et al., 2009) (Clements Croome, 2006) (Mujan, et al., 2019).

The process of achieving perfect thermal comfort is a very complicated one, and it requires knowledge of how individuals react to changes that occur dynamically within the environment. Because it is affected by things like age, sex, metabolism, and other things like that, thermal comfort has a character that is both individual and geographical in nature (Mujan, et al., 2019) (Cena & De Dear, 2001) (Ngoc, et al., 2014) (Leaman & Bordass, 2006). It has been discovered that when thermal

comfort is improved from within acceptable bounds to a point where an occupant prefers it, there is an increase in productivity (De Dear, et al., 2013).

In the literature, this topic is discussed, and methods such as thermal sensitivity, thermal acceptability, and thermal priority are used to describe people's subjective experiences with temperature (Langevin, et al., 2013). Thermal comfort is a subjective condition, whereas the thermal feeling is an objective state that can be defined as the direction and intensity of a person's perceptual experience of the indoor environment.

At the moment, the ASHRAE Global Thermal Comfort Database II is the greatest repository that can be accessed on the topic of thermal comfort. It represents a massive database that is made up of research gleaned through field studies and compiled and standardized over the course of the previous two decades. (Licina, et al., 2018).

4.4.b Indoor Air Quality

IAQ is an indication of the air quality inside buildings, and it has a significant influence on the quality of life in residential buildings as well as the productivity in commercial and public buildings (Olesen, 2005). The effect on business in the form of increased productivity on routine tasks such as basic mathematical operations, text typing, or proofreading has been documented and experimentally confirmed (Fanger, 2000) (Wargocki, et al., 2000) (Ng, et al., 2012). Studies that have been carried out on commercial and residential buildings that are currently in use have shown that a significant number of workers and residents are dissatisfied with the air quality, and that this dissatisfaction is directly related to the health problems that occur in people's places of employment (Bluyssen, 1996) (Fisk, et al., 1993) (Mendell, 1993) (Mujan, et al., 2019). The symptoms might range from something as minor as a light respiratory irritation to something as severe as sick building syndrome (SBS) or even asthma (Fisk, 1997). SBS is directly related to the building, and the most common symptoms are inflammation of the eyes (including itching and

burning), irritation of the nose, and problems with the sinuses. Less frequently, the symptoms and consequences include irritation of the respiratory system, headache, lethargy, and mental fatigue (Mendell & Smith, 1990) (Otto, et al., 1992). The field of indoor air quality is a direct endeavour by researchers to identify, quantify, and solve the problems associated with these health concerns.

The measurement of parameters such as carbon monoxide, carbon dioxide, nitrogen dioxide, sulphur dioxide, volatile organic compounds, relative humidity, temperature, oxygen, ozone, ammonia, air velocity, formaldehyde, and levels of particulate pollution are the foundation of indoor air quality (IAQ). (Mujan, et al., 2019) These parameters are also impacted by the conditions that exist outside the building (for example, nitrogen dioxide and sulphur dioxide), the construction of the building itself, the HVAC system (heating, ventilation, and air conditioning), the spatial layout, and the activities that take place in the building, such as work and daily life. IAQ is a very difficult entity to measure due to the fact that its properties are complex and interrelated with one another (Szczurek, et al., 2015) (Mujan, et al., 2019).

There are three different processes that can be used to control IAQ: the ventilation rate procedure, the IAQ procedure, and the natural ventilation procedure. To get optimal indoor air quality, you can accomplish this goal by employing any one of these three approaches singly or in whatever combination you choose (Mujan, et al., 2019). The IAQ procedure can be used for any zone or system and determines the outdoor air intake based on the limit of pollutant concentrations and their limits allowed inside of the building in combination with the occupant's perceived acceptability of the indoor air quality. It is permissible to employ natural ventilation in any zone of the building as long as it is accompanied by a ventilation system. Natural ventilation procedures involve the direct infiltration of air from the surrounding environment through gaps in the structure (ASHRAE, 2016). This has been demonstrated by study conducted by scientists in Europe, who also found a strong association between SBS and poorly ventilated areas, defined as those with air exchange rates of less than 10

l/s per person living there (Mujan, et al., 2019). Additionally, there is an improvement in productivity in areas that have adequate ventilation (Seppanen, et al., 1999) (Kosonen & Tan, 2004) (Fisk, et al., 2009) (Dimitroulopoulou & Bartzis, 2013). However, it is obvious that from the perspective of energy consumption, a higher number of air changes also results in an increase in the amount of energy that is consumed by the ventilation system, which in turn results in a reduction in the overall energy efficiency of a structure.

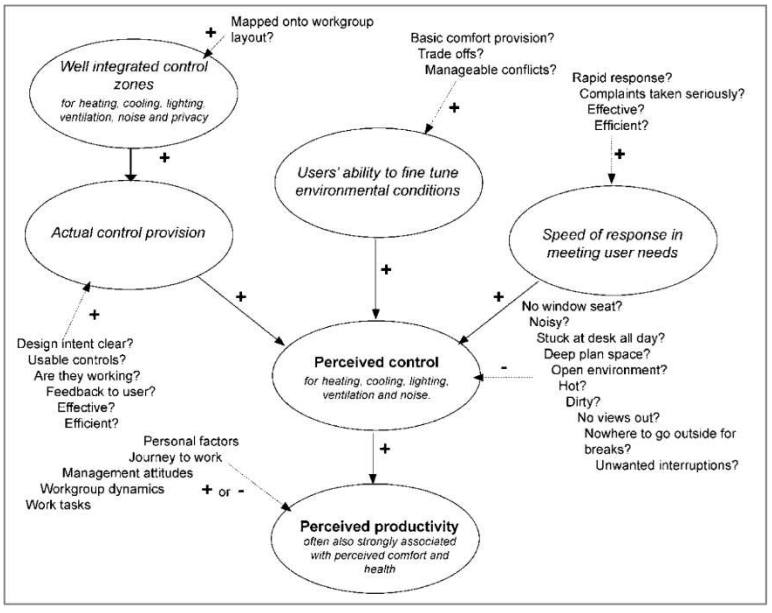
Seppanen and Fisk (2002) found that compared to natural ventilation, air conditioning showed a stronger link to SBS symptoms, ranging from 30 percent to 200 percent. The selection of the ventilation system ought to be determined in accordance with the climatic conditions that prevail outside, with consideration given to the kind of structure that is being used and the activities that are carried out there. The use of mechanical ventilation systems is prevalent in climates that are warm and humid; nevertheless, there has been a growing trend toward the adoption of individualised ventilation in more recent times. Specifically, in addition to the normal central ventilation, the user is given the ability to control the fine regulation of the circumstances in his closest environment and to produce acceptable conditions for himself. These devices deliver clean air straight to the user, whether they are in their living or working space (Sekhar, et al., 2005).

Pollutants in the air are one of the factors that contribute to decreased productivity in offices. The most prominent examples of this can be found in the research on volatile organic compounds (VOC). VOCs, both chemical and biological, have an effect on the quality of the air inside of buildings (Wolkoff, 2013) (Panagiotaras, et al., 2014). Internal sources are obtained from human activities such as cooking or smoking, in addition to materials that are used in the construction of the structure itself. The vast majority of components that make up VOCs are known to irritate the respiratory system (Mujan, et al., 2019). Because of the significant role that these factors play in shaping the human psyche, it is essential to identify the particulars of their influence.

4.4.c. Personal Control

Of the factors influencing productivity within the built environment is being able to personally control occupant environment to a certain degree, in temperature, air quality, light, and noise level (Leaman, 1995) (Boerstra, et al., 2014) (De Been, et al., 2016). According to Wyon (1996) when concluding the effect of personal control over productivity effect in the case of thermal environment; Logical thinking, typing, skilled office work, and repetitive office work found an increase in their productive percentage. Furthermore, Boerstra, Loomans and Hensen (2014) found that having personal control had a 6%-10% increase in productivity.

Clements-Croome (2015) spoke of the importance of personal control and its correlation to productivity in his book multiple times, one chapter in particular which speaks of the 'Killer' variables by Leamon and Bordass (2006) naming control one of those variables.



[Interpretation] Perceived productivity, comfort and health are often strongly associated and may even be surrogates of each other. Usually but there are exceptions, the more occupants perceive that they have some control over their personal environment, the better the rating for productivity, health and comfort. Many factors are involved in the wider picture, some with positive effect (+ sign) and others with negative (- sign).

Figure 6 *Factors affecting perceived control and perceived productivity. Source (Clements Croome, 2006)*

Research conducted in the 1980s into what was then called "sick building syndrome" confirmed to a new generation of researchers what was already well known to an older one: that people's comfort and satisfaction are affected by their

perception of control over their environment. People appeared to have a higher level of tolerance for conditions when they had more opportunities to control those conditions, such as switches, blinds, and the ability to open windows. (Leaman & Bordass, 2006) (Clements Croome, 2006)

This is an essential finding that can be taken away from pioneering research on thermal comfort, and it serves as the foundation for what was subsequently dubbed the "adaptive comfort theory." People are more tolerant of pain if they have some effective means at their disposal to alleviate it, and they are more likely to forgive those who cause it. On the other hand, it appears that many contemporary buildings have the exact opposite effect. They remove control from the human occupants and attempt to place it in automatic systems, which then govern the overall conditions of the indoor environment and remove the occupants' ability to intervene. In the extremely unlikely event that such systems are able to account for every possibility, they have the potential to perform marvellously well; however, this is not the case very frequently (Bordass, et al., 1997)

Figure 6 depicts the extent of the relationship between comfort and productivity, as measured by the BUS (Building Use Studies) variables "overall comfort" and "perceived productivity" (Leaman & Bordass, 2006). This figure also displays the strength of the relationship. The more productive people report feeling, on average, across all of the buildings in the dataset, the more comfortable they are

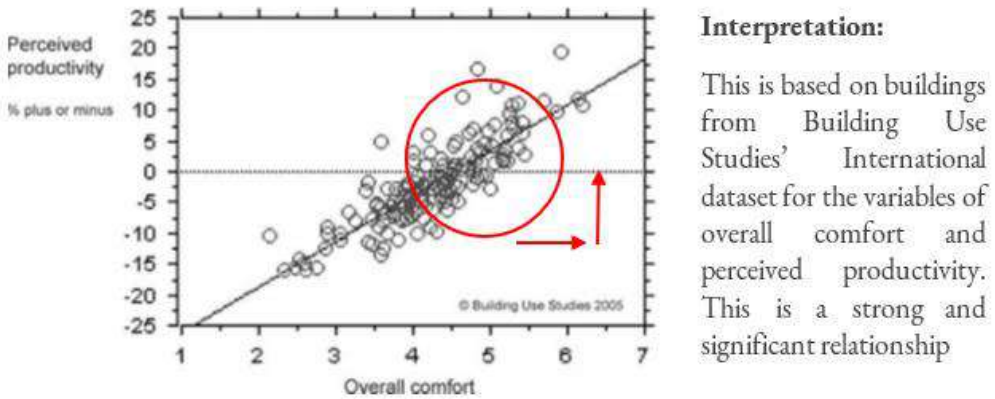


Figure 7 *Perceived comfort and perceived productivity. Source: (Clements Croome, 2006)*

reporting themselves to be (again taking the average score for each building). "Overall comfort" is an umbrella variable that encompasses people's perceptions of heating, cooling, ventilation, lighting, and noise when all of these factors are considered in an overall evaluation.

Of the five perceived control variables—heating, cooling, lighting, ventilation, and noise—noise is the most significantly associated with perceived productivity, despite the fact that the association is not very strong. Despite this, the only one that does not hold any significance is the perceived control over the illumination.

Even though there is a wealth of research and evidence from occupiers that high perceptions of personal control bring benefits such as improved productivity and health, designers, developers, and sometimes even clients appear to be remarkably reluctant to act on it.

4.4.d. Visual Comfort & Light

Light can be arguably one of the most stimulating factors in the built environment. In a research study done by Galasiu and Veitch in 2006, over daylight in office environment, going over sixty research, they found that occupants have a high favor in regards of daylight in the workplace. Some studies argue that exposure to higher illuminance for some part of the day effect

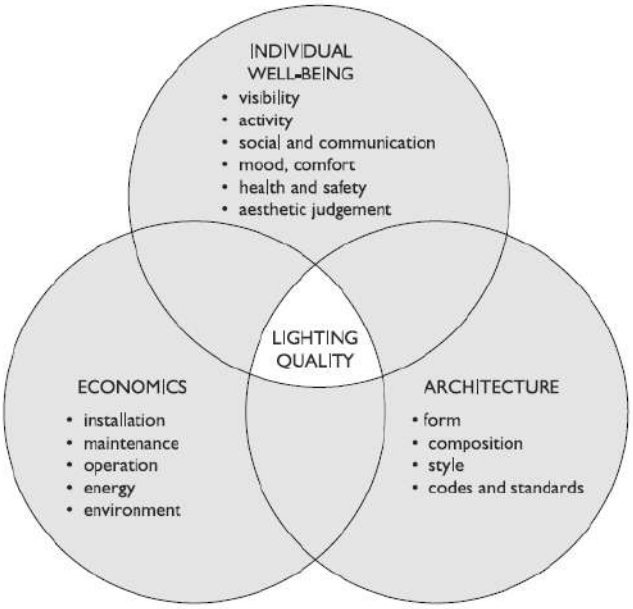


Figure 8 *Lighting quality: the integration of individual well-being, architecture, and economics (Clements Croome, 2006)*

well-being, however lighting conditions that surpass the body's responsive capability is considered an environmental stressor (Clements Croome, 2006). As mentioned earlier, personal control, fully automated lighting system has been associated with low productivity levels (De Been, et al., 2016). Especially since lighting illuminance level, and discomfort with daylight glare is differently perceived from one individual to the other.

Daylight is essential for people to have a properly functioning biological clock and the energy necessary for engaging in both physical and mental activities during the day (Aries, 2005). Because the majority of people spend the most of their day inside, it is vital to design the interior so that it makes maximum use of the natural light that is available throughout the day (Leech, et al., 2002). The most optimal conditions for human visual comfort are created by natural daylight. It has a beneficial effect on the human psyche, and people who are exposed to this light during the day tend to have a more positive attitude and experience less stress (Aries, 2005) (Li, 2010).

Figure 10 *NUS School of design and Environment / Serie Architects. Credit: Rory Gardiner via ArchDaily*

Figure 9 *BUGA Fiber Pavilion, University of Stuttgart, Credit: ICD via ArchDaily*

The people living in the building prefer natural light (Aries, et al., 2010). Although there is lighting available that can simulate the spectrum of daylight, it should be remembered that this lighting has an impact on physiological and psychological processes and has the potential to disrupt the human body's natural 24-hour internal clock (Rea, et al., 2002). The intensity levels of daylight are one decimal higher than those that are produced by artificial light, which

causes the body to secrete the hormone melatonin, which is responsible for the regulation of the body's internal clock (van Bommel & van den Beld, 2004). When performing repetitive tasks, workers are more likely to pay attention to what they are doing, which in turn boosts productivity (van Bommel & van den Beld, 2004).

As a result, the Daylight Factor (DF) is referred to as the amount of daylight that enters an area that is indoors. It takes into account direct light, the reflectance of light from external sources, as well as reflection from interior sources (Fontoynont, 2014). At the same time, environments that promote increased productivity—such as rooms that have the right temperature and are shielded from direct sunlight—have a significant impact. The quality of sleep you get when you get home from work is also impacted, and it varies according to your age, gender, and the season (Serghides, et al., 2015).

Regarding the dimensions and contours of the window openings, the residents of the building do not seem to be able to agree on anything. On the other hand, it is well knowledge that the geometry and physical characteristics of a building have a significant influence on the amount of light that enters it (McNicoll & Lewis, 1994). The vast majority of inhabitants believe that having easy access to windows and having sufficient lighting are both extremely significant (Wotton & Barkow, 1983). Visual comfort has a significant influence on overall productivity as well as health, and there are important factors to take into account when deciding how much artificial lighting to install versus how much natural light to let into an indoor space (Yun, et al., 2012).

4.4.e. Greenery

Many studies built a correlation between the presence of greenery and vegetation within the work environment and the increase of occupants well-being, mental comfort, and productivity (Smith & Pitt, 2009) (Knight & Haslam, 2010) (Bakker & Van der Voordt, 2010). Plants have also been associated with affect over people's physiological reactions like blood pressure and headaches as well as improvement in mood and enhancement in cognitive abilities (De Been, et al., 2016). Accordingly, through their influence on overall well-being and health, plants could have an effect over productivity.

Figure 11 *ARTi Architect Office*
Credit: ARTi Architect via ArchDaily

Figure 12 *NUS School of Design & Environment*
Credit: Rory Gardiner via ArchDaily

Researchers Ulrich (1984), Fjeld et. al. (1998), and Lohr et. al. (1996) found significant statistical correlations between seeing plants and a variety of responses including physical/physiological, affective, and cognitive.

When the findings are examined in greater detail, a consistent effect on physical/physiological, affective, and cognitive responses is found. This lends credibility to the claims made by a great number of well-known individuals who highlight the beneficial effects that nature has on people. The so-called "peri-pathetic method," which consisted of walking through the academy garden while discussing their ideas, was utilized by Greek philosophers (Csikszentmihalyi, 1996). It is possible to draw the following conclusion based on research such as that which was presented earlier: there is a connection between seeing and

experiencing plants and various physical/physiological, affective, and cognitive responses.

In his research Bakker (2010) studied the effect of plants on people's productivity, finding that people who spend time around plants report feeling happier overall, with increased self-assurance and a more open mind to the world around them. There is a correlation between the number of plants present and the effect on the impression of productivity. People react in a variety of ways when they are stimulated by the presence of a plant. However, the effect of plants can change depending on the activities that are being performed. According to the study, a very clear indication that there is a positive relation between productivity and creative work was found.

Although all of the studies that were mentioned found that plants had a consistent and positive influence on creative output, they found that the influence of plants on overall productivity varied. Plants, in general, have a beneficial effect on both the physical/physiological response and the affective response of people (Bakker, 2014) (Fjeld, et al., 1998) (Fjeld & Bonnevie, 2002). People have, over the course of centuries, developed an awareness of how impressive nature is. The so-called "Biophilia Hypothesis," which refers to the biological basis for human values in nature, has received support from recent scientific research (Kellert & Wilson, 1993). There is also a growing awareness of the importance of nature to children's development on a variety of fronts, including the intellectual, emotional, social, and spiritual domains, as well as the physical domain (Kellert, 1995) (Moore & Cooper Marcus, 2008). Because every plant possesses a distinct structure, people's sense of security is bolstered by the presence of plants. The effects of different plants on one's cognition are distinct for a variety of different reasons. There are a lot of different things that go into this (Bakker & Van der Voordt, 2010).

Like all issues regarding perception, a challenge is the infinite variety of people and the ways in which they exist, live, act, feel, and think. Intelligence, emotional stability, spiritual development, and even physical vitality can vary greatly from

one person to the next. Their personal circumstances are also very different from one another. Because of this, one might wonder whether it is actually possible to measure the effects that plants have on people.

4.4.f. Noise and Acoustic Comfort

The sounds from the work environment could be among the most distracting noise in the work environment (Sundstorm, et al., 1994). Uncontrollable background noise could have a negative effect over occupant's productivity, when compared to performance in a quiet working environment (Furnham & Strbac, 2002).

One of the five primary senses that are unique to humans is their ability to hear. The World Health Organization considers any sound that is not sought to be noise. The psychological impacts of noise on people include uneasiness and a loss in focus (Mujan, et al., 2019). These effects reflect the physiological effects of noise. Both the pressure and the sound power that it generates can be measured, as well as the noise's strength, which is measured in decibels (dB). In the context of a building, "acoustic comfort" refers to an acoustic environment that is adequate for the building's residents while also preserving the building's original purpose and insulating the building's occupants from outside noise.

Noise and acoustics are two factors that have a significant influence on the design of buildings. When it comes to residential structures, noise is not nearly as significant of an issue as it is in commercial settings. Therefore, noise control is vital for the efficient operation of people, and badly designed spaces can produce employee unhappiness, which in turn can lead to a loss in productivity. (Frontczak, et al., 2012).

The indoor environment is impacted by a variety of noise sources. Human speech, the functioning of machinery, and office equipment are the three most typical types of internal sources (Banbury & Berry, 2005). According to research conducted by Landstrom et al. in 1995, there is a direct association between occupant productivity and acoustic comfort in the business sector. The source of

occupant unhappiness in each given structure can be traced back to the occupants' discontent with some aspect of the quality of the internal environment. It has also been discovered that those who are subjected to elevated levels of noise have elevated blood pressure as well as an increase in the secretion of hormones that produce stress (GW, et al., 1998). In addition, exposure to high levels of noise impairs one's memory, makes it more difficult to concentrate, and can in certain instances bring on feelings of worry.

The occupants inside of the building can be protected from noise, in part, by the buildings outside features, as well as by the illumination. According to the British standard, an open office schedule cannot have noise levels that are higher than 40 dB, and a closed office schedule cannot have noise levels that are higher than 45 dB. When these levels cannot be obtained, the designers utilise a public speaker system through which they generate sounds that disguise the noise of "white noise." White noise is characterised by the fact that it emits a vast range of sound frequencies with the same intensity (U.S.G.B. Council, 2003).

4.5. Space

Other than the pure physical qualities of the environment, the activities and the natural occurrence that happen by the working nature of the occupants, influence and could affect their productive process. The design discipline needs to be informed of how users perceive, judge, and evaluate spaces in order to create architectural spaces that meet the dynamic, conflicting, and complex multifaceted social and physical requirements. This is necessary in order to create architectural spaces that can meet the requirements. According to Lefebvre (1994), the goal of the search was to find a unitary theory of the physical, mental, and social space. This theory was supposed to reconcile the mental space, also known as "the space of the philosopher," and the real space, also known as "the physical and social spheres in which we live." Canter (1983) was a prominent social psychologist who placed an emphasis on the social, geographical, and services aspects of a location. His methodology has now been adopted by a number of other academics, who have used it to explore environmental meaning

(Groat, 1985) and building users' assessments of places (Hacket & Foxall, 1995). Both Massey (1994) (1995) and Harvey (1989) are examples of modern geographers who have conducted critical analyses of the social relations and geographical organisation of the place that was produced while a capitalist system of production was in control. In general, developments in the theory of place on the one hand, and empirical evidence in support of the multifaceted impact of the place on the individual's social behaviour on the other hand, have induced the emergence of a new approach to building appraisal that focuses not only on the geometry of space, but also on its social, cultural, and emotive aspects. This new method of evaluating buildings takes into account not only the dimensions of the space, but also its social, cultural, and emotional components. (Farshchi & Fisher, 2006)

4.5.a. Communication and Concentration

Being able to perform your task while comfortably focused and alert is an important factor towards one's productivity. In addition, being able to sustain that mental state of focus facilitate the task completion. The formation, sharing, and application of concepts, ideas, and knowledge that are stored in individual brains is the primary obstacle that must be overcome in order for a cognitive workplace to be successful. This process of information transfer can be aided by the physical environment through the creation of settings that cater to the cognitive requirements of both individuals and groups. (Heerwagen, et al., 2006)

The ability to concentrate one's attention on activities that are of high importance is the primary cognitive obstacle faced at the individual level. At the level of the group, the most important problem is the efficient distribution and utilisation of information. It's not uncommon for the settings and actions that support these cognitive demands to be in direct opposition to one another. To concentrate well, one needs to withdraw and maintain silence. Conversation and a lot of eye contact are requirements for effective communication. To arrive at the optimal solution for the workplace, one must have a solid grasp of how space effects individual and

group cognitive work as well as the particular job needs that are present in a certain organisational setting.

When surveying 13,000 employees of different working settings, Brill and Weideman (2001) found that of the different factors affecting performance and satisfaction two had the largest impact; being able to work distraction free and being able to have spontaneous interactions with co-workers. Further studies by Haynes (2008c) confirmed the largest impact on productivity comes from interactions as well as distractions. Similarly, another study concluded that among employees, satisfaction with concentration possibilities within the work environment is of key importance to individual productivity, while possibilities to communicate held the most importance within team productivity (Maarleveld & De Been, n.d.). Creating an environment which support both activities is challenging but of high value when it comes to productivity.

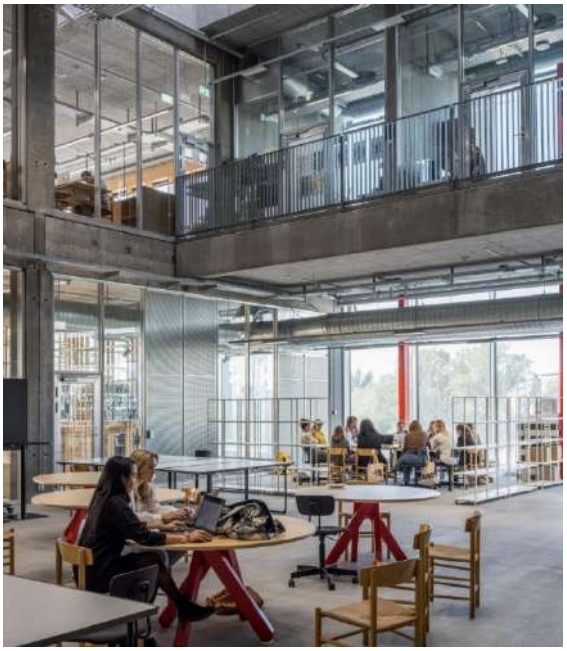


Figure 13 *Aarhus School of Architecture*
Credit: Rumus Hjortshoj via ArchDaily

The utilisation of project rooms is a significant factor that contributes to the success of collaborative endeavours. Typically, project rooms are equipped with shared information screens for monitoring project assignments and progress, as well as space for individual work, project files, and access to organisational databases. Other places intended for collaborative work, such as informal teaming spaces interspersed among private workstations, are less successful due to noisy disturbances and an inability to keep group materials exposed for future work. Examples of these types of venues include (Brager, et al., 2000).

4.5.b. Social Interactions

Figure 14 *NUS School of Design & Environment / Serie Architects*
Credit: Rory Gardiner via ArchDaily

Continuing on from the previous point, spatial arrangements that permit spontaneous interactions (Brill & Weidemann, 2001) and cooperation and collaborative work (Strubler & York, 2007) revealed to be of high value when it comes to enabling productivity. Having wide span of visible accessibility within the work environment can result in an increase in interactions between co-workers which could assist with productive communication among peers and colleagues (Becker & Sims, 2000) (Bouttelier, et al., 2008). Having visible proximity and flow have high positive influence on the interaction occurring within the work environment which could subsequently lead to stimulating innovation. However too much of an open space with unassigned workplaces can lead to a negative impact over productivity as well (De Been, et al., 2016).

It is not purely spontaneous interactions, having dedicated spaces for meeting provide further stimulation to communication in addition to the perceived support to collaboration within the work environment (Oseland, et al., 2011) (Peponis, et al., 2007) (De Been, et al., 2016).

Many encounters are unanticipated and take place largely as a result of movement patterns that influence the perceived 'availability' of others for recruitment into a conversation. These patterns play a significant role in the formation of many interpersonal relationships (Backhouse & Drew, 1992). The building's layout, density, and visible access into space, as well as its circulation

system, all have an impact on the availability of space. Workspaces that are visually open, like bullpens, also boost the possibility of contact amongst employees. According to the findings of Becker and Sims (2001), employees who worked in an open bullpen setting interacted four to six times more frequently with one another than employees who worked in private offices or in workstations with high partitions. The ability to engage in social discourse and joking, which contributes to the development of a sense of camaraderie and community (Carletta, et al., 2000) (Heerwagen, 2000), is influenced by the ease with which one can see and hear other people and activities.

Another important factor that determines the extent of informal engagement is its proximity to the people involved. Allen (1971) discovered that when researchers in R&D were separated by at least 30 metres, the amount of informal communication that occurred between them reduced significantly. In addition to this, he discovered that the complexity of the moving path had an effect on the interactions. Interactions are progressively decreasing as a result of paths rapidly becoming more complicated, which includes having more corners to turn and more connected pathways. The proximity of the workplaces contributed to a greater number of impromptu interactions, which was one of the factors that led to the variations in collaboration. (Heerwagen, et al., 2006)

4.5.c. Distraction and negative stimulation

On the other hand, open plan setting is often found to be a source of distraction and disruption in the work environment, leading to a lower in perceived productivity (Brill & Weidemann, 2001) (Hayens, 2008) (De Been & Beijer, 2014). Not only when doing work requiring focus, too much openness can be distracting to creative work as well. Good acoustic enclosure is needed in open spaces, meeting spaces and communication areas to avoid distraction (De Been, Beijer, & Den Hollander, 2015).

When employees are diverted from their work, they frequently either direct their attention to the thing that is distracting them (for example, someone talking

nearby) or they make a greater effort to concentrate on the task at hand. The effectiveness of work can suffer when there are frequent shifts in attention.

The difficulty of the task can lessen the negative effect that interruptions have on one's productivity at work. The distraction that comes from other individuals chatting is more destructive to difficult jobs than it is to easy tasks (Jones & Morris, 1992). The information-processing needs of complicated activities are higher, and distractions from noise may interfere with memory or may require adjustments to the working strategies.

Distractions can come in the form of sight as well as sound. According to research conducted by Kirsh (2000) and Lahlou (1999), the end consequence is mental overload in most workplaces, along with an inability to select what to accomplish and how to stay focused on tasks at hand. Distraction can be also a result of negative sensory stimulation. Overload happens when the amount of information offered by the environment is greater than the individual's capacity to process the information (Bell, et al., 1996). The extent to which various environmental cues interact is an essential factor in behaviour. This idea is referred to as environmental load or overstimulation, and it has the potential to influence behaviour as a result of the strain it places on attention and the processing of information.

Under stimulation can also result in extreme anxiety, in addition to a host of other psychological abnormalities. According to the findings of certain studies, in order to revive excitement and a feeling of belonging, settings should feature a greater degree of complexity and stimulation. Wohlwill (1966) proposed that the environment be scaled along a variety of dimensions of stimulation in order to combat the issue of under stimulation. These dimensions include intensity, novelty, complexity, temporal shifts or variations, surprisingness, and incongruity (Bell, et al., 1996).

4.5.d. Task complexity and personal characteristics

Many of the buildings that perform well in post-occupancy studies appear to have the capacity to fulfil people's requirements in an extremely timely manner, either by anticipating those requirements or by responding to them as they come up (Leaman & Bordass, 2006). This pertains to personal control, but it also operates at other levels, such as the capacity to rearrange furniture, or the adaptability of spaces to allow change, or the speed with which the facilities management department responds to concerns.

It would appear that the complexity of the tasks being performed by the user of the building, in addition to the activities themselves, play a significant effect in the relationship between the environment and productivity. It was discovered that those who worked on hard activities were more satisfied and productive in a private office, whereas those who worked on easy jobs appeared to perform better in a setting that was not private (Block & Stokes, 1989) (Haynes, 2008a). Comparatively speaking, introverts appear to have a greater degree of difficulty than extraverts when it comes to completing tough activities while being distracted (Furnham & Strbac, 2002). How well does the built environment support the different activities happening within the building and their different complexity satisfying the task's needs could affect users' productivity (Haynes, 2007) (De Been, et al., 2016).

4.6. Ergonomics

Ergonomics is all about supporting our physiological body needs to provide a comfortable setting. The physical design of the environment's furniture and workspaces is greatly connected to ergonomics which is connected to health and productivity (De Been, Van der Voordt, & Haynes, 2016). The work office is where the work user spends most of the time, adequate ergonomic consideration should be given to it, especially when there is a change in the work performed, individual ergonomic solutions designed for the special work nature could help with productivity rate.

Workstations and other pieces of office furniture have a significant impact on ergonomics, which in turn can have repercussions for employees' health as well as their ability to get work done. For example, Karakolis and Callaghan (2014) conducted a literature analysis and found that installing sit-stand workstations in an office setting will most likely result in decreased levels of body discomfort and may also have a favourable influence on performance. Research conducted by Barber (2001) revealed that, in addition to variables related to control, concentration, and indoor climate, office workers also consider other variables to be important for their productivity. These variables include ergonomic chairs, advanced technology (supporting IT facilities), and adequate (electronic) filing space. In their thorough research, Brill and Weidemann identify ergonomics, sufficient room for goods, and access to technology as crucial elements that influence outcomes (Brill & Weidemann, 2001). When people in an office utilise the same desk day in and day out for their job tasks, there is an opportunity to incorporate specific ergonomic concerns into the design of their desk and chair. As a result, an individualised solution that is more ergonomic can be devised for each and every office worker (Sauter, et al., 1991) On the other hand, the modern office atmosphere of today leans more toward group interactions, with collaborations being carried out at workstations that can accommodate many people at once. Because these multi-user workstations may be utilised by a variety of people throughout the course of a single workday, careful consideration must be given to the creation of an ergonomic layout that will ensure a comfortable experience for a wide variety of people (Mahoney, et al., 2015).

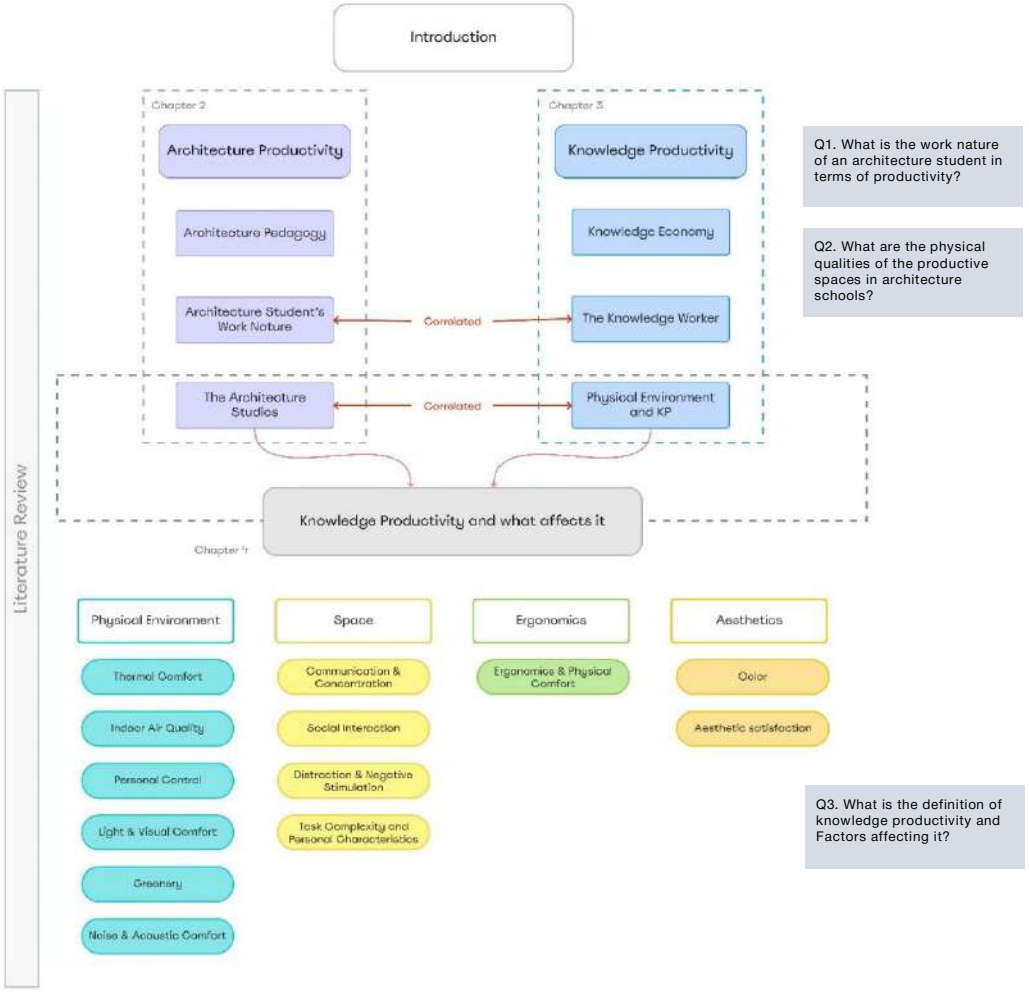
4.7. Aesthetics

Aesthetics focuses on the architecture design of the environment, both exterior and interior. Colours, texture, shapes, and forms used within the design influence general occupants' mood. Colour is one of the aspects that can affect people's well-being and mood (Bakker, 2014), as well as people's behaviour (Elliot & Maier, 2007), and as a result, it may also affect people's productivity (Bakker, 2014). Previous studies have established a connection between occupant comfort

and indoor environmental quality (Been, et al., 2016). On the other hand, the research conducted by Barrett et al. (2013) establishes a connection between these variables and student performance. In addition to this, they contribute to the ongoing discussion by suggesting that the aesthetic variable colour has an effect on the overall performance of the students (Barret, et al., 2013).

4.8. Conclusion

Through this chapter we explored the factors affecting KP within the built environment. Dividing them into the physical environment, space, ergonomics, and aesthetics. Seeing how they work together in order to provide a healthy, efficient, effective, and engaging workplace for the knowledge worker in effort to improve their productivity. This concludes our literature review which delved into architecture student and their work nature, which hence is correlated to knowledge work and knowledge productivity. Further understanding the terms and the need of knowledge productivity and factors affecting them. In the following chapter, the case study of architecture schools in Cairo, Egypt is selected and studied in effort to explore how much the theory fares with the reality.


Introduction
Chapter 2
Architecture Productivity
Architecture Pedagogy
Architecture Student's Work Nature
Correlated
Chapter 3
Knowledge Productivity
Knowledge Economy
The Knowledge Worker
The Architecture Studies
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Physical Environment and KP
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Color
Aesthetic satisfaction
Q1. What is the work nature of an architecture student in terms of productivity?
Q2. What are the physical qualities of the productive spaces in architecture schools?
Q3. What is the definition of knowledge productivity and Factors affecting it?

5. Methodology and Data collection

5.1. Case study: Chosen sites, and status quo

In order to further explore the reality of the environmental quality and its effect on students' productivity, a cross case study analysis model was formed between Architecture schools in Cairo, Egypt. In this study, two universities in Cairo have been chosen, first being Ain Shams University [ASU], Faculty of Engineering campus, and second was Misr International University [MIU]. The reason behind the choice of those two case studies was to further see the different setting between a public university and a private one, in addition to the context, the first at the heart of Cairo city while the other is located at the periphery.

Ain Shams campus is a faculty exclusive campus, for it only have departments of Engineering and Architecture. Its location is in the heart of Cairo government where it is in the urban dense area of Abdo Basha in Abbasiya. For that, the micro-climate in this area is relatively higher due to higher pollution rate creating heat islands. MIU Campus is on the outskirts of Cairo City, located on Cairo-Ismailia Road, on the edge of Obour district. It is in a relatively less dense, especially since it is surrounded by relatively suburban districts, which gives it a slightly different micro-climate.

Figure 15 *Ain Shams University, Faculty of Engineering Campus in Abbasiya*

Figure 16 *Misr International University Map Location*

In comparison, since ASU is a public university, the number of students enrolled in it is of a much higher count than MIU. Approximately 14000 students are enrolled to ASU, around 650 of them are enrolled in Architecture school, and 3700 of them are enrolled in the credit hours program which also accommodate Architecture. MIU's average architecture students count however is

approximately 450 students. Moreover, in regards of campus conditions, ASU is specialized for engineering and architecture schools, thus it is designed to curate to the specific needs more than MIU. MIU campus accommodate multiple faculties other than Architecture and Engineering, varying between Dentistry, Pharmacy, Business, Mass-communication, Literature and Linguistics, and Computer Science. For that the design for the campus curates more towards having general spaces that can be used by multiple different disciplines.

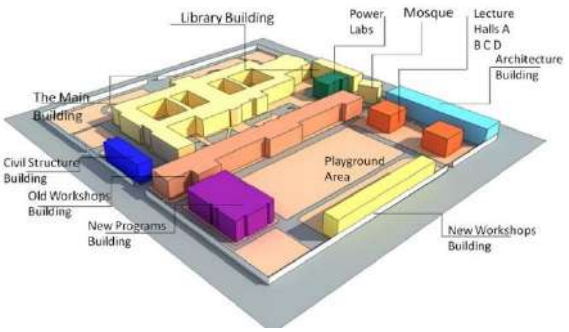


Figure 17 *ASU Campus*

In MIU the school of architecture doesn't have a designated building for the studios, rather they are located on the first floor of the main building with two more studios on the second floor. Creating a total of six design studios to be used by architecture students.

Figure 18 *S01 at MIU*

Figure 19 *S06 at MIU*

The four studios on the first floor share similar design, in regards of size, aesthetics, furniture and light. Not so similar are the studios on the second floor, they are similar to each other but different from the ones below.

On the other hand, in ASU there is a designated building for architecture students accommodating studios, and lecture halls. The number of different studios in the building is more than the ones in MIU, as each floor has studios that are different in design and in purpose. For the sake of the research two studios with similar visual characteristics between each university have been chosen to be the case study for the research.

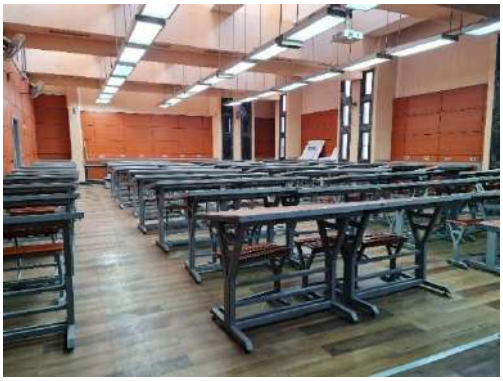


Figure 20 *Studio 500 at ASU*

Figure 21 *Studio 504 at ASU*

As for the outdoor spaces, there are areas in both campuses with surfaces that can be used for students work, seats and tables. However, they are rarely used as productive spaces in MIU, unlike ASU where it is used more frequently; especially when the work does not require a power source. For such reason, an outdoor space from each campus is also chosen to be compared to each other.

Figure 23 *Outdoor spaces at MIU*

Figure 22 *Outdoor Spaces at ASU*

5.2. Methodology Design

For the research methodology, a comparative analysis approach is taken to explore the effect of the built environment and Architecture student's perceived productivity using primary data tools (interviews, measurements, etc.). Starting by understanding the physical conditions of each case study, environmental quality measurements are taken for both campuses, indoor and outdoor. Measuring the light, noise, and temperature of both the studios on different occasions and days. In addition, observing the students' behaviour around the spaces and mapping it. Those measurements and observations are to understand the status quo of the spaces and how they fare in comparison to international and global comfort standards for a productive workspace.

Alongside the measurements and observations, Semi-Conductive interviews and a questionnaire is done among the students themselves to understand and measure their own perceived productivity within the spaces. A comparison between the theory and the reality then is done by comparing the measurement results with the questionnaire results, drawing conclusions to how the environmental quality facilitates or hinders the students' productivity in comparison between the two universities.

5.3. Data Collection

For the research, ASU studios 504 and 500-B/C were the studios chosen for the studies due to some physical similarities they hold with the studios in MIU. More so, due to them being easily accessible to the students across the day. The data collection happened across the span of 3 weeks in May 2022, following the midterms up till the time their final submissions were due. The observation period is around an hour long, more, or less. The Academic years observed were 2nd, 3rd, and 5th year Architecture students in both universities.

5.3.a. Observations

Ain Shams University

The building of architecture in ASU is of a linear design, the longer sides oriented North-East and South-West. It is also important to notice that the studios being studied are at the top floor of the building, which have a saw-tooth roof design allowing for lighting to enter from the ceiling. When observing the behaviour of the students in the studios in ASU, the sides of the studios proved to be a preferred area for most of the students in both studios. Taking into consideration that the sides of the studios is where the windows and the electrical outlets are in both studios. However, in the case of 500-B/C, where the windows are on one side only, the students preferred the side with the windows more than the one without.

In 504 (figure 24), the majority of the students were localized mainly by the entrances and sides, few were seated closer to the centre of the hall. In the case that one of the doors was closed, the side with the closed door becomes almost empty due to how far it is from the other exit. In regards of their productivity, while most of the students were doing work in the studio, there was few that lost focus more than once, stopped working and started pacing around or using their phones. During the early hours (from 8am to 2pm) observations the students were sitting more closely and concentrated closer to the exit than later (from 2pm after) in the day. In the later hours, the students were more spread around the studio and the clusters where more but smaller. The more they stayed, the more heads started resting on the tables showing signs of lethargy and fatigue. Students would constantly stop working and stretch their arms or backs which as well could relate to signs of muscles discomfort. In the times of observations done later in the day, it was noticeable that more students would massage their temples and close their eyes for more than a blink which could be signs to headaches and eye fatigue. In conclusion the behavioural observation showed that the longer time students stay within the studio, they start showing signs of discomfort. Needing to add that there is no air conditioning within the studio, and the place

relies on fans as a mean of ventilation and cooling. This doesn't allow for a complete ventilation for space, in addition to lack of control over relative humidity and temperature. Taken into consideration Cairo is a city with hot summer climate, especially with multiple heat islands effect that increase with pollution. The fans used to ventilate the room are a major source of noise within the room as well, sometimes being louder than the students talking.

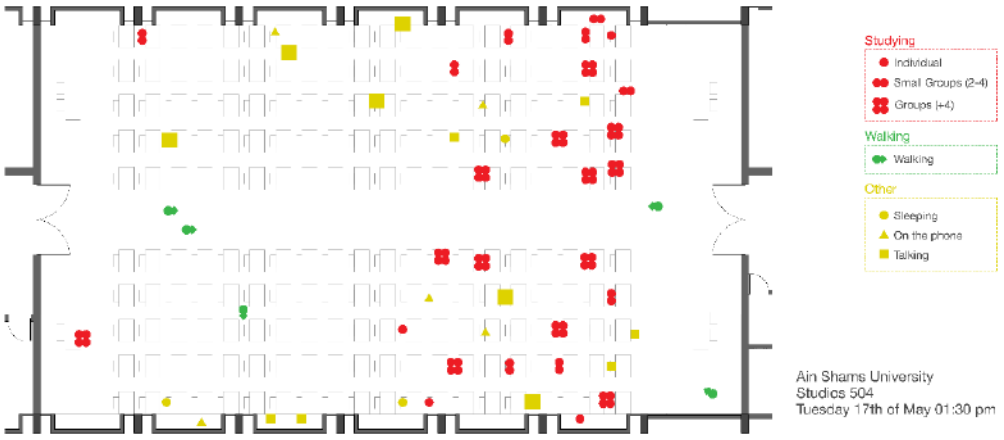


Figure 24 *Behavioural mapping of students in studio 504 at ASU*

As for studio 500 (figure 25), it is divided into two studios labelled B and C. The studio is much smaller in comparison to 504, almost half in size, which makes it much comfier in scale. Unlike 504, and due to the smaller size, the students were almost spread across the whole studio, with almost very few areas that were left unused. But as mentioned earlier, areas close to natural lighting such as the windows were favourable to the students, added reason would be their proximity to electrical outlets. Almost all desks by the side of windows were used, especially the ones on the northern Elevation. Even when the studio was accommodating fewer students, they sat by the windows. Second favourable seats were the ones by the AC vent and the door. Like 504, most students were doing work within the studio, yet the space was not distraction free. The further away from the windows and doors the seat is, the more distracted the students became. If by the first half of the studio almost 70% of the students were performing productive tasks, past the midpoint the percentage changed in favor of those distracted and not performing productive tasks. The studio 500 is divided into two studios however

they are connected by doors which are sometimes opened, allowing the students to move from and to the other which gives them a choice to change their setting and get away from distraction.

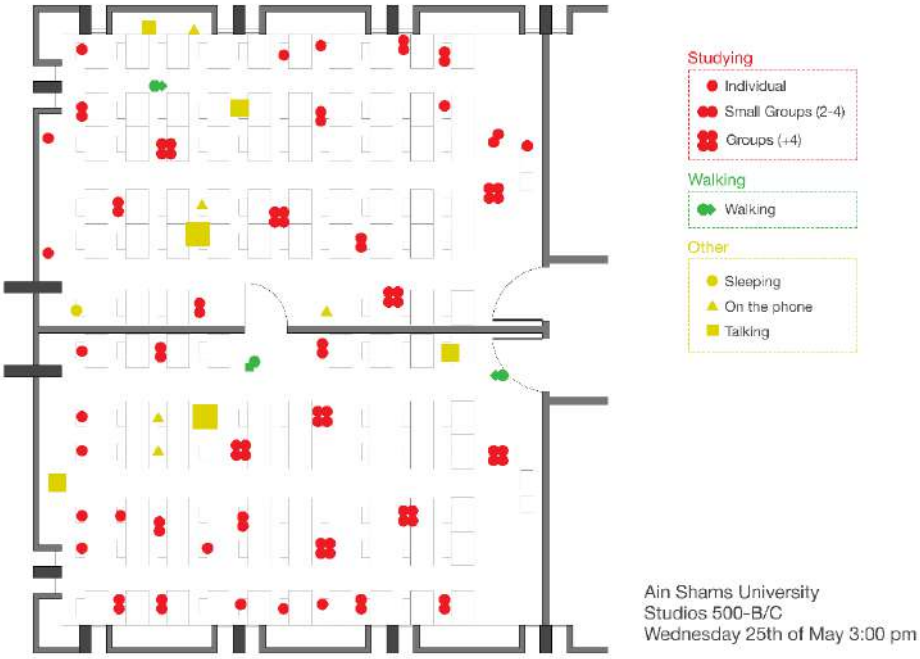


Figure 25 *Behavioural Map of students using studios 500-B/C at ASU*

Lastly for the outdoor spaces, in ASU they are usually used for productive tasks along with socializing. Students of younger years are usually the ones occupying them and not all of them are architecture students. The productive task students do outdoor would always be something manual that doesn't require any electrical power supply as there is no outlets in the outdoor area.

Misr International University

As for MIU, the studios usually would have an average of 20 students per studio when they are working during class hours and less when not within class hours. It is not so common for students to be found working in the studios out of actual class studio hours, especially within the younger years. Student often prefer to socialize on campus than work on their tasks and assignments. However, when choosing to do work on campus the studios on the first floor S01-4 are the most favourable for the majority of the students.

Figure 26 *Behavioural Map of students using studios S04 at MIU*

When observing students working in S01-4 (figure 26), similar to ASU the seats closer to the windows were usually the ones taken by the majority of the students, followed by the seats close to an electrical outlet. Seats in the back of the studios are usually the least used, and it is usually where students leave their materials instead. As the AC vents in the studios are on one side, it is observed that the side opposite the vents is usually not as favourable among students and is accommodated by a few of them. The number of students getting distracted in the studios on the first floor is close to half. After the first hour students start

going out of the studio more often and it is common that they just go out to stand in the corridors. By the first hour mark, students start getting restless, side talks and lack of focus starts becoming apparent by the later hours. Occasionally students would take their work and go outside to the corridors to sit by the rail and continue working. In the studios, as time progress a clear divide starts showing between those who are performing productive tasks within the studios and those who are idling around. A cluster of students working usually is found around the sides and closer to the window, while others idling sit closer to the centre and the door. A common observation among student performing tasks in all studios, is that they usually have headphones on while working.

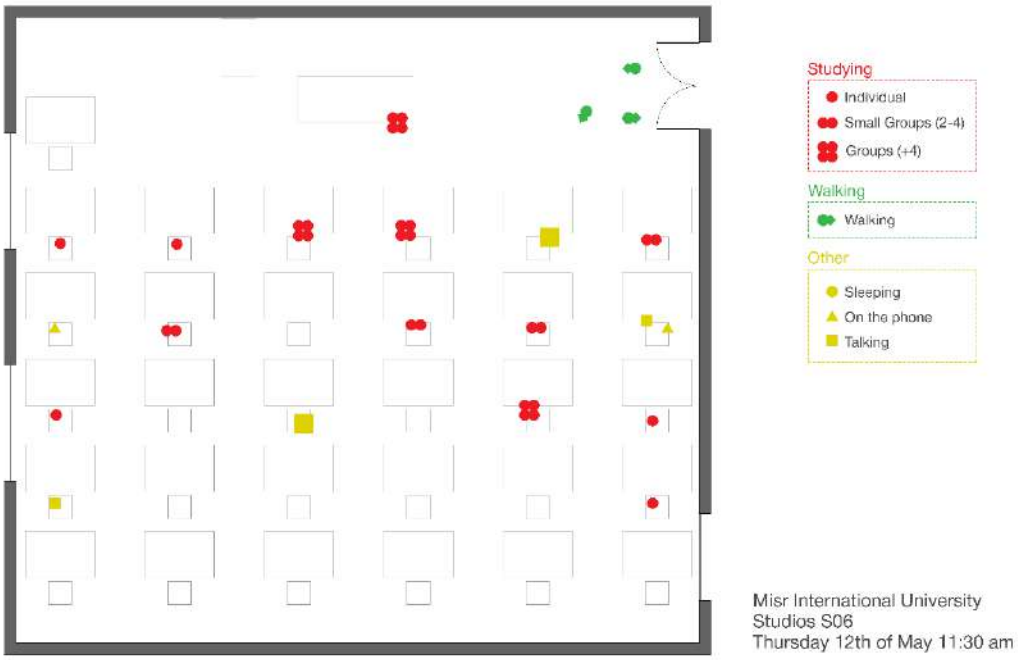


Figure 27 *Behavioural Map of students using studios S06 at MIU*

For the studios on the second floor (figure 27), students still chose to sit by the windows, however the blinds are usually pulled down to 80% of the window. Followed by them comes the other sides as a preferred seating by the students. All due to convenience as the outlets are by the wall. Unlike the studios on the first floor, the students don't go out of the studios as frequent. By the first hour mark, some students however start showing signs of eye strain and headaches, in

the form of head and eye massage movements. Also, as time progress, around 30% of the students start showing signs of lethargy and tiredness, with the occasional yawn and laying down of heads. However, as the time progress past noon, the movement out of the studios return, where students would go out to sit by the corridors. After the first hour inside the studio, students would once again start idling or socializing, however this time it's either in the back or the centre of the space. While students performing tasks move towards the front and the sides of the studio.

The outdoor space at MIU, rarely sees students from architecture working on productive tasks in it. It is usually rather used for social activities and recreation among students. Even for manual tasks and studying, it is not common to find architecture students working in the outdoor.

5.3.b. Measurement

In an effort to study the physical environment of the case studies, environmental qualities are measured in both indoor and outdoor spaces of both campuses. The environmental qualities measured are temperature, noise, and lighting. Measurements were taken more than once in the daytime, on different days and then the average is used as the final count.

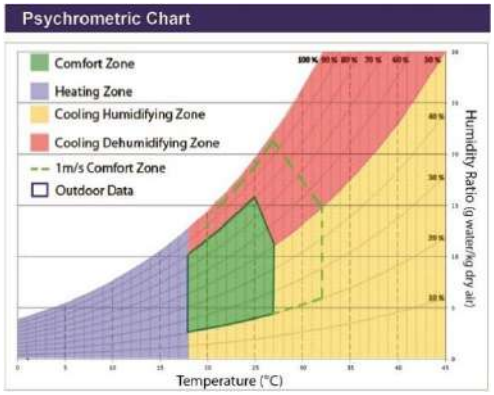


Figure 28 *Example to a psychrometric chart for thermal comfort and relative humidity (Vecchi, et al., 2017)*

Space type	Visual Comfort	Audio Comfort
Offices / Workspace	*500 – 700 Lux*	*40 – 50 dB*

Table 1 *Reference comfort levels (Kwabena, et al., 2019)*

Ain Shams University

Measurement taken in April 2022

Studio 504	Light	Sound	Temperature	Relative Humidity
By the right door	*Avg. 200 Lux* *Max. 220 Lux*	*Avg. 76 dB* *Max. 80 dB*	*30 C°* *(Average 1-2 Degrees more or Similar to outside temperature)*	*34%* *(Average 5% More humid than the outside)*
Centre of the studio	*Avg. 880 Lux* *Max. 920 Lux*			
By the left door	*Avg. 930 Lux* *Max. 1130 Lux*			
By South-West Windows	*Avg. 750 Lux* *Max. 780 Lux*			
By North-East Windows	*Avg. 570 Lux* *Max 600 Lux*			

Table 2 *EQ measurement of studio 504 at ASU*

Studio 500-B	Light	Sound	Temperature	Relative Humidity
By the door	*Avg. 140 LUX* *Max. 160 LUX*	*Avg. 64 dB* *Max. 80 dB*	*27 C°* *(Colder than outside temperature)*	*37%* *(More humid than the outside)*
Centre of the studio	*Avg. 250 LUX* *Max. 430 LUX*			
By the back	*Avg. 200 LUX* *Max. 260 LUX*			

Table 3 *EQ measurement of studio 500-B at ASU*

As we mentioned 500-B/C are much smaller than 504. However, the smaller scaler makes it more prune to being stuffier, especially when not well ventilated. The AC within the rooms is not always on so the temperature varies majorly, however the readings here were taken with minimal AC as most of the times the room was running on fans for cooling.

Outdoor Space	Light	Sound
Shaded	*5325 LUX*	*87 dB*
Unshaded	*72260 LUX*	

Table 4 *EQ measurement of outdoor working area at ASU*

Misr International University

Measurement taken in April 2022

Studio S01-4	Light	Sound	Temperature	Relative Humidity
By the door [Natural Lighting]	*Avg. 23 Lux Max. 24 Lux*	*Avg. 66 dB Max. 76 dB*	*26 C°*	*36%*
Centre of the studio [Natural Lighting]	*Avg. 60 Lux Max. 123 Lux*			
By the Window [Natural Lighting]	*Avg. 215 Lux Max. 371 Lux*			
Centre of the studio [Artificial Lighting]	*Avg. 162 Lux Max 240 Lux*			

Table 5 *EQ measurement of studio S01-04 at MIU*

Studio S06-07	Light	Sound	Temperature	Relative Humidity
By the back of the studio [Artificial Lighting]	*Avg. 230 Lux Max. 250 Lux*	*Avg. 64 dB Max. 70 dB*	*28 C°*	*36%*
Centre of the studio [Artificial Lighting]	*Avg. 320 Lux Max. 500 Lux*			
By the Window [Natural Lighting]	*Avg. 670 Lux Max. 1315 Lux*			

Table 6 *EQ measurement of studio S06-07 at MIU*

Although the studios look different in term of walls cladding and flooring. They are similar in terms of the environmental qualities. However, the studios on the first floor are more favoured by the students than the ones above. In addition, the cladding choices give different colour temperature for the studios and lighting, which is very evident when experiencing the space.

Outdoor Space	Light	Sound
Shaded	*5300 LUX*	*70 dB*
Unshaded	*57750 LUX*	

Table 7 *EQ measurement of outdoor spaces at MIU*

5.3.c. Questionnaire

Following the assessment of the physical environment, comes the need to assess the perceived productivity of the students using said environment. For that a questionnaire was devised to measure the perceived productivity. Formulating the questionnaire came from multiple case studies and previous research that used similar method of data collection, especially the research done by the British council in regards of measuring productivity. The population size was calculated based on the number of students enlisted in both universities around 800 students, the sample size covered 81 students, ratio of ASU to MIU students within the replies are 46% to 54% respectively. Margin of error was 5.6% and the level of confidence was 85%.

Starting off the questionnaire of basic demographic questions, in regards of their enrolled university and gender.

1. University Name? Misr International University / Ain Shams University
2. Gender? Male / Female
3. Current Academic Role? Bachelor student / Post-grad student / Other

The questionnaire then had to measure how familiar the participant is with the environment they are being asked about. Similarly, it is important to identify how familiar the participant is with the nature of architecture schoolwork and how experienced they are with the tasks needed to be productive.

4. Years on Campus? 1-2 / 3-4/ 5-6 / More than 6 years
5. How familiar are you with the campus and its facilities? Scale from 1 (Unfamiliar) to 5 (Very Familiar).
6. How frequently are you on campus, represented by days per week? 1 to 6
7. What is the average duration (in hours) you spend in the indoor spaces on the campus per day? Less than 4 / From 4 to 6 / More than 6 hours
8. Where do you prefer spending your working/studying time? Studios / Outdoor / Other

9. Where do you prefer spending your working/studying time? Less than 4 / From 4 to 6 / More than 6 hours

Following that, the questions start measuring and assessing the participants' satisfaction with the physical environment and the environmental qualities.

10. Which studio do you prefer to work at your university? [ASU] 500 / [ASU] 504 / [MIU] S01-04 / [MIU] S06-07
11. How would you rate the Indoor Environmental quality in your university buildings? Scale from 1 (Very Unsatisfying) to 5 (Very Satisfying).
12. Rate the impact of the indoor environmental quality of building on your, Work Productivity, Physical Health, & Mental Health? Not effective / little effective / Effective / Very effective
13. How many days in the last month have you come to university despite not feeling well? 1-3 / 4-6 / 7-10 days
14. Do you agree with this statement "I find it easy to work with my colleges in the studios in campus"? Strongly disagree / Disagree / Neutral / Agree / Strongly Agree
15. Do you agree with this statement "I am able to focus and concentrate when needed in the studios in campus"? Strongly disagree / Disagree / Neutral / Agree / Strongly Agree
16. Rate the effect of your study area on the following mental states, Motivation, Focus, Group work, & Solo work? Very negatively affecting / negatively affecting / Neutral / Positively affecting / Very positively affecting
17. Rate your study area's condition according to what you see of most influence on your productivity, first being most influential and fifth being least. 1. Comfortable, 2. Free of distraction, 3. Clean and tidy, 4. Portrays a creative image, & 5. Promotes innovation at work.
18. How satisfied are you with the following characteristics of your workplace, Artificial Lighting, Natural lighting, Temperature, Air quality, Noise? Very Unsatisfied, Unsatisfied, Neutral, Satisfied, Very Satisfied

19. Rate according from most to least how influential the environmental quality to your perceived productivity, first being most influential and sixth being least. 1. Lighting, 2. Temperature, 3. Air quality, 4. Noise
20. Do you use the outdoor spaces in campus to work? Yes / No
21. How would you rate the Outdoor Environmental quality in your university buildings? Scale from 1 (Very Unsatisfying) to 5 (Very Satisfying).
22. Rank the most negative factor in the outdoor spaces most negative to least. 1. Noise, 2. Light, 3. Temperature, 4. Air Quality, 5. Furniture, 6. Access to Electricity

Lastly the questionnaire considers some intangible factors that also affect the participants' productivity in term of their relationship with the organization they belong to and work under, in this case their university.

23. Do you agree this statement "My university sees my wellbeing as a priority"? Strongly Disagree / Disagree / Neutral / Agree / Strongly Agree
24. Do you agree this statement " My university supports my physical wellbeing"? Strongly Disagree / Disagree / Neutral / Agree / Strongly Agree
25. Do you agree this statement " My university supports my mental & emotional wellbeing"? Strongly Disagree / Disagree / Neutral / Agree / Strongly Agree

Lastly an open section for extra comments in regard of how the students perceive their environment affecting their productivity was optional for the students. The data was collected during the month of May of 2022 online via Google Forms.

The questionnaire was not the only method in collecting data regarding their perceived productivity, semi-conductive interviews is already used to further understand the reason behind how they perceive their productivity within campus workspaces.

5.3.d. Semi-Conductive interviews

Along with the questionnaire, semi-conductive interviews of students at both universities are held to further understand how they perceive their campus environment as productive. During the field study an average of 30 interviews were done in each university.

The general questions of the interview revolved around:

1. How they feel when working on campus
2. How satisfied are they with the environmental qualities? Why?
3. Further questions would focus on their main issues within the environmental quality that hinders their productivity.
4. What would you change / improve within your work environment to support being productive?

Ain Shams University

Understanding more regarding ASU students' perceived productivity, many approved with the idea of using the campus facilities as a productive workplace. However, they established that while they used the spaces that doesn't mean they find it the most optimal for being productive, however it is to a certain extent convenient and hence efficient. However, many of the students highlighted that temperature is the major factor hindering their productivity. Studio 504 is not air conditioned, so most of the time fans are used to cool the space, while Studio 500 has AC, yet it isn't always on or working. Most of the students showed dissatisfaction with the air quality as well, stating that both Air quality and temperature are the biggest issue affecting their productivity. Followed by that comes the furniture as a big factor affecting their work progress, while it isn't an environmental quality, it is one of the most complained about factors. Emphasizing that for a space that they usually spend an average of 6 hours to more at the space is clearly not comfortable for them. That obvious lack of comfort then hinders not only their productivity but also their creative energy,

stating how it is difficult to design good architecture when the architecture they are surrounded with is harming them.

Many of the students complained about how furniture is not comfortable for long work periods of time nor the changing work tasks needed for architecture. The seats the student use in the studios end up causing physical ailment and pain when used for long periods. While the spaces are not quite for a working place, many responding that while it may be an issue it is simple to fix with a pair of headphones. When asked about the outdoor spaces, the opinion was split almost in half between those willing and unwilling, however both highlighted that the outdoor spaces need to be equipped with electrical outlet to be able to accommodate digital tasks not only manual ones. Many then also focused on the fact that, while the spaces might be convenient for doing productive work, the demanding nature of the architecture student life is too strenuous to be productive. Emphasizing how the environment is not aiding with stress or recharging of energy to be able to do the task needed, saying that they often find themselves too tired to begin with to work.

When asked about what they would prefer to have changed in their studios, many mentioned the furniture, before fixing the air conditioning. Followed by that came the view. Some expressed how they would prefer having a different view within the studio than the one already there. When asked to elaborate, change in cladding, windows sized and addition of indoor greenery. The general response was similar in choosing the factors and how they affect their perceived productivity. While unique responses are present, they mainly revolve around furnishing choices and workload. Overall, the general picture was of using the spaces for convenience rather than effectiveness.

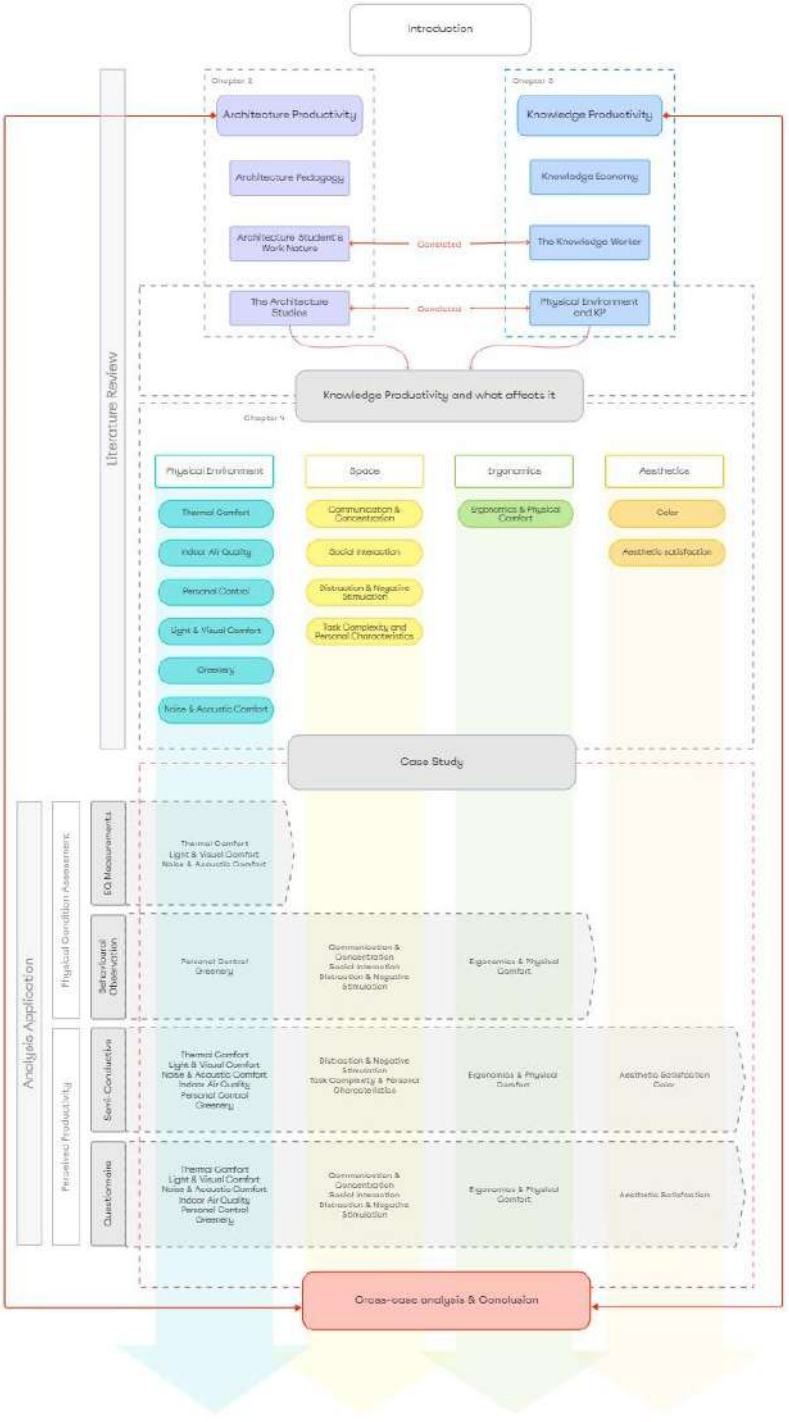
Misr International University

When interviewing students at MIU, the majority of the students didn't find the workplaces on campus productive. Especially the outdoor, as it wasn't specialized or fitting for the majority of their work needs. However, students of younger years were more open towards the idea of working outdoor if the place was fitting for their needs than the older years. When asked about the environment they mostly prefer to work at, most of them referenced co-working spaces as their go to workplace, especially for its flexible environment, highlighting how the fixed and limited environment the studios offer is restricting their work. When asked specifically about environmental qualities, lighting ranked high among most of them, lack of good lighting proving to be their main issue. Many responded how the quality of lighting is poor for the work needed and puts extra strain over their vision and eyes. Second major factor they named as challenging their productivity was noise followed by the air quality. Many stressed how they can't stay in the studio spaces for long hours without going outside to change the air they are breathing, especially when it is summer and the indoor is fully running on AC.

Other factors that were of high influence on the students perceived productivity, or lack of in this case, is the fact that many come to the university already stressed and tired from the ever-demanding nature of architecture work. Consequently, highlighting the need for the work environment need to relief that stress and tiredness to be able to be productive, instead of adding on the stress. Many Students chose different to change the design of their workplace when asked whether they would or not. In response many chose bigger windows and having a view within the workplace, followed by a change in the furniture to have one that would respond better to solo-work and group-work needs.

Other than the prior general comments, some unique answered highlighted how a universally furnished space is not efficient to the work needed for architecture school, especially with the diverse tasks that are usually needed to be done. Other highlighted that while lighting is a major key in visual comfort, aesthetic value

can be of a factor as well, when the space is bleak and lacks character, it affects the students work. One student said, *"An architect is eyes seeing everything, how can an architect be creative when their eyes have nothing to see"*.



Q1. What is the work nature of an architecture student in terms of productivity?

Q2. What are the physical qualities of the productive spaces in architecture schools?

Q3. What is the definition of knowledge productivity and Factors affecting it?

Q4. What are the intangible and tangible elements affecting one's productivity in and architecture productive space?

Q5. To what degree do the Universities of Architecture built environment affect and relate to the students' perceived productivity?

6. Data Analysis

Following all the data collected in regards of the case study, the presented data is analysed in reference to the literature. Relating to each other and in comparison, to the case studies. Understanding the specific conditions and characteristics of architecture students in Cairo. The analysis of the data starts first by focusing on a single case study and how the statuesque relate to the students perceived productivity then follows with a cross case study analysis.

6.1. Collected Data results

The sequence of the analysis follows the sequence of the factors presented in the literature. Taken into consideration that within the literature it was more than once highlighted how the environment experience is a holistic process not singled on one factor or element.

6.1.a. Ain Shams University

Throughout the study for the case of Ain-Shams university, it is found that the students are highly sensitive to the built environment around them. That was clear especially in their answers of the interviews, there is also good understanding to how the environment impact their productivity and their comfort within the work environment.

Physical Environment

Figure 29-a/b *Students using the outdoor spaces "Tak'eeba" at ASU*

Figure 30 *Students using the outdoor spaces "Tak'eeba" at ASU*

Starting off by their preferences in regards of the choices of the built environment. It is evident through the questionnaire results (figure 31) that the majority prefer working indoors. This is also backed up by the interviews question, when asked about their willingness to study and work in the outdoors spaces, the opinion was majorly hesitant towards it, especially students of the upper grades. However, many expressed reasoning behind their hesitancy being their dissatisfaction with the arrangement and design of the outdoor spaces, in terms of enough area, furniture, and absence of electrical outlets for efficiency. Although the outdoor working area in ASU is designed to accommodate working students with seating and tables as well as shade from the sun, when assessing the environment, it was still uncomfortable for work, especially past an hour long.

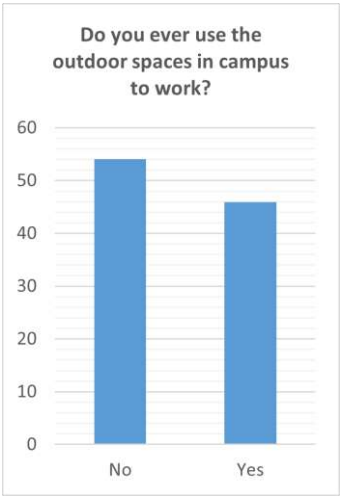


Figure 31 *ASU students' willingness to work outdoor on campus*

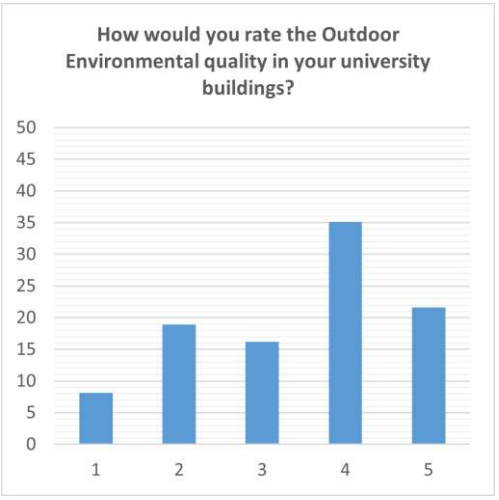


Figure 32 *ASU students' rating for the outdoor environment on campus*

Especially with the climate of Cairo where it gets hot and humid in the summertime and cold and windy at winter, thermal comfort was not provided within the outdoor setting. While the outdoor area was noisy for a working place, averaging 87 dB which is even louder than a noisy street, the students' feedback in regards of noise was that it can be easily controlled personally using headphones, and that the majority of them would much prefer listening to their own choice of audio, or music while working.

The responses towards noise and sound were interesting in terms of noise and perceived productivity. Throughout the literature it was highlighted how effective noise and distraction can be over KP, and that was supported by the students reply. However, with the advancement in technology and ease of access to a source of music and an earphone or headphone, the issue of noise didn't seem to be that concerning to the students. The observation of the student's behaviour as well back-up the finding as almost 7 out of 10 students working would be using their headphones or earphones listening to something. Few even just use them for noise cancelling.

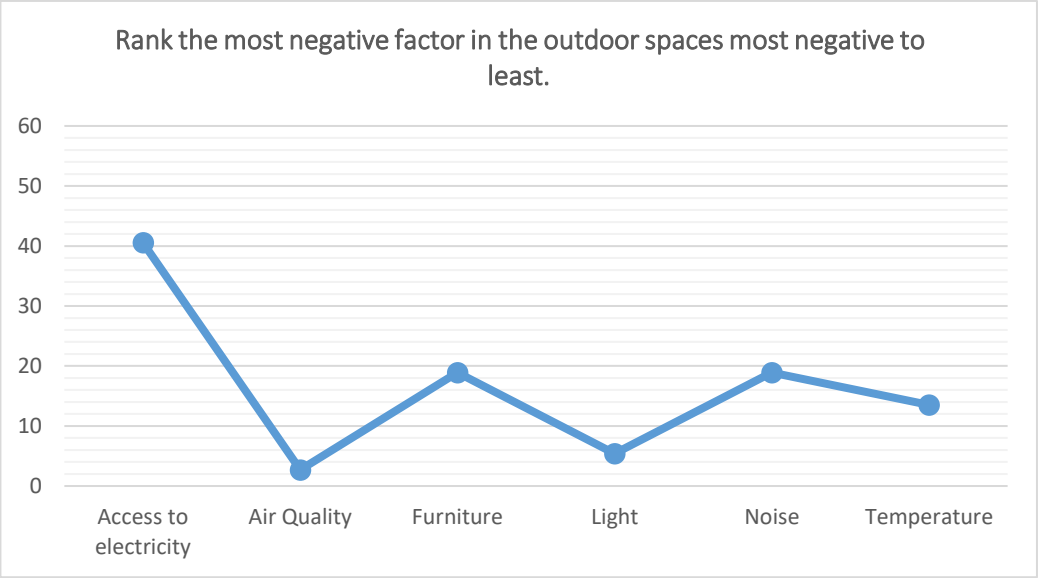


Figure 33 *ASU students rating of issues with the outdoor environment hindering their productivity*

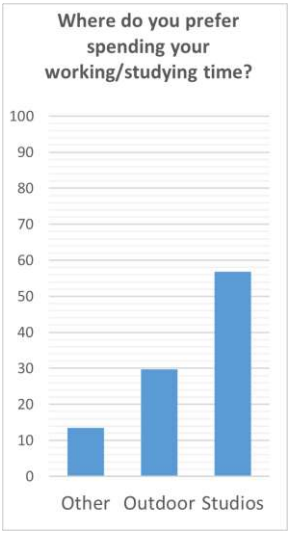


Figure 36 *Percentage of student's choosing their preferred working place in ASU*

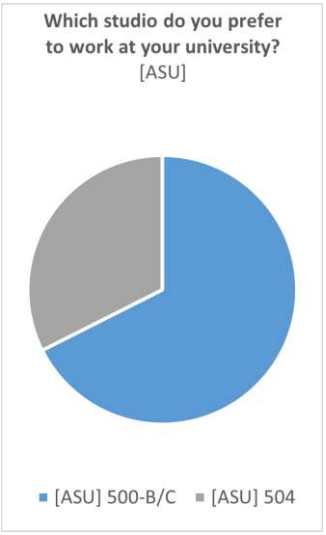


Figure 35 *Students' choice of their preferred indoor studio to work at ASU*

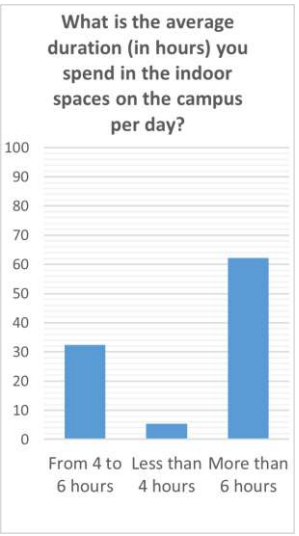


Figure 34 *Average time spent indoor according to ASU students' response*

Moving on to the indoor spaces, when we look at the amount of time spent inside for the students 94.5% of it is more than 4 hours long, with 62% being longer than 6 hours. This emphasis the significance of the environmental quality in regards of overall comfort and wellbeing and specifically productivity. This amount of time indoor is susceptible to causing sick building syndrome (SBS) if present within an uncomfortable environment. Most of the students questioned in both the questionnaire and the interview chose studios 500 (figure 35) as their preferred working place out of both studios on the top floor. One of the biggest reasons highlighted in the interview being their size and them having air conditioning (AC).

In regards of the student perceived impact of the environmental quality on their overall performance and wellbeing when it came to productivity and mental health, the environment was perceived more effective over the students than when it came to Physical health. However, the majority saw it to have little impact in regards of those states. When discussed further in the interviews however, it was highlighted that the students don't perceive their working environment to have a positive impact on their performance. In addition, when asked to rate the

IEQ of their faculty building most of responses gave it a barely adequate score. The interviews reasoned these scores for it being efficient but not effective nor healthy to be in. As mentioned in the prior chapter within the interviews many students highlighted the convenience of the working studios as a workplace. According to the behavioural observation, students who has been at the studios for long hours (figures 24 & 25), symptoms of SBS were shown, as lethargy and distraction as well as stretching of muscles were all present among the students. Such symptoms pointed to how uncomfortable the working environment is for students especially when their work nature require long working hours of them.

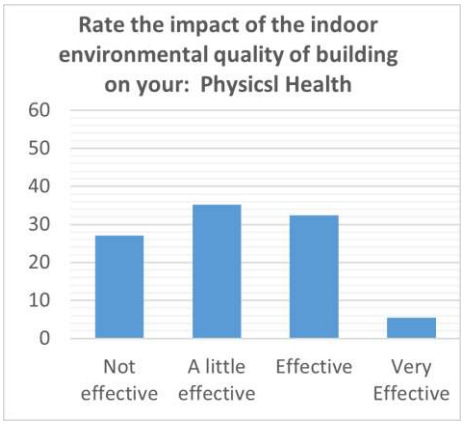


Figure 37 *ASU students' response to questionnaire question regarding physical health, in percentage.*

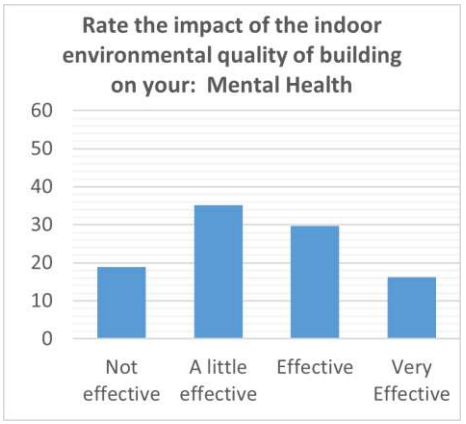


Figure 38 *ASU students' response to questionnaire question regarding mental health*

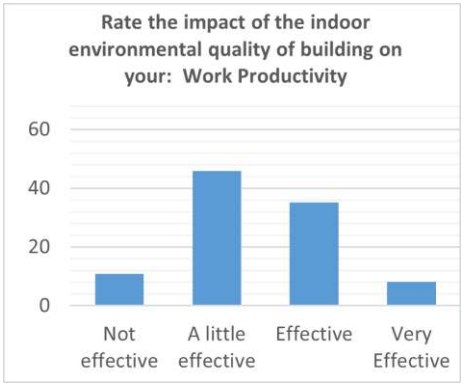


Figure 39 *ASU students' response to questionnaire question regarding mental health.*

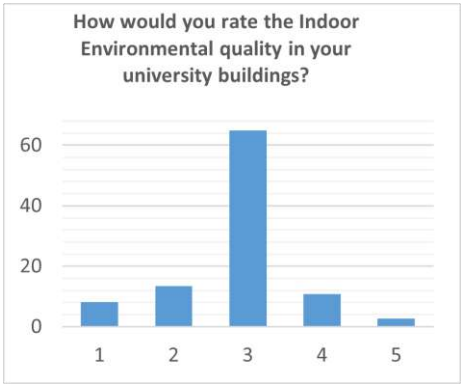


Figure 40 *ASU students' response to questionnaire question rating ASU Architecture building IEQ, in percentage.*

When it comes to specific EQ and their effect on perceived productivity, students were asked in the questionnaire and throughout the interviews to rate their satisfaction towards each element. Starting by the least satisfied element which is noise. As previously stated, when doing the EQ measuring, noise within the studios in ASU is very loud for a working place, averaging 70 dB in both studios and going up to 80 dB.

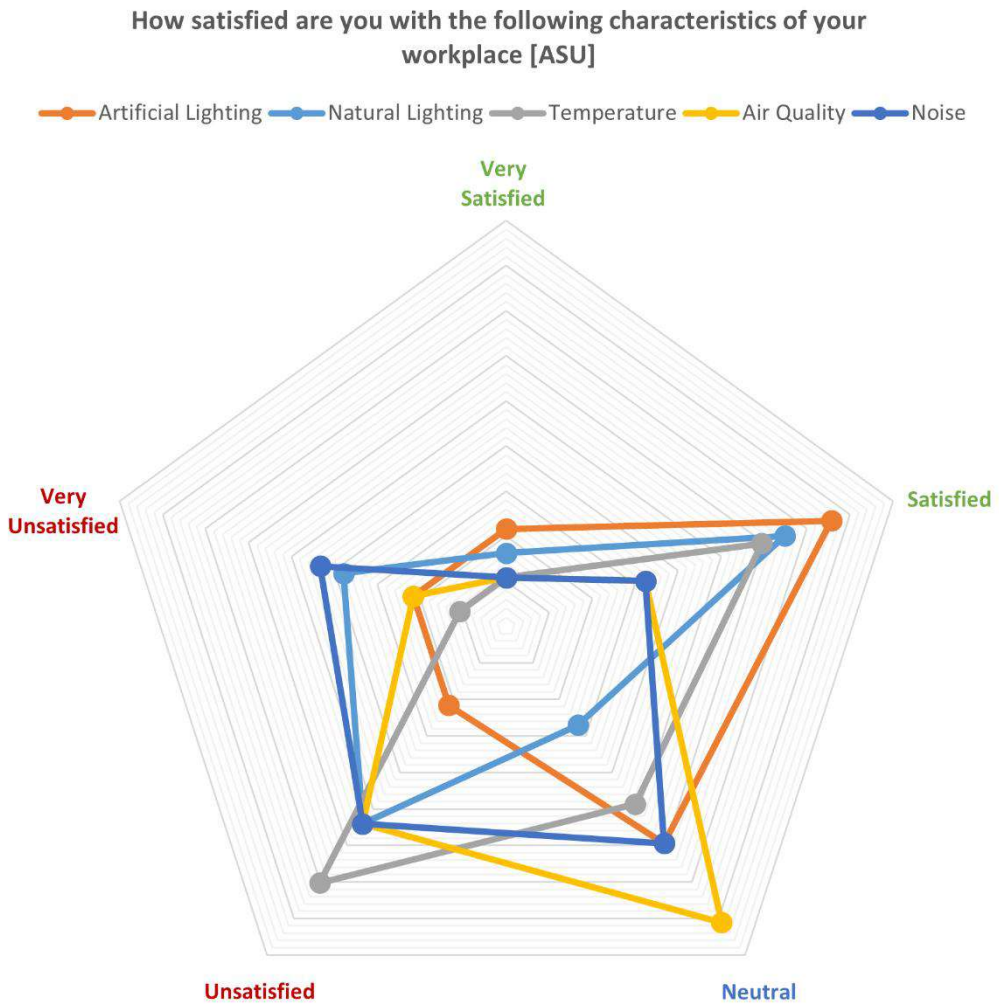


Figure 41 *Students' Satisfaction rate with IEQ of their studios in ASU*

When observing the physical environment, the source of noise was not just the people within the place, rather the fans used to ventilate the studios were a bigger source of noise, especially with studio 504. Added reason for high noise level was the size and scale of the studios, while 504 is a huge 780 m^2 room, 500-B/C are 176 m^2 each. One studio is too big that it creates echo and noise with the fans, while the other is much smaller but hence densely packed with students which lead to more noise as well. All of this doesn't fall within the acoustic comfort range required for a place of work and productivity. When asked to rank EQ influence on productivity (figure 42) Noise ranked 4th. In addition, although the students did state when interviewed that they usually tend to use headphones to cancel the noise around them, that is not an adequate nor sustainable solution for the workplace. Especially for an architecture student who usually stay within the studios, and their required task need long hours to do, using a personalised solution to solve noise issues is not healthy nor effective. As mentioned in the literature, high amount of noise leads to distraction especially when trying to work, and that is the most common kind of distraction found within the workplace. Not to mention that being present in a noisy environment for long hours could be one of the triggers to SBS such as headaches.

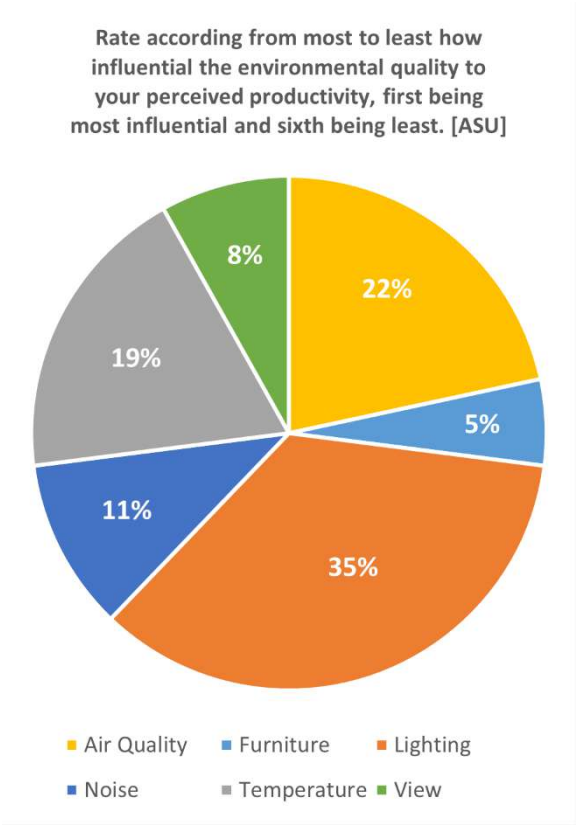


Figure 42 *Ranking of Environmental qualities and characteristics according to influence on productivity, according to ASU students' response in the questionnaire*

Natural Lighting and Artificial Lighting were the second and third quality that students expressed dissatisfaction with (figure 41), however in those regards the majority leaned towards satisfied. Lighting is also the highest ranked quality in regards of influence among the students' response (figure 42). Interesting take, seeing as the studios on the top floor of the architecture building in ASU, 504 and 500 has saw roof ceilings as we mentioned earlier, which allows for natural light to enter from the top, as well as through the side windows. However, in studio 504 the light is not so evenly distributed, some areas are really dark averaging 200 Lux while others are overly bright averaging 800 Lux, both are out of the visual comfort zone for an office space. While on average illuminance ranging from 500 to 700 Lux is the most optimum, in 504 the range usually average 700 above which is above the comfort scale, to anyone the studio is considered overly lit, and to someone with photosensitivity this room is extremely uncomfortable. The light reflecting over the surfaces in the studio doesn't help with the brightness. When asked to describe the visual comfort in 504, a very common response from students was that it hurts their eyes especially on longer working days. *"Too bright"* and *"Headache inducing"* are terms used a lot among the students interviewed when describing the studio, take into consideration the huge scale of the studio is a general dissatisfaction among all students interviewed. The large scale of the studio makes it possible to have areas where it is dark, especially the corners where there isn't much light coming in. As mentioned earlier when observing the students in 504 students, it was visible that after 30-45 minutes

Figure 43 *Students working in studio 504 in ASU*

Figure 44 *Contrast in lighting showing in studio 504 at ASU*

have passed visible signs of visual discomfort started showing with students rubbing their eyes, strongly blinking, and closing their eyes. As mentioned in the literature, studies argue that exposure to higher illuminance for some part of the day effect well-being, however lighting conditions that surpass the body's responsive capability is considered an environmental stressor (Clements Croome, 2006). As well as occupants' preference toward natural lighting over artificial, however the studios have a mixed lighting system, where there is natural lighting entering yet artificial lights are still on most of the time, with no mean of controlling them. Such quality of light is highly related to the students perceived productivity according to their responses in both the interviews and the questionnaire.

In regards of 500-B/C the overall room light leans towards temperature that is much warmer white than studio 504, that is due to the overall use of warm colour cladding and flooring. The issues with both studios of 500 is the opposite to that of 504, while one is overly lit, this one is not lit enough. The illuminance within the room ranged between 160 to 430, Lux, all is below the recommended range for a workplace. In addition, the artificial light is not diffused enough to prevent glaring, rather it is very focused top

Figure 45 *students working in studio 500-B at ASU*

Figure 46 *This figure shows the harsh lighting coming from the fixtures which is not visually comfortable.*

Color Temperature (KELVIN)	2000K - 3000K	3100K - 4500K	4600K - 6500K
Light Appearance	Warm White	Cool White	Daylight
Ambience	Cozy, calm, inviting, intimate	Bright, vibrant	Crisp, invigorating
Best for	Pendants, wall/coach lanterns, restaurant/commercial ambient lighting, residential recessed lighting, table & floor lamps	Basements, garages, work environments, task lighting	Display areas, security lighting, garages, task lighting

Figure 47 *Light temperature chart elaborating different light temperatures for recommended tasks. Credit; aisledlight.com*

down. Similar to 504, students start showing signs of visual discomfort when staying in the studio for long hours to work. When interviewed in regards of the light, many highlighted that the light quality especially is not satisfactory to them. Further explaining that in terms of enough luminance, light temperature, and glare, all are issues that are supported as well by the physical assessment.

Third quality influential over students perceived productivity was the Air quality, due to limitation of access to measuring devices, there isn't a physical assessment of the air quality of the case study. However, throughout the interview, questions regarding air quality has been raised to further understand the perceived satisfaction of the students. First understanding the status quo of the studios, 504 doesn't have any air conditioning and the source of ventilation relies on fans and opened windows from the ceiling, which are not all opened or working. 500 on the other hand have air conditioning. Throughout the literature it has been highlighted how IAQ relates to the health of the indoor occupant, and hence affect their productivity. Eyes and Sinus irritation, lethargy, headaches, and mental fatigue are symptoms that are correlated to bad IAQ. It is important to highlight, that architecture students use lots of tools with volatile chemicals over the course of their study years, example art supplies, lack of adequate ventilation not only increase discomfort it also prolongs students' exposure to the volatile chemicals. During the interviews, multiple students expressed how after hours in the studio they start finding difficulty breathing and usually more than once get out of the studio for a *"change of air"*, that reply was for both studios. Even 500 with air conditioning didn't provide enough ventilation that allows for change of air,

usually the air is recycled through the HVAC system and used only to cool the space down. Students yawning and sleeping within the studio and mid-work is clear sign to the lack of adequate ventilation which has been observed through the students' behaviour. All that lost focus and lost time affect students perceived productivity, which relates to why air quality was highly unsatisfactory and highly influential.

Regarding temperature and thermal comfort, students see it as the third most influential aspect in regards of productivity. When it came to satisfaction rate, temperature saw a divide in opinion, this however relates to how the conditions of the studios are different. One has air conditioning while the other doesn't, meaning one has more controlled temperature and the other not. Thermal comfort and productivity are highly correlated, as people are only able to perform to their maximum potential when they do not have to worry about their temperature. A person will experience cognitive processes that connect physical, physiological, and psychological components in order to accomplish the goal of achieving this mood (ASHRAE, 2017b). Productivity is directly correlated to thermal comfort; therefore, maintaining a consistent temperature range of 21–25 degrees Celsius creates the optimal conditions for working and remaining inside the premises. However, one's tolerance to temperature sees slight change due to regional adaptation. Climate in Cairo sees cold winter temperature ranging around 7 & 8 degrees Celsius and hot summer with temperature going up to 39 degrees Celsius. The summer months are the most challenging in regards of thermal comfort especially when there is lack of Air conditioning. When measuring the temperature of the studios, 504 was usually 1 or 2 degrees more than the temperature outside, while 500 was 2 to 3 degrees colder than the outside temperature. While 500 was colder it was still ranging outside of thermal comfort zone. As when the average temperature outside during the time of the study was ranging 30 to 34 degrees, the temperature inside would be 27 with AC and 34+ without. Needing to add that although studio 500 has AC, due to the density of the student inside it isn't easy to cool. In addition, 504 with its large

area and only relying on fans lead to uneven attempt at cooling the place. The students showcased higher tolerance towards heat in their responses to the interview however the lack of adequate cooling and any control over it led to a division of opinion in regards of thermal satisfaction. In regards of the effect of temperature on their productivity, their response was that it was *"exhaustive"* and would lead to loss of track and distraction during worktime.

Space

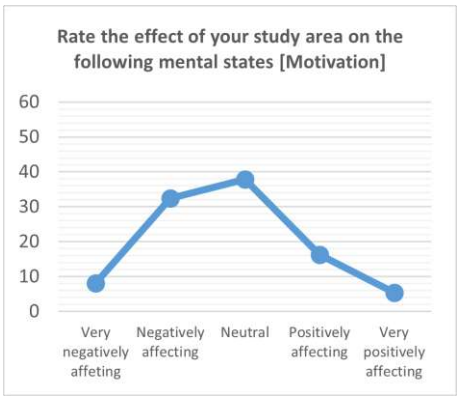


Figure 48 *ASU Questionnaire response in regards of environment effect on motivation.*

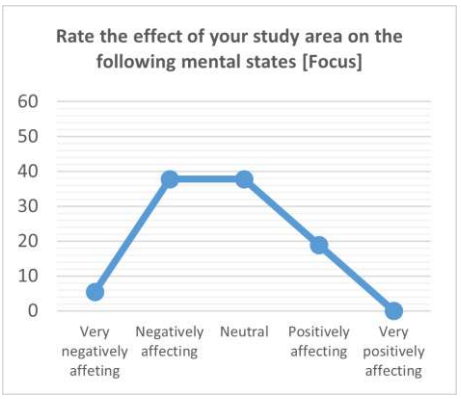


Figure 49 *ASU Questionnaire response in regards of environment effect on focus.*

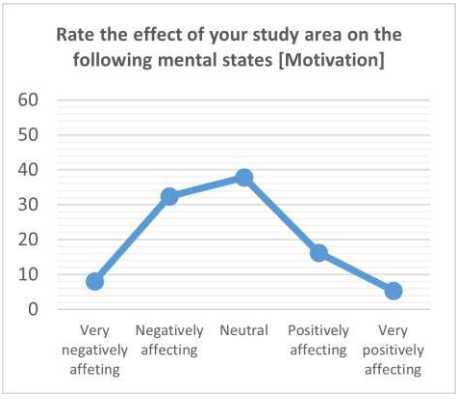


Figure 50 *ASU Questionnaire response in regards of environment effect on Solo work.*

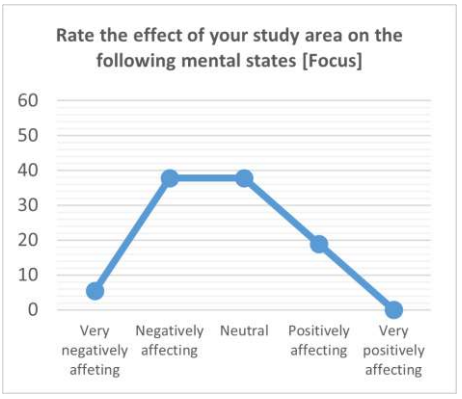


Figure 51 *ASU Questionnaire response in regards of environment effect on Group work.*

The literature explained how the relation between the built environment and the type of activities it accommodates relates to knowledge productivity and is considered and intangible factor affecting it. Focusing on the ability to concentrate and encouraging productive tasks as well as allowing for group and

solo work to be done efficiently and effectively. When it came to being able to concentrate and focus (figure 49), the students perceive the working environment negatively affecting that. It then reasons in how they see "being able to work solo" as neutral (figure 50) when it comes to extrinsic factors. This result in lost time and hence lack of productivity within the studios. When questioned in regards of focus and motivation (figure 48 & 47), students related it to lack of satisfaction with the overall work environment which was discussed earlier. Relating *"too many distractions and stressors"* within the built environment to lack of perceived productivity. However, group work (figure 51) was expressed as positively influenced by the environment. When asked to elaborate, students highlighted efficiency and convenience to be major reasons, the studios provide to them a place with adequate space and facilities to perform group tasks together.

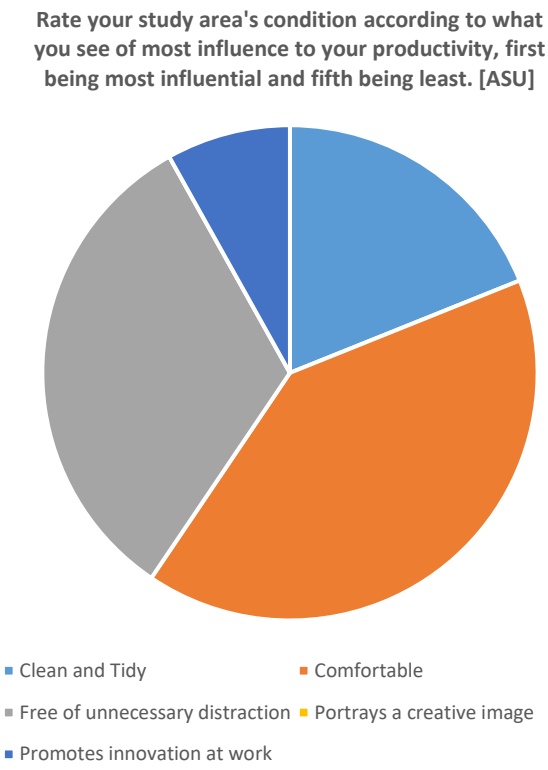


Figure 52 *ASU Ranking influential environmental conditions in relation to PP.*

Students expressed that being not able to finish the tasks on campus during the time they are working in the studios lead to them needing to work on it extra time, which leads to more stress that ends up being carried over to the day after. This cycle only hinders their ability to work more and make them less productive.

Ergonomics and Aesthetics

As we established the importance of comfort to wellbeing and hence productivity, physical comfort is one of them. Expressed in furniture and how well it responds to physical needs and body ergonomics, good ergonomics arguably could improve productivity. Observing students' behaviour supported the claim, as signs of physical discomfort was visible among students working in the studios, especially back pain. This was brought up by the students first during the interview that the author found a need to include it within the study. 90% of the students interviewed mentioned furniture as a major source of discomfort which leads to lack of PP. *"I cannot sit comfortably on the desk I am supposed to be working on, how can I be productive?"* Said one of the students, emphasising seating choices to be a major source of physical pain which hinder their perceived productivity. For students who stay within the indoor environment of a studio for over 6 hours, furniture is of outmost importance. While different furniture that should accommodate different task needs was expressed, furniture that is physically comfortable is the basic necessity.

Then comes aesthetics, which the students had a unique outlook on as well. During the interviews many students started talking about how the environment is perceived to them aesthetically and how their unsatisfaction could block their creativity and thus their perceived productivity. Such unsatisfaction was found towards choice of cladding material and colour, especially with the extreme difference between the two studios 500 and 504. Another point worth mentioning that lack of view within the studios gave way to an increase of influence in regards of aesthetic value as well.

6.1.b. Misr International University

Students of MIU are highly perceptible of their environment, especially their work environment and its effect on their well-being. Similar to the students at ASU, their interview and questionnaire answers showcased clear understanding of factors of environmental qualities and its probable effect over productivity. It is worth stated however, that as priorly mentioned, other than electrical engineering, architecture is the only other engineering school at MIU. In addition, considering school of Architecture is a mix of science and art, that makes it even more selective among the other faculties.

Physical Environment

Figure 53-a/b *Students using outdoor spaces at MIU*

Starting in similar fashion, in regards of students' preference of working environment (figure 54), the indoor environment was favourable for students to work at. Throughout the observation of the students' behaviour conducted during the study, the outdoor space was found to be used mainly as a socializing outlet for the students over a place of work or study. When asked for reasons during the interviews, many expressed dissatisfaction with furniture or clear design of an outdoor working place. Most frequent reason was inefficiency, whether furniture wise or availability of an electrical outlet, which for a university student of the current age is crucial However, the students also expressed a clear interest towards the idea of working outdoor, highlighting how they are satisfied with the outdoor area on campus in regards of shading and specifically landscape.

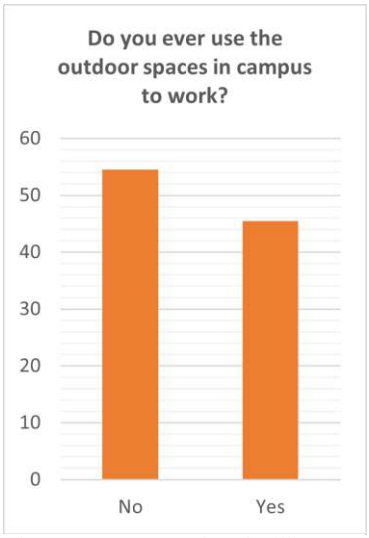


Figure 54 *MIU students' willingness to work outdoor on campus*

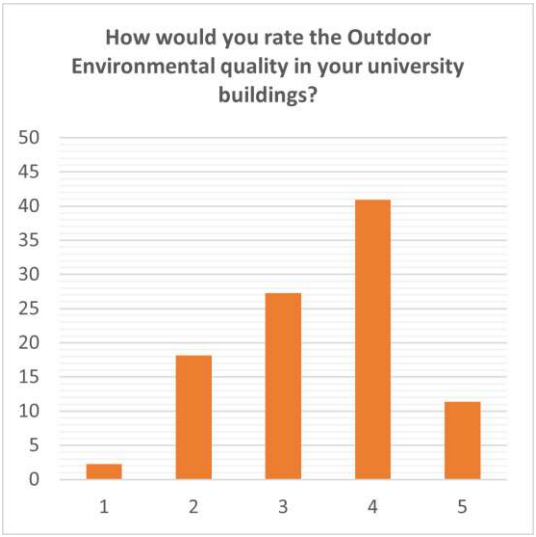


Figure 55 *MIU students' rating for the outdoor environment on campus*

In regards of environmental qualities such as noise and thermal comfort, as expected of a university campus outdoor space it is loud for task performances. Noise was second highest ranked as a negatively effecting factor over students' productivity within the outdoor space. Noise here was expressed as a major source of distraction in regards of focus, especially with presence of other multiple faculties that use the same outdoor space. Third came temperature was to be expected due to the climatic nature of Cairo, as discussed similarly with ASU there is no mean of outdoor ventilation used outside to try and cool down the weather, however one area with landscape shading (figure 57) is expressed by multiple students to be generally cooler even within the summer weather. When measured during study phase the tree shaded area in the outdoor was 2 to 3 degrees cooler than the weather. It was evident throughout the interview and the questionnaire how the majority of the

Figure 56 *Architecture students at MIU's outdoor*

students were somewhat satisfied (figure 55) with the outdoor environment of their campus, especially with the lower grades. A desire for an outdoor working space which is furniture adequately was expressed multiple times within the interview which relates to the students' perceived productivity within the outdoor settings at MIU.

Figure 57 *The use of Chorisia Crispiflora as the main tree in this area with its dense crown provides a lot of shade over it.*

59% of the students responding with preferring indoor studios as their productive space over the outdoors, with the time spent indoor being a 98% over 4 hours and 61% of them being over 6 hours. Again, similar to ASU that put emphasis over how significant the environmental quality of the studios is to an architecture student and how of long

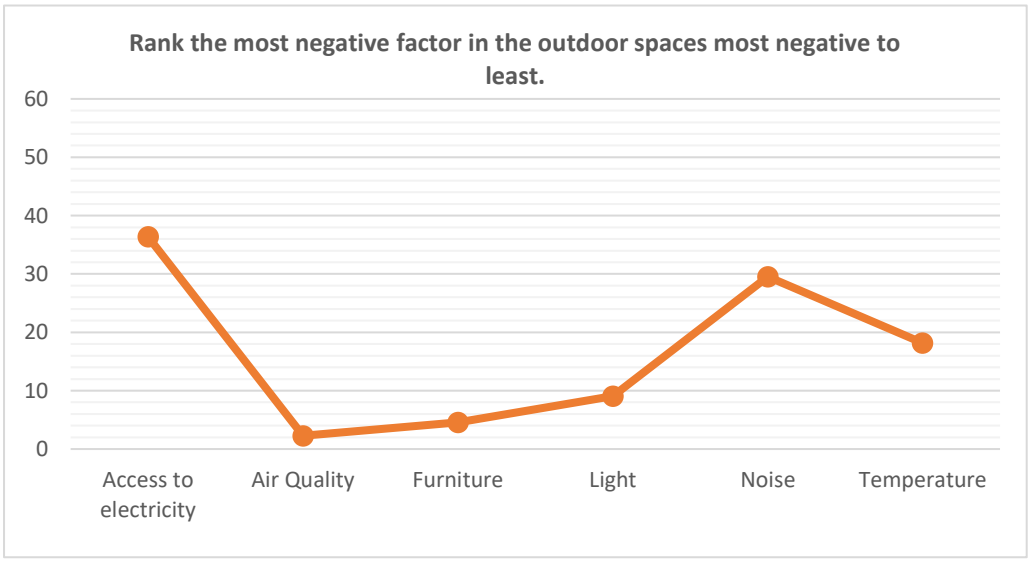


Figure 58 *MIU students' rating of issues with the outdoor environment hindering their productivity*

hours they spend during the studios for productive tasks. With that much time spent in working indoors, it is important for the environment to provide a comfortable, healthy, efficient, and effective space for the students to be productive

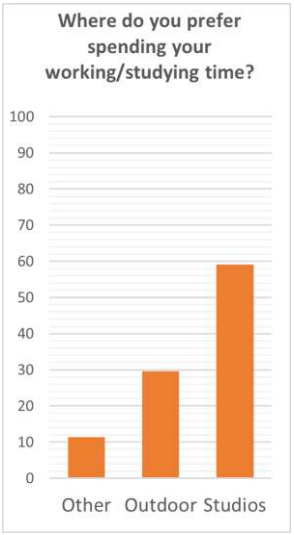


Figure 59 *Percentage of student's choosing their preferred working place in MIU*

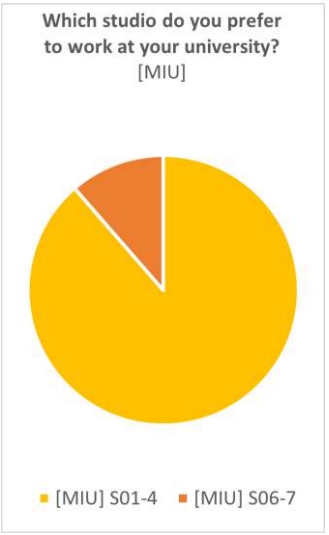


Figure 60 *Students' choice of their preferred indoor studio to work at MIU*

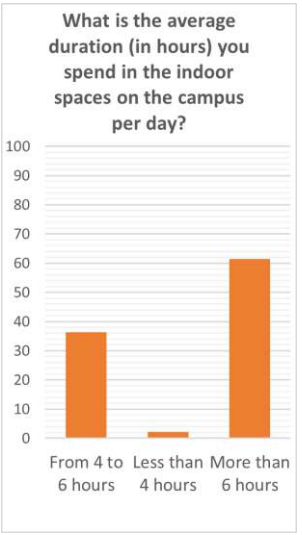


Figure 61 *Average time spent indoors according to MIU students' responses.*

When it came to student preference in regards of studios, the studios on the lower floor, S01-04 (figure 60) where found preferable by 89% of the students. Most of the reason the students presented during the interviews was Aesthetic comfort, Noise, Light and View. In case of the studios on the first floor, S01-04 is that they have access to a view of the landscape of campus (figure 62) which is unique for those studios and not for the ones above. Especially considering that some palms and trees are high enough to reach the first-floor windows but not the second.

Figure 62-a/b *View from S02 at MIU*

Overall satisfaction and rating of the indoor environmental qualities among the students at MIU is neutral. During the interviews they would express dissatisfaction with the built environment and the studios but end up with them not being that negatively affecting over their perceived productivity.

According to the students' perception the environment and its relation to their wellbeing and health. The majority deemed it little to no effective in regards of mental health (figure 64). While for physical health (figure 63) the opinion was slightly divided, as 73% saw it to have effect over it, yet the majority of that percentage claimed it to be only minor effect. In regards of productivity 75% of the students stated that it does have an impact over productivity. Nevertheless, similar to the case of ASU, the students didn't see that impact to be always positive in favor of their productivity. As mentioned in regards of their perception over the EQ of their working studios the majority claimed neutral when asked about satisfaction. Continuing on with reason behind it being convenience and efficiency due to the availability of space, but they didn't deem it healthy nor productive. For the students, the studios are the most convenient place to work due to it being free and available. However, during the interviews they would highlight how during long hours working sessions at the studios, they feel uncomfortable, having symptoms like headaches and muscle pain. That was visible during the observations of the students' behaviour which again proved

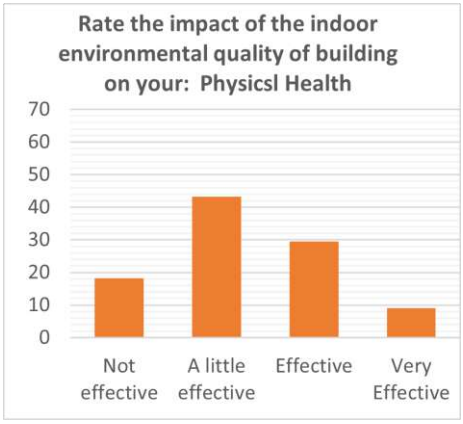


Figure 64 *MIU students' response to questionnaire question regarding physical health, in percentage.*

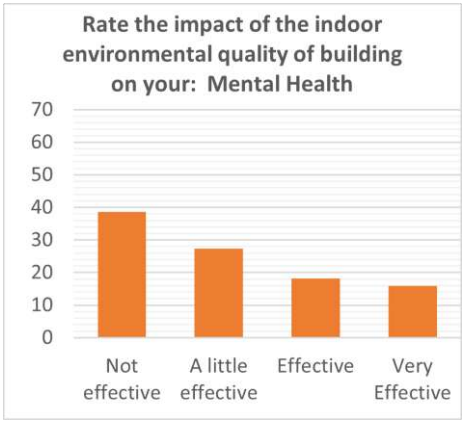


Figure 63 *MIU students' response to questionnaire question regarding mental health.*

similar to ASU, where students start showing mild SBS signs after long hours at the studios, especially lethargy, headaches, and lack of focus

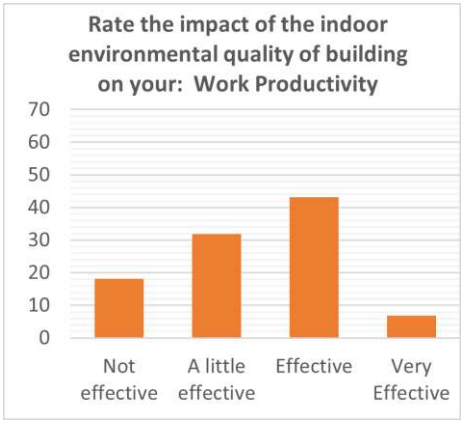


Figure 65 *MIU students' response to questionnaire question regarding work productivity, in percentage.*

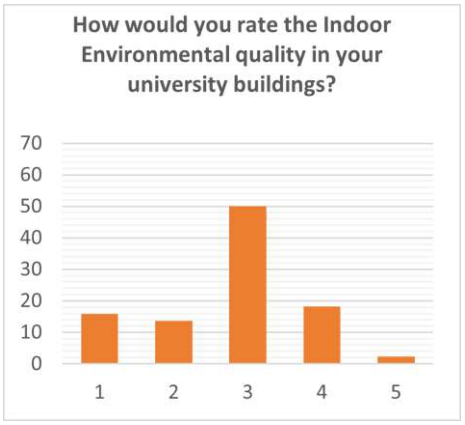


Figure 66 *MIU students' response to questionnaire question rating ASU Architecture building IEQ, in percentage.*

For specific EQ and in regards of how satisfied the students are regard them and their effect over PP; the students rated their satisfaction and perceived importance toward those EQ. In addition, they further elaborated on why they deem them satisfying or not and their relation to their productivity during the semi conductive interviews. Some of the EQ have been also studied through physical measurements as elaborated with the methodology.

From the first look over the satisfaction radar (figure 67) it is visible that there is somewhat overall neutrality in regards of the environmental qualities, which was the case with the other questions as well. This is somewhat in contrast with ASU where there was more clear satisfaction and unsatisfaction with different qualities.

Going in accordance with what the students at MIU ranked the most influential in regards of their PP (figure 68) and how they perceive it within their built environment (figure 67). The first quality being lighting which was also the case at ASU. However, looking at the students' satisfaction towards the studios lighting comes at polar opposite between artificial lighting and natural lighting.

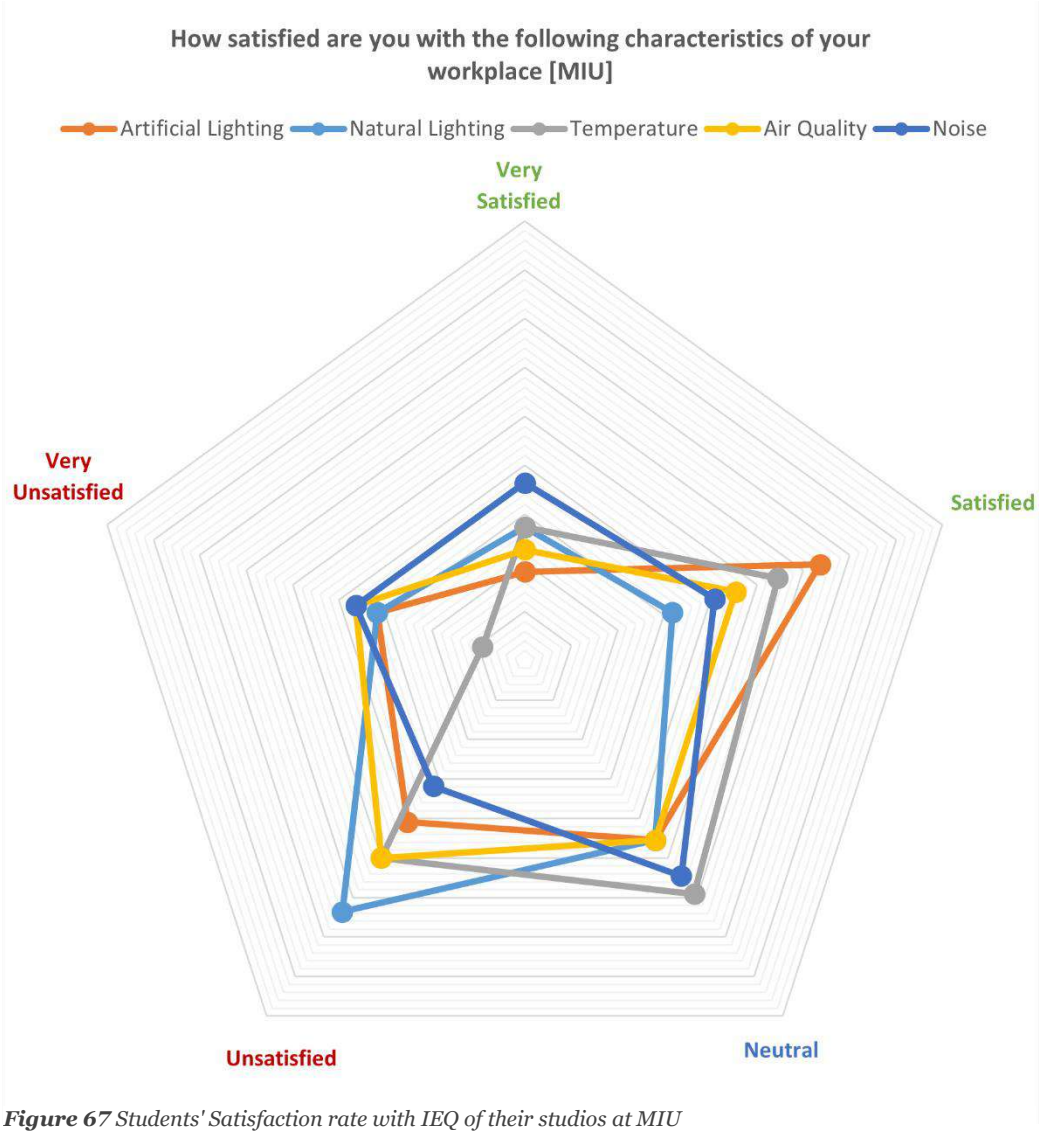


Figure 67 *Students' Satisfaction rate with IEQ of their studios at MIU*

For a profession such as architecture, the value of lighting should come as no surprise. For the students at MIU artificial lighting was the most satisfying EQ. Yet according to the measurements that is not the case for all studios, While S06-07 reach the minimum required illuminance of a working space which is 500 Lux, S01-04 are much less illuminated, maxing at 240 Lux under artificial light. Even by the window the illuminance goes up to 371Lux which is still below the minimum. However, the students prefer the lighting of S01-04 over S06-07, especially in term of light quality and light temperature. As in S06-07 the

dominance of the colour white reflects too much light which ends up being uncomfortable for the eyes. When interviewing the students, they stated that lighting can be a constant issue for them within the studios, especially with the quality of the light, emphasizing the use of florescent lighting as uncomfortable and glare inducing. On the other hand, natural lighting is the most unsatisfying quality based on the students rating and interview responses. Around 90% of the interviewee claimed preference towards natural lighting as a source of light especially in daytime. During the time the author spent the case study, sometimes students would choose to work with the no artificial lighting, and only using natural light as a source of illumination. Granted the studio would always be considered dark as with natural lighting the maximum all studios reach with illuminance was averaging 300 Lux and that is close to the windows, away from the windows can reach as low as 23 Lux, yet the students would rather work on the light coming from the windows if they can. This also explains why the window side is the most preferred side for the student especially with S01-04. Students highlighted on the quality of light when it came to artificial lighting to be a key issue in regards of how well they perceive the studios, especially in regards of how well it helps them with their PP. In regards of S06-07 many showed dissatisfaction with the light quality as the light

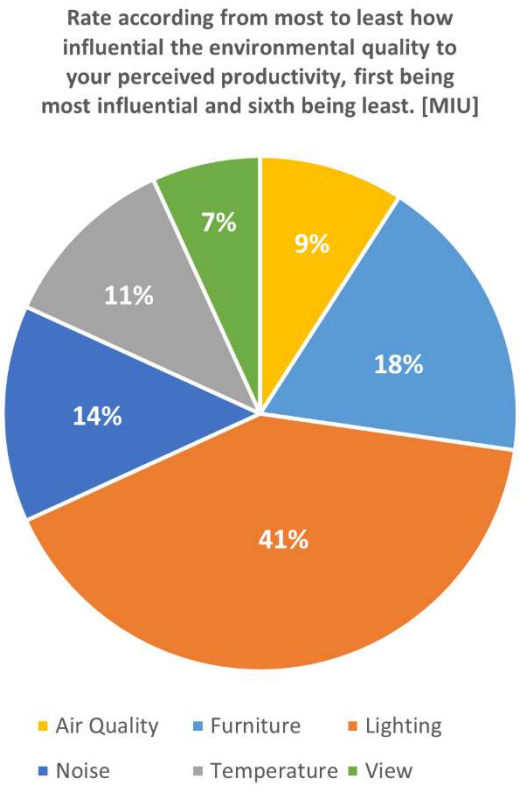


Figure 68 *Ranking of Environmental qualities and characteristics according to influence on productivity, according to MIU students' responses in the questionnaire*

temperature was too warm white leading to headache and eyes irritation, this was supported throughout the observation of the student behaviour in the studios.

As for noise, which was the second EQ influential towards PP and third overall. It saw equal percentage with very satisfied and very unsatisfied. Yet the majority leans towards satisfied and very satisfied with 38% followed by neutral 27%. During measurement the studios measured higher than the comfortable range of acoustic comfort, with both studios averaging the 65 dB, the source of noise being mainly the students and their chatter. While this plays a major role in distraction and loss of productive time, the students didn't see it much of an issue. Advanced technology and access to earphones solved such issue, yet similar to what was priorly discussed such solution is neither healthy not sustainable for the occupants PP.

Among the highest unsatisfying rates came Air quality, which was second most mentioned EQ among the interviews after lighting. Due to all of the studios using HVAC system for cooling, the air is often recycled through the HVAC ducts, with minimum air regeneration. As mentioned earlier as well, architecture students tend to use different tools and art supplies in the studios that contain volatile substance, which prolonged exposure to is considered unhealthy. This can easily cause respiratory, eyes or sinus irritation, all which falls under SBS. During observation of students' behaviour at MIU, a recurring action among students was that they would go outside of the studios for a change of air at the corridor. This sight was brought up multiple times during the interviews, which many of them happened in said corridors, for the students the corridor was considered an extension to the studio spaces. Nevertheless, it was a space for winding down and having a *"change of air"* or *"recharge"* instead of work. According to the students, the corridors had better EQ to them than the studios in regards of light and air, especially the ones on the first floor as they are opened to the outdoor.

This leads to view and greenery. Especially since at MIU the campus has lush collection of landscape areas that provide good view of greenery across the campus. As mentioned earlier, most of the students chose the studios on the lower floor as their preferred ones for work, one of the major reasons discussed by the students was having access to a view which is visible in figure 69-a/b. Another reason was the priorly discussed corridors as well. This was supported by the behavioural observation as the seats by the windows were always the ones preferred in S01-04, which are the ones with greenery view. For S06-07 the windows usually allow for too much sunlight which cause glare, neither do they have view of greenery, so the students don't sit by them much. Rather the seats by the door closer to the corridors are the ones usually preferred by the students at S06-07.

Figure 69-a/b *Students at the corridors in front of the studios at MIU*

As for temperature, it was the second quality to be regarded as very satisfying and satisfying by the students. Since the studios all run on HVAC as mentioned earlier, they have almost consistent controlled environment when it comes to cooling. The temperature at the studios usually ranges around the thermal comfort range, if not then they are barely over it by a degree or two. However, as we mentioned, due to regional climate students were observed to have slightly higher tolerance to warmer temperatures. When asked during the interviews nonetheless, barely any student showed dissatisfaction with temperature. The did agree to its significance in regard of productivity and being able to perform, yet it wasn't their highest-ranking influence.

Space

When experiencing the work environment in regards of its more intangible qualities such as encouraging and motivating productive tasks (figure 70), the students perceived the environment more hindering than supporting. Some of the reason behind it are more organizationally related, yet one of the reasons was lack of destressing qualities to the environment. While the students see the environment as convenient and adequate, it doesn't provide them with enough comfort to destress from the work stress that being an architecture student is already under. The challenge is even more evident when it comes to focus (figure 71), relating it to the monotonous design of the studios, providing a single setting for multiple activities, which adds on the stressors within the environment for them leading to loss of productivity.

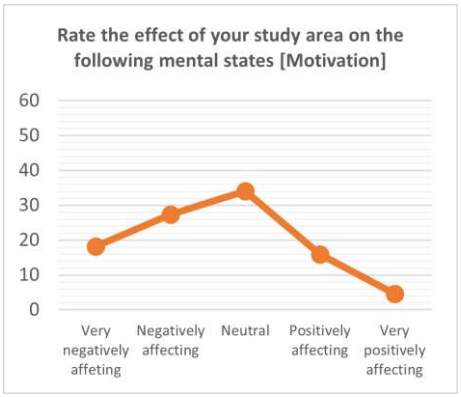


Figure 70 *MIU Questionnaire response in regards of environment effect on motivation*

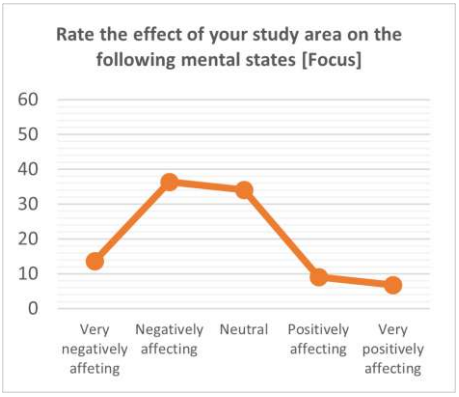


Figure 71 *MIU Questionnaire response in regards of environment effect on focus.*

For the ability to work solo (figure 72), a change towards the positive is present, as students mainly consider the environment to be positively affecting their PP. During the interviews the students mentioned it was easy taking a side of the studio and working on your task if you need to be on your own, it was yet again convenient, but being able to work solo didn't precisely mean they were focused.

Distraction and environmental stressors were once again mentioned as factors of lost time and productivity. However, in groups (figure 73) the opinion was divided between both sides. Absence of adequate furnishing that could

accommodate group activities was one of the major reasons mentioned when interviewing the students. On the other hand, students commended the available space of the studios to be efficient when needing to work as a group.

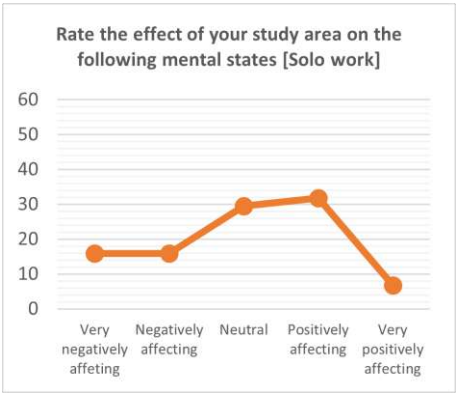


Figure 73 *MIU Questionnaire response in regards of environment effect on Solo work.*

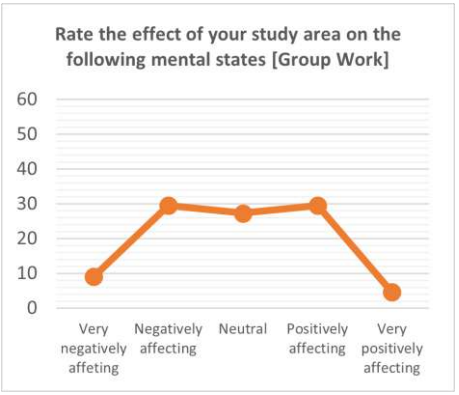


Figure 72 *MIU Questionnaire response in regards of environment effect on Group work.*

Ergonomics and Aesthetics

A comfortable and a tidy environment came of outmost influence on students PP (figure 74). Environmental comfort and physical comfort were frequently highlighted as key issues in the students' interviews. Furnishing and ergonomic comfort were precisely brought up on multiple occasions as a key element towards students' PP. Similar to students' responses in ASU, the ergonomics comfort related to furniture choices within the studios is found highly related to students PP.

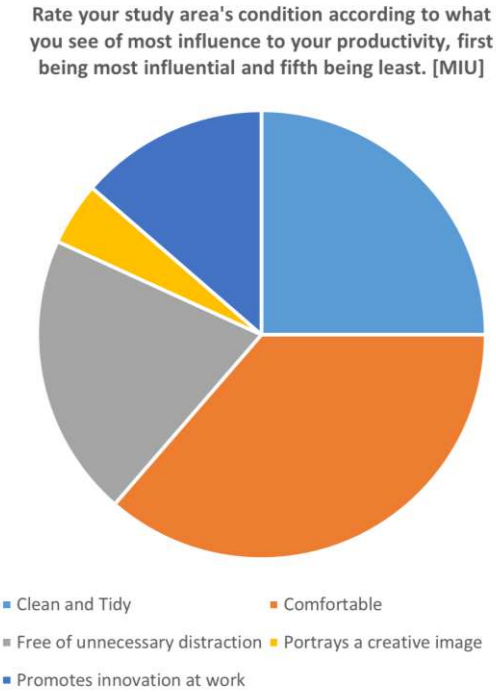


Figure 74 *MIU Ranking influential environmental conditions in relation to PP.*

As for aesthetics, as architecture students, the students are sensitive in regards of spatial perception of their surroundings. They related aesthetics satisfaction to their productivity and especially motivation. Similar to ASU, this satisfaction was related to used materials for cladding and colour choices for finishing. Lack of architecture showcasing even in the form of displaying students' projects saw dissatisfaction from the students as well, many describing the studios to be *"bland"* and *"boring"*.

6.2. Cross Case Study Comparative Analysis

The study of the two case studies showcased differences and similarities in regards of students perceived productivity. Students' awareness of their physical environment and understanding in regards of its effect on their perceived productivity was clear in both universities. Certain issues in regard of the built environment and the environmental qualities, showed clear effect over the students' behaviour within the space and their PP. That all tie up to found phenomenon that is discussed further in the next chapter.

Reflection and Glare

Studying the built environment of the two case studies found that when it came to lighting as an EQ, the quality of the light was the key issue. Lighting was not only a matter of illuminance. Overall light quality was the issue, illuminance plays a part, but also light temperature, glare, and light reflection of surfaces. For example, in ASU studio 504 as mentioned earlier, the overall temperature of the studio was warm white which, and the light fixtures emitted harsh lighting which resulted in glare on papers and harsh reflection of desktops. While in studio like S06 at MIU, all the white and light-coloured surfaces created a bright reflection effect especially with the florescent lighting that was harsh on the students' eyes. Such quality of lighting was the main issue of concern with students in regard of affecting their productivity.

Reverberation noise

Second issue was reverberation caused by the scale of the studios. This issue was mainly obvious in studio 504 at ASU, the scale of the studio and the use of industrial fans for cooling, created a never-ending noise of reverberations. This resulted in a noise above the comfort level especially for a work environment where students stayed for long hours.

Furniture

Even if there is a lack of comfort, comfort is always sought after by the students. The third issue was in regards of overall comfort and efficiency. Furniture was a major factor towards affecting students perceived productivity, add to it also efficient furniture. For architecture students, who work for long hours, being able to work while being physically comfortable was a need. That was a common regard in both case studies. When the furniture didn't deliver such comfort, the students started making their own solutions. In ASU, students would sit on the platform by the wall as it is efficient due to the proximity of electrical outlets, and they can rest their backs against the wall, as their chairs don't have a back rest. Similarly, at MIU students would often sit on the normal leather chairs whenever they get the chance, as they are more comfortable than the usual desk highchairs. Furniture also plays a major role in the students' ability to work in groups or focus and to focus. Not just furniture, but access to electricity is vital for them to be able to work on their laptops, multiple outlets make a difference in the studios' efficiency. Furniture and electricity issues are not only for the indoor, rather for the outdoors they play an even bigger factor in regards of students' ability to be productive.

Connection to Nature

Last issue is connected to the outdoors and the landscape around campus. Buildings' porosity in terms of openings and level of transparency between exterior walls and the outdoor of campus was found to be of importance to the students through the observation of their behaviours around the studios.

Especially at MIU, where the studios have a view of the landscape on campus as mentioned earlier, while in ASU many students expressed how the almost absence of windows would often demotivate them to work for long hours. Secondly, the use of landscape for shading for the outdoor spaces, not just shading devices, provided more environmental comfort when it came to temperature outdoor.

Throughout those similar and different issues, findings in regards of students' perceived productivity and its relation to the environment is evaluated and discussed. In the following chapter, a discussion over the conclusions of the literature and the study will be presented and delved onto. Building understanding in regards of specific phenomenon and relation between students and the physical environment.

7. Finding Discussion & Conclusion

Throughout the study, the literature in relation to the theory and practice of Architecture pedagogy and the notion of knowledge productivity was explored and elaborated. This responds to the first three research questions in regards of understanding the theory and the science. Followed by the case study of the architecture school ASU and MIU at Cairo, Egypt. The literature and the study both answered the fourth question in regards of the elements affecting the students' productivity. Highlighting how sensitive architecture students are to their surroundings. As their study and their profession is related to the built environment, the space, and the place, they experience the surrounding with more attention to details. Their perception of the environment is highly in tune with its quality and how it affects their wellbeing and comfort, this plays a key role in their satisfaction or lack of with the built environment. They experience the environment in terms of architecture, that includes function and design. Due to that high sensitivity to the built environment this created distinct phenomenon that relate to how they react in term of their perceived productivity. Along the study, a grasp of specific phenomena and the relationship between students and their physical surroundings is developed. Those phenomena revolve around productivity's relation with the environmental qualities, the space, the campus typology, and the campus setting. Formulating an answer to the fifth and last research question, the rest of this chapter will explore each phenomenon on their own to expand the discussion.

7.1. Productivity and Environmental Qualities

William James, a well-known psychologist, believed that consciousness was not a thing, but rather a mental activity requiring attention and short-term memory. From a brief awareness, the brain constructs a representation centred on the view, and visual inputs activate a greater degree of attention. An attempt is being made in the process of building a productive workplace to develop settings that will allow specific information to be quickly noticed and relayed by the human perceptual sensory system (Clements Croome, 2006). As expressed earlier, architecture students' perception of the environment is more sensitive than the

normal person as this is highly related to their profession and study. Consequently, they are aware of how the environmental quality can affect their overall wellbeing. They experience a space both on the holistic and atomistical level. Hence, it isn't just a matter of comfort that the environmental qualities provide to them, it is an impression in regards of how well the environment or in other term, a design, is for the function needed. During the interview and through the behaviour observation, it is shown how the students prefer working in the studios with their perceived better EQ, even if those EQ values are not up to international comfort standards. They start building their perceptive preferences, this relate to how productive they are in said preferred spaces over the other.

In addition, due to their understanding of how the EQ and the design of a space can help with elevating stress off the occupant, lack of such factors highly effects their perceived satisfaction. The literature supports the need of a learning environment to be safe, healthy, and effective, hence when the basic comfort is not delivered that affects the architecture student PP. They start focusing on the issues with the space they are in, rather than the task at hand. During the interview, it was highlighted by the students how the built environment can obstruct their creative energy which as result also hinders their productive abilities. As most university students, architecture student receive stress from the work nature of their study, when this stress is added on through extrinsic factors such as lack of comfort and inadequate work environment this relates to their loss of productivity. During the interviews this point was a recuring comment that the author received, as many students highlighted the negative effect the stress from their studies brings on their wellbeing and how they wish their workspace would not add more stressors.

In both case studies, it was evident how the students tend to lean towards preferred spaces to work at based on their perceived comfort. A general trend however was that spaces near sources of noise were left unsought, and spaces with natural lighting and cooler temperature were the most desired. In the case

of MIU, access to a view as well was proven to be an attraction factor in regards of students seating preferences. This relates to how perceived comfort is of high importance towards students PP which is supported by the students' responses to the questionnaire and the interviews. Air quality and ventilation has a big effect on students' condition within the studios, and that was observed throughout the students' behaviour. An architecture student would spend an average time of 5 hours in one studio, the lack of adequate air quality results in increase of fatigue and lethargy which results in wasted work time. All of this builds up on the students' discomfort and lack of wellbeing which hinders their productivity even more. A studio needs to be healthy and efficient to be effective to make way for an improvement in architecture students' PP.

7.2. Productivity and the Space

The architecture student not only sees the details, but the whole experience is also of value to them. In that regard they focus also on the function of the space and the changes present in term of uses and design. As discussed in the literature, aside from the pure physical aspects of the surroundings, the actions and natural occurrences that happen as a result of the occupants' working nature influence and may affect their productivity. In order to develop architectural spaces that fulfil the dynamic, competing, and complicated multiple social and physical requirements, the design discipline must respond to how people perceive, judge, and evaluate environments. This is required in order to design architectural spaces that satisfy the standards. All of those mentioned parameters are constant factors an architecture student is aware of, add to that the fact that a studio is not only a working place for them. The studio is the learning/working environment where students spend the majority of their time learning, networking with lecturers, and connecting with their peers. A studio is a room where students may participate in a range of activities ranging from learning, brainstorming, concept creating, designing, or model making, all of which can be done in groups or solo. Not to mention it isn't only a space where they work, it is also a place for socializing among their peers, since to them it is their own space.

Due to that, the range to which the studio accommodates those different activities with their different curated needs relates to the students PP. Providing different furniture and spacing for different functions can make a big difference in regards of the students perceived productivity. When interviewing the students, a studio with a massive area like 504 at ASU was found optimal for group work among students, because it can accommodate their needed space, while studios at MIU were not big enough for the students' needs. On the contrary, 504 at ASU is considered too big for solo work, although it is functional, the students' perception of it was that it lacked any sense of zoning that tends to make them feel lost in the place. When observing students' behaviour, it was found that the students look for areas of proximity to the wall, the corners, or the recess in the wall to work solo. As for MIU, the students found it easier performing solo tasks in the studios rather than in groups, where distraction played a role in the reason. For the smaller studios made the students more aware by the noise and movement going on when doing group works and related that to high distraction rate, which consequently affected their PP.

For such, lack of functional character within the studios could be a reason at lost productivity. Adding a sense of reason and directionality with what should be done and where, could help facilitating the task needed to be done and hence improve productivity. Simple factors such as furniture and electrical outlets define whether the student can work on their computer in the space for long time or not, which is a necessity for any student now. Such phenomena as the corridor priorly discussed at MIU, was a by-product of the students need to a difference in scene or space function. The corridors usually are found to be hosting the opposite activity students are doing in the studios, so if they are working in group, you would find those in need of solo time to be outside and vice versa. This is another sign of how perceptive and sensitive the students are to their surroundings in term of architecture perception, which is relating to their PP. Through developing the studios to fulfil the dynamic, competing, and

complicated multiple social and physical requirements, according to the students' perception, their productivity might improve.

7.3. Productivity and Campus typology

Another theme of changes found throughout the study was the result of having a faculty focused campus which is the case of ASU, in differ to a multi-faculties campus such as in the case of MIU.

In the case of ASU, faculty of engineering has a stand-alone campus which accommodate all of the departments including architecture. Hence, the architecture students on campus find similarities among their peers of the other facilities that build a homogenous sense of belonging. In addition, during their prep year, they are all together with no regard to the department they will be enrolled in, all of that builds a community among the students. Throughout the study the author finds that the sense of community plays a role in the students' familiarity and comfort towards the university and its facilities which would have a role on their PP. Moreover, having a faculty focused campus, provides more area to localized spaces and facilities that aid the students learning experience, all of which plays a role in the perceived value of the students' self-worth which plays into their motivation towards working and being productive.

On the other hand, MIU has a multi-faculty campus, which accommodates fields ranging from medicine, to business, to engineering which includes Architecture. The diversity of faculties provides a rich student life experience which in theory and in general would improve the student educational input, which could enhance their productivity, especially when enriching their creative energy. However, for the case of MIU with the faculty of architecture being one of the smallest faculties on campus and with a small faculty area, which consist of two floors that accommodate the studios and a lab, students could feel disregarded. When asked about organizational satisfaction during the questionnaire and the interviews with the students at MIU, many expressed that they feel marginalized and somehow alienated among their peers in the other faculties. Especially since

there is no other faculty that have similar time schedule of working lectures as architecture. Lack of facilities that could aid with an architecture student work was a cause of dissatisfaction among the students that they related to them not being able to work efficiently on campus.

In this sense finding a medium between both the cases seems to be the optimal case scenario. As it is important for an architecture student to be exposed to as much different people as they can, as it plays part in enriching their creativity. However, it is important for the student as well to feel a sense of belonging among their peers, especially with the long hours they spend on campus, providing them with their basic specialized needs could promote that sense of belonging and enhance their motivation towards being productive. Not to mention that being unable to perform the task needed due to lack of equipment's on campus directly relates to lost time.

7.4. Productivity and Campus setting

Last but not least, the relation between the indoor and the outdoor on campus, as well as the relation between them and the students, is found to possibly effect their productivity. At ASU, architecture department have their own building, which accommodate all the studios and labs, while at MIU the department studios accommodate two floors of the main building, as mentioned prior. As for landscape across the campus, both faculties have their diverse collection of luscious landscape, with MIU having a little more landscape dense outdoor spaces than ASU.

The MIU architecture studios overlook the campus landscape as mentioned earlier through the study, this created a tangible connection between the students and the campus landscape. Although they do not frequent upon the landscape as an outdoor working space, the main reason against it was the lack of adequate furniture for architecture work. However, many expressed their desire towards an outdoor working space with adequate furnishing. This relation is observed as well in the students' preferences towards windows seats, reasons being daylight,

followed by view next. Continuing on architecture students' sensitivity to the environment, this extends over towards the landscape around campus and its ease of access both visually and physically. Through the literature, it is discussed how many studies built a correlation between the presence of greenery and vegetation within the work environment and the increase of occupants' well-being, mental comfort, and productivity. Accordingly, through their influence on overall well-being and health, plants could have an effect over productivity.

In the case of ASU, the architecture department has their own building, although a bit far from the garden space on campus, the students still built connection towards the landscape on campus, which further highlight on greeneries significance towards productivity as mentioned by the literature. The outdoor spaces on campus, are usually fully occupied with students working on productive tasks, the majority of them however tend to be of younger grades due to the lack of electrical outlets that hinder any form of digital work outdoor. Nevertheless, the area the architecture building hosts, influence the students' attraction towards the indoor rather than the outdoors. The students' most preferred seats in the studios are the one closer to the entrances as it is closer to the gathering nodes within the building.

While students at MIU would gather around the corridors or at the outdoor spaces, the students at ASU gather around the stairs in the building and right outside it by the benches. This observation ties to the spatial need of intermediate spaces between the studios as areas of socializing and unwinding, to allow students to recharge and better perform. The nature of the space could be both an outdoor and an indoor space as it is interchangeable between students' preferences.

7.5. Conclusion of findings

Through this research and this study, the author found that in term of the effect of the built environment of architecture students perceived productivity is highly correlated. Major reason towards that, is the architecture students' high sensitivity towards their surroundings which comes as a by-product to the nature of their study and profession. The environment affects their general comfort and well-being which could affect their productivity, however their perception of said environment as well plays a role as well towards their PP. Daylight, noise, ergonomics and furnishing, temperature, and aesthetics are factors that play a role in effecting their productivity the highest accordingly. The students' sensitivity towards the environment plays a role in their relation to the surroundings as well in term of natural elements around them, like the landscape on campus, which affect their motivation and creativity which hence also relates to their perceived productivity.

7.6. Limitations

Throughout the research, the study faced some limitation, being:

- There was limitation in accordance with the time the students were present on campus with relation to the time of the study.
- Students' willingness to participate in the study with regards to the questionnaire or the interview.
- Access to some of the environmental measuring devices, like the CO2 air quality meter, was limited due to unavailability.
- Lastly there was a limited time for the research itself as the research was done on the span of five months, in accordance with IUSD MT schedule.

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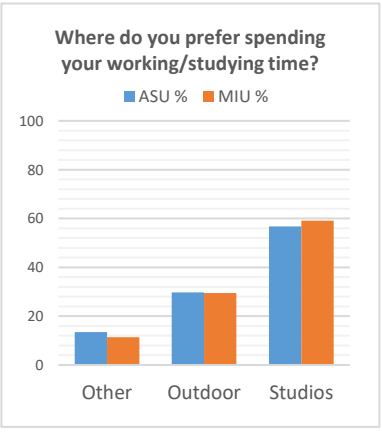
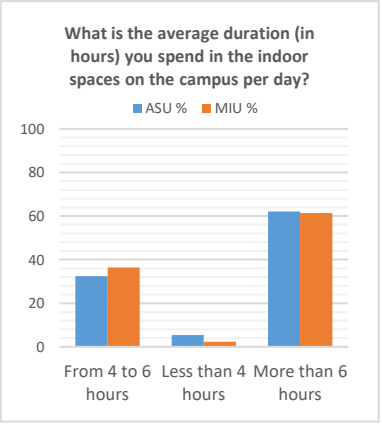
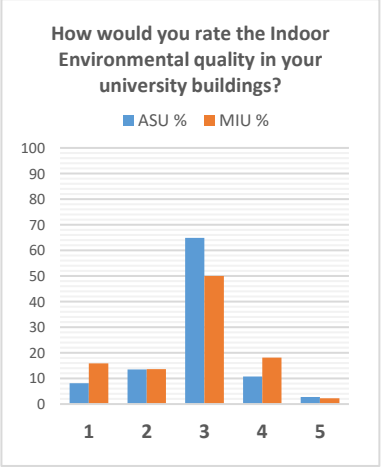
Appendices

Appendix A. Questionnaire Results







Q1. Current Academic Role

	Ain Shams University		MIU	
	Count	%	Count	%
Bachelor Student	25	67.6	21	47.7
Other	7	18.9	19	43.2
Post-Graduate Student	5	13.5	4	9.1

Q2. How familiar are you with the campus and its facilities?

	Ain Shams University		MIU	
	Count	%	Count	%
1 - 2 years	1	2.7	6	13.6
3 - 4 years	23	62.2	26	59.1
5 - 6 years	11	29.7	6	13.6
More than 6 years	2	5.4	6	13.6

Q3. Where do you prefer spending your working/studying time?

	Ain Shams University		MIU	
	Count	%	Count	%
Other	5	13.5	5	11.4
Outdoor	11	29.7	13	29.5
Studios	21	56.8	26	59.1

Q4. How frequently are you on campus, represented by days per week?

	Ain Shams University		MIU	
	Count	%	Count	%
Two days	10	27.0	0	0.0
Three days	20	54.1	2	4.5
Four days	6	16.2	29	65.9
Five days	1	2.7	13	29.5

Q5. What is the average duration (in hours) you spend on campus per day?

	Ain Shams University		MIU	
	Count	%	Count	%
From 4 to 6 hours	12	32.4	16	36.4
Less than 4 hours	2	5.4	1	2.3
More than 6 hours	23	62.2	27	61.4

Q6. What is the average duration (in hours) you spend in the indoor spaces on the campus per day?

	Ain Shams University		MIU	
	Count	%	Count	%
From 4 to 6 hours	19	51.4	32	72.7
Less than 4 hours	4	10.8	3	6.8
More than 6 hours	14	37.8	9	20.5

Q7. Which studio do you prefer to work at your university?

	Ain Shams University		MIU	
	Count	%	Count	%
[ASU] 500-B/C	25	67.6	N/A	N/A
[ASU] 504	12	32.4	N/A	N/A
[MIU] S01-4	N/A	N/A	39	88.6
[MIU] S06-7	N/A	N/A	5	11.4

Q8. How would you rate the Indoor Environmental quality in your university buildings?

	Ain Shams University		MIU	
	Count	%	Count	%
1	3	8.1	7	15.9
2	5	13.5	6	13.6
3	24	64.9	22	50.0
4	4	10.8	8	18.2
5	1	2.7	1	2.3

Q9. Rate the negative impact of the indoor environmental quality of the building on your: *Work Productivity*

	Ain Shams University		MIU	
	Count	%	Count	%
Not effective	4	10.8	8	18.2
A little effective	17	45.9	14	31.8
Effective	13	35.1	19	43.2
Very Effective	3	8.1	3	6.8

Q9. Rate the negative impact of the indoor environmental quality of the building on your: *Physical Health*

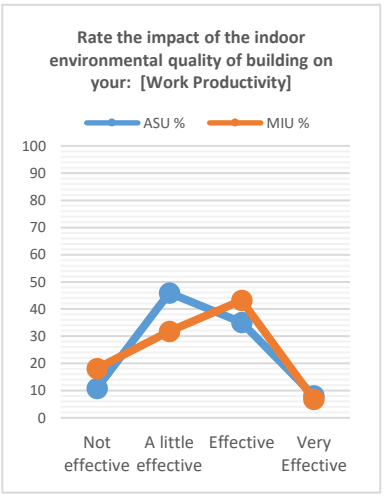
	Ain Shams University		MIU	
	Count	%	Count	%
Not effective	10	27.0	8	18.2
A little effective	13	35.1	19	43.2
Effective	12	32.4	13	29.5
Very Effective	2	5.4	4	9.1

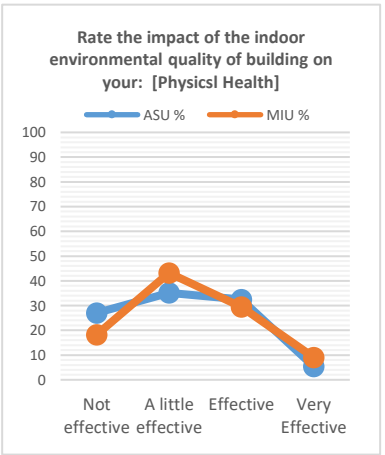
Q9. Rate the negative impact of the indoor environmental quality of the building on your: *Mental Health*

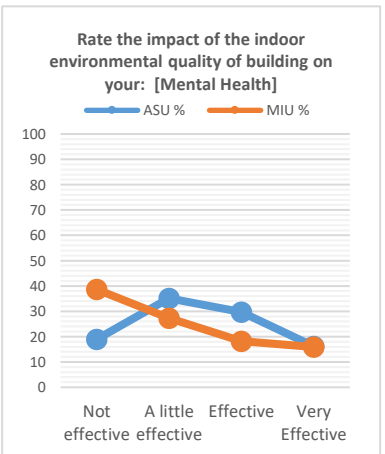
	Ain Shams University		MIU	
	Count	%	Count	%
Not effective	7	18.9	17	38.6
A little effective	13	35.1	12	27.3
Effective	11	29.7	8	18.2
Very Effective	6	16.2	7	15.9

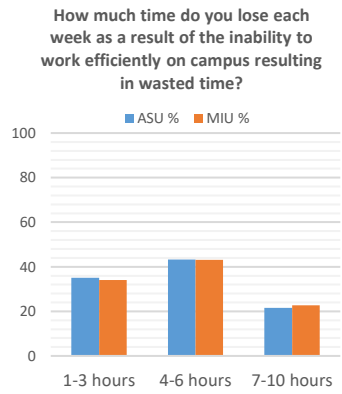
Q10. How many days in the last month have you come to university despite not feeling well?

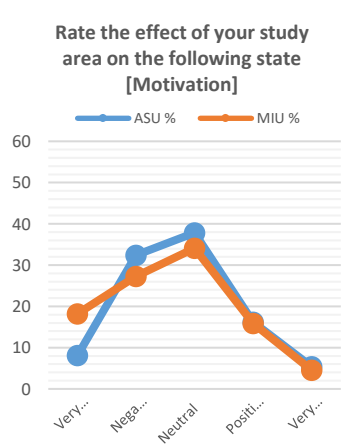
	Ain Shams University		MIU	
	Count	%	Count	%
1-3 days	10	27.0	6	13.6
4-6 days	13	35.1	13	29.5
7-10 days	14	37.8	25	56.8

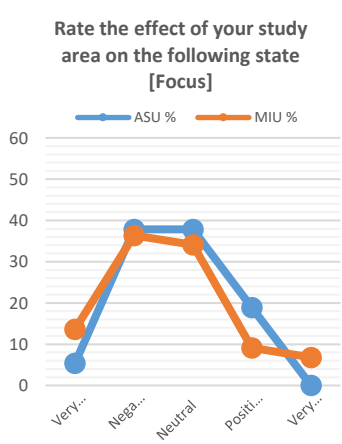












Q11. How much time do you lose each week as a result of the inability to work efficiently on campus resulting in wasted time?

	Ain Shams University		MIU	
	Count	%	Count	%
1-3 hours	13	35.13	15	34.09
4-6 hours	16	43.24	19	43.18
7-10 hours	8	21.62	10	22.72

Q12. Do you agree with this statement "I find it easy to work with my colleges in the studios in campus"

	Ain Shams University		MIU	
	Count	%	Count	%
Strongly disagree	2	5.41	6	13.64
Disagree	7	18.92	10	22.73
Neutral	15	40.54	22	50.00
Agree	11	29.73	6	13.64
Strongly agree	2	5.41	0	0.00

Q13. Do you agree with this statement "I am able to focus and concentrate when needed in the studios on campus"

	Ain Shams University		MIU	
	Count	%	Count	%
Strongly disagree	1	2.70	2	4.55
Disagree	12	32.43	12	27.27
Neutral	16	43.24	23	52.27
Agree	8	21.62	7	15.91
Strongly agree	0	0.00	0	0.00

Q14. Rate the effect of your study area on the following; *Motivation*

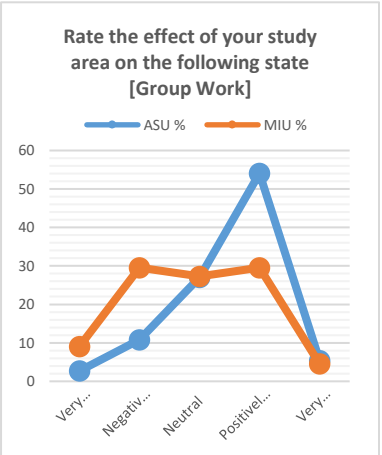
	Ain Shams University		MIU	
	Count	%	Count	%
Very negatively affeting	3	8.11	8	18.18
Negatively affecting	12	32.43	12	27.27
Neutral	14	37.84	15	34.09
Positively affecting	6	16.22	7	15.91
Very positively affecting	2	5.41	2	4.55

Q14. Rate the effect of your study area on the following; *Focus and Concentration*

	Ain Shams University		MIU	
	Count	%	Count	%
Very negatively affeting	2	5.41	6	13.64
Negatively affecting	14	37.84	16	36.36
Neutral	14	37.84	15	34.09
Positively affecting	7	18.92	4	9.09
Very positively affecting	0	0.00	3	6.82

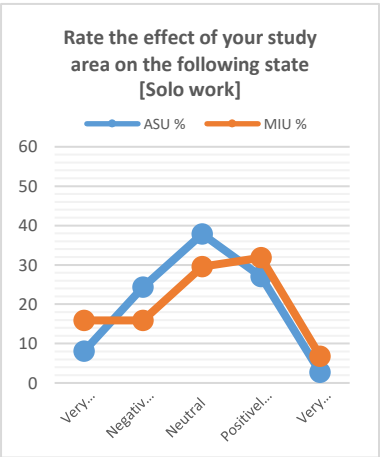
Q14. Rate the effect of your study area on the following; *Group Work*

	Ain Shams University		MIU	
	Count	%	Count	%
Very negatively affeting	1	2.70	4	9.09
Negatively affecting	4	10.81	13	29.55
Neutral	10	27.03	12	27.27
Positively affecting	20	54.05	13	29.55
Very positively affecting	2	5.41	2	4.55



Q14. Rate the effect of your study area on the following; *Solo Work*

	Ain Shams University		MIU	
	Count	%	Count	%
Very negatively affeting	3	8.11	7	15.91
Negatively affecting	9	24.32	7	15.91
Neutral	14	37.84	13	29.55
Positively affecting	10	27.03	14	31.82
Very positively affecting	1	2.70	3	6.82



Q15. Rate your study area's condition according to what you see of most influence on your productivity, first being most influential and fifth being least.

	Ain Shams University		MIU	
	Count	%	Count	%
Clean and Tidy	7	18.92	11	25.00
Comfortable	15	40.54	16	36.36
Free of unnecessary distraction	12	32.43	9	20.45
Portrays a creative image	0	0.00	2	4.55
Promotes innovation at work	3	8.11	6	13.64

Q16. How satisfied are you with the following characteristics of your workplace; *Artificial lighting*

	Ain Shams University		MIU	
	Count	%	Count	%
Very satisfied	4	10.81	4	9.09
Satisfied	14	37.84	14	31.82
Neutral	11	29.73	10	22.73
Unsatisfied	4	10.81	9	20.45
Very Unsatisfied	4	10.81	7	15.91

Q16. How satisfied are you with the following characteristics of your workplace; *Natural lighting*

	Ain Shams University		MIU	
	Count	%	Count	%
Very satisfied	3	8.11	6	13.64
Satisfied	12	32.43	7	15.91
Neutral	5	13.51	10	22.73
Unsatisfied	10	27.03	14	31.82
Very Unsatisfied	7	18.92	7	15.91

Q16. How satisfied are you with the following characteristics of your workplace; *Temperature*

	Ain Shams University		MIU	
	Count	%	Count	%
Very satisfied	2	5.41	6	13.64
Satisfied	11	29.73	12	27.27
Neutral	9	24.32	13	29.55
Unsatisfied	13	35.14	11	25.00
Very Unsatisfied	2	5.41	2	4.55

Q16. How satisfied are you with the following characteristics of your workplace; *Air Quality*

	Ain Shams University		MIU	
	Count	%	Count	%
Very satisfied	2	5.41	5	11.36
Satisfied	6	16.22	10	22.73
Neutral	15	40.54	10	22.73
Unsatisfied	10	27.03	11	25.00
Very Unsatisfied	4	10.81	8	18.18

Q16. How satisfied are you with the following characteristics of your workplace; *Noise*

	Ain Shams University		MIU	
	Count	%	Count	%
Very satisfied	2	5.41	8	18.18
Satisfied	6	16.22	9	20.45
Neutral	11	29.73	12	27.27
Unsatisfied	10	27.03	7	15.91
Very Unsatisfied	8	21.62	8	18.18

Q17. Rate according from most to least how influential the environmental quality is to your perceived productivity, with first being most influential and sixth being least.

	Ain Shams University		MIU	
	Count	%	Count	%
Air Quality	8	21.62	4	9.09
Furniture	2	5.41	8	18.18
Lighting	13	35.14	18	40.91
Noise	4	10.81	6	13.64
Temperature	7	18.92	5	11.36

Q18. How would you rate the Outdoor Environmental quality in your university buildings?

	Ain Shams University		MIU	
	Count	%	Count	%
1	3	8.11	1	2.27
2	7	18.92	8	18.18
3	6	16.22	12	27.27
4	13	35.14	18	40.91
5	8	21.62	5	11.36

Q19. Do you use the outdoor spaces on campus to work?

	Ain Shams University		MIU	
	Count	%	Count	%
No	20	54.05	24	54.55
Yes	17	45.95	20	45.45

Q20. Rank the most negative factor in the outdoor spaces from most negative to least

	Ain Shams University		MIU	
	Count	%	Count	%
Access to electricity	15	40.54	16	36.36
Air Quality	1	2.70	1	2.27
Furniture	7	18.92	2	4.55
Light	2	5.41	4	9.09
Noise	7	18.92	13	29.55
Temperature	5	13.51	8	18.18

Q21. Do you agree with this statement "My university sees my wellbeing as a priority"

	Ain Shams University		MIU	
	Count	%	Count	%
Strongly agree	1	2.70	1	2.27
Agree	0	0.00	0	0.00
Neutral	12	32.43	13	29.55
Disagree	10	27.03	12	27.27
Strongly disagree	14	37.84	18	40.91

Q21. Do you agree with this statement "My university supports my physical wellbeing"

	Ain Shams University		MIU	
	Count	%	Count	%
Strongly agree	0	0.00	1	2.27
Agree	1	2.70	3	6.82
Neutral	12	32.43	7	15.91
Disagree	7	18.92	14	31.82
Strongly disagree	17	45.95	19	43.18

Q21. Do you agree with this statement "My university supports my mental/emotional wellbeing"

	Ain Shams University		MIU	
	Count	%	Count	%
Strongly agree	0	0.00	1	2.27
Agree	4	10.81	1	2.27
Neutral	6	16.22	5	11.36
Disagree	8	21.62	10	22.73
Strongly disagree	19	51.35	27	61.36

Appendix B. Interviews data

Collected data from the interview, in form of questions and major keywords responses.

Ain Shams University, Number of interviewees 34

Q/A	(n)
Q. How do you feel when working on campus?	
Productive	6
Stressed and Tired	24
Unfocused	12
Q. How satisfied are they with the environmental qualities?	
Satisfied	9
Not Satisfied	25
Q. What is the major issues you find in the built environment?	
Temperature	27
Lighting	29
Noise	23
Furniture and physical comfort	32
Furniture efficiency for work needed	24
Stressful atmosphere	18
Air quality	16
Aesthetics (Colour)	8
Windows and opening (building porosity)	13
Electrical outlets and Wi-Fi	19
Q. What would you change / improve within your work environment to support being productive?	
Improve furniture	33
Change and improve Lighting	25
Change studios zoning	21
Increase opening and windows	16
Improve outdoor space design to fit architecture students' needs	20
Improve technological facilities	23
Improve or add HVAC system	29
Add greenery to the studios or building	11
Improve acoustics and decrease noise	16

Misr International University, Number of interviewees 37

Q/A	(n)
Q. How do you feel when working on campus?	
Productive	10
Stressed and Tired	27
Unfocused	24
Q. How satisfied are they with the environmental qualities?	
Satisfied	10
Not Satisfied	27
Q. What is the major issues you find in the built environment?	
Temperature	17
Lighting	26
Noise	20
Furniture and physical comfort	30
Furniture efficiency for work needed	33
Stressful atmosphere	27
Air quality	16
Aesthetics (Colour)	15
Windows and opening (building porosity)	6
Electrical outlets and Wi-Fi	30
Q. What would you change / improve within your work environment to support being productive?	
Improve furniture	37
Change and improve Lighting	26
Change studios zoning	33
Improve outdoor space design to fit architecture students' needs	30
Improve technological facilities	28
Improve or add HVAC system	8
Add greenery to the studios or building	3
Improve acoustics and decrease noise	19

ملخص:

في عصر اقتصاد المعرفة ، تزداد الحاجة إلى إنتاجية المعرفة ، حيث يجب على المرء الجمع بين المعلومات والمعرفة وتفسيرها لإيجاد حلول إبداعية للمشاكل الجديدة التي يواجهونها في حياتهم اليومية. المهندسين المعماريين أيضًا ، كمهنة تعتمد بشكل كبير على الإبداع ، من الضروري إيجاد توازن بين الطاقة الإبداعية والإنتاجية ، بدءًا من أيام دراستهم الجامعية. على الرغم من وجود ترتيبات مختلفة ومساحات إنتاجية مصممة ، يواجه الطلاب كفاح عامل المعرفة من أجل أن يكونوا منتجين. يهدف هذا البحث إلى فهم وتقصي إنتاجية طلبة العمارة وعلاقتها بالبيئة البنائية. فهم كيف يمكن أن تؤثر العوامل المختلفة للبيئة البنائية على الإنتاجية ، ولأي غرض هو حجم هذا التأثير. التركيز على رضا المستخدمين عن البيئة البنائية وإنتاجيتهم المتصورة بالإضافة إلى قياسات الجودة البيئية الموضوعية.

يركز البحث على المساحات الإنتاجية في كليات الهندسة المعمارية ، من دراستي حالة من جامعة عين شمس وجامعة مصر الدولية في القاهرة ، مصر. استخدام منهج مختلط في دراسة الارتباط بين البيئة البنائية والإنتاجية المدركة.

تكشف الدراسة عن بعض الظواهر والقضايا التي قد تؤثر على الإنتاجية المتصورة لطلاب الهندسة المعمارية. ترتبط هذه العوامل الملموسة وغير الملموسة بالبيئة البنائية لمكان عملهم وتصور الطلاب للبيئة المذكورة. من خلال هذه النتائج ، قد يساعد إجراء مزيد من البحث نحو النظر المحسن في تحسين إنتاجية الطلاب.

في حين كانت هناك جهود متعددة في البحث عن إنتاجية المعرفة ، لا تزال هناك فجوة في الأدبيات المتعلقة بالمهن المتخصصة المركزة بالإضافة إلى تحليل الحالات المتقاطعة. يركز هذا البحث على طلاب الهندسة المعمارية في القاهرة كدراسة حالة محددة.

الكلمات الرئيسة:

العمارة، الهندسة المعمارية، مدرسة الهندسة المعمارية، السلوك البيئي، علم النفس البيئي، البيئة البنائية، الإنتاجية المدركة، الإنتاجية المعرفية، جودة البيئة، القاهرة.

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام. إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في في مكانه في مختلف أجزاء الرسالة.. الإشارة إلى المواد المؤخوذه من المراجع العلمية كل في مكانه في مختلف أجزاء الرسالة

وهذا إقرار مني بذلك...

التوقيع:

الباحث: شيري ا. اسكروس

التاريخ:

دراسة البيئة البنائية وإنتاجية الطلاب في جامعات العمارة.

دراسة حالة مقارنة لبعض مدارس العمارة في القاهرة

رسالة مقدمة للحصول على درجة ماجستير العلوم الهندسية في العمران المتكامل و التصميم المستدام.

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