



Impact of Flexibility Principle on the Efficiency of Interior Design

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ABSTRACT

The flexibility in architectural design can solve the area problems and multi-use plan. It could provide many possibilities to change the shape and size of internal space in addition to the economic and social impacts on the housing system. The increasing of moving from the rural and suburban to the main city offset router by new and creative designs and experiences that seek to solve the problems associated with immigration, as these non-deliberate immigration led to make the city as a template of ice in the vicinity of hot water and cause the melting of this city and ending the efficiency of the economically live, housing and social. Because of these necessary needs, designers have started new and creative ideas to design skyscrapers and multi-storey buildings to cover the housing and economic needs. These solutions vary mechanism from one area to another mismatch of vertical buildings and uses them depends on the reduced space. This research studies the possibilities of flexible designs and the impact on the efficiency of interior design in addition to the using of integrated serves to get a creative and sustainable design to make our city more livable. The principles interior design of the housing unit has a significant effect in increasing or decreasing economic and housing building. In this paper the principle of flexibility design is studied in two line: line 1: Flixibility plan (space, wall, floor, ceiling), and line 2: Flixibility details (furniture).

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1. Introduction

Livability depends on how sufficient services, energy and enough area for every person in addition to economics that considered the most important factor that helps immigration from city to suburbs and makes unbalanced budgets. But at the same time people stay connected with the cities by workplace, as an example; in Iraq, we considered low cost housing is the best solution for this problem as we can build low initial cost housing with less areas 100-250 square meters, but the problem of selecting building sites stills as the most of housing facilities locates at suburbs which helps leaving the mother city and as a result that will increase transportation costs. So, people invented other odd solutions by dividing the plot area for building as some reaches lower than 50 square meters for each housing unit with very low living spaces efficiency. This paper will study how to find optimum methods for reaching an economic, functional, psychic and aesthetic efficiency in a small area spaces by using flexibility principles, which makes the city a livable place. Flexibility also helps finding new architectural solutions to get the maximum benefits and functional use of small areas.

Flexibility is one of the physical properties of materials and geometrical forms used in interior design, that property depends on the physical shape in addition to its compositional and other structural properties, so that repetition, balance, similarity can be used for making flexible space, which means that we can use that geometrical properties in order to gain a flexible space that can be transformable and multi-uses in the same plot area.

The social and environmental pollution is the main reason why people emigrate from rural areas to main cities in addition to living cost at city as compared with the suburbs. And that's what makes the study of possibilities of making the city a place that able to live properly by using all designable means that connected directly with people and society life is very necessary. This is the reason why we must study environment surrounds people starting with living space and then the whole city space. Some architectural engineers apply several means to reach flexibility in the designed space, which used in the whole composite, detail levels and relationship between them depending on flexible structure that shapes space and the possibilities of changing it as needing to, with the furniture flexibilities and possibilities of its arrangement and transforming an additional to use some forms that allow free formations.

There are several principles of geometrical designs that are using flexibility and the flexibility assisting properties as basics for thoughts and these are under three main points:

1.1 Flexibility in Vertical Partitions

Some designers used vertical partitions that are movable and reshaping space for aesthetic, functional and economical uses in the same time in order to make best and maximum use of plot area that responds increasing peoples' needs.

1.2 Flexibility in Horizontal Planes and Levels

Flexibility in horizontal planes and levels is used for getting appropriate interior spaces that responds people demands, so that it makes possible to control space levels and the economical efficiency that reached from responding multiple needs in the same space as it reduces demanded plot area. As we can use vertical partitions and horizontal planes and levels flexibilities together, as we can change the vertical partition to horizontal one and verse versa, to reach maximum flexibility at minimum space and materials.

1.3 Flexibility in Furniture

This term is used for describing nowadays furniture as a physical property of furniture itself, so as a chair can be converted to a bed or table... etc.. Despite of that, there is another design ideas that depends on the relationship between furniture and space so that (as an example) the bed can be hide into a wall or ground, or raise it to the ceiling to be part of design, as well as, the furniture can have some shape properties that add another type of flexibility which gained from repeating the furniture piece with changing the arrangement or adding other pieces without decreasing the aesthetic and functional efficiency of space (Figure 1).

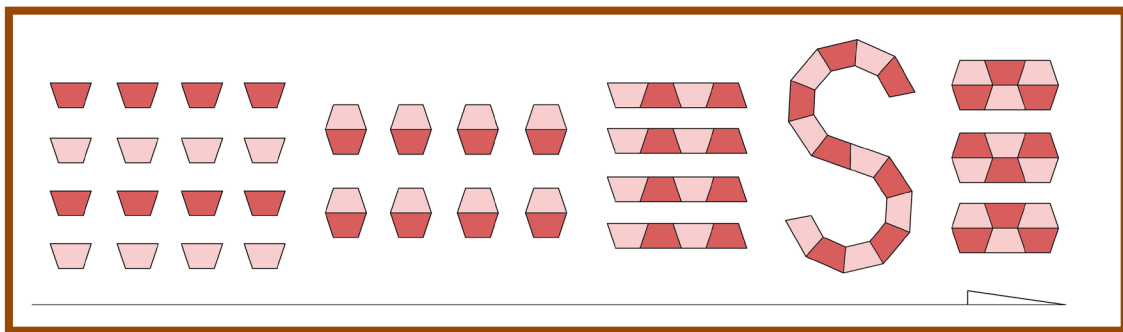


Figure 1: Flexible used on tables in the classroom.

2. Litterateur Review

There are a lot of geometrical and artistic studies that focused on several geometrical shape properties in interior design, with tat properties we can produce many interior spaces that have an aesthetic, functional and economical functions at the same time.

Some of these studies suggested that interior design depends on client rules and demands (functional, psychic and aesthetic), at the first place we can reach the appropriate space for people with the structure as it is an interactive process between designer and user (Silverstein & Lorinda, 1993). Using shape construction principles is necessary in interior design because space perception and sense depend on it, as some studies mentioned that balance and scale as basic principles in interior and furniture design that is the shape balance lead to a better space perception in addition to better abilities to reach functional demand (Qasim, 2005). Some other studies focused on space form and how its composite and its generation fundamentals which should be depended on aesthetic sense and imagination, and information process from user to designer must be clear so that is design reaches the client demand of design (Silverstein & Lorinda, 1993). Good design cannot be produced if it didn't reach client psychic, expressive and aesthetic demands in addition to function which is designed for in order to get comfortable, moving flow, good seeing and needs of thermal comfort (Qasim, 2005).

2.1 Environmental Basic Parts System

Interior design process is an innovative process of an object or idea and putting it functionally in our life, Interior design locates in the bigger field which is the environmental design, and this environmental system has two basic parts as referred by Environment design Research Association (EDRA):

Physical Environment: this can be measured and described by visual in real like thermal and dimensional. etc.

Spatial Environment: This can be aware and measured by size, number, type and shape in addition to aesthetic and formal relationships which connect it.

2.2 Element of Design and Form

Studying form and its relationship with space is so important because the elements are organized in groups and do not act as parts in space, but they define space that could be percept through several relationships as (Qasim, 2005):

Shape and Background: The contrast between shape and background leads to strength form and can be considered a unique form in space, contrast case gives shape legibility, importance and identity within the space.

Continuity: Continuous relations between elements through keeping same shape, colour,

texture & pattern.

Sequences: Continuity of organized elements perception within space and ensure that any change will not cause any cut but increase effects and intense space.

Repetition: A kind of sequence that can achieved by repeating an element and gives more flexibility to space, repetition does not condition to be in shape and structure of interior space but can be in furniture and additional elements in space.

Rhythm: Sequence of repeated elements in certain periods within one composition.

Dominance: Giving more importance to one element within space, that can be possible by increasing size or selecting a focus point, etc.

Similarity: The repetition of one element around a point or axis, similarity provides order and legibility for elements that it contains and ease its perception.

Proportion: Proportion is one of the most properties that used in interior and exterior design and it is the basic reason that effects of form shapeliness perception, the relation between human and space proportion makes the space more efficient (M. & M, 2008). Using Modular in design helps space to be more flexible and that causes easier and faster modelling and arrangement possibility of space.

There is many definitions for proportion; some of them defined ratio as numeric quantities shapes mathematical relation between two objects or more among whole group parts, and the fracture formula used for expressing ratio like the ratio of length to width of rectangle, proportion in architecture is the consistency of architectural form dimensions and architectural elements among each other and between them and the whole architectural composition, proportion linked by functional, aesthetic and structural sides of architectural form as it helps of presenting the building certain architectural character and its compositional structure. And it is a process aimed adjustment and balancing architectural composition by certain principles. At the beginning of architectural interactive architect usually can not adjust proportion directly as he proceed the general logical composition counting on his experience and aesthetic sense then comes the adjustment of proportion and balancing the composition an advanced stage (Ching & Binggeli, 2012).

2.3 Interior space and livable

Some studies suggest that the main reason of reversed immigration from rural areas to cities is the environmental and social pollution in addition to economical cost in the city as compared with suburbs, which makes the study the possibilities of making the city a livable place is a basic priority (Philips, 2010).

The study of (Newman, 1999) (role in delivering city live ability) refers that one of the sustainability fundamentals is flexibility and variety, and the main standards of sustainability are: capacity, fitness, resilience, diversity, and balance. (Newman, 1999).

There are variables related to sustainability, including the flexible shape of the building and has the following characteristics: Scalability, modification and adaptation of functional variables, the possibility of multiple use and saving on space and energy, compacted the building for more than one function with less size, and consolidation method that allows for flexibility in services and a reduction in operating costs. There are many examples of using the principle of flexibility to achieve sustainability, as in the windows for BMS building which can opened a two-way and high levels of adoption of natural ventilation. The roof has also been used in the interior design waveform to be interacting with cooling services in order to integrate the methods of ventilation and avoid problems as well as the impact of audio waveform in increasing the capacity of space in addition to aesthetically sense. Aggregates of cooling and heating pipes was also used in the division office spaces in this building, In addition to the use of hollow glass tubes containing a water chute is working to isolate and divide spaces, and in this case, it's used as functional object and interior element in addition to achieve sustainability because the recycled water is the same water-cooling and heating.

In another study Ecological buildings, it means the internal environment of health as it is used less energy as possible for the air conditioning systems and cooling to achieve energy efficiency and systems operation and maintenance, services and events, either the types of the construction materials indicate the study to the importance that the materials are good quality to reduce the destruction of the internal environment, some studies have indicated that good design is tested by use of space efficiency standards, regulations and construction technology as well as the symbolic and its relationship with the beauty of the design, either environmental form is a relationship between the formal design process Active in climatic terms (Hui, 2002). The environmental form is a relationship between the formal design process Active in climatic terms (Hui, 2002). The relationship must be flexible as to achieve sustainability linked to green

building standards, which depend on reducing energy and environmental pollutants used in addition to the conservation of non-renewable energy, which could be achieved through flexible space as in which you can achieve energy savings and space (Edwards, 2001).

The study discussed the Theo Van Doesburg, a founder of "De Stijl" ideology who expresses his theories in a paper titled "toward a flexible architecture" as follows; "Modern architecture is an open one. A unique space constitutes the whole house that is partitioned according to required application and performance. Such partitioning takes place through internal divider walls and external supporting ones. The former divide the house space in accordance with performance and application which could be portable (in contrast to traditional dividing walls), that is such walls could be designed in a way that frames and handy plates could be replaced" (Emamgholi, 2011).

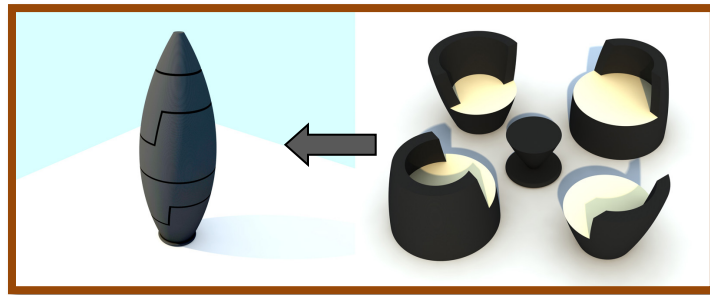


Figure 2: Using Flexibility in furniture design.

Some of studies pointed to the residential complex, which designed by Mies van der Rohe that the interior walls can move to change the interior space as the owner wants – rooms without door between it to keep the area for each person (Poldma, 2013). By trying to create the perfect flexible space, there are many problems with the cost and functional properties because each designer creates his flexible space without a serious study for the cost and efficiency of space. In the first time flexible building design without a real method, but at this time there are so many methods to create flexible space and depended on the new material and technology method (Poldma, 2013). There two kinds of using flexibility to create a multi-used space – the first one is used with furniture (Figure 2), and the second is used with building construction like wall and floor, each has many branches as the researchers mentions. Maximum & optimum utilization of the interior space require the flexible design of furniture in the space as combined. Many furniture pieces are designed using folding patterns or drawer included with mechanical or electrical features and this furniture can make from the interior space maximum efficiency takes place through ergonomic and human fitness (Emamgholi, 2011).

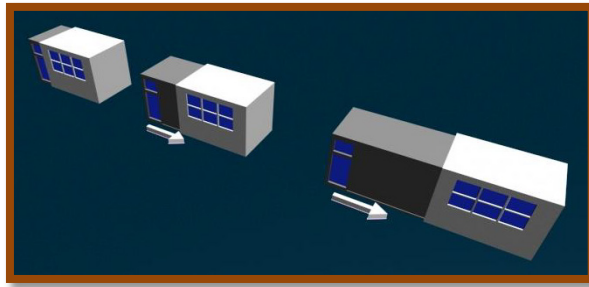


Figure 3: Idea of flexible structure and volume.

Other studies pointed on the properties of flexibility which were used in most flexible building and its idea. There are many properties for flexibility, but the most five used are: assembling and disassembling, folding and unfolding, adapting, combining, transporting, wearing, and carrying. Figure 3 shows idea of flexible structure and volume.

3. Conclusion from previous studies and identify element research

After reviewing the previous studies, some of which are concentrated form and flexibility, and some flexibility in general, and others of the importance of sustainability and the ability to adapt and livable. Studies show that there is a strong relationship between flexibility and structural characteristics of the form as well as the relationship between sustainability and form and function. As studies indicated the possibility of achieving flexibility through using of formal characteristics as follows:

3.1 Repetition

There are three levels (partial, whole, both) and in contain three main variables as follows:

Type of Repetition: As the previous studies there are two type the first one is Linear repetition (horizontal X, Y and Vertical Z) and the second one is Central repetition (round point, radiant).

Repetition's Method: Involving transformation in shape, size or direction.

Ratio of Obviousness: Sometimes using repetitions in interior design lead to monotony, so the architect makes the repetition unclear to cover the monotony which causes of lost the repetition properties.

3.2 Proportion and Scale

It's considered from the important geometric characters which related to flexibility. As the

adoption of non-standard ratios in the design of interior space leads to a wrong perception of space in addition to the difficulty of performing the function. It can make the space more flexibility through the adoption of measures to achieve a good fit for space and greater flexibility. This involves three variables (numerical, fractional, and with scale).

3.3 Axiality

The Axiality property has a real impact on applying flexibility, as it depends on the type of the increase in axial space or repetition in design elements without affecting the perception of form efficient functions, but could have a positive impact, and axial types are: linear, radical, point, and interaction (Ching & Binggeli, 2012), *see* Figure 4.

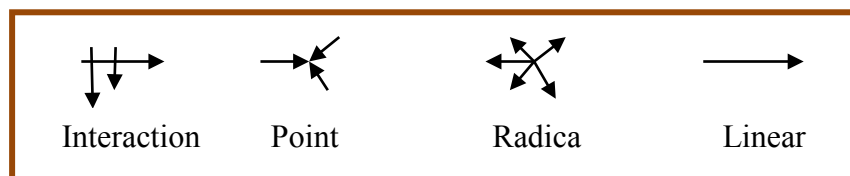


Figure 4: Types of Axiality.

3.4 Flexibility

The studies, which focused on the concept of flexibility can be the conclusion of some vocabulary which is on three levels (Partial, Whole, Both), which are two main types.

Furniture and flexibility are divided into (flexible furniture, flexible furniture with anthers, flexible furniture with the structure of space) and its impact on the aesthetics of the interior space. Flexible structure is divided into (horizontal flexible, vertical flexibility, flexibility in both directions) and its impact on the aesthetics of the interior space. Michael Hollander designed room with movable levels in New York in 1970 which considered from the first applicable idea. Another early idea was applied in residential building near Osaka around 16th-17th century by Shigeru Ban which named “Curtain Wall House”. (Jones, 2001)

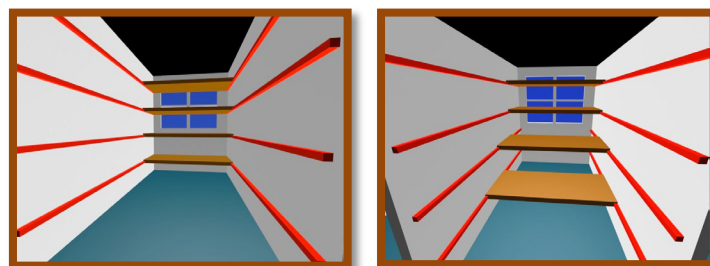


Figure 5: The figure shows flexible level within one space.

3.5 Sustainability variables

Studies on the efficiency of space and the and sustainability can use the following variables:

- Area savings.
- Size savings.
- Ability to adapt at using the space.
- Materials savings.
- Energy savings.
- Division and increasing portability.

Selecting the variable form is designed to measure the variables.

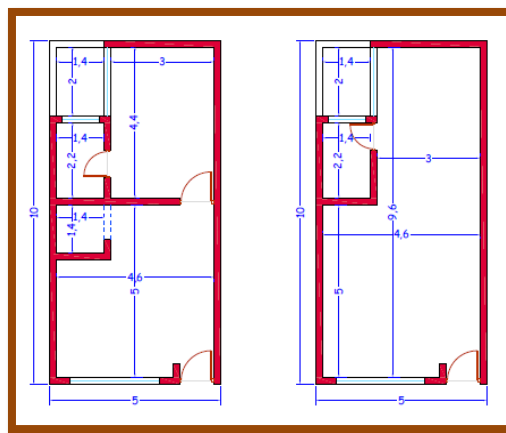


Figure 6: Basic model of the housing unit.

4. Practical Study

After selecting the variable related with the flexibility and livability in cities, one models of housing in the city of Mosul-northern Iraq was selected, As the value of land is too high, residents in the city were able to find individual solutions in the residential land use, They divide the land into more than one section, in some areas to 50 square meters for residential unit, But with low efficiency in terms of spaces and functional, aesthetic and economic Different dimensions proportional, In this paper, the adoption of the shape of a rectangle with proportionality 1 to 2 and an area 50 m^2 ($5 \text{ m} \times 10 \text{ m}$), using the variable resulting from previous studies had been producing alternatives design depends on the flexibility and as a form of measurement, as shown in Figure 6. Because of the large number of measurement table will be the inclusion of a single model for each case.

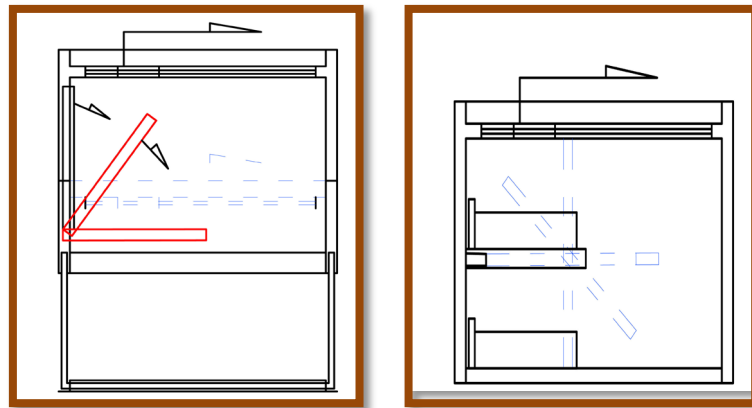


Figure 7: Furniture and space can transform as the functions.



Figure 8: Different models of 10m X 5m area.

This work attempts to find the best strategy of a compact space design but with full efficiency in term of economic and functionality performance of the building. Plan and sections of Figures 7 and 8 shows some samples of 10m x 5m area designed by using the element of flexible space.

Table 1: Measurement form variables for sample A1.

Sample No.		A1				
Main Variable		Secondary variables		Partial level	Whole level	Both
X1	Repetition	Repetitions type	Linear	Horizontal		
				Vertical		
			Central	Around point		
				Radiant		
		Repetitions method	With transformation	In shape		
				In size		
			In direction			
		Without transformation				
Ratio of obviousness	Clear					
	Medium clear					
	Unclear					
X2	Proportion & scale	Numerical				
		Fractional				
		With scale				
X3	Axiality	Linear				
		Radial				
		Point				
		Interaction				
X4	Flexibility	Flexibility types	Furniture	Furniture self		
				Furniture with anthers		
				Furniture with space		
		Structure	Horizontal			
			Vertical			
			Both			
		Method		Transformations		
		Flexibility in material				
X5	Space efficiency	Area savings				
		Size savings				
		Ability to adapt at using the space				
		Materials savings				
		Energy savings				
		Division and increasing portability				

Table 1 is to measure the efficiency in term of economic and functionality performance of sample A1 which designed by fix structures and furniture, to make comparative process with other samples that depended on flexibility in its design. The table contained the main variables which found out from previous studies.

Table 2: Measurement form variables for sample B1.

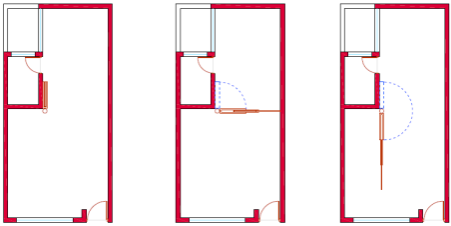
Sample No.		B1					
Main Variable		Secondary variables		Partial level	Whole level	Both	
X1	Repetition	Repetitions type	Linear	Horizontal			
				Vertical			
			Central	Around point			
				Radiant			
		Repetitions method	With transformation	In shape			
				In size			
				In direction			
		Without transformation					
		Ratio of obviousness	Clear				
			Medium clear				
Unclear							
X2	Proportion & scale	Numerical					
		Fractional					
		With scale					
X3	Axiality	Linear					
		Radial					
		Point					
		Interaction					
X4	Flexibility	Flexibility types	Furniture	Furniture self			
				Furniture with anthers			
				Furniture with space			
		Structure	Horizontal				
			Vertical				
			Both				
Method		Transformations					
		Flexibility in material					
X5	Space efficiency	Area savings					
		Size savings					
		Ability to adapt at using the space					
		Materials savings					
		Energy savings					
		Division and increasing portability					

Table 2 also is to measure the efficiency in term of economic and functionality performance of sample B1 which designed with flexible partitions only. The measurement process included the possibility models from this sample after editing the flexible partitions.

Table 3: Measurement form variables for sample B2.


Sample No.		B2				
Main Variable		Secondary variables		Partial level	Whole level	Both
X1	Repetition	Repetitions type	Linear	Horizontal		
				Vertical		
			Central	Around point		
				Radiant		
		Repetitions method	With transformation	In shape		
				In size		
			In direction			
		Without transformation				
Ratio of obviousness	Clear					
	Medium clear					
	Unclear					
X2	Proportion & scale	Numerical				
		Fractional				
		With scale				
X3	Axiality	Linear				
		Radial				
		Point				
		Interaction				
X4	Flexibility	Flexibility types	Furniture	Furniture self		
				Furniture with anthers		
				Furniture with space		
		Structure	Horizontal			
			Vertical			
			Both			
Method	Transformations					
	Flexibility in material					
X5	Space efficiency	Area savings				
		Size savings				
		Ability to adapt at using the space				
		Materials savings				
		Energy savings				
		Division and increasing portability				

Table 3 is to measure the efficiency in term of economic and functionality performance according to the main variables which were found out from previous studies, to test sample B2 and the possibility models for the same sample which contained furniture that designed with flexible principles moreover flexibility in furniture positions.

Table 4: Measurement form variables for sample B3.

Sample No.		B3					
Main Variable		Secondary variables		Partial level	Whole level	Both	
X1	Repetition	Repetitions type	Linear	Horizontal			
				Vertical			
			Central	Around point			
				Radiant			
		Repetitions method	With transformation	In shape			
				In size			
			In direction				
		Without transformation					
Ratio of obviousness	Clear						
	Medium clear						
	Unclear						
X2	Proportion & scale	Numerical					
		Fractional					
		With scale					
X3	Axiality	Linear					
		Radial					
		Point					
		Interaction					
X4	Flexibility	Flexibility types	Furniture	Furniture self			
				Furniture with anthers			
				Furniture with space			
		Structure	Horizontal				
			Vertical				
			Both				
		Method	Transformations				
Flexibility in material							
X5	Space efficiency	Area savings					
		Size savings					
		Ability to adapt at using the space					
		Materials savings					
		Energy savings					
		Division and increasing portability					

Table 4 measures the efficiency in term of economic and functionality performance according to the main variables learnt from previous studies, to test sample B3 and the possibility models for the same sample which depended its design on flexibility principles for

partitions and furniture , sample B3 is a mix situation form sample B2 and B1.

5. Results

After completing the practical study that measured efficiency designs and functional requirements and residential and measuring the economic efficiency solutions, has been found that the use of flexibility in planning and details (B-3, Table 4) leads to savings in space and costs dramatically with the efficiency to meet the functional need in ratio 76% by comparative with the other samples. The models B-2 (Table 3) and B-1 (Table 2) are incompetent, but also by 53% for model B-3 (Table 4). Diagram 1, the results showed that the model A1 was the least efficient, while model B3 gives highest efficiency element. This design makes a city more livable and sustainable, we can conclude that the small detail in design like furniture and the integrating of design are the important element in developing the life in our cities.

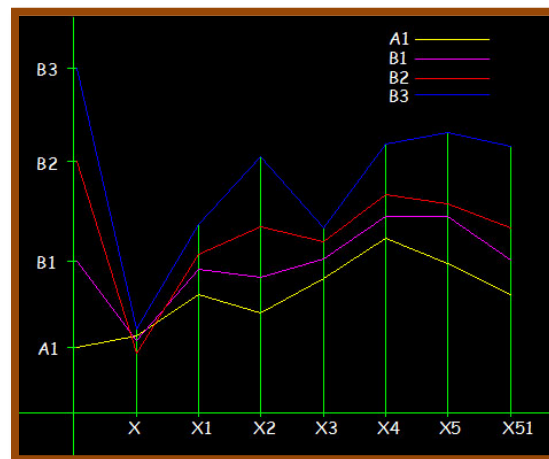


Diagram 1: Efficiency element four models.

6. Conclusion

Using flexibility in interior design offers many functional and formal alternatives which can help to increasing livability in city and reduce the reverse migration, The use of the principle of flexibility and shape properties In furniture design and space structure to achieve efficiency in the exploitation of horizontal space in addition to the space size efficiency and the adoption of flexibility in the floors and recoverable levels of movement and expansion, The use of modern techniques in furniture manufacturing self flexibility provides efficient economic and space as the use of the same furniture for more than one function it helps to sustain the internal space and thus bring us scalability more to live in cities, these cities that use this style of designs related to the concepts of sustainability space which is considered the most important criteria (capacity, fitness, resilience, diversity, and balance)(Newman, 1999).

The ability to live in cities depends on the efficiency of a smaller space in the city (interior design for living space) and also depends design method based on sustainability criteria and flexibility in order to be economically efficient space and aesthetic, this help a citizen to live inside the city and thus keep cities alive.

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