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The Impact of Applying Environmental Sustainability Standards and Symbolism of Formation in Museums: Proposed Evaluation Model

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Keywords
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Museum formation
Signification
Symbolism
Environmental sustainability.

Abstract

The museum is a building with a distinctive visual mass, which must have its own symbolism that expresses society and content, In addition, the museum must consider the global trend in applying sustainability standards. In this research, the question is about the possibility of achieving an evaluation model that can be made to measure the impact of applying environmental sustainability and symbolism of formation in museums. Three steps were taken to discuss this question: The first step was to identify the elements and characteristics of formation in museums, the principles of environmental sustainability, then the types and elements of symbolism. The second step was to study the effect of sustainability and symbolism on the elements of formation in museums. From the previous two steps, an evaluation model was proposed to measure the impact of applying environmental sustainability and symbolism of formation in museums. The third step was to test the evaluation model by using it to analyze some international museum samples that have obtained a certificate from one of the global sustainability systems. Finally, the research has proven that an evaluation model can be made to measure the impact of environmental sustainability and symbolism of formation in museums.

1. Introduction

The main role of museums is to spread culture, artistic awareness, and knowledge for everybody. Also, to maintain cultural community resources for present generation and future generations. The formation of museums has a symbolic value that reflects the community and the content and provides a healthy, sustainable environment for visitors, and preserves the contents at the same time.
The objective of this research is how to How to measure the impact of environmental sustainability and symbolism on the formation of museums.

1.1. Research problem:

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By reviewing the literature on this topic in global search engines such as International Council of Museums (ICOM), Molecular Diversity Preservation International (MDPI), ScienceDirect.com, and.researchgate.net. They have studied the effect of sustainability or symbolism on the formation of museums in a separate way. And there is no study to evaluate their combined effect on the formation of museums.

1.2 The objective of the research:

Proposing an evaluation model to measure the impact of sustainability and symbolism of formation in museums, this is carried out by:

- Studying the impact of symbolism on the formation of museums and their different types.
- Studying the different methods that achieve sustainability in museums.
- Proving the validity of the evaluation model through the analytical study.

2. Museums

The museum is a non-profit building, which displays everything related to man and his environment with the aim of preservation, study, and education [1].

2.1 Classification of museums:

Museums, as shown in Figure (1), can be classified into two types[2]:

a. Open museums: Archaeological, historical, and natural sites.
b. Built museums: scientific centers, old buildings that have become museums, modern buildings designed to serve as a museum.

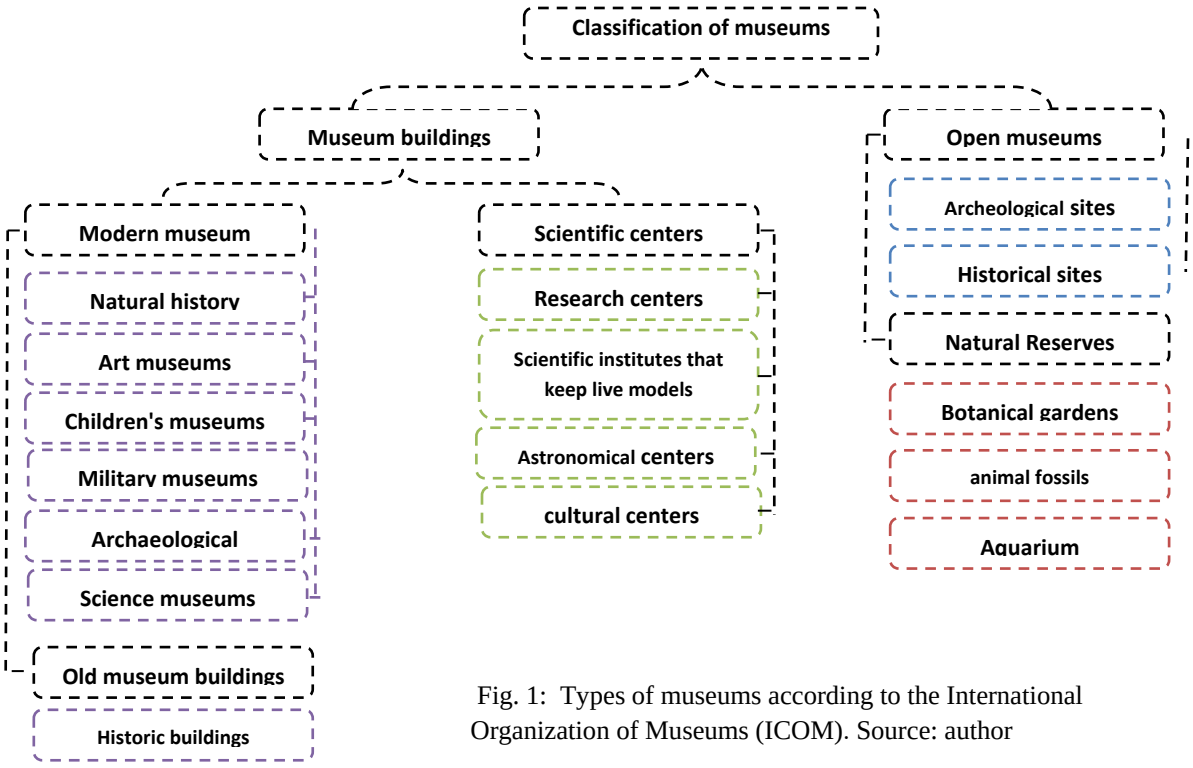


Fig. 1: Types of museums according to the International Organization of Museums (ICOM). Source: author

3. Formation in museums:

There are three main elements of formation in museums as Shawn in figure (2):

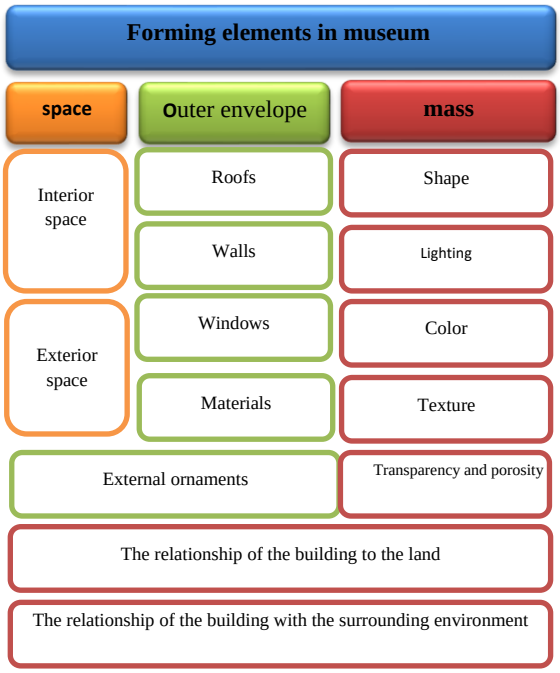


Fig. 2: Elements of museum form.
Source: author

3.1 Mass

It is the main element through which the architectural work and its visual characteristics are perceived the main characteristics of the mass are (shape - color - texture - transparency and porosity - lighting)[3].

3.2 Outer skin

They are the architectural elements that envelop the mass and do not affect its general formation like (roof – walls – windows – materials – External ornaments) [4].

3.3 Space

The space is divided into two types[5]:

- Interior space: it is inside the building which is determined by its components (walls - ceilings - floors) and the required psychological effect in each space separately.
- Exterior space: it is the void that forms with the building externally through the elements of space, the effect of the external space varies according to the degree of enclosure of the building and the nature of the surrounding environment.

4. Sustainability in museums

The goal of applying sustainability in museums is to provide a suitable and healthy environment for building users. The idea of green museums that integrate sustainability concepts into design has spread throughout the world.

Sustainable principles consist of four pillars:
(Human, social, environmental, and economic sustainability) however, this paper is concerned with the environmental aspect that preserves the biological diversity of the local environment, whether living or extinct[6].

4.1. Standards of environmental sustainability for museums

Standards of environmental sustainability consist of [7]:

- Site sustainability: Which is done by considering (general site planning - impact on environmental systems - means of transportation - site coordination).
- Effectiveness and efficiency of resources and materials: Through the use of materials that preserve the museum's content and human health and have the characteristic of sustainability and to benefit from local resources.
- Efficient use of water resources: By rationalizing water consumption and recycling for reuse.
- Effectiveness and efficiency of energy sources: This is done through (estimating energy consumption - energy efficiency - benefiting from renewable energy).
- Efficiency and improvement of the internal environment: This is done by considering (natural ventilation - natural and artificial lighting - thermal efficiency - shape and orientation).

4.2. The impact of sustainability on the formation of museums

The architectural formation contributes to supporting elements of environmental sustainability in each of its three elements, figure (3).

4.2.1 The impact of the sustainability of the site on the formation

- In terms of mass: The mass formation must consider the environmental and cultural influence and the general character of the site.
- In terms of the outer envelope: In the mass, the orientation is taken into account to make the best use of natural lighting and ventilation, while maintaining the visual extension with the building's surround.
- In terms of space: Where it considers the design of the external space with mass, reducing heat islands and creating an external space that takes advantage of the surrounding environment and works to create a comfortable internal environment[8].

4.2.2 The impact of materials and resources efficiency on formation

- The impact appears on the vocabulary of the façade skin in terms of the use of building materials that have little heat permeability with the use of thermal insulation, local and natural materials that have the characteristic of sustainability[9].

4.2.3 The impact of the efficient use of water resources on the formation

- By reducing water consumption and benefiting from rainwater and recycling wastewater for use in irrigation, the effect of this on the formation is shown through the design of green walls and

ceilings, also the technology that is used in the outer envelope to receive rainwater, which affects the orientation and shape of the building[10].

4.2.4 The impact of energy conservation on formation

- In terms of mass: The use of formation elements that contribute to achieving thermal comfort in a natural way.
- In terms of the outer envelope: It often uses the idea of double facades and modern technology to benefit from energy production from its renewable sources (sun - wind).
- in terms of space: The external space must interact with the building to produce different pressure areas that allow air movement and reduce reflection around the building to reduce the effect of radiation on the building's heat.

It also considers the work of open internal spaces to perform the same function[11].

4.2.5 The impact of improving the internal environment on formation.

- In terms of mass: The use of formations that reduce the rate of exposure to solar radiation and allow the movement of air that softens the mass surrounding.
- In terms of the outer envelope: Ceilings are exposed to sunlight, so materials and formations must be used in the ceiling that reduces the rate of permeability.

The walls are exposed to solar radiation in addition to reflected rays and hot air, so materials must be used to reduce permeability and increase the shading rate in the walls. Windows should be designed to reduce energy consumption while maintaining internal heat and achieving adequate natural lighting and ventilation.

- In terms of space: Climatic factors such as sound and light affect the distribution of interior spaces in terms of the required level of sound and lighting.

Each space in the museum needs an environment with a different temperature, light and sound level, so the internal spaces differ in the same building[12].

5. Symbolism in architecture:

One of the most important definitions of architecture by Charles Jenks is “It is the use of formal indications (materials - emptiness - openings ... etc.) to explain and indicate the meanings of life (values - culture - .... etc.) With the use of some tools (constructivism - economic ... etc.) [13].
Symbolism in architecture can be defined as the use of architectural forms that touch human emotions and feelings internally and externally[14].

5.1 Elements of Symbolism in Architecture

- Meaning (idea - content): It is what the recipient realizes by understanding the implicit concept targeted in the architectural work.

And is divided into:

a. Semantic meaning: The physical properties of matter.
b. Direct meaning: The forms that are placed in the building to indicate a specific meaning.
c. Implicit meaning: The non-explicit meaning that the visitor feels from shape of the building.

Among the factors that help to change and confirm the meaning (time - culture - technology - environment - system of government)

- Symbol (signifier-shaping tool): It is the physical visual tool that expresses the meaning to be conveyed to the recipient[18].

China Folklore Museum- The impact of materials and resources Efficiency [15]

Louvre Museum - Abu Dhabi[16]
The impact of improving the internal environment& energy conservation

Los Angles Museum of the Holocaust [17]
Sustainability of the site - The impact of the efficient use of water resources

Fig.3: The impact of sustainability on the formation elements conservation

5.2 Types of Symbolism in Museums

Types of symbolism in museums are divided into two main types as shown in Figure (4) [19].

5.2.1 Direct Symbolism

It is a symbolic figure that any recipient can perceive, like the minaret expressing the Mosque. Among its types are environmental (natural- cosmic), biological (plant, animal), and historical symbolism.

5.2.2 Indirect Symbolism

It relies on the architect's own vision to convey the idea without using a heritage or historical meaning such as ideological symbolism, or by integrating different symbols to convey a holistic meaning, or through abstraction in shaping the building to convey a specific meaning by provoking the recipient to think and imagine.

5.3 The impact of symbolism on the formation elements:

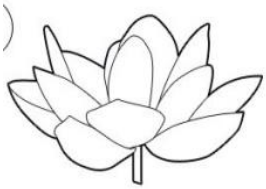
Expression in architecture (symbol and meaning) is considered along with the Formative side, which gives an emotional effect to the recipient, and the effect on symbolism on formation is in one or more elements of the form. Figure (5) [22].

5.3.1 The impact of symbolism on mass

One example of the most important elements that symbolically affects the recipient, is mass and its proximity to the ground symbolizes stability and strength, while distance from the ground symbolizes weakness and instability.

Another example, central shapes symbolize balance and control, while linear shapes symbolize movement and extension...etc., Also the culture of the place affects the mass formation of the museum.

Holocaust Museum Berlin [20]- an indirect symbolism from the idea of suffering.



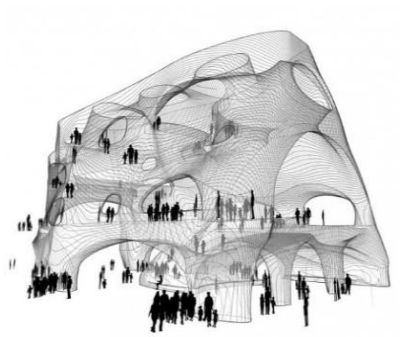
Singapore Museum of Science and Art [21]– direct symbolism from the lotus flower

Fig. 4: Types of symbolism in museums

5.3.2 The impact of outer envelope

- The effect of facades' details is related to the culture of the recipient, as each element has a significant impact on it, such as:

San Francisco Museum of Modern Art
The impact of outer envelope[23]
Horizontal moving lines symbolize the fog spreading in the city



Natural History Museum extension in New York[24]
Symbolism in mass and inner space - the use of organic shapes to express caves

Heydar Aliyev Center Azerbaijan[25]
Symbolism in mass, space and inner space – by the use of smooth shapes with white color to express Stillness and peace, A visual connection between the inner and outer space

Fig. 5: The impact of symbolism on the formation elements conservation

- The walls express security and separation if they are solid, and express freedom and expansion if they are glass.

- Windows express comfort and transparency if they are wide, while they express ambiguity and insecurity if they are narrow.
- The texture of natural materials such as wood gives a sense of warmth and connection to nature, while industrial materials such as zinc panels give changing sensations according to the angle of view and time.

5.3.3 The impact on space

The relationship between the mass and the void is affected by the inspiration to be reached (homogeneity or contrast - wideness or narrowness - the degree of communication between inner and outer space).

6. Suggesting an evaluation model to measure the impact of environmental sustainability and symbolism of formation in museums:

Through the research, the elements indicating the impact of sustainability and symbolism in the formation of museums were identified as shown in table (1).

Table (1) A proposed evaluation model for the impact of sustainability and the symbolism of formation in museums (source: author)

elments of formation					mass	symbolism	sustainability	outer envelope	symbolism	sustainability	space	symbolism	sustainability	project dat
					shape			roof			interior space			
					color			walls						
					texture			windows			exterior space			
					tranparency and porosity			materials						
					light			External ornaments						
					mass and land relationship									
symbolism	types of symbolism	reigion			***			***			***			
		merge												
		historical												
		environmental	natural											
			universe											
			Sophisticated universe											
		biological	plants											
			animal											
	elements of symbolism	meaning levels	Direct											
			implicit											
			Semantic											
		symbol express meaning												
Standards of environmental sustainability	Site sustainability				***			***			***			
	Effectiveness and efficiency of resources and materials				***			***			***			
	Efficient use of water resources				***			***			***			
	Effectiveness and efficiency of energy sources				***			***			***			
	Efficiency and improvement of the internal environment				***			***			***			
total				54	18			18			18			
mesurement points	x nothing	* weak	** medium	*** stronge										

- Form elements: mass – outer envelope – space.
- Elements of symbolism: type of symbolism – elements of Symbolism (meaning- symbol).

- Elements of sustainability: Site sustainability- Effectiveness and efficiency of resources and materials- Efficient use of water resources- Effectiveness and efficiency of energy sources- Efficiency and improvement of the internal environment

This section of the paper proposes an evaluation model that ensures a balanced relationship between symbolism in formation and environmental sustainability standards in museums. The implications of this evaluation model are:

- Evaluating projects during the design phase to identify weaknesses that must be taken care of in order to reach an ideal design that takes into account symbolism in formation and the standards of sustainability in museums.
- Evaluation of existing museum projects in terms of applying symbolism in formation and sustainability criteria, and standing on strengths and weaknesses.

The proposed model consists of 18 main measurement points, the evaluation is based on four values: 0 no effect - 1 weak effect - 2 medium effect – 3 strong effects, for this the highest measurement value is 54 degrees.

7. Verify the validity of the proposed Model:

First, in order to prove the validity of the proposed evaluation model it was tested on samples of museums that have obtained a certificate from one of the global evaluation systems for sustainability (LEED- BREEAM- CASBEE- ESTIDAMA- GPRS…etc.), and at the same time applied symbolism through their formation.

- Sample (1): Los Angeles Museum of the Holocaust, Los Angeles-USA, Belzberg architects, 2010, golden LEED, table (2).
- Sample (2): Abu Dhabi-Louvre Museum, Abu Dhabi- emirate, Jean Noval, silver LEED and three pearls in Estidama, 2017, table (3).
- Sample (3): Shanghai Natural History Museum, China, Perkins & will, 2015, golden LEED, table (4).

7.1 Results of validation of the proposed model

The study shows the results that can be drawn from the evaluation model, through which the strengths and weaknesses of the samples under investigation are identified.

7.1.1 The overall model result:

The average result of the samples achieved 84% of the standard model, and this proves the validity of the evaluation model as a tool to measure the impact of environmental sustainability and the symbolism of formation in museums. Figure (5).

Also, from the total results, it was observed that the highest value in the model was obtained by the Shanghai Museum with a percentage of 92%, and the lowest was Abu Dhabi Museum, which scored 74%, this means the possibility of comparison between several design alternatives for the same project. Figure (6).

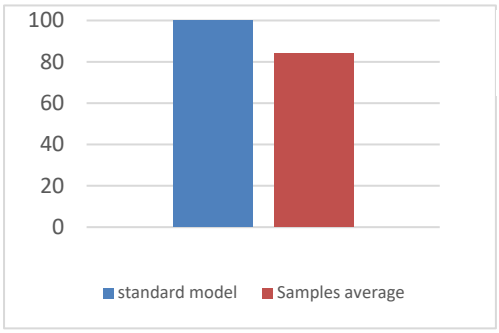


Fig. 5: The overall model result

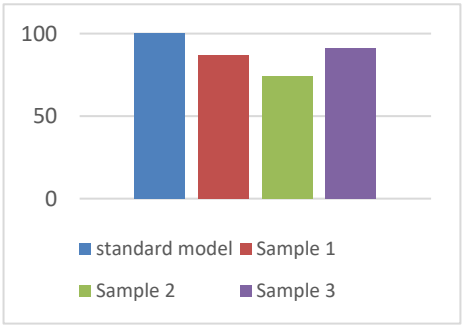


Fig. 6: The overall model result for each

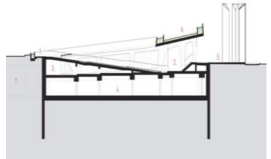
7.1.2 The overall result of the impact of sustainability and symbolism on the formation of museums

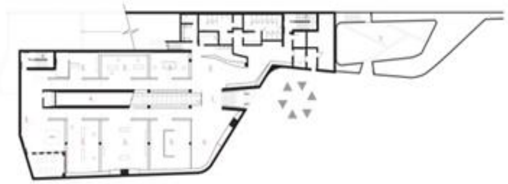
The average result of the samples achieved 100% in symbolism and 81% in sustainability from the standard model, this means the need to pay attention to the elements of sustainability to raise their efficiency. Figure (7). From the comparison of the samples, we observe that the building most concerned with sustainability is the Shanghai Museum and the least is the Abu Dhabi Museum figure (8).

Table (2) an evaluation model for Los Angeles Museum of the Holocaust[26].

elments of formation			mass	outer envelope	space
			shape / color / texture / tranparency and porosity / light / mass and land relationship	roof / walls / windows / materials / External ornaments	interior space / exterior space
symbolism	types of symbolism	reigion	***	***	***
		merge			
		historical			
		environmental: universell / cosmic / universe·ated / cosmic			
		biological: pla… / animalism			
	elements of symbolism	meaning levels: Direct / implicit / Semantic			
		symbol express meaning			
Standards of environmental sustainability		Site sustainability	***	***	**
		Effectiveness and efficiency of resources and materials	***	***	***
		Efficient use of water resources	*	***	**
		Effectiveness and efficiency of energy sources	***		**
		Efficiency and improvement of the internal environment	*	***	***
total		47	14	18	15
mesurement points	x nothing	* weak	** medium	*** stronge	

project data: Los Angeles Museum of the Holocaust- Belzberg arch 2010





symbolism:
The idea of the underground bunker - the narrow entry downwards to express persecution - the upward protrusion to express peace

sustaainability:
Green roof (preserving green space - thermal insulation to reduce energy consumption) Use of groundwater and recycling - natural lighting - use of recycled materials.

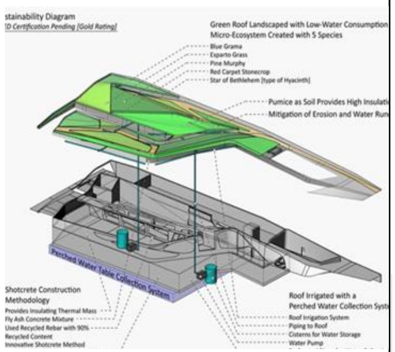
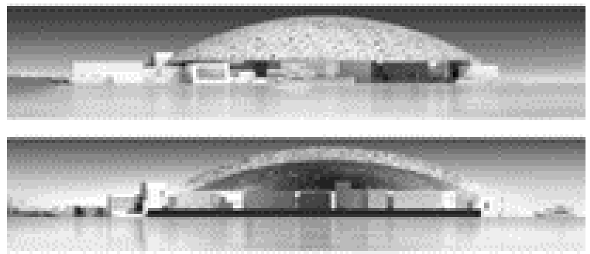


Table (3) an evaluation model for Abu Dhabi - Louvre museum[27].

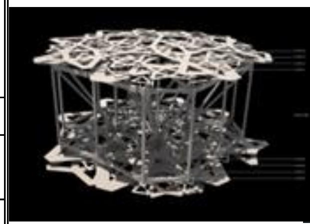
elments of formation	mass	symbolism	sustainability	outer envelope	symbolism	sustainability	space	symbolism	sustainability
	shape			roof			interior space		
	color			walls			exterior space		
	texture			windows					
	tranparency and porosity			materials					
	light			External ornaments					
	mass and land relationship								

				mass	outer envelope	space
symbolism	types of symbolism	reigion		***	***	***
		merge				
		historical				
		environmental	natural			
			universe			
			Sophisticated			
			universe			
		biological	plants			
			animal			
	elements of symbolism	meaning levels	Direct			
			implicit			
			Semantic			
		symbol express meaning				
Standards of environmental sustainability	Site sustainability			***	***	**
	Effectiveness and efficiency of resources and materials			***	***	***
	Efficient use of water resources			x	x	x
	Effectiveness and efficiency of energy sources			**	**	**
	Efficiency and improvement of the internal environment			**	***	***
total			40	13	14	13
mesurement points	x nothing	* weak	** medium	*** stronge		

project data abu dhabi - louvre museum- jan noval arch- 2017



symbolism:
inspired dome shape from islamic architecture- mashrabiya idea on the ceiling whose shadow shape changes with the movement of the sun - massaes represent the arabic architecture



sustainability:
Green roof (preserving green space - mashrabiya idea on the ceiling allow light and natural air to pass through to make aventilation- building on water reduce heat inside the museum- using recycling steel- white paint to reduce heat.

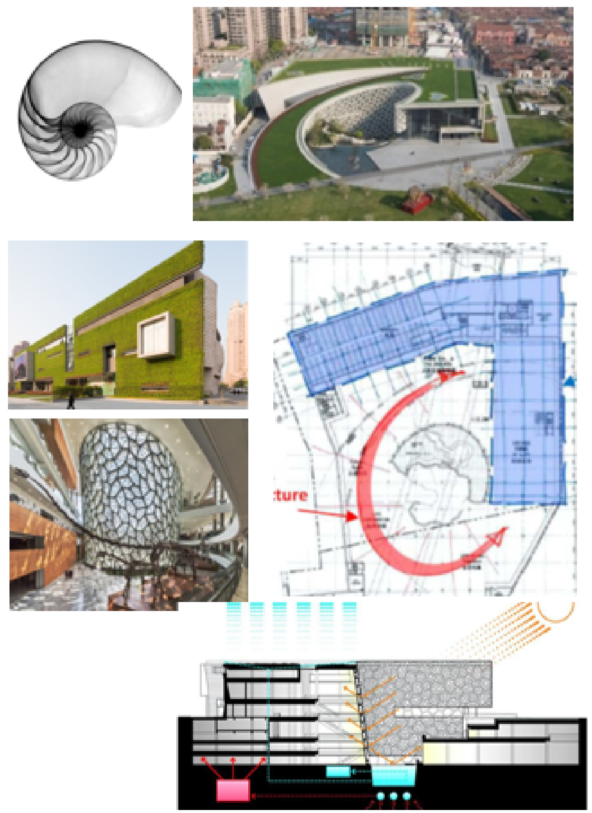
Table (4) an evaluation model for shanghai Natural History Museum[28].

elments of formation	mass	uter envelop	space
	shape	roof	interior space
	color	walls	exterior space
	texture	windows	
	tranparency and porosity	materials	
	light	External ornaments	
	mass and land relationship		

				mass	uter envelop	space
symbolism	types of symbolism	reigion		***	***	***
		merge				
		historical				
		environmental	natural			
			universe			
			Sophisticated			
			universe;			
		biological	plants			
			animal			
	elements of symbolism	meaning levels	Direct			
			implicit			
			Semantic			
		symbol express meaning				
Standards of environmental sustainability	Site sustainability			***	***	**
	Effectiveness and efficiency of resources and materials			***	***	***
	Efficient use of water resources			***	***	***
	Effectiveness and efficiency of energy sources			**	**	**
	Efficiency and improvement of the internal environment			**	***	***
total			49	16	17	16

mesurement points | x nothing | * weak | ** medium | *** stronge

project data | shanghai Natural History Museum- Perkins and Will- 2015



symbolism:
The mass is an abstraction of the snail - the shell stems from the shape of the cell - the mass touches the ground at its beginning and then returns to touch it at the end

sustainability:
The interaction of the mass with the surrounding environment - the use of rainwater and groundwater - the use of green walls to improve the natural environment and save energy - the use of lighting and natural ventilation - using bio smart skin.

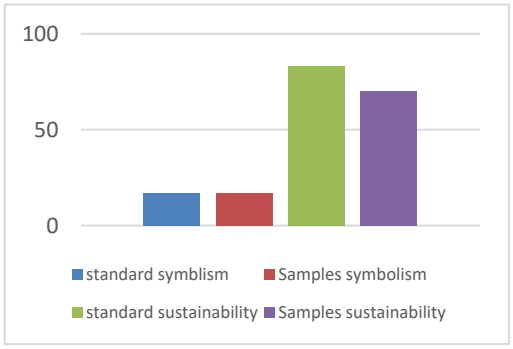


Fig. 7: The overall model result on

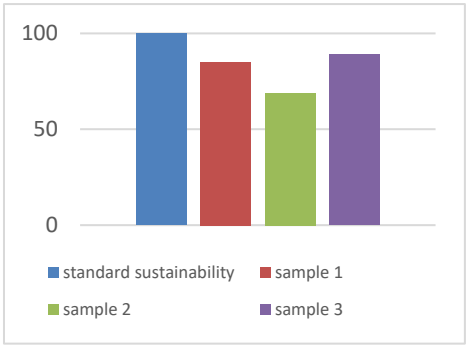


Fig. 8: The overall model result on symbolism for each

7.1.3 The detailed results of the impact of sustainability and symbolism on the formation of museums:

Through the model detailed results can be reached in order to identify the strong and weak elements that must be considered to improve the architectural output.

From Figure (9): It was noted that symbolism was achieved in all elements of the formation.

From figure (10): It was noted that the strongest sustainable formation elements are the outer envelope and the weak is the space elements.

From figure (11): A comparison is made between the study samples in terms of the elements of sustainability achieved in relation to the standard model, which shows that the highest three elements applied in all samples are (Effectiveness and efficiency of resources - materials - site sustainability) and the least used elements are (The Efficient use of water resources- Effectiveness and efficiency of energy resources).

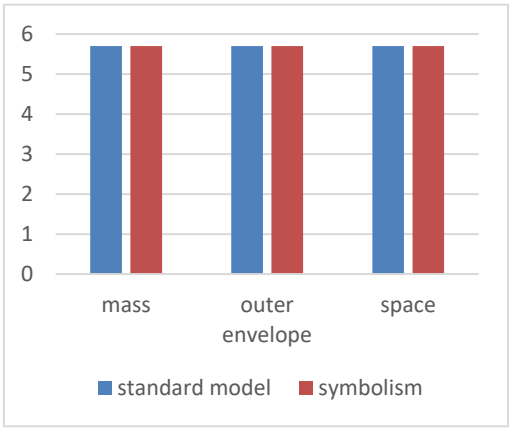


Fig. 9: The influence of symbolism on the formation

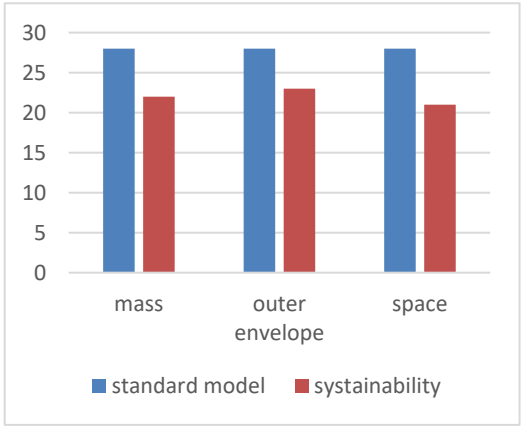


Fig. 10: The influence of sustainability on the formation

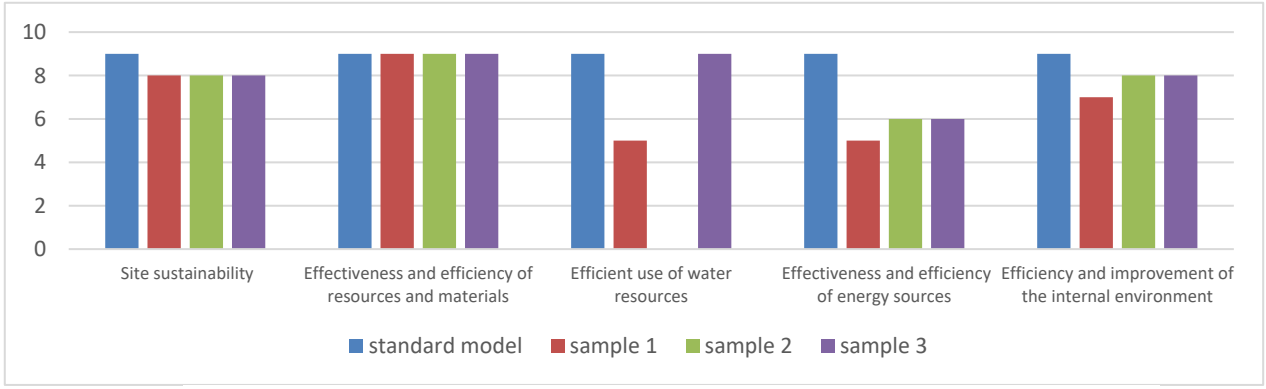


Fig.11: The influence of sustainability on the formation elements in each sample

8. Conclusion

The Research presented a background from previous studies that classified the elements of formation in museum buildings, environmental sustainability standards, and symbolism theory. This research composed a relationship between those three domains in a proposed model that aims to evaluate the level of impact environmental sustainability and symbolism of formation in museums.

- The research validated and applied this model by analyzing three existing museums that have international sustainability certificates, where the results show an average of 84% of the standard model. This indicates the validity and suitability of the model for application, whether during the design phase or for existing buildings.
- The achievement of environmental sustainability does not negatively affect the achievement of symbolism in the formation of museums, where Symbolism achieved 100% in all samples.
- It was found from the previous analysis that the most used elements of sustainability in museums are (Effectiveness and efficiency of resources - materials - site sustainability) and the least used are (The Efficient use of water resources- Effectiveness and efficiency of energy resources).

9. Recommendations:

1- Suggesting the application of the proposed evaluation model during the design of modern museums in Egypt and on existing museums to find out the points that need to be developed.
2- Suggesting computer software for the evaluation model for ease and accuracy of inputs and outputs.
3- It is proposed for future studies to pay attention to the other pillars of sustainability (cultural - social - economic) and study their impact on the formation in museums, so that an integrated evaluation model can be reached.
4- Awareness of the importance of applying sustainability standards to new and existing projects.

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أثر تطبيق معايير الاستدامة البيئية والرمزية علي التشكيل في المتاحف: نموذج تقييمي مقترح

الملخص العربي:

المتحف عبارة عن مبنى ذو كتلة بصرية مميزة ، والتي يجب أن يكون لها رمزيتها الخاصة التي تعبر عن المجتمع والمحتوى ، بالإضافة إلى أن المتحف يجب أن يراعي التوجه العالمي في تطبيق معايير الاستدامة.

الاشكالية في هذا البحث حول إمكانية تحقيق نموذج تقييمي لقياس أثر تطبيق الاستدامة البيئية ورمزية علي التشكيل في المتاحف.

تم اتخاذ ثلاث خطوات لمناقشة هذا السؤال والاجابه عليه:

* الخطوة الأولى: هي تحديد عناصر وخصائص التشكيل في المتاحف ، ومبادئ الاستدامة البيئية ، ثم أنواع وعناصر الرمزية.
* الخطوة الثانية : دراسة تأثير الاستدامة والرمزية على عناصر التشكيل في المتاحف.

من الخطوتين السابقتين ، تم اقتراح نموذج تقييمي لقياس تأثير تطبيق الاستدامة البيئية والرمزية علي التشكيل في المتاحف.

* الخطوة الثالثة: اختبار صحة النموذج التقييمي المقترح عن طريق استخدامه في تحليل بعض عينات المتاحف العالمية الحديثة والتي حصلت على شهادة من أحد أنظمة الاستدامة العالمية.

في نهاية البحث تم اثبات أنه يمكن عمل نموذج تقييمي لقياس تأثير الاستدامة البيئية والرمزية علي التشكيل في المتاحف.