

The Role of Industrial Design in Sustainable Office Environment

With Emphasis on the Utilization of Industrial Design for Social Sustainability.

Lee, Kiwon* , Nam, Kiyoun **, Choi, Eunjung***

* KAIST, Seoul, Korea, kiwon0811@kaist.ac.kr

** KAIST, Seoul, Korea, knam@kaist.ac.kr

*** KAIST, Seoul, Korea, nave03@gmail.com

Abstract: Recently many leading nations have tried to apply environmentally-friendly technology to their office environments as environmentalism has become and increasingly discussed necessary issue. In this study the author researched the characteristics of sustainability commonly used in various fields; then having gone through analysis, a synthesis was made in order to re-establish the concept of ‘sustainability’ as the outcome of this study. As a result, a three-clause sustainability model is presented with human needs as a core and clauses of ecology, economy and sociology. Through literature review, the author found the underlying reason why the concept of this sustainability must be applied to human centric environments, and especially why it should be applied to work environments such as offices and factories in which the average modern human spends a significant portion of their lives. The author analyzed, focusing on framework, twenty successful environmentally friendly buildings in the US, Japan and Europe by using this model of sustainability presented for the preceding research, using these results, the author arranged the actualization methods and characteristics of sustainability of office environments. Also the author found that the current environmentally-friendly office environments are focused on technical solutions such as ecological and environmental solutions and thus was able to explain the need of improvement of the social sustainability of these contexts. To comprehend the methods of improving social sustainability and to identify the present problems, in-depth interviews were conducted with people working with environmentally friendly buildings and the building’s architect. As a result, the author figured out that the social sustainability can be solved by industrial design. Therefore the author suggest re-established sustainability model that involves an industrial design methodology for restoring overall sustainability. The method of achieving social sustainability, to suggest that three kinds of considerations based on basic human satisfaction must be sought prior to unconditional technological application seeking efficiency, as a conclusion.

Key words: *Sustainable Design, Sustainable Office Environment, Role of Industrial Design*

1. Introduction

1.1. Research Background

The controversy of various theories of environmentalism became active with the fanatical reaction against the destruction of nature and has naturally shifted to focus on sustainability as one solution. In this manner, many leading nations (such as U.S, Japan, Europe and etc.) are performing on-going research related to environment and are developing various environmentally-friendly technologies. L.Richard(1992) emphasized that these kinds of technologies have to be applied to office environments where human spend more than 70% of their time on average. In spite of that, environmentally-friendly technologies are generally only focused on economical and technological sustainability related to hardware centered solutions. This means recent sustainability stays in short-sighted policy concentrated technical problem solving and alienates some human centered social aspects. This research focuses on the human being as the centre of sustainable development and suggests the role of industrial design as means of social sustainability improvement for sustainable office environments to contribute to developing balanced sustainable workplace.

1.2. Research Aims

This research focuses on the role of industrial design to establish holistically sustainable office environments. There are specific aims to precede this research

- To define sustainability model though literature review of empirical research of sustainable office environments
- To explore the areas which can be solved by industrial design through analyzing case studies
- To propose the role of industrial design that can be applied in sustainable office environment

2. The Notion of Sustainability in view of Sustainable Design

2.1 Definition of Sustainability

In this chapter, the meaning of sustainability is established from different perspectives. According to the Report of the Brundtland Commission (1987), "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The meaning of sustainability became consolidated through UNCED (United Nations Conference on Environment and Development) in 1992 (Rio Declaration on Environment and Development). In this conference, the concept of sustainable development was extended to economic and social aspects while focusing on ecological direction that prevents environmental pollution and maintains a self-regulated system. Tiffany (2007) defined sustainability by combining various definitions of sustainability concept. His definition is such that the human being contributes to the maintenance of resources without damaging environmental diversity in every culture. From the definitions above, sustainable development could consist of three main factors: economic needs, environmental capacity and social needs. Figure 1 shows related issues surrounding the three factors.

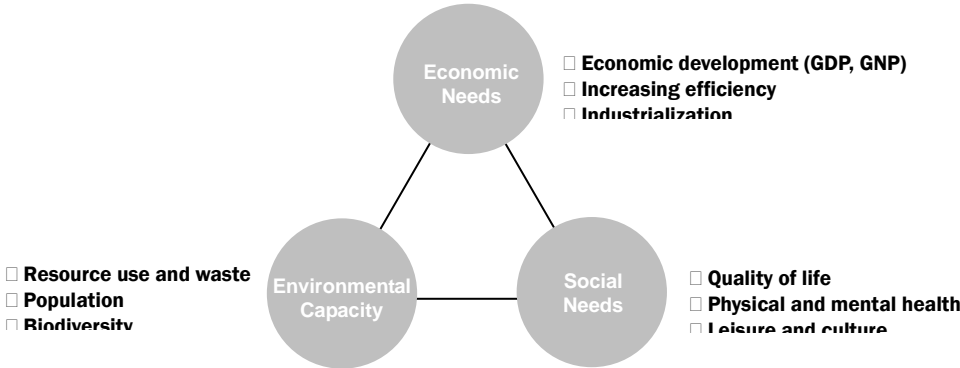


Figure.1 Three factors of sustainable development

The model of sustainable design by IDSA (2005) as shown in Figure 2, closely resembles that of sustainable development. Its ultimate goal is the consideration for both social contribution and ecologically acceptable solutions in the design process. In other words, people can suggest available solutions that can make the present environment, society, and culture to the next generation through the use of sustainable design. The fundamental



Figure.2 Basic idea of sustainable design

concept of sustainable design can be explained in this way, by Figure 2. Sustainable design is an intersection of social, economical and environmental values, which mean sustainable design can be considered completed when these three values are satisfied.

Looking through sustainable development and sustainable design, environmental aspects can be summarized as an ecological approach that pursues environmental conservation and use regenerative energy. In the economical case, it follows efficiency of resource utilization and system flexibility. The social perspective, however is relatively ambiguously valued. In D.A Murano (1995) account of

sustainability he explains that social sustainability involves four characteristics, ‘need-sufficient’, ‘reliable’, ‘adequate’, ‘equal’. The term ‘need-sufficient’ suggests every development has to provide physical and psychological satisfaction to human. ‘Reliable’ suggests that final deliverable has to be conveyed in a stable way, users also have to perceive this reliability. ‘Adequate’ is the property that consider user context such as culture, geography, economic situation and other user appropriate needs in the development process. ‘Equal’ has close relationship with universal design. It aims to enable every user to consume the resource or product equally, and in this way, the basic user-ability has to be secured so giving the user a feeling of ‘convenient’. Three main factors of sustainability can be thus defined, however, it has to be noticed that these three factors are hardly separated. As figure.2 explains, sustainability can exist when ecological, economical and social aspects are satisfied at the same time. This means the three aspects form an essential part of sustainable solution, and they are correlated closely.



Figure.3 Sustainability model

2.2 Sustainability Model for Research

Grasping the point of sustainability, a sustainability model is defined for the following research. This model is extracted by review of basic concept of sustainability and it will be used as frame work to analyze case studies and interview results. From sustainable development, sustainable design and understanding social sustainability, three main aspects can be extracted. That is ecological, economic, and social sustainability and these aspects comprise nine characteristics to fulfill overall sustainability. However, humans must be considered as a top priority, and they form the common denominator of all other design characteristics.

3. Sustainability in office Environment

The office work context and its purpose can be defined as organization with particular goals performing the role of conveying, manufacturing, accumulating, and creating information to accomplish that goal (Yu, 2005). The office environment is the place where office work is conducted and a context to encourage creative activity, and by extension, controls every kind of information while increasing productivity between human and the organization. The office environment has been implemented since human orchestration began, and its importance has been discussed actively since 1960s when offices and factories became more aggressively optimized and improvements of the office environment was focused as the industrial revolution began. Table 1 explains development of the office environment over this history.

Table 1. Development of the office environment (Duffy, 1999)

	1960s	1970s	1980s	1990s	2000s
Theme of the office	Data processing	Efficiency of production	Coexistence with OA devices	Recognition as resource of strategy	Harmonize human with nature
Market economy	High growth of economy	Low-growth period (Oil shock)	Active promotion of OA devices	Information-oriented society	Protection of environment
Building Construction	-Spreading office landscape: Proficiency of office work and interaction between worker - Sharing space and equipment -Economical way due to decrease occupation space per a person - Possibility to make ownerless and huge space	-Appearance of energy-efficient building: Distinguished windows that extremely small -Office device: Typewriter -Constructing technique the make compartment variable	-Progress of Office Automation: Computer based office work -Comfortable office environment is demanded	-Rapid progress of OA: Decrease of simple work based office work -Increase knowledge based office workers who work in the field of planning, investigation, publicity, etc	- Spread the concept of Sustainable design that can be applied in office environment

Over time, the office environment has been developed in efficiency raising ways. In the beginning, physical efficiency was raised considering work space organization. Later, people's concern moved toward raising energy efficiency. Finally work efficiency has focused on information-oriented technology. But only raising efficiency in various ways has been considered, nature factors, which cannot be independently considered from human beings have mostly been neglected. People want to harmonize with nature so that sustainable office environment becomes influential. In this situation, exploration of practical office environment is required to establish sustainable office environments, and it has to be identified according to a sustainability model to examine the present situation effectively.

4. Case Study : Office Environment

The case studies on sustainable office environments aim to identify sustainability features. Through classifying factors of sustainability, the area of industrial design that contributes to establishing sustainable office environments can be identified. Furthermore, potential design opportunities can be discovered through the existing process of developing sustainable office environments.

4.1 Collection of Cases in Japan, Europe and U.S.A.

First, several cases in Japan, Europe and America were collected from well-composed sustainable office environments. Limitations to include only sustainable offices built after late 90's were set, and winner of related eco design competition would be more focused to add confidence to these cases. The Japanese study concentrated on Shiodome where environment-friendly technology application of buildings exist and there are plans to reconstruct a green buildings. In the American cases, prizewinning works of the Cote Green Building Top 10 Award from AIA(American Institute of Architects) were considered, the cases of Sustainable Architecture : Europe Top 10 written by Donald Watson who is an expert on eco-friendly architecture.

4.2 Case Study Framework

To analyze the cases, a specific frame work based on the previously mentioned sustainability model will be used (See Figure.3). That contains three main aspects which are ecological, economical and social sustainability involved nine different kinds of characteristics regarding each aspects. Using this frame work, over all office situations will be discussed and how environmental factors can be reflected in sustainability categories can be identified practically.

Table 2. Frame work for case study

Aspects	Ecological Sustainability		Economic Sustainability		Social Sustainability				
	Regenerative	Conservative	Effective	Flexible	Needs-Sufficient	Reliable	Adequate	Equal	Convenient
Feature									



Figure.4 Criteria for selecting category

As previously mentioned, ecological, economical and social aspects are correlated and it's hard to deal with them separately. Therefore each characteristic in specific sustainability aspects cannot be set apart by case studies, so a certain criteria is needed that gives means of approach to how each factor of the case studies is described according to characteristics of sustainability. According to figure.4, key factors of sustainable office environment set in a triangle. The location of factors that related to specific sustainable characteristics can be used to decide the associated factors in the frame work. The different colors of the circle indicates that the cluster that has factors of cases, and implies characteristic of sustainability. For example, controlling indoor temperature using a green roof involves ecological issues but in this case more leans to economical sustainability. Because the major issues is a using green roof that contributes to the economical sustainability (energy saving) so this detail belongs to the economical sustainability cluster. Therefore the 'controlling indoor temperature using green roof' factor is placed in the economical sustainability part in frame work.

4.3 Case Analysis

According to the case study frame work, well established twenty cases of environment-friendly office environments around Japan, America and Europe were analyzed. Matsushita Electric Works Head Office is one of cases we've already investigate. It is given first prize form 2004 Japan green office. It substituted natural light and high efficient LED for large amount of interior lightings which saves energy and allow for easy adjustment. Also, it has a system for water reuse that comes from rainfall and foul water. There are strict rules in place for separate garbage collection, and energy is generated onsite using solar panels. Table 3 shows specific features of Matsushita Electric Works Head Office withinn the framework.

Table 3. Matsushita Electric Works Head Office analysis

Feature	Ecological Sustainability		Economic Sustainability		Social Sustainability				
	Regenerative	Conservative	Effective	Flexible	Needs-Sufficient	Reliable	Adequate	Equal	Convenient

-Setting solar panel	-Using decomposition system for food waste in cafeteria	-Water saving	-Physical and mental satisfaction through roof garden	-Condensed high technology
-Water reuse	-Optimized separate garbage collection	-Creating air convection through indraft of saved outdoor air, which promotes energy	-Satisfaction through high efficient natural light (Auto blind)	-Promoting optimal indoor environment through automation
-Using natural light		-High efficient LED		
Adjust indoor temperature				

The rest of the sustainable office environment cases were analyzed in the same way and all the notable factors were listed. Then, the factors were putted together according to ecological, economic and social sustainable aspects and the features were classified into each characteristic so they could belong to three aspects.

Table 4. Category of sustainability and main features based on case study

Category of Sustainability		Main feature of sustainability
Ecological Sustainability	Regenerative	Solar energy generation using roof top system Setting the solar panel on the outer wall of the whole building Using wind power and geothermal energy being compatible with temperature and territory Using fuel cell Generating energy using electric pressing tile Refraction of natural light rays in all indoor sides Reuse construction waste as a constructive material Optimizing natural light Using convection current efficiently, Reducing expenses of air-conditioning and heating equipment Reusing grey water that comes from rainfall and sewage purification Applying natural circulation cycle and adapting as semi-permanent use Applying LCA estimation and planning environment-friendly way to construction Considering natural circulation of industrial waste
	Conservative	Formation of greens such as the roof top garden and artificial stream where people can take a rest Minimize design, industrial process Using natural material such as stone and wood, decorating interior Making harmony with human and environment Planning energy system contributing reduction of CO2 emission Inflow of air Reducing food waste by using decomposition food facility Optimizing separate garbage collecting system Realizing ecology using remained space (Office garden, refresh corner, etc)
Economic Sustainability	Effective	Reducing power waste using triple-glazed windows and bounded light Using recycling resources, reducing cost Automatic diabatic ventilate control system Using LED lights Simple work process applying property of matters (Cutting, folding, inserting) Controlling indoor temperature using green roof Saving water resources using water saving equipment Energy saving using intelligent lighting system (Motion perception sensor) Applying alternative energy Utilizing midnight surplus electricity Modularized and unitized plan to construction helps to use space effectively Reducing the volume by minimum design Cutting down the cost through standardized mass production Easy to disjoint (Non-glueing) Saving personnel expenses Considering reuse of recycled material Convergence of various functions
	Flexible	Arbitrary use of space (Modularized and unitize system) Designing easy to supplement and removal Utilizing the way to apply by user themselves
Social Sustainability	Needs-Sufficient	Giving psychological satisfaction through people can practice environment-friendly way doing usual behavior Giving mental and physical satisfaction providing enough green tract of land in the building Combination of natural light and LED light Providing agreeable indoor air through indraft of outdoor air Giving attachment to user by designing user themselves
	Reliable	Condensed recent high technology satisfied safety and durability Planning unmanned automation system Using human harmless constructing material Stability of energy supplying
	Adequate	Applying land mark of local area Using local material Utilizing alternative energy based on local characteristic
	Equal	Considering universal design principles
	Convenient	Realizing universal design arranging the space between floors effectively Giving user experience related green tract of land in the building

This frame work developed by our sustainability model has purpose to make an exhaustive investigation of well-established sustainable office environments. Through this frame work of case study, a large amount of factors related office environment were identified. Based on this classification, several principles to design the sustainable office environment can be extracted. This principle can be summarized into 10 methods citing; ‘using alternative energy to save electricity’, ‘Establishing green spots such as artificial garden and stream in the building’, ‘Controlling indoor temperature using in draft of outdoor air and natural light’, ‘Saving water resources’, ‘Managing the industrial waste’, ‘Using environment-friendly material’, ‘Minimum planning and modularization’, ‘Providing stability and reliability in terms of technologies’, ‘Applying local characteristics to design’, ‘Realizing universal design’, which can be carried out in practical situations. But these methods imply factors of sustainability which are just spread out without any relationship between those. Looking into main features of sustainability (Table 4) and extracted 10 methods precisely, each aspect has different level of access so that it is formed a hierarchy based on three different kinds of sustainable aspects. In the case of economic sustainability, most features intend to provide ecological improvement by reducing cost effectively. Social sustainability contains the means that fulfill ecological sustainability to give satisfaction to the user by considering user centered direction. In other words, all the factors of different characteristic sustainability aim at

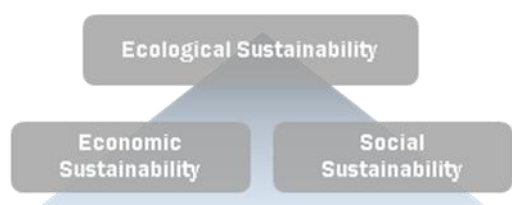


Figure.5 Hierarchy between sustainability constituent

developing ecological sustainability having different approach. In spite of that, the present office environment is just adressed ecological and economic aspects separately. Especially ‘Regenerative’ and ‘Effective’ categories show remarkable proportion rather than others through embodiment of alternative energy and electricity saving. Otherwise social

aspects are given relatively little importance. This means recent office environments lose the balance to achieve complete ecological sustainability. Table 5 shows the proportion of attention which is dedicated in each category and which aspects are concentrated though itemizing the main feature of sustainability.

Table 5. Category of sustainability where recent cases focus on

Aspects	Ecological Sustainability		Economic Sustainability		Social Sustainability				
	Regenerative	Conservative	Effective	Flexible	Needs-Sufficient	Reliable	Adequate	Equal	Convenient
Number of lists	24.6%	15.4%	27.7%	7.7%	9.2%	6.2%	4.6%	1.5%	3.1%

4.4 Emphasis on Social Sustainability

Previously mentioned, sustainable office environments intend to provide ecological sustainability while they satisfy social and economic approach. But social sustainability is not considered enough so that present sustainable office solutions do not succeed in a balanced way. From the social sustainability’s point of view, five sub-categories reflect user behavior and convenience that can be consequent on fundamental user satisfaction while other aspects focus on efficiency of system and physical material itself. In this section, in-depth interviews are discussed from people working with environmentally friendly buildings and building architects, it will help to signify the value of social sustainability.

4.4.1 Interview: Matsushita Electric Works Head Office Worker

The opinions from four workers related social sustainability that can cause human inconvenience could be obtained through our in-depth interviews. Practical office workers recognized cleanness and modernization of the building but it was only emphasized in the automation of energy saving aspects so that user cannot control

the system voluntarily. That means limitation to economize in all areas and causes lack of user basic satisfaction.

Table 6. Finding through in-depth interview with practical works

Aspects	Social Sustainability				
	Needs-Sufficient	Reliable	Adequate	Equal	Convenient
Opinion	Compatible way to energy saving with satisfying human needs	Weighting user's inconvenience lacking technological reliability allowing that energy expenses reduce though high technology based solution	Not only for showing, giving enough rest space to user considered human behavior practically	Giving alternative solution adapting user's motivation rather than emphasizing use of saving facility that isn't used well	Sublating excessive automation and giving flexibility and spontaneity to user when it needs

4.4.2 Interview: Developer of reconstruction Shiodome Area

The in-depth interview with Hara Hidenor, engineer of green building, who involved with Shiodome reconstruction committee. The interview was also analyzed with the developed frame work to find relevance to social sustainability. The interviewee admitted that office workers hardly recognized consisting technologies that don't appear the exterior of the buildings and claimed that the present sustainable office environment development process does not treat satisfaction of the user as a primary goal. He stressed role of industrial design to enhance existing technologies as applying affordance and software based design that actualize sustainability more effectively.

Table 7. Finding through in-depth interview with practical works

Aspects	Social Sustainability				
	Needs-Sufficient	Reliable	Adequate	Equal	Convenient
Opinion	Keep providing fundamental satisfaction to user instead of stressing green office itself	Possibility to adapt industrial design as enhancing present technologies. Industrial design do the role of conversion ideas through space arrangement and convergence of function	Allowing limitation of present technologies and leading user to participate actively to save resources through industrial design		Keeping the international standard of office environment, user has to abide kind of inconvenience

Present sustainable office environment was only emphasized an ecological and economical aspect which does not reflect the user's convenience in which a user could be isolated in the high technology dense context. For this situation, industrial design can be a solution to consider users involved in the sustainable office environment. Therefore we could conclude that the sustainable office environment has to be changed by reflecting a social sustainability direction, and the way to achieve this in the office environment has to be adapted by industrial design solutions. IDSA(CHI 2005 Development Consortium) officially defines that industrial designer's unique contribution places emphasis on those aspects of the product or system that relate most directly to human characteristics, needs and interests. This contribution requires specialized understanding of visual, tactile, safety and convenience criteria, with concern for the user. Education and experience in anticipating psychological, physiological and sociological factors that influence and are perceived by the user are essential aspects of industrial design. This means industrial design can provide a significant role in developing office sustainability that fulfills the human centered environment. Particularly social sustainability's subcategories, needs-sufficient, reliable, adequate, equal, convenient, can be satisfied by industrial design.

5. Improvement of Office Environment through Industrial Design

5.1 Sustainability Model Re-established

As the case studies stated above, the three sustainability aspects cannot be separated and they have to form combined structure. In this way, social sustainability has to be enforced by industrial design. However, present social sustainability is just a way to make user feel comfortable and give reliability regardless of other

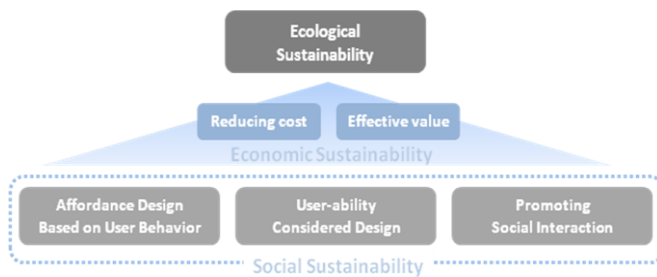


Figure.6 Sustainability model to develop office environment

major considerations; 1. Adapting usual human behavior to establish ecological sustainability, affordance design has to be provided. 2. Considering a user-ability system has to be designed. 3. The way to promote human interaction and raise social ability. Economic sustainability also has to be supported to establish. Figure 6 explains how office environment can accomplish ecological sustainability through the approach of social and economic aspects and industrial design can offer the important role in each process.

5.2 Consideration for Social Sustainability through Industrial Design

Three considerations based on social aspects to enhance ecological sustainability. In this section, we will discuss how these considerations can be applied in office environment through examining related cases and existing examples.

a. Affordance Design Based on User Behavior



Figure.7 The power tile in Franz Hass

Franz Hass Waffelmashchinenfaric in Wien uses power tile that can generate energy while people press the tiles as they walk. The generated electricity is not that significant, but it can be supplied where it needs effectively. The power tile can be set up where people often pass such as building lounge and main aisle. Applied technology is not developed well but it has a significant value that contributes sustainability by adapting people's behavior.

b. User-ability Centered Design



Figure.8 Fukuoka Nanakuma subway line

Fukuoka Nanakuma subway line follows universal design principles actively to give a satisfaction to users. Using different color to identify major facilities, setting the particular buttons, lighting, aisle for the disables can be the example of user-centered universal designs. As a result,

Nanakuma line became one of the most popular universal design cases and most successful public transportation systems in the world and it shows high use rate.

c. Promoting Social interaction



Figure 9. Sanyo Solar ark overall view

Sanyo Solar Ark is a large scale solar energy generating facility built by Sanyo. It has been applied recent solar related technologies and shows the highest efficiency in Japan. Generated energy from solar ark can be used in solar lab where can reduce electricity expenses considerably. It has another noticeable function that solar ark became landmark encourages city's outlook. In this way, internal office

workers obtain space to take rest while they enjoy the scenery. From the external residents and visitors points of view, they can have tourist attraction since solar ark acts as landmark.

Through researching these examples, applications of social sustainability in office environment have been identified and its characteristics help to promote ecological sustainability. Therefore the role of industrial design

for sustainable office environments with emphasis on the utilization of social sustainability has been shown to be significant and necessary.

6. Conclusion

In this study, the concept of 'sustainability' as the basic operation for following research was established primarily. As a result, a three-clause sustainability model was presented with human needs as a core and the clauses of ecology, economy and sociology. Based on sustainability model case study was conducted, and it could be identified that ecological, economic and social sustainability had a co-relationship. That means social sustainability was needed to fulfill the ecological sustainability since ecology could only be maintained by people, and had to be supported by economic means also. And, it is found that social sustainability can be satisfied by industrial design. The role of industrial design can be described as three considerations; Affordance design based on user behavior, User-ability centered design, Promoting social interaction between workers to restoring sustainable office environment. This perspective aims to fulfill basic human satisfaction that must be sought prior to unconditional technological application seeking efficiency.

Through this research, the role of industrial design can be indentified finally. It will contribute to make well balanced sustainable office environment. But the role of industrial design is not strong enough practically adapt present office environment situation. Therefore specific design guide lines and check list are needed that can be applied in the construction stage. In further research, investigation on how industrial design can be applied in social and economic sustainability deterministically according to ten methods that can be carried out in practical situations.

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