

# A Methodological Framework for Enhancing the Modern Office Spaces and Solving their Problems

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## Abstract

The modern offices has major setbacks that can affect the space's design, function and it's users comfort and production levels that's why this study assumes a framework that can be applied in the early design stages, aims to create a better office spaces and provides a solution for their major problems. This Framework starts by explaining the assumed Design Methodology with its different patterns and levels, illustrating the suitable Interactive Systems and Techniques then analyzing some case studies that stands up for this methodology and ends up by explaining the effect of using this methodology on reshaping the modern office spaces and in solving the previously stated problems.

**Keywords** Design Methodology, Semi-Closed office design, Non-Territorial Work Environment, Interactive Methodology, Internet of Things (IoT), Interactive Furniture.

## 1. Introduction

The office spaces are one of the main elements that construct the identity of their cities and provides a clear indication on the existing employment patterns, the concept of those spaces are very complex as they contains a lot of aspects that needs to be sorted out through their early stages such as the large number of users, must fulfill their different needs, each tenant occupies their spaces in a slightly different way and many more which can severely affect those space's efficiency, functionality, performance and even their user's satisfaction and productivity levels.

Which brings us to the fact that the process of enhancing such spaces can be a very complicated process that needs to take into consideration how to improve all the aspects of the office spaces together without neglecting any of them to avoid creating some severe problems as those presented in the modern office spaces. Those problems were formulated as the designers tried to enhance those aspects separately and forgot the fact that the office spaces are a large environment that contains some user's and features that needs to be integrated together in order to fulfill their targeted aims, some of those trials are:

•**Taylorism and The Rise of the Open-Plan Office:** which grew in popularity throughout the early 20th Century and followed the principles of **Taylorism** that tended

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to maximize the efficiency by utilizing a rigid office layout with an endless rows of desks for the employees with managers located in encircling offices where they could observe. But its major problems were neglecting the human and social elements and focused on ensuring employers gained maximum productivity from their staff.

• **The Cubicle Farm:** This concept relied on using tall and cheap modular walls that separates each/some of the employees from each other to create a semi-private area in order to increase the employee's focus and productivity but it turned out to be one of the most depressing (if not, the most) designs since the concept of the office spaces emerged as it focused on the profitability at the expense of the working condition.

• **The Modern Workplace:** The designers tended to change the fabric of the known office spaces by using open office spaces that tends to foster large number of employees with only small partitions that separate them from each other to increase the communication levels between them while providing a sense of isolation. Which created a noisy workspace where the employees will not be able to focus or handle a private task which can be devastating for them.

• **The Integrating of Technologies:** as the designers tended to implement the technologies inside the fabric of the office spaces without any limits which created a lot of distractions, consumed a lot of working time, decreased the social interactions between the employees and so on.

So in this research we seek to find a methodology that can enhance those office spaces by trying to provide a solution for their current problems, provide a suitable work environment for its employees and can integrate the suitable technologies that can aid in increasing both the performance and productivity levels of the spaces and the employees. This methodology is based on using the different design strategies and the suitable interactive methodologies that can improve those office spaces, tries to solve the majority of their problems and connects the users with their workplaces.

### **1.1 Research Problem**

As been said before, the majority of the modern office spaces had a lot of problems that are related to both the space's design and the implemented technological interventions which failed (if existed) at providing the convenient work environment for its employees and at aiding them while handling their tasks which had an effect on the space's performance, its user's productivity levels as well as their health and well-being.

### **1.2 Research Aims**

This research aims at investigating the office spaces problems and assumes a framework that deals with full filling the following objectives:

- Define the current office spaces problems and their effect on both the space's design and the user's comfort and productivity levels.
- Determine the needed modifications on the existing office spaces design (based on the previously stated problems) using the different design patterns to provide the suitable spaces for the user's to perform the desired activities.
- Provide the technological solutions that are suitable to be implemented alongside the purposed design patterns, the activities performed inside those spaces and can aid the users while handling their tasks so those offices can keep up with the current and the future technological developments.

- Analyze the impact of using the purposed strategies on solving the stated problems, reshaping the fabric of the existing office spaces and on improving those spaces to become more functional and comfortable to their users.

### 1.3 Research Methodology

For achieving the purpose of this work, the research will rely on the Qualitative research methodology as it is can be used to:

- Understand the user’s experiences, attitudes, behavior and interactions inside the work environment and study the effect of such context on those user’s behavior.
- Study the subjects that are relatively new or when there is no sufficient data presented about this subject which is the case of this research.

This Qualitative methodology follows a certain strategy in order to achieve its targeted aims, this strategy starts with:

- Discussing the various opinions, point of views and experiences of the different office space’s users to state the problems that faced them while using such spaces.
- Analyzing the current situation of the modern office spaces and their problems as an attempt towards understanding the overall picture for those spaces.
- Understanding the previous information related to the subject of this research in order to develop the current theories about how to enhance the modern office spaces.
- Analyzing some case studies for various existing office spaces as a tool to gather the needed information on how to utilize the purposed design strategy and the various technological interventions inside the fabric of the office spaces.
- And it ends up by evaluating the gathered data in order to formulate a framework (based on the researcher’s point of view) that can enhance the modern office spaces, solve the majority of the presented problems and provide some technological solutions that aids in creating a more developed office spaces.

## 2. Terms and Definitions

In this part we will explain some important terms that are related to the office spaces in general and are essential to understand the purposed framework, those terms can be classified into two main group, the first group defines the terms related to the office spaces design while the other one deals with definition associated with the interactive process, and we will start with:

**Table 1, the definitions related to the purposed methodology:**

Cat.	Term	Definition
Design Related Definitions	<b>The Design Process [1].</b>	It is a process that focus on meeting the requirements of the clients or users to create a more developed and what can be called a “living office space”.
	<b>Semi-Closed Office Space [2].</b>	Which is an intermediate design techniques that lies between the open and closed office spaces and has the advantages of both them.
	<b>Non-Territorial Work Environment [3].</b>	Which refers to a more flexible way of working where the workplaces are no longer permanently assigned to a certain employee but are used frequently upon demand.
	<b>Lack of Culture [4].</b>	Which is a term used to describe the workplace that doesn’t foster a positive working environment or encourage a sense of community between its users.
	<b>Reflection Spaces [4].</b>	Those are spaces that can be used to take time away from the busy office or perform the tasks that needs concentration.

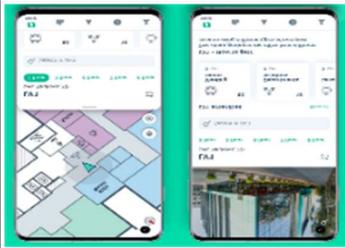
<b>Interactive Related Definitions</b>	<b>Interactive Office Spaces [5].</b>	Those are spaces that are integrated with the required technologies to be able to interact with its users, transforms the ordinary spaces to become more developed and meet the evolving user needs.
	<b>Interactive Systems [5].</b>	Those systems deals with how to integrate the different technologies and devices inside the space’s context as well as how to connect them together to allow the users to interact with their environment.
	<b>Interactive Features and Tools [6].</b>	Which is the technological tools and implementations that are used to increase engagement and interactions with the target users by getting them to click, tap, type make a gesture or take any other action

### 3. Analyzing The Current Situation

As being stated before, it is very important to start this framework by analyzing the current situation of the existing office spaces and their problems in order to provide the suitable solutions that can contribute in the process of enhancing those office spaces. And to do this, it is very important to investigate both the previous attributes concerned with this field and the user’s experiences while using such spaces and by doing so we concluded that most of those problems mainly affected both the Space’s Design as well as the User’s Comfort and Well-Being, those problems can be described as following:

**Table 2 Problems of the Office Spaces and their Description**

Cat.	Problem	Description	Example
<b>The Space Design Problems</b>	<b>Poor Space Utilization</b>	This problem occurred because of creating office spaces that are not suitable for its users, have no space variety and doesn’t have a planned extension spaces. So the space becomes too small and overcrowded which will affects the user’s productivity. [4]	 <p style="text-align: center;">Fig.1,some small offices [4].</p>
	<b>Lack of Quiet areas and Reflection spaces</b>	The office doesn’t provide some Reflection spaces or the ability of having a time away from the busy and noisy offices to do some work or having a break which affects the user’s well-being. [4]	 <p style="text-align: center;">Fig.2, Example on a Reflection Space [4].</p>
	<b>Lack of Community and Workspace Culture</b>	Most of the existing office spaces often feels flat, doesn’t inspire, they were designed to be practical and not to be creative or interactive which means it lacks the presence of culture and the formation of its own small community. [4]	 <p style="text-align: center;">Fig.3, Example on some community areas [4].</p>
	<b>Not Enough Workspaces</b>	In order to save space and reduce the furnishing costs, most of the existing offices neglect the importance of providing each employee with their own desk which can create overcrowding and a lack of personal space. [4]	 <p style="text-align: center;">Fig.4, The lack of assigned desks in an office space [4].</p>

The Space Design Problems	<p><b>Difficulty in Space Navigation</b></p>	<p>Especially for the new staff and visitors, when the office layout is complicated, unclear to navigate or contains no signage, it will take time to find the destination rather than getting the job done. [7]</p>		<p>Fig.5, example on how to navigate through the office using a Mobile App [8].</p>
	<p><b>Trouble Finding Colleagues</b></p>	<p>As the user can take time finding their colleagues or team especially in the hot desk or remote working techniques. [7]</p>		
	<p><b>Trouble in Space Booking</b></p>	<p>Which happens due to the absence of a clear strategy or system that can be used to book a space, so some employees have to improvise and handle a meeting in a space that's unsuitable for this function which can affect the company's image. [7]</p>		<p>Fig.6, example on how to use the app in space booking [9].</p>
	<p><b>Integrating The Latest Technologies</b></p>	<p>Most of the existing office spaces doesn't have the suitable infrastructure to integrate the recent technologies and some may not even have the needed space for such technology [10].</p>		
The User Comfort and well-Being	<p><b>Noisy Open Spaces and Distractions</b></p>	<p>The open offices are noisy by nature which can create a negative impact as not everyone can work in such distractions, noise and lack of privacy. [4]</p>		<p>Fig.7, An example for the open office spaces. [4]</p>
	<p><b>Poor Indoor Environmental Quality</b></p>	<p>Studies have shown that poor indoor environmental conditions have a huge effect on the employee's productivity levels which can be improved by 4-10% when being improved. [11]</p>		
	<p><b>Lack of Privacy</b></p>	<p>The open office spaces has a major setback when dealing with tasks that are confidential, needs concentration or privacy as the surrounding colleagues can listen to the phone calls, meeting or the conversations between the team. [12]</p>		<p>Fig.8, the Lack of privacy in some office spaces[13].</p>
	<p><b>Low Productivity Levels</b></p>	<p>Surveys showed that the productivity levels of the employees can be affected mainly by the crowded work places, the job dissatisfaction and their physical environment, that's why it is important to provide the suitable environment that aids them in becoming more creative, encourage them to interact with each other and become more productive. [11]</p>		

#### 4. The Purposed Framework

After mentioning the setbacks of the existing office spaces (based on the relative studies) it's time to formulate the framework that shall provide a solution for those problems and helps in creating a more convenient office spaces for its users, this framework can be summarized into two main categories each with some phases that should be followed carefully, those categories are **the Design Strategy** and the **Interactive Techniques** and they contains:

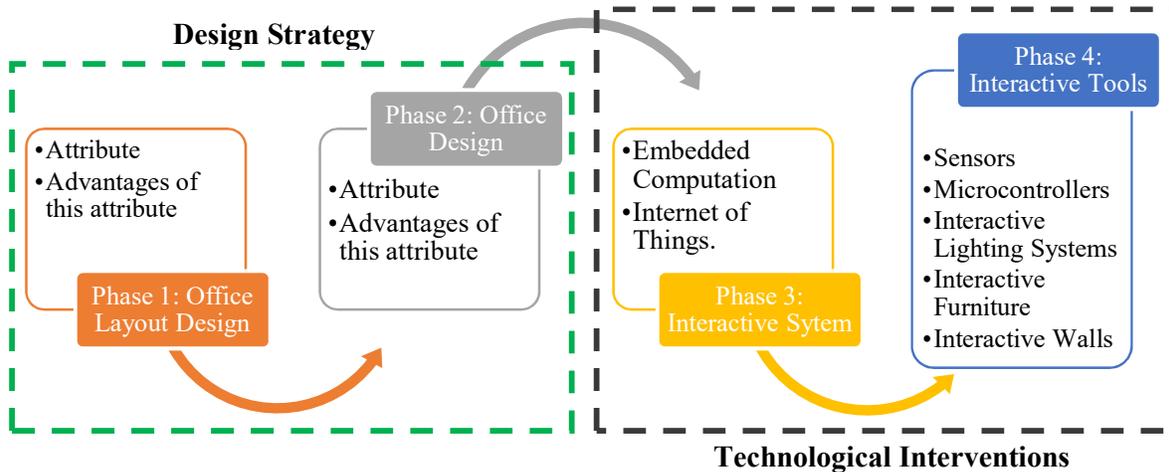


Figure 9 The Components of the Purposed Framework.

##### 4.1 Design Strategy

The design strategy plays an important role in the process of enhancing the office spaces and may cause the majority of the stated problems, that's why in this part we will provide a design strategy that can contribute to the enhancing process through explaining the suitable office layout design and typology that fits the aims of this framework and we will start with:

##### Phase One: The Office Layout Design

This phase deals with studying how a change in the office layout design can improve the user's experiences, attitudes and behavior inside the space, that's why we will start by explaining a Hybrid office layout design that lies between the open and closed office layouts, has the advantages of both of them, compatible with the nature of the work environments, creates a positive atmosphere, allows for more communication between the co-workers and can be called the **Semi-Closed** Layout Design [2]:

##### I. Attributes

The Semi-Closed layout design starts by doing some modifications to both the open and closed layouts design to solve their problems and provide a better office spaces, those modifications are:

- Combining between both the layouts through creating some closed offices that can be used when concentration is needed and an open office space that can be used for handling the ordinary or teamwork tasks [2].
- Allowing for the combination (when able to or needed) of some individual offices with each other to create a larger work space [2].

- Using some low height semi-transparent partitions or the space’s furniture instead of the walls for separating between the workplaces, to prevent the impression of complete isolation [2] and provides a sense of dedication to the users [3]. Those partitions can be covered with an extra layer of an acoustical absorbing material that can minimize the noise levels inside the office spaces [3].

## II. Advantages of Using This Strategy

Table 3 The advantages of using this design attribute.

Cat.	Point of Discussion	Description
Advantages of Closed Plan	Cost Effective	As it can accommodate different types of offices which will be reflected on the number of heads/sq.ft. and will decrease the cost of furnishing for each individual office.
	Different Levels of Privacy	By providing the different levels of privacy that varies from a completely private space (closed offices) until it reach the non-private spaces (open office).
	Flexibility	To be reshaped according to the need and not committed to a single layout.
	Space Utilization	It has the optimum space usage by including different types of office spaces and offers a variety of spaces to be used.
	Accessibility	As all the spaces are extremely and easily accessible from the open offices.
	Work Conditions	it offers a variety of work conditions for each of the needed tasks, users, privacy levels, concentration and teamwork.
Examples		

### Phase Two: Office Spaces Design

This phase deals with explaining the approach that the office spaces are relying on in its design and the system that will guide the users on the work typology and we will build our framework on using a relatively new office spaces typology that is called the **Non-Territorial Work Environment** which can be explained as following:

#### I. Attributes [3]

Table 4 The Attributes of this technique in changing the Office Design.

Point	Explanation
Description	The term non-territorial work environments refers to a flexible way of working where the workplaces are no longer permanently assigned to a certain employee but are used flexibly as the demand arises.
Approach	The main aim here is to focus on the new ways of working as the use of the classic workplace turned to be largely redundant and created a lot of problems.
Components and Features	It can easily accommodate any office space type inside it and requires the presence of a wide range of communication zones, which will change the fabric of the classic office typologies.
Arrangement	It is hard to specify an arrangement for its elements as it varies according to a large number of factors such as the type of offices used, the number of employees, the activities performed in it and so on.



Fig.12, examples for the Non-Territorial work environments. [16] [17]

## II. Advantages of Using this Pattern

- This design pattern decreases the need for extra spaces or desks needed to accommodate all the employees at the office.
- It provides a wide range of work zones for each user to choose from according to the tasks in hand.

### 4.2 The Technological Interventions

In this part we will discuss the interactive implementations that is can be included inside the work environment in general and inside the Semi-Closed office spaces in particular, and the reasons for choosing those technologies in precise lies in those technologies can connect the users with their place, can provide the users with a unique experience, can aid them in performing their tasks (as will be explained later on), can increase the spaces and its users productivity and so on. So we will highlight the role of those technologies in reshaping the classic workspaces as well as the way the employees work and we will start by explaining the following:

#### Phase Three: Interactive Systems

The interactive systems can be defined as the computer application that takes into account the information gathered from the users and produces a perceptible representations of its internal state (Beaudouin-Lafon, 1997) \*[18], based on this illustration we can conclude that those systems plays an important role in the interactive process but to have such role they needs to vary in their applications and interaction techniques in order to cover the various user’s needs, but the scope of our research is limited within the systems that are suitable to be implemented inside the Semi-Closed office spaces and with the Concept of the Non-Territorial workplaces those systems are:

### I. Human-Computer Interaction (HCI)

Table 5 the HCI System and its Characteristics.

Point	Description
Definition	This system deals with studying the relationship between the users and their technological environment by means of design, evaluation and implementation for the hardware and software components of the system [5].
Concept	In order for the two main parts of this technique (Humans and Computers) to interact they must have the ability to act, an internal processing system and to be able to change. So this process goes as following: The user control the system using the <b>Effectors</b> (Hands, voice, etc.) to act using the system <b>Input devices</b> , the computer then can realize those actions by using its <b>Processing</b> systems to act upon those given data and finally show the results through its <b>Output</b> devices (screens, loudspeakers, etc.) so the human can perceive once again by their <b>Senses</b> , and the loop continues [5].

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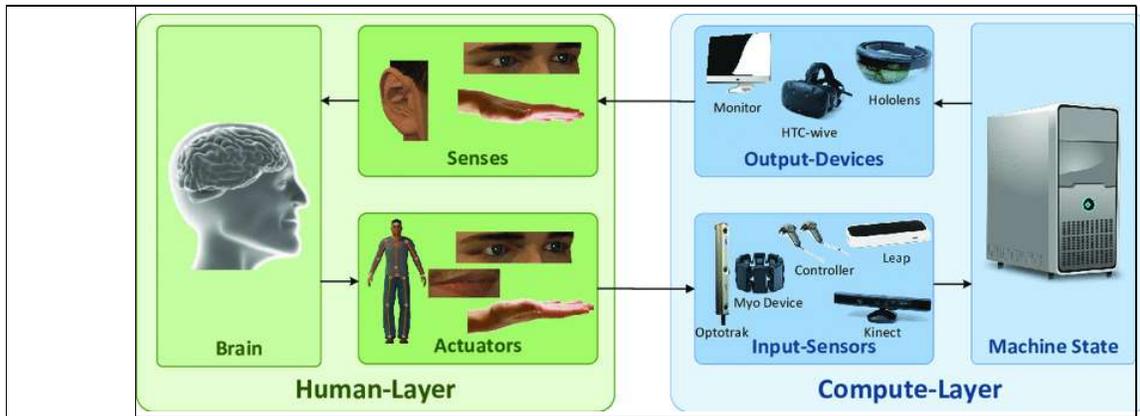


Figure 13, the Human-Computer Interaction Loop [19].

<b>Categories</b> [5]	<p>The Field of HCI systems has a lot of systems that can be used inside the work environments, such as:</p> <ul style="list-style-type: none"> <li>- <b>Tangible Paradigms HCI System:</b> which can provide a physical form to the digital information by using motion sensing, gesturing, tactical feedback or even utilizing the physical components of the space as representations or to control the system.</li> <li>- <b>Surface Based Interactions:</b> Which uses sensors fitted with other systems as infrared, ultrasonic, acoustical systems, etc. to sense the location of a user inside the space and sense the pressure on a selected surface.</li> <li>- <b>Kinetic Typologies:</b> Which provides the ability of making a kinetic response in its physical surfaces, as the changes in the shape, typology, position and other physical properties in respond to the user's actions.</li> </ul>
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## II. Internet of Things System (IoT)

Table 6 the IoT System and its Characteristics

Point	Description	
<b>Definition</b>	Which is a network of interconnected devices and users each with a unique ID to be able to communicate with each other or with the system and can share the data over the network without any interventions [20].	
<b>Concept</b>	The process here starts with Sensors gathering the data ( <b>Perception</b> ), then using the <b>Network</b> to send those data to the system which uses the Microcontrollers to <b>Process</b> those information to make decisions and finally Communicates with other devices/users for <b>Application</b> [21].	
<b>Categories</b> [20]	<b>Perception</b>	This layer is concerned with sensing the environmental conditions like temperature, air quality, humidity etc. and are able to gather the data from objects then converts them into digital signals to be sent to the Network Layer for further action.
	<b>Network</b>	It is called the transmission layer as it receives the collected information from the perception devices and transmit it to the processing layer through various mediums like Wi-Fi.
	<b>Processing</b>	Known as the middleware layer as it stores, analyzes and processes a huge amounts of data coming from the Network layer with the aid of technologies as cloud computing and so on.
	<b>Application</b>	This layer is concerned with applying the actions and decisions that were made in the processing layer and defines the way of interactions with the users.
<b>Applications</b>	<ul style="list-style-type: none"> <li>- It can be used as a guiding application inside the Semi-Closed offices as it can identify the users, locate them and their colleagues in the space, guide them through the space, book an office space and so on.</li> <li>- It can be linked up with a mobile app. that is connected to the system and the users can utilize it to control the indoor conditions, see the space's overall data, consumption rates and so on.</li> </ul>	

## III. Ubiquitous Computing (UC)

Table 7 the Ubiquitous Computing System and its Characteristics

Point	Description	
<b>Definition</b>	It is the system where the computers are hidden into the background of the physical context and the space is fitted by the needed devices and infrastructure that support performing the different types of interactions [5].	
<b>Categories</b> [5]	<b>Smart Devices</b>	Those devices can operate a set of applications as the mobile phone, computers and so on.
	<b>Smart Environments</b>	Where computers are used to enhance the user's activities and has the ability to gather information about their context through a set of networked devices as sensors.
	<b>Physical Environment</b>	Which depends on using complex interaction models to achieve the aimed goals as using a distributed software and hardware resources, dynamic cooperation and the completion between multiple devices of the system.

## Phase Four: Interactive Tools

In this part we will discuss the interactive tools that are suitable to be implemented inside both the Semi-Closed office spaces and the Non-Territorial work environments. Those tools can aid in facilitating the work flow inside those offices, plays an important role in increasing the user’s spatial connections and experiences as well as their comfort and productivity levels which will improve the overall space’s performance, those tools are:

### I. Sensors

**Table 8 Sensors and its Applications.**

Point	Description	
<b>Definition</b>	They are the tools that can be used to collect information from the physical space they are inherited in (as the light, motion, temperature, etc.), can give an extremely detailed information (when combined with a processing software) to the user’s behavior inside the space and identify whom that person is by using cameras, optical input devices, text or sound input and so on [22].	
<b>Applications [22]</b>	<b>Motion Detecting</b>	Which can locate objects inside the space using infrared, ultrasonic and microwaves.
	<b>Pressure Detecting</b>	They are sensors that uses push-buttons and fingerprint as a way of sensing the presence of users and inhabitants.
	<b>Environmental Conditions Sensing</b>	Which can sense the different environmental conditions like humidity, temperature, air flow rates and so on.
	<b>Light Sensors</b>	Which can sense the lightning conditions in a space to know whether it is dimmed or lit using infrared lights from cameras to transmit information about that space.
		
Fig.14, The Different Types of Sensors [5].		

### II. Microcontrollers

**Table 9 Microcontrollers and its Applications.**

Point	Description	
<b>Definition</b>	It is a type of an actuator that analyze the data collected from sensors and act based on it as well as can perform a single task which makes them smaller, less power consuming and more affordable. Also they can be considered as the link between the digital and physical world since they work on the both the human and technological levels starting from collecting the data from the sensors and up to controlling the kinetic parts of any system [5].	
<b>Applications</b>	<b>Motion Microcontrollers</b>	They control the motion of the kinetic and movable objects to assure that they perform their assigned function [23].
	<b>Signal Receiving</b>	Which control those kinetic or movable objects based on the signals received from the other system parts [5].
	<b>Embedded Design</b>	As it can be embedded in a system or act alone [5].

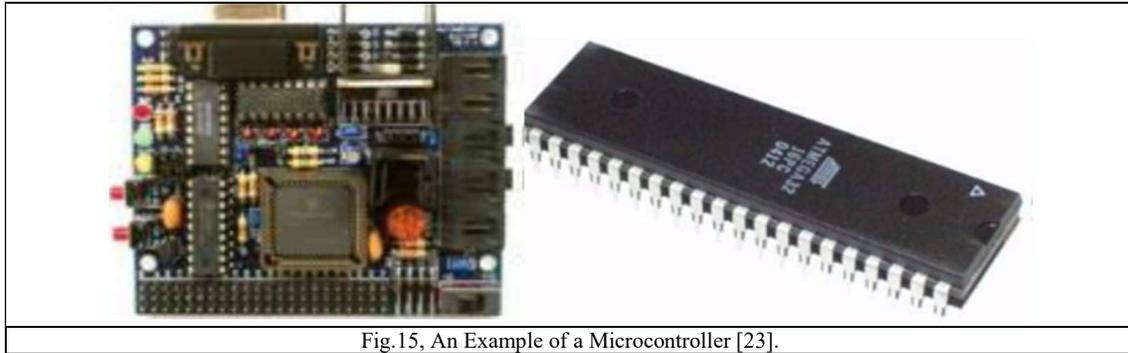


Fig.15, An Example of a Microcontroller [23].

### III. Interactive Lighting System

**Table 10 Interactive Lighting System Characteristics and Applications.**

Point	Description	
<b>Definition</b>	Which is an interactive system that allows the users or the system to have full control over the lighting into their office spaces making which makes them more comfortable while working [24].	
<b>Applications [24]</b>	<b>Smart Phone App.</b>	It's an application that allows the users to manually control the light, by scanning a QR-code (added to each desk) to install the app. that is linked to the luminaries above it, the app then will show different sliders to adjust the light intensity then the server informs all the connected devices at that location about those adjustments.
	<b>Room Control Tablet</b>	Where light adjusting tablets are fitted in each office that can control the lamps installed in it and contains a fixed light scenarios that is suitable for the different activities that can be held inside that space. While the screen shows a QR- Code that can be scanned by a smartphone to enable a more detailed control to the users.



Fig.16, The Smart Phone Application [24].

Fig.17, a Room Control Tablet [24].

### IV. Interactive Furniture

**Table 11 Interactive Furniture Characteristics.**

Point	Description	
<b>Definition</b>	Which can be defined as furniture that is more comfortable, entertaining, multi-functional and have at least two forms of appearance or functions in order to aid the users in performing their tasks, provides them with a new experience and gives a better space organization [25].	
<b>Characteristics [25]</b>	<b>Useful</b>	As it must fulfill a certain or multiple user's needs or issues.
	<b>Usable</b>	To be easily understood and can be used clearly.
	<b>Entertaining</b>	To be fun to use and provides a new experience.
	<b>Durable</b>	To be used for the longest period of time and can keep up with the evolving user's needs.
	<b>Fit in Context</b>	In the office space it will be implemented in.
	<b>Strategic Location</b>	As it must be located in a place that is easy to reach and doesn't make any crowd or obstruct the visibility.



Fig.18, Examples on the Interactive Furniture [26].

## V. Interactive Walls:

Table 12 Interactive Furniture Characteristics.

Point	Description	
<b>Definition</b>	Which can be defined as a collaborative large HD display that allows for the user's interactions through touch, multi-touch or even gestures [27].	
<b>Characteristics [28]</b>	<b>Large Size</b>	As it makes more sense to display objects in a life-like size.
	<b>High Resolution</b>	Displaying large amounts of information requires high resolution to provide a good view from any location in the space.
	<b>Touch/Gesture Sensitive</b>	As they can handle multi-tasking from multiple touch inputs or gestures.
	<b>Multi-User</b>	Which is a collaborative tool that allow multiple users to use its surface providing an engaging and motivating collaborative context.
	<b>Different Forms</b>	As those walls can be digital walls, movable walls that can be moved to enlarge the space, editable to be reshaped as needed or manually interactive as to draw on it with a pen, connect some shapes and so on.



Fig.19, Example on the Interactive Walls [28].

## 5. Case Studies

In this section, some case studies will be analyzed in order to see how those spaces adopted the previously discussed strategies, the effect of using it on reshaping the fabric of the existing office spaces and to see the applicability of the purposed framework on a real life model.

Those examples were chosen to be the subject of this research as they are considered the pioneers in field of interactive office spaces, combined between some if not all the strategies that were stated before, adopted new ways of thinking about how to change the fabric of the work environment and provided a more innovated office spaces that are better for its users. The analysis process will be concerned with explaining the space's design strategy, the technological interventions that were implemented inside it, their effect on the user's comfort and well-being ending up by providing the results of this analysis and we will start with:

### 5.1. The Edge-Amsterdam, PLP Architecture, 2015

The edge building goal was to create an intuitive, comfortable and a more productive environment for its employees while setting an example on how the interactive workplace environment should be [29].



Figure 20 the Edge-Amsterdam building [30][31].Figure 21 the Edge spaces types[32].

Table 13 Evaluation of the used techniques in the Edge-Amsterdam Building.

Category		Feature	Description
Design Strategy	Layout Design	Semi-Closed Layout Design	The building depended on using the Semi-Closed layout design as it contain both open and closed open spaces. Fig.21
	Spaces Types	Non-Territorial Work Environment	The building relied on the concept of the Non-Territorial work environment (Hot-desk) as the employees can use any empty desk as the demand arises.
Interactive Interventions	Interactive System	Internet of Things	The building applied the Internet of Things (IOT) as its foundational system for its applications and implementations [33].
	Interactive Features	Sensors	<ul style="list-style-type: none"> <li>- The Philips Lighting Panels.</li> <li>- The Mapiq App.</li> <li>- Interactive Coffee Machines.</li> <li>- Cameras fitted with Sensors to guide the Robots.</li> </ul>
		Microcontrollers	<ul style="list-style-type: none"> <li>- Detecting Cameras.</li> <li>- Security robots.</li> </ul>
		Lighting System	<ul style="list-style-type: none"> <li>- The Philips Interactive Lighting Panels.</li> </ul>
	Interactive Furniture	<ul style="list-style-type: none"> <li>- Interactive Screens.</li> <li>- Interactive Dashboards.</li> </ul>	



Fig.22 the Interactive Dashboards [33]



Fig.23 The Lighting Panels [34]



Fig. 24, A Security Robot [35]



Fig.25, The Mapiq App [36]



Fig.26, Interactive Coffee machine [37]



Fig.27, Interactive Screen [38]

### 5.2. DirecTV HQ Building, AECOM and Electroland, 2014.

The famous video service provider DIRECTV wanted to update their workplace and give their employees a new dynamic environment that embraces an innovative strategy to allow its employees to work in a collaborative and inspiring way that embodies their brand [39].



Figure 28, The DirecTV space types [40]. Figure 29 DirecTV building [41].

Table 14 Evaluation of the used techniques in the DirecTV HQ Building.

Category		Feature	Description
Design Strategy	Layout Design	Semi-Closed Layout Design	The building depended on using the Semi-Closed design pattern as it contains both open and closed offices.
	Spaces Types	Individual Offices Open Office Spaces	As The building contained both a flexible open-office space as well as some individual offices as in Fig.28.
Interactive Interventions	Interactive System	Tangible Paradigms - HCI	The system implemented in the building's interactive installations is the Tangible paradigm-HCI System.
	Interactive Features	Sensors	- Rooms Occupancy Sensors. - The Aurora's Interactive Screen.
		Microcontrollers	- The Aurora's Interactive Screen. - The Room Conditions Controllers with the Occupancy Sensors
		Interactive Furniture	- The Interactive Presentation Room. - Interactive Screens. - Meeting Rooms Control Tablets.
	Interactive Walls	- The Aurora Interactive Art Installation.	



Fig.30 The Aurora Art Installation [42] [43].



Fig.31 Interactive screens at the Aurora's End [43].



Fig.32 An interactive screen [43].



Fig.33 The Presentation Room [43].



Fig.34 The Occupancy sensors and the Control Tablets [43].

### 5.3. Frasers Towers – Singapore, DP Architects, 2018.

The Frasers Tower tended to create a new innovative building that can be equipped with the latest “Future work experiences” technologies, so the designers provided a 38-Stories office building with up to 21,000sqft. Hybrid workspaces implemented with the targeted technologies [44].



Figure 35 Fraser Towers Plan [45]. Figure 36 The Towers From The Outside [45].

Table 15 Evaluation of the used techniques in the Frasers Towers.

Category	Feature	Description	
Design Strategy	Layout Design	Open Office Spaces	The building used the Open-office spaces so each tenant can configure the spaces as they want.
	Spaces Types	Open-Offices	The building contains open office spaces, meeting rooms, multiple lounges and restaurant as well as four community zones presented in The Sky roof, The Terrace at level 4, The Oasis at the podium and The Park at level 1 [45].
Interactive Interventions	Inter-active System	Ubiquitous Computing	The building used two interactive systems, the Ubiquitous-Computing (UC) in the Centralized Intelligent Building management system, and the Internet of Things (IOT) for the Digital Twin app. - The QR Code Scanner. - Centralized Intelligent Management System. - The Digital Twin Feature. - Face Recognition, CO, PhotoCell and occupancy Sensors. - The QR Code Scanner to open the gates. - Centralized Intelligent Management System. - The Digital Twin Feature. - Occupied with the implemented Sensors. - Lighting System fitted with PhotoCell Sensors
		Internet of Things	
	Interactive Features	Sensors	
		Microcontrollers	
	Interactive Lighting System		
<p>Building Management System</p> <ul style="list-style-type: none"> <li>Ventilation System</li> <li>Air Purging System</li> <li>Energy Management &amp; Metering</li> <li>Lighting Control</li> <li>Fire Protection System Monitoring</li> <li>Lift System Monitoring</li> <li>Security System Monitoring</li> </ul> <p>Utility Services</p> <ul style="list-style-type: none"> <li>Elevator Destination Control System</li> <li>High-Speed Wireless Internet</li> <li>Energy Efficient Elevator &amp; Regenerative Lift</li> </ul> <p>Basement Car Park</p> <ul style="list-style-type: none"> <li>CO Monitoring</li> <li>Plug-in Electric Hybrid Vehicle Charging System</li> <li>Parking Guidance System</li> </ul> <p>Security System</p> <ul style="list-style-type: none"> <li>Access Control</li> <li>IP CCTV System</li> <li>Turnstile Gate Automation</li> </ul>		<p>A screenshot of a digital twin application interface. It features a 3D architectural model of a building on the left, overlaid with various data dashboards, charts, and graphs on the right, representing real-time building performance metrics.</p>	<p>A photograph of a woman in a light blue blazer using a QR code scanner at a turnstile entrance. The turnstile has 'FRASERS TOWER' branding on it.</p>
<p>Fig. 37 Centralized Intelligent Management System Uses [46].</p>		<p>Fig. 38 The Digital Twin App. [47].</p>	<p>Fig. 39 The QR Code Scanner [48].</p>

### 5.4. The PARQ-Bangkok, TCC Assets Thailand, 2020.

The PARQ is a mixed-use building, which is created to promote wellness, enhance the quality of life and aims at leading the corporations to create an innovative building [49].



Figure 40 The PARQ Plan [49]. Figure 41 The PARQ building from the outside [50].  
Table 16 Evaluation of the used techniques in the PARQ Building.

Category	Feature	Description	
Design Strategy	Layout Design	Open Office Spaces	The building used the Open-office spaces “which allows for a greater flexibility for the tenants to design their floor plan and layout.” Said by Sern Vithespongse, director at P&T Thailand [51].
	Spaces Types	Open-Offices	The building contains open-office spaces, an exhibition space and the Q-steps which is a staircase-like public area intercut with platforms and seating [51].
Interactive Interventions	Inter-active System	Ubiquitous Computing	The building used on two interactive systems, the Internet of Things which can detect and control the internal building conditions by the PARQ app. and the Interactive & physical environment - UC system for the rest of the building.
		Internet of Things	
	Interactive Features	Sensors	- Touch-less Features. - Filtering System. - The PARQ App. - The CCTV-Equipped Smart Poles.
		Microcontrollers	- Disinfecting Robots. - Touch-less Features. - The PARQ App. - Filtering System.
		Lighting System	- Philips Smart Lighting Technology.
Interactive Furniture	- Interactive Elevators. - Self-Service Kiosks. - Interactive, Touch-less Control screens. - Washrooms Touch-less Features.		
<p>Fig.42 The PARQ App. [52]      Fig.43 Touch-Less Entry [48].      Fig.44 Disinfecting Robot [48].</p>			

## 6. Results and Discussion

**Results:** After discussing the phases that resembles the purposed framework and analyzing some case studies that stands for it, it was observed that those office spaces applied this framework with different techniques and levels, as some of them only used

a feature or two from the purposed phases while others used the entire framework in both its design and technological strategies and the results were obtained as following:

**Table 17 Analyzing the Usage of the Purposed Framework and its Phases [Author].**

Point of Discussion			Project Name			
			The Edge-Amsterdam	DirecTV HQ	Frasers Towers	The PARQ
Design Strategy	Layout Design	Semi-Closed Layout				
		Open Office Layout				
	Space's Types	Non-Territorial Work Environment				
		Open Office Spaces				
		Individual Offices				
Interactive Interventions	Interactive Systems	Human- Computer Interactive System				
		Ubiquitous Computing				
		Internet of Things				
	Interactive Features	Sensors				
		Microcontrollers				
		Lighting Systems				
		Interactive Furniture				
Interactive Walls						

- Most of the analyzed case studies either relied on using the Semi-Closed or the Open office layouts which resembles to how they are reliable to be used inside the context of the office spaces.
- While the Majority of those spaces relied on using the Open office spaces while some of them relied on using the concept of Non-Territorial work environments which is relatively new and were later embedded inside other office spaces.
- As for the interactive systems, almost all the purposed systems were utilized inside the analyzed case studies and some even tended to combine between some of those systems to offer a better experience to the users.
- The Interactive Features mainly utilized the sensors and microcontrollers which is the core for any technological implementation, while the majority of them used the interactive lighting system and furniture with its different applications and it was noticed that the other features weren't reliable or needs a special settings in order to be implemented inside the office space's context.

**Discussion:** in this part we will analyze the results in details to interpret their meanings, puts them into context and explain their contributions in enhancing the office spaces, and we will start with:

**Phase One: The Office Layout Design:**

As being stated before, the majority of the analyzed case studies relied on either the Semi-Closed or the Open-office Layout and that's because:

**Table 18 Analyzing the Results from using the mentioned layout types [Author].**

Type	Discussion
Semi-Closed Layout	It offers a variety of work conditions and privacy levels for its employees which provides them with the ability to choose their preferred conditions, makes them feel more comfortable and that they matter (as in the cases of the Edge and DirecTV HQ buildings). It also provides high levels of flexibility as the office layout can be changed, rearranged or gathered into certain groups according to the work needs to create a more innovative, collaborative and dynamic work environment that can be suitable for the different types of tasks and can also accommodate some open and closed office spaces together to benefit from the advantages of both of them (which was presented in the aims behind creating the Edge-Amsterdam's office spaces and also for the renovation that took place in the DirecTV HQ office spaces) which better suits the aims of this research and its framework.

<b>Open-Office Layout</b>	which offers more freedom when it comes to choosing the workplace settings, can be easily equipped with the different types of interactive technologies, easily accessible and can be understood effortlessly by the users (as in the cases of both the Frasers Tower and the PARQ buildings that chose this layout type in order to provide the tenants with the ability of choosing their desired work settings) , but it has a lot of setbacks including wasting a lot of area, can encourage the spreading of diseases, has a huge noise and distraction levels and so on.
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**Phase Two: Office Spaces Design:**

The office spaces provided here mainly used the Open office spaces and some of them relied on the Non-Territorial work environments and that’s because:

**Table 19 the Results of using the previous Design patterns in the office spaces [Author].**

Type	Discussion
<b>Open Office Spaces</b>	Which contributes in creating a collaborative work environment where the employees can easily work, communicate and interact with each other ( which is better for their social relations and mood), provides high levels of flexibility and can accommodate large number of employees within (which is the case in most of the analyzed examples) but on the other hand, it has a lot of problems such as the high noise and distraction levels, wastes a lot of space, has no clear boundaries and so on (as stated before) which doesn’t help much in the process of enhancing the modern office spaces.
<b>Non-Territorial Work Environment</b>	Which were used (in the Edge-Amsterdam office spaces) to promote the idea of not having a dedicated desks and decrease the issues of claiming the territories, force the users to change their habits and desks regularly as the demand arises and make them enthusiastic about trying something new. It also provides some communication zones within its context in order to encourage the employees to communicate with each other and provides a more creative work areas (which adds to the value of the office spaces and the user’s mental health) as well as can accommodate more employees without the need for extra spaces or workstations all of which can contribute and adds to the process of improving the modern office spaces.

**Phase Three: Interactive Systems:**

From the analysis we concluded that the majority of those examples relied on using the Internet of Things and the Ubiquitous Computing systems and barley used the Human-Computer interactive systems and that’s because:

**Table 20 analyzing the usability of the stated interactive systems [Author].**

Type	Discussion
<b>Internet of Things</b>	Most of the modern interactive office spaces strongly dependent on this system, as it facilitates the connections and the interactions between the different parties of the interaction process, provides a wide range of solutions for the users and the clients, can be implemented in various levels, fields and techniques that can be applied separately or combined such as a mobile app (as the PARQ, Mapiq and Digital Twin apps), Lighting systems (as the Philips lighting system inside the Edge building), Interactive devices ( as Screens, Robots, platforms), etc. and most of all it doesn’t demand much change in the fabric of the existing office spaces, which explains why it is frequently used by the majority of the interactive office spaces.
<b>Ubiquitous Computing</b>	Which is the second most utilized system, as it deals with how to provide the users with the feeling that the space is interacting with them and not some technological devices which can be achieved by completely encapsulating the interactive devices inside the background of the space’s physical context, this process aids at increasing the spiritual value of the space, enriches the interactive process and provides the users with a unique experience as the space is seen as a large interactive environment which severely serves the aims and purposes of this research and its framework.
<b>Human-Computer interactions</b>	This system were the least used system within the purposed systems as it demands large area for such implementations, creates a lot of distractions for the employees while they are working (so it must be implemented in the common areas as he lobbies) and has a low field of application as it needs a lot of modifications in the fabric of the office spaces and can’t be implemented inside the small offices which decreases its chances in contributing for the purposed framework.

**Phase Four: Interactive Tools:**

And finally, the interactive tools and features which will be discussed as following:

**Table 21 discussing the usage of the purposed interactive tools [Author].**

Type	Discussion
<b>Sensors and Microcontrollers</b>	Which are the core for any technological implementations and resembles the foundations for any interactive system, that’s because they can monitor, act and react to the user’s interactions inside the office spaces and provide the needed information about them, which assure on their importance in the interaction process or in any interactive device.

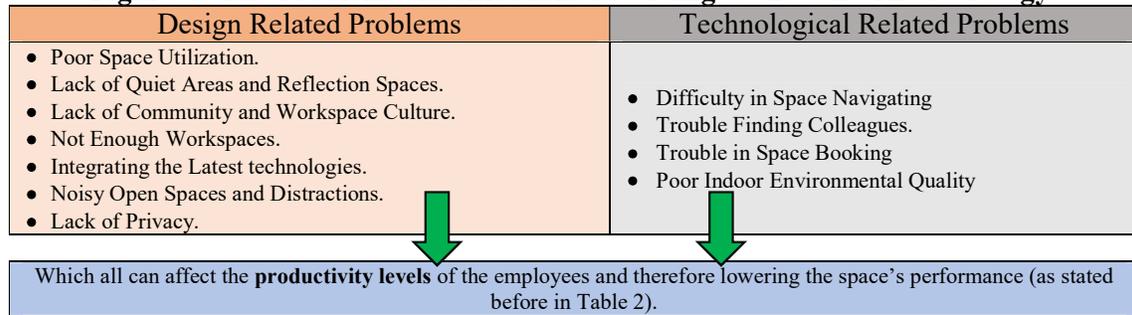
<b>Lighting System</b>	Which is an important feature to be implemented inside any office space as it provides the users with control over the lighting conditions inside their offices and spaces so every user can adjust those conditions according to their needs.
<b>Interactive Furniture</b>	It is very important to implement some interactive furniture units inside the office spaces which provides the users with a unique experience while handling their tasks or performing some activities, facilitates their workflow and provides them with an entertaining practice while using such devices for example the interactive coffee machines (The Edge), screens, dashboards and so on.
<b>Interactive Walls</b>	Which is barley used inside the office spaces as they need large spaces, implementations and can negatively affect the workflow inside the office spaces (as being said before) so it is preferred to be used inside the large common areas as entrance halls, lobbies and so on.

## 7. Conclusions and Recommendations

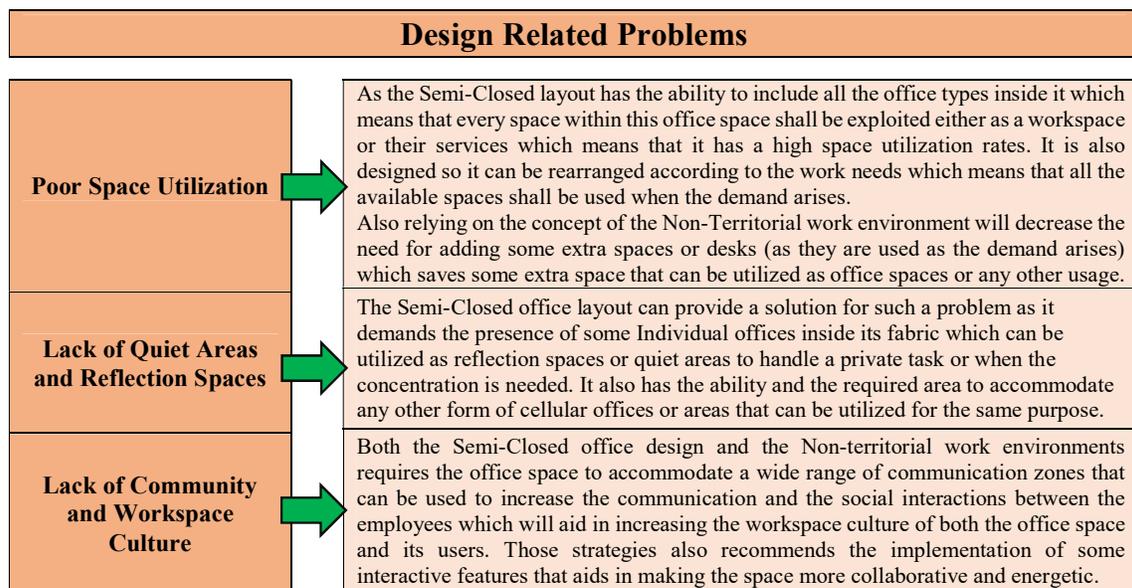
### 7.1. Conclusions

After discussing the assumed framework, explaining its different phases and analyzing some case studies, we shall now highlight the role of this framework in solving the modern office spaces problems in order to see whether it fulfilled the aims of this research or not and we will start with the following:

**Figure 45 The Problems classifications according to the concerned Strategy.**



After this classification, we will assume a solution for each of those problems based on the information provided in this research and relying on the data gathered from the analysis of the case studies and we shall start with:



<b>Not Enough Workspaces</b>	→	The concept of the Non-Territorial work environment can provide a solution for such problem, as the desks and workstations in this type are no longer dedicated to a single employee but belongs to whoever needs them according to the task they are handling, which means that in most of the cases there will be a lot of empty desks and workstations that are available inside the office spaces.
<b>Integrating the Latest Technologies</b>	→	The Semi-Closed office spaces are flexible spaces that can reconfigured easily in order to accommodate any changes that can take place inside the office spaces including the implementation of the needed technologies, but the important thing is that the office spaces infrastructure must be suitable to accommodate such installation.
<b>Noisy Open Spaces and Distractions</b>	→	As being stated before, the Semi-Closed office layout requires the presence of some closed and individual offices that can be used when needing for some quiet, privacy, concentration or as a retreat space to escape the noise and distractions. Another solution is presented in adding an extra layer of some acoustical absorbing materials to the partitions separating the open space workstations in order to decrease the noise levels and provide a sense of privacy for the employees.
<b>Lack of Privacy</b>	→	The Semi-Closed office spaces offers a wide range of office spaces that provides its users with different level of privacy starting from the completely private offices as the individual offices to the completely non-private offices such as the open office spaces.

<b>Technologically Related Problems</b>		
<b>Difficulty in Space Navigation and Finding the Colleagues</b>	→	As explained previously on the case studies, the <b>IoT</b> interactive system can provide a solution for this problem by using a mobile app that is linked up with a network of interconnected sensors and microcontrollers that can identify each user's position inside the different office spaces, guide them to reach their targeted destinations, can show the users where their colleagues are and guide them to their location inside the office spaces.
<b>Trouble in Space Booking</b>	→	Another application for the IoT system and the mobile app is that they can be connected with sensors and microcontrollers in order to see the availability of the different office spaces and can be used also to book any of those spaces such as the meeting rooms, conference halls or even the workstations and desks for the needed time at any day.
<b>Poor Indoor Environmental Quality</b>	→	Controlling the indoor environmental conditions is one of the major advantages of using the Internet of Things interactive system which provides the ability to control those conditions in different ways as following: <ul style="list-style-type: none"> <li>• The First one is when the system uses its sensors to sense the indoor environmental conditions and act upon those data using the microcontrollers.</li> <li>• The Second way is when the users have control over those conditions by using the app or the system to control those parameters as needed.</li> <li>• The Third type of control is the Hybrid control where the system do what it sees fit then informs the user about its decision and why it took it and may even take a long time interval to do such changes so the user can stop it or make a better decision if needed.</li> </ul>

<b>General Problems</b>		
<b>Low Productivity Levels</b>	→	As stated before there is a lot of problems that can affect the productivity levels of the employees such as the indoor environmental quality, comfort levels, noise, distractions and so on, those are the problems that this framework tried to solve which in turn will be reflected on the employee's productivity, comfort, satisfaction levels and so on.

After discussing how the purposed framework contributes in solving the majority (if not all) the problems of the modern office spaces, we can say that this framework has a huge role in the

process of enhancing the existing office spaces which will be in favor for both the office space's design, its performance as well as its users satisfaction and well-being.

With this being said, we can summarize and formulate the general guideline for this Framework to be as following:

- Investigating the targeted users and identify their potential requirements that needs to be included inside the fabric of the office spaces.
- Identify the adequate layout design that tends to create a more creative, dynamic and suitable work environment, provides the users with the ability to choose from a wide range of work places that suits their needs as well as aids the users in achieving their goals and handling their tasks which is presented in the Semi-Closed office layout.
- Relying on a more innovative design concept that encourage the users to change their habits, to try something new, provides some extra spaces as well as adopts new ways of working which can be presented when using the Non-Territorial work environments.
- Providing various types of office spaces to provide the users with the ability of choosing from a wide range of office spaces according to their need.
- Implement the latest technologies that are suitable to be implemented inside the context of the office spaces, provide the users with a more unique, immersive and entertaining experience, creates a collaborative environment between the employees as well as aids the users while handling their tasks which is presented in both the interactive systems and tool.

## **7.2. Recommendations**

- It is advised that the purposed Framework should be applied during the early design stages of the new office spaces and also as a guide to analyze some of the existing office spaces or buildings.
- The designers should look for new opportunities concerning the design of the office spaces and layout, but it is highly recommended to rely on the Semi-Closed office layout in the design of the office spaces as it has a lot of advantages on solving most of the existing offices problems.
- The Non-Territorial work environment or what can be called the Hot-Desk system is a very good example for providing a dynamic, flexible and innovative workplace which is highly desired.
- The designers should execute a comprehensive research about the latest available technological interventions that are suitable to be implemented in such spaces, fulfill its targeted requirements and perform its functions in the most proper way.
- After performing the previously discussed steps, it is highly recommended that the designers should create a prototype for the purposed space to have a full evaluation for the current situation, avoid any possible issues and try to solve them before the construction starts.
- It is very important to raise the awareness (especially for the clients and tenants) about the risks and hazards of the workplaces and how they can affect the user's health, comfort and productivity levels as well as on the environment and so on in order to avoid creating a non-suitable office spaces and help in changing the idea of creating a new office space.

At the end, this research provides a complete guide to assist the designers on how to create an interactive office space that tends to create a better workplace for its users, avoid repeating the same setbacks that occurred in most of the existing office spaces as well as increasing the user's comfort, production and collaboration levels so it can be called as their second home.

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## الإطار المنهجي المقترح لتحسين الفراغات الإدارية الحديثة و حل المشكلات المتعلقة بها.

### ملخص البحث

تواجه الفراغات الإدارية الحديثة العديد من المشكلات التي قد تؤثر علي تصميم الفراغات ووظيفتها إلي جانب التأثير علي راحة المستخدمين و معدلات الإنتاج الخاصة بهم. ولهذا فإن هذا البحث يهدف إلي إيجاد منهجية يمكن تطبيقها في مراحل التصميم الأولية، تهدف إلي إنشاء فراغات إدارية أفضل و تقديم الحلول اللازمة للمشكلات المتواجدة حالياً في تلك الفراغات. و يبدأ هذا الإطار بشرح المنهجية التصميمية المقترحة لتلك الفراغات بمختلف مستوياتها و أنماطها، توضيح الأنظمة و التقنيات التفاعلية المناسبة معها، تحليل بعض الأمثلة المشابهة والتي تدعم تلك المنهجية المقترحة و ينتهي بتوضيح التأثير الخاص باستخدام تلك المنهجية علي تشكيل الفراغات الإدارية الحديثة و في حل المشكلات المتعلقة بها.