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Mosques Functional Efficiency

A Comparative Study using Space Syntax Theory

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Abstract - *The research paper Highlights the engineering and morphological properties of ancient mosques, using the rules of space syntax analysis, through a mathematical and graphical re-representation of the spatial and mass systems to determine the characteristics and features governing their spatial structure and the elements of difference, explaining how the design affects the behavior of users.*
The research adopted an analytical approach represented in determining the characteristics of a spatial organization as a standard for comparison, caused to reach the distinctive features of the design and judge the efficiency of the patterns under study using the analyzes of the space syntax theory.
to get clear, quantitation, comparisons to reach the conclusions that determined the discrepancy between mosque designs in the characteristics of space organization. The research relied on the analysis of the Agraph program

Key Words: Mosque layout; Space syntax; Spatial configuration; Functional efficiency, a spatial organization

1. INTRODUCTION *(Size 11 , cambria font)*

The term Islamic architecture denotes all the building characteristics that Muslims followed and their method of constructing buildings to form their own identity throughout the ages, whose characteristics and qualities were derived from the religion itself and the scientific renaissance that the Islamic countries experienced during the period of the domination and spread of Islam, where the Islamic civilization produced thanks to its geographical extension Zamani is a rich and diverse architecture that had the greatest impact on the development of the global architectural product. Where the mosque space represents the most important feature of this civilization at all.

The disparity of societies in different civilizations regarding their beliefs and religious rituals has produced buildings of worship that differ in their spatial organization, which is a conclusion that can be easily reached when making a simple visual analysis of the plans and designs of these buildings, which is attributed to the difference in activity according to the creed. Agreement on the doctrine raises questions about the reasons for the divergence of those designs and which are more efficient. Therefore, the research undertook to determine the nature of this discrepancy in a comparative study of the discrepancy in the spatial organization between different types of mosques..

1.1. The problem of the search

Many previous studies dealt with the question of the relationship between belief and architectural design in religious buildings and the effect of religion in shaping architecture in general and buildings of worship. Where the religious rituals determine the nature of the activities that are carried out within the architectural spaces, and thus it is the main problem for the form and nature of the spatial organization and the main ruler on the efficiency of these buildings
The spatial organization of the basic styles of Islamic mosques has not received sufficient study and analysis, as most studies focused on the physical properties of these buildings through mass and axial relationships, symmetries, and design foundations, and dealt with them as an architectural vocabulary separate from the perception of users. [2]

1.2. Research objective

This research is a comparative study to determine the nature of space organization in the styles of Islamic mosques to find out the essential differences in their spatial organization.

- Make a more aim and accurate comparison to provide useful indicators for evaluating the future designs of mosques, as it will provide scientific knowledge that can enrich the history and theories of architecture on this topic.
- Discovering the most energetic and functional model to perform the prayer.

2. Hypothesis

- The stability of the design content of the mosque and the unification of its program and architectural elements, despite the different patterns (styles) in the spatial arrangement, does not mean that they have the same functional competence
- The change and development of mosque patterns aim to improve functional efficiency
- Prayer is the basic function of mosques of different styles, and therefore the prayer space (the house of prayer) is the most important space and the highest functional efficiency.

3. The mosque

Mosques are the homes of God on earth, and the mosque in its simplest form is nothing but a clean area of land on which the Qiblah is located. The content of the mosque's design has been constant since the time of the Prophet, which calls it unity in design. The mosque as a building with a religious and functional specificity led to the unification of its program and its architectural element, which does not differ despite the different environments and styles, so the presence of the qiblah and its direction is one and does not change and the presence of the prayer house is an essential element in the design A mosque, even if this does not prevent its diversity in the external form or the engineering design or the different arrangement of spaces, as it is not possible to deny the diversity in the design due to the diversity and multiplicity of the environments, which showed various styles, the core of extensive studies in the classification of mosques [3]

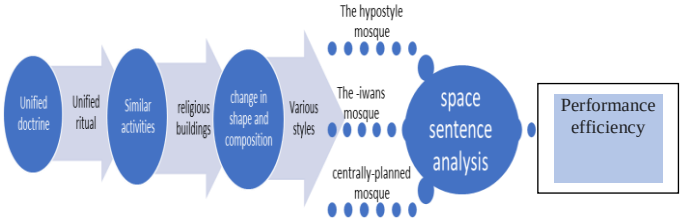


Fig 1. The basic classification of mosques

3.1. Classification of mosques

The classification of mosques was an important topic for studies of Islamic architecture, which presented different classifications of mosques Fig. (1)

Despite the functional agreement of mosques, but with the spread of Islam and the expansion of its area, the patterns, and shapes that mosques adopted varied as a result of the different economic, social, and cultural factors that were reflected on their architectural characteristics such as size, shape, architectural elements, and spatial composition

The importance of classifying mosques is due to being an important part of Islamic architecture theories. Which documents multiple patterns and identifies common characteristics, dissimilarity, and factors affecting the design, physically and morally,

On the other hand, knowledge of the characteristics of different styles enables the designer to employ historical precedents in modern designs without prejudice to the essence of the design [2]

Where studies classified mosques in general into large mosques (Masjid) and mosques in which daily prayers are held, and the consequences of the small size of the second and the breadth of the first. However, in-depth studies sought more in-depth analyzes, especially after the emergence of multiple styles of mosques with the spread of the Islamic state, so the classifications of these studies differed according to the purpose of the study and the methodology used into two types descriptive and analytical studies.

3.1.1. Descriptive documentary studies

It seeks a general picture of the history of mosques and the historical periods in which built- in it with an explanation of the building materials and form of decoration, including the study [4] , which included an account of different models of mosques that he identified within the study in seven types of the Moroccan style, the Andalusian style ,and the Egyptian style The Turkish-Seljuk style, the Indian style, the Iranian style, the Turkish-Ottoman style, as well as the study of Dr. suad maher [5] in her book The Mosques of Egypt and Its Righteous Saints

Which was classified within the archaeological descriptive documentary studies, which accompanied by images and horizontal projections with a historical account of facts and events, where the author dealt with the biography of the owner of the mosque or the tomb and related to the history of the political and economic period with an architectural description of the mosque and its elements and what that includes mention of construction methods and building materials.

3.1.2. Analytical studies

[6] classified mosques into three types, such as the Prophet, the two-yawn style, and the basilica style. Here we note that the classification depended on the general shape more than on the temporal or spatial period, as happened in the descriptive studies, where the spatial and mass composition of the mosque formed the basis for analysis, and comparison.

Also, [3] Dr. Yahya Al-Waziri in writing Islamic architecture and the environment, he classified mosques into six models based on types of design, functional elements they contain, construction methods and roofing method. (The hypostyle mosque - the model with a central nave - the model with constructive shoulders - hanging mosques - the iwan model - the centrally planned) [2]

And because the classification criteria differed according to the study's priorities, whether the classification was chronological, or according to the shape and composition, the method of construction, or even the building material, the results of those studies differed in determining the number of patterns among studies that identified the models in three patterns and other into four and the third into six patterns and more which appeared in the study of Jamil [2] table (1)

The number of patterns of mosques' types						Examples from previous studies	Classification criteria	Type of study
7<	7	6	5	4	3			
■						Hoag 1975	Chronological classification	Descriptive studies
■						Michell 1978	Chronological classification	
					■	Hillenbrand,1994	Anthrographic classification	
	■					Mu'nis 1981	Geographical classification	
		■				Kuran, 1966	Morphological properties Classification criteria Chronological classification Chronological classification Anthrographic classification	Analytical studies
					■	Shafi'i 1970		
			■			Ardalan, 1980		
		■				Prokhazca, 1986		
				■		Zaki		
				■		Al-Omari, 1987		
					■	Ibrahim, 1982	Geographical classification	
				■		Taher, 1994		

table (1) mosques classification studies [2]

A closer look at the previous classifications, as identified by the researchers, finds that the number of patterns exceeded the seven patterns in descriptive studies that depended on the temporal and geographical component of the classification, and the number of patterns decreased when the classification becomes more in- depth and depends on fundamental differences affecting on the design mass so that the difference appears visually, which makes Structural classifications are less the number of styles because they depend on design changes regardless of the temporal change that occurs often without entailing an actual change in the architectural design.

Or even in the external forum, which enables us to place the mosques with the hypostyle mosque (the Arabic style) within the same pattern despite the extended period in which appeared in it even with the occurrence of formal changes in this style due to the dependence of the structural classification on the basic design criterion for this style (The central nave), which was incorporated due to several sub-patterns (the model with a central nave and the model with the shoulders and the model of the hanging mosques) within the Arabic style. The same applies to mosques with iwans (Persian style), whose classification depended on the presence of iwans regardless of their size or number, as well as mosques with a central dome (basilica) whose classification depended on the presence of the central dome, whether the mosque included an external courtyard or not. Although the patterns differ according to the evaluation criteria, the functional competence required for the type of ideological activity must be the same, otherwise, the change in the pattern becomes a formal change that does not have anything to do with the essence of the creed. To determine the extent of its impact on the behavior of the users and the efficiency of performing the basic function of the mosque (prayer), which is determined by the existence of the prayer hall according to its location in the space design

4. Explanation of static sentence analysis methodology

Space syntax theory arose and developed, in 1970 at Bartlett School of Architectural Studies, University of London, and it is one of the powerful techniques used to explain and analyze architectural and urban spaces as it aims to assess the relationship between the morphological structure of designs and between the activities and social activities that are practiced within them.

The beginnings of using the technique of analyzing the spatial syntax were through a paper presented in the Journal of Environment and Planning explaining an introduction to the analytical method of space syntax theory [7]. In which the researchers established a morphological language to describe the basic elements of space using some computational indicators. The main goal was to describe the structure of space, the relationships, and the main rules governing human activities.

The group of authors took upon themselves the task of presenting a method for analyzing the patterns of arranging spaces during the different designs, as the research paper assumed that the biggest problem was to describe the existing spatial formation first and then study and analyze its effect on users' behavior, which was referred to in the last part of their research paper, which became a point the beginning of the development of space syntax methodology. It was used in many research projects. Hanson described the social and cultural implications of various plans to rebuild London, and in 1989 Miller used spatial syntax as a tool in the urban renewal process in Swedish cities. In 1989 Hillier and others tried to predict spatial patterns of crime in urban areas, 1989. In 1984 Hillier and Hanson published a book entitled (The Social Logic of Space) dealing with the effect of spatial formation on social life and vice versa, as the theory proved that how spaces are combined Their arrangement influences the users' behavior and thus determines the efficiency and suitability of the design for the activity [8]

This method allows the analysis, evaluation, and comparison of different spatial systems as it combines physical and social indicators in explaining spatial and functional systems to identify differences and similarities between those systems, which allows quantitative diagnosis of strengths and weaknesses, which lacks studies and classifications of mosques.

Where the Agraph program calculates the analysis indicators of the space sentence theory namely

5. The technique used:

Justified Graph is one of the techniques used to help in reading the spatial structures of buildings and urban spaces using AGRAPH and according to the Space Syntax theory.

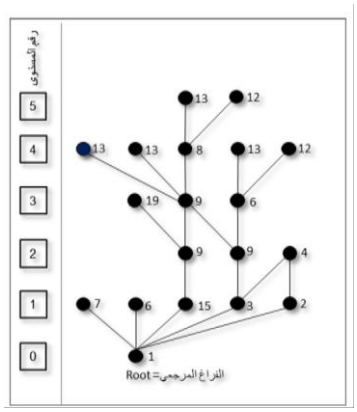
6. Space Syntax theory

An analytical mathematical method of measurement is adopted in many kinds of research dealing with spatial systems of buildings. This method for assessing functional efficiency requires dealing with building spaces as an

integrated functional system. The relations between its components are clarified through a numerical analysis that gives specific importance to the spaces, each according to its local importance and Inclusiveness through its connection with other spaces within the one building system, Where it is simply a graphical re-representation of the space formation on several levels starting from the space to be calculated from, which is often the main entrance and is called the Root, then the successive spaces are linked by lines that express the movement communication paths (doors) the measurement and evaluation are done on the amount of transition from one space to another and what is required By passing through a specific number of spaces (interstitial moves) and thus the spaces are represented graphically by nodes and movement paths between them in the form of lines, which are expressed by (Justified Graph) Fig.(2)

As Hillier specified, the method of spatial analysis of any architectural system is governed by several factors related to the qualitative values of spaces that can be obtained through mathematical analysis, and these values are the main expression of the extent of space efficiency

This technique is used to obtain several mathematical indicators.



(**Fig .2. Justified Graph**)

[15]

•depth
- Mean Depth (MD)
- Total Depth (TD)

•integration
- integration value (I)

•connectivity
- Relative Asymmetry (RA)
- Control Value (CV)

6.1. Depth:

The term "depth" refers to the number of overlapping lines that must be crossed to move from space to another, the minimum number of steps indicates the amount of (integration), while the maximum number of them indicates separation (isolation). [9]

6.1.1. A number of Depth Levels:

They represent the number of levels of depth that make up the Justified Graph and the distribution of nodes that represent the spaces of the building, giving this diagram its formal features. When the number of levels of depth is small, the Justified Graph acquires a dendritic shape, and when the number of levels of depth is large, the graph acquires a linear shape (Fig.3) [10]

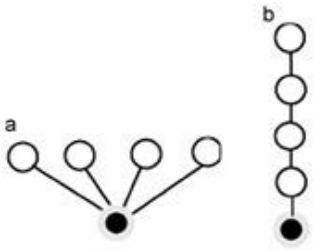


Fig .3. The deeper form is less integrated (linear form) (b) and the less deep is more integral (the tree form) (a) [10]

ndex of average relative depth = MD (Mean Depth)

This scale is considered an index to measure the degree of symmetry of total space spaces, as it determines the number of visual-movement steps that

Space moves away to the spaces of the system as a whole, and the depth can be calculated from the following equation:

$$MD = (\Sigma D K) / (K-1) \quad \text{.....(1)}$$

Where:

MD = mean relative depth

DK = the depth of other spaces relative to the base space, and is calculated from the number of visual steps moving away from the base space. o Total depth criterion = (TDn)

It is the "total of the smallest number of moves from any space to all the spaces in the interstitial composition"

6.2. Integration

Integration is the most frequently used feature in the void fitting literature and is obtained by dividing the total depth

On the number of spaces in the system (the more integration lines mean less depth. And deeper spaces are the least integrated)

On the other hand, the deeper voids are more separate (isolated) and vice versa [11]

K = Number of spaces for the system

6.3. Connectivity

Connectivity is defined as the number of nodes directly related to each node in the Justified Graph and is measured by the number of connections of a given space with the neighboring spaces, where the degree of permeability, integration, and control is determined Fig. (4) [12]

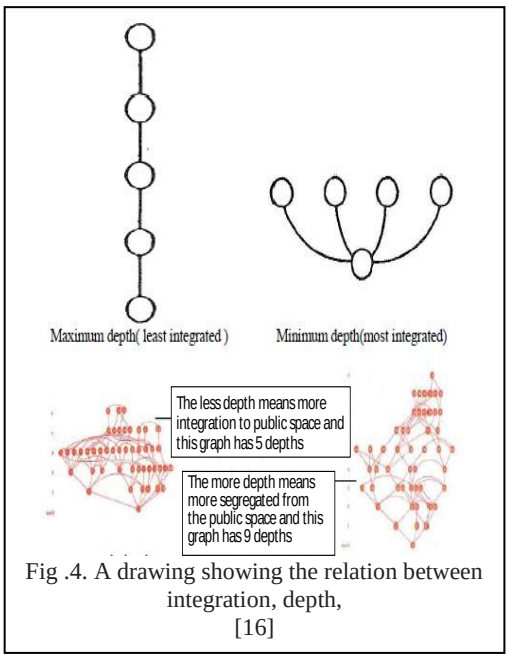


Fig .4. A drawing showing the relation between integration, depth, [16]

6.3.1. Control:

It is defined as the scale that expresses the degree to which a certain space has control over entry into the rooms directly adjacent to it. In general, the control of space is inversely proportional to the connectivity of directly adjacent rooms.

The use of the previous indicators in the representation of the three basic styles chosen for mosques is a mathematical representation that gives a quantitative indication of how the function increase in efficiency with the development of the design or not, and on the other hand, gives a clear indication of the most suitable models for prayer function [13]

Fig.5 the main indcators of space syntax

TDn	: Total Depth (TD) for actual node	
MDn	: Mean Depth (MD) for actual node	MD=TD/(K-1)
RA	: Relative Asymmetry	RA=2*(MD-1)/(K-2)
i	: Integration Value	i= 1/RA
K	: Number of nodes	

7. Cases studies

- First style (The hypostyle mosque) (Arabic Type)

Mosque of Sultan al-Muayyad - mosque of al-Salih Tala'i' - Al Aqmar Mosque

It was represented by

- The second style (The four-iwan mosque)

Mosque of Sultan al-Ashraf Qaytbay - El Sultan Hassan mosque - Mosque of Sultan Barkouk

It was represented by

- The Third style (centrally planned mosque)

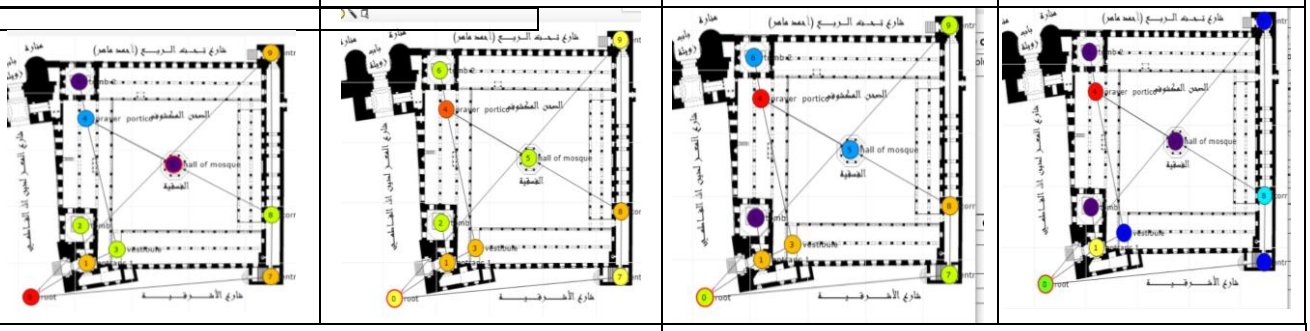
It was represented by

al-Malika Safiyya mosque Mohamed ali mosque Abu dahab mosque

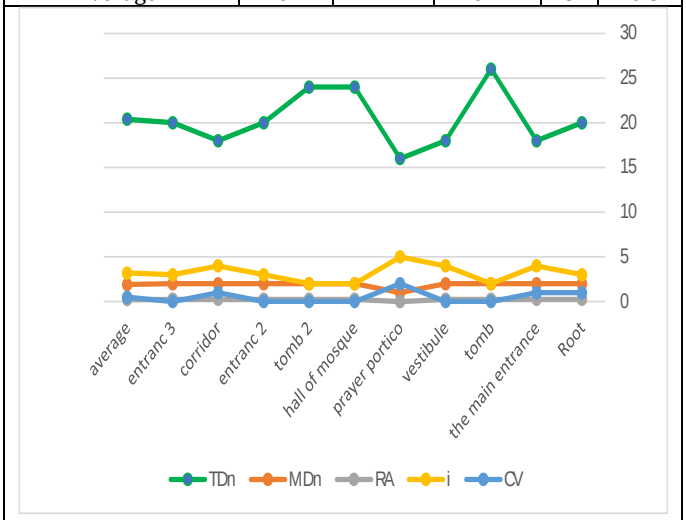
(Arabic Type) First style (The hypostyle mosque)

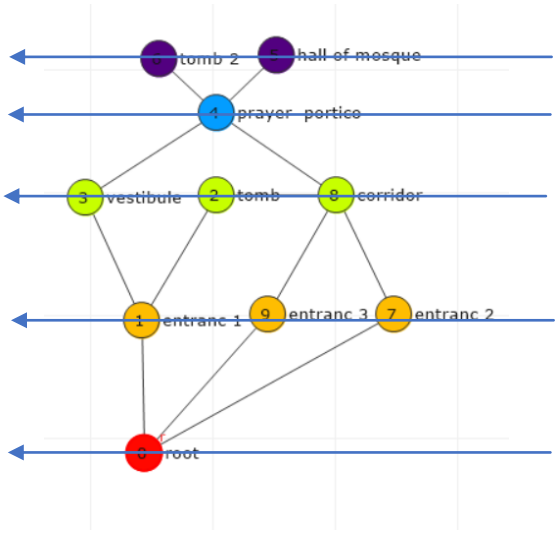
Table (2) data analysis of : Mosque of Sultan al-Muayyad

depth from root	integration absolute	integration relative	control value

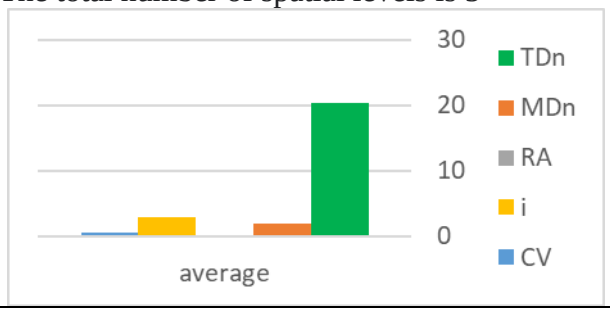


spaces		TDn	MDn	RA	i	CV
0	Root	20	2	0.25	3	1
1	the main entrance	18	2	0.25	4	1
2	tomb	26	2	0.25	2	0
3	vestibule	18	2	0.25	4	0
4	prayer portico	16	1	0	5	2
5	hall of mosque	24	2	0.25	2	0
6	tomb 2	24	2	0.25	2	0
7	entranc 2	20	2	0.25	3	0
8	corridor	18	2	0.25	4	1
9	entranc 3	20	2	0.25	3	0
Average		20.4	2	0.2	3	0.5





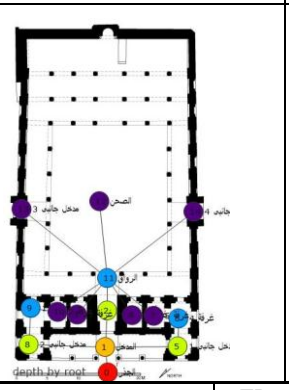
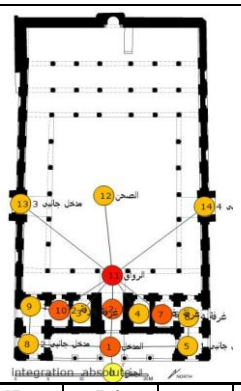
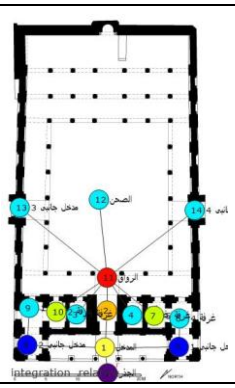
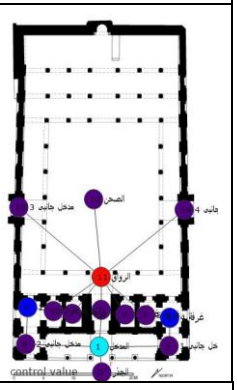
The total number of spatial levels is 5



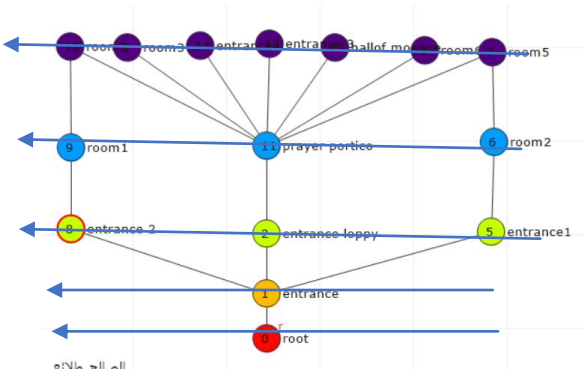
The indicators of the important place

The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 2, which resulted in a large amount of connectivity of 5.

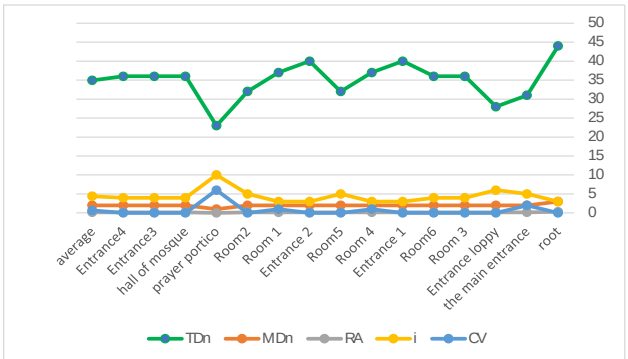
Table (3) data analysis of : mosque of al-Salih Tala'i'

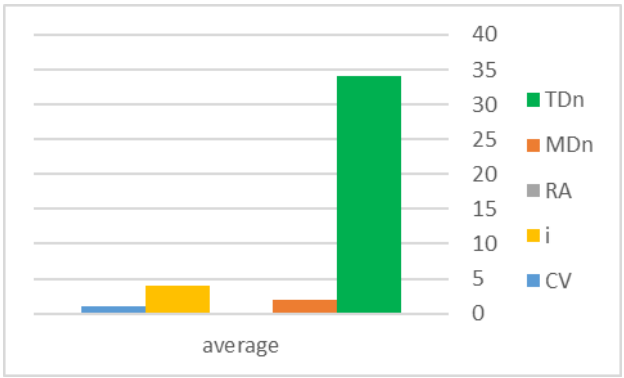
depth from root	integration absolute	integration relative	control value
			

	spaces	TDn	MDn	RA	i	CV
0	root	44	3	0.33	3	0
1	the main entrance	31	2	0.17	5	2
2	Entrance loppy	28	2	0.17	6	0
3	Room 3	36	2	0.17	4	0
4	Room6	36	2	0.17	4	0
5	Entrance 1	40	2	0.17	3	0
6	Room 4	37	2	0.17	3	1
7	Room5	32	2	0.17	5	0
8	Entrance 2	40	2	0.17	3	0
9	Room 1	37	2	0.17	3	1
10	Room2	32	2	0.17	5	0
11	prayer portico	23	1	0.00	10	6
12	hall of mosque	36	2	0.17	4	0
13	Entrance3	36	2	0.17	4	0
14	Entrance4	36	2	0.17	4	0
	Average	34	2	0.17	4	1



The total number of spatial levels is 5

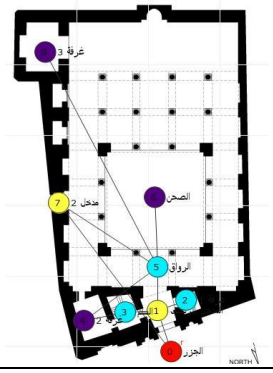
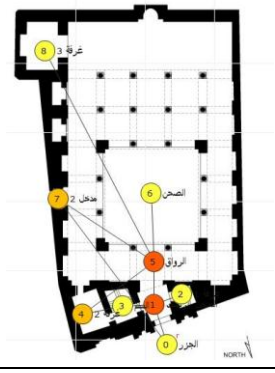
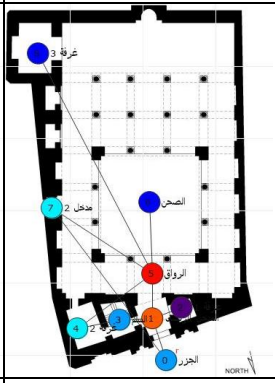
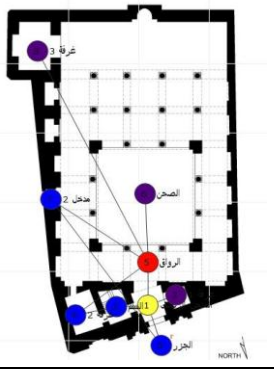




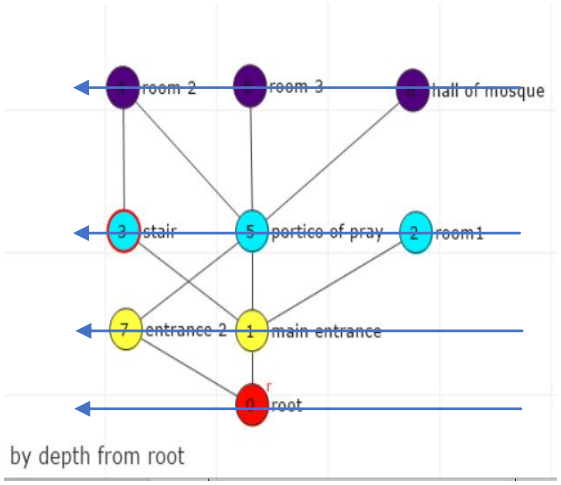
The indicators of the important place

The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 6, which resulted in a large amount of connectivity of 10

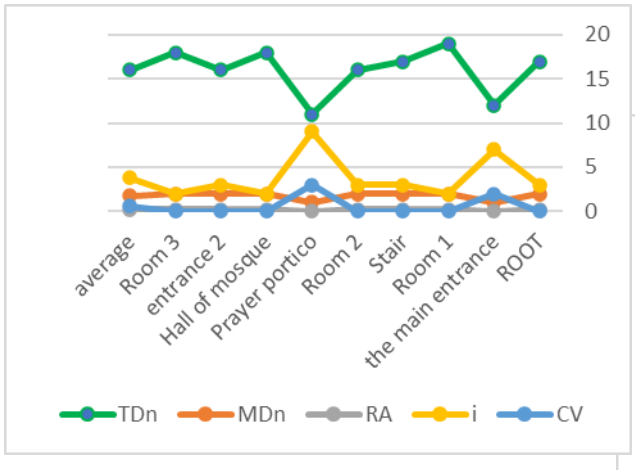
Table (4) data analysis of : **Al Aqmar Mosque**

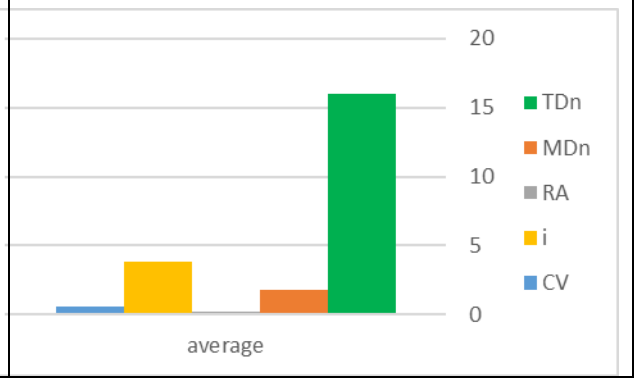
depth from root	integration absolute	integration relative	control value
			

	spaces	TDn	MDn	RA	i	CV
0	Root	17	2	0.3	3	0
1	the main entrance	12	1	0.0	7	2
2	Room 1	19	2	0.3	2	0
3	Stair	17	2	0.3	3	0
4	Room 2	16	2	0.3	3	0
5	Prayer portico	11	1	0.0	9	3
6	Hall of mosque	18	2	0.3	2	0
7	entrance 2	16	2	0.3	3	0
8	Room 3	18	2	0.3	2	0
average		16.0	1.8	0.2	3.8	0.6



The total number of spatial levels is 4



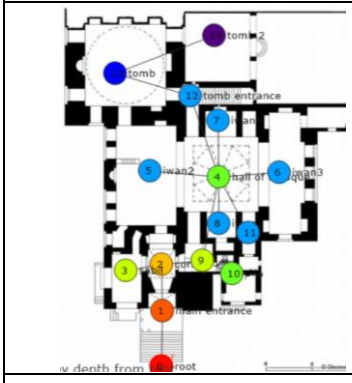
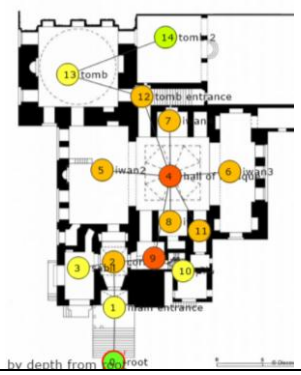
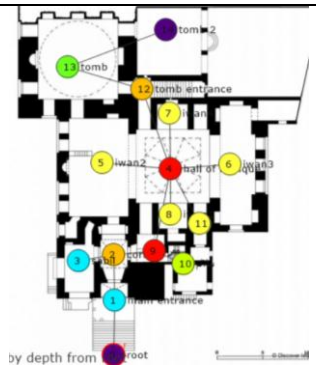
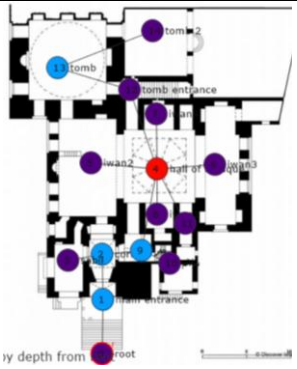


The indicators of the important place

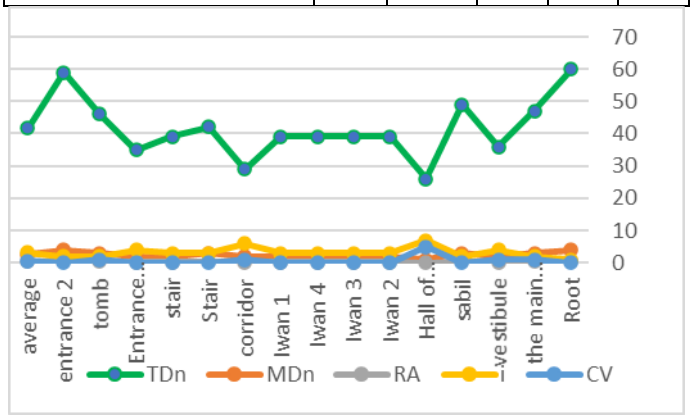
The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 3, which resulted in a large amount of connectivity of 9.

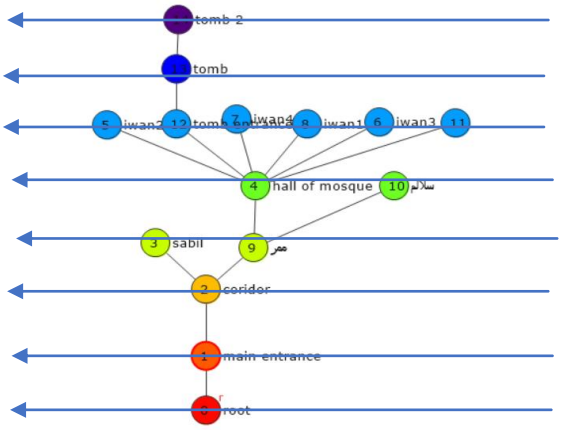
Table (5) data analysis of: The second style (The four-iwan mosque)

Mosque of Sultan al-Ashraf Qaytbay

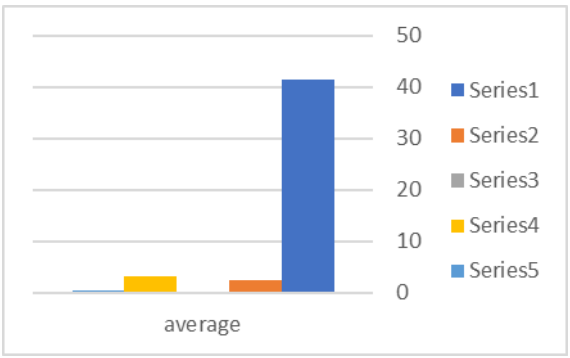
depth from root	integration absolute	integration relative	control value
			

	spaces	TDn	MDn	RA	i	CV
0	Root	60	4	0.5	1	0
1	the main entrance	47	3	0.3	2	1
2	vestibule	36	2	0.2	4	1
3	sabil	49	3	0.3	2	0
4	Hall of mosque	26	1	0.0	7	5
5	Iwan 2	39	2	0.2	3	0
6	Iwan 3	39	2	0.2	3	0
7	Iwan 4	39	2	0.2	3	0
8	Iwan 1	39	2	0.2	3	0
9	corridor	29	2	0.2	6	1
10	Stair	42	3	0.3	3	0
11	stair	39	2	0.2	3	0
12	Entrance tomb	35	2	0.2	4	0
13	tomb	46	3	0.3	2	1
14	entrance 2	59	4	0.5	2	0
average		41.6	2.5	0.3	3.2	0.6





The total number of spatial levels is



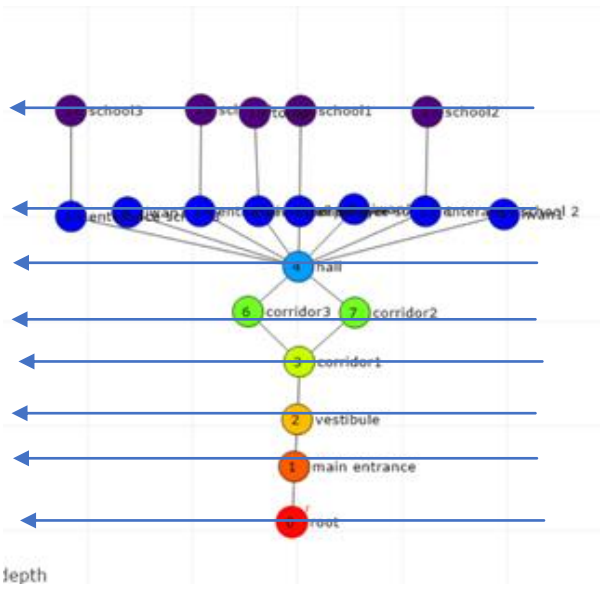
The indicators of the important place

The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 5, which resulted in a large amount of connectivity of 7, Iwans came in second place with less functional efficiency, despite being the main space for prayer.

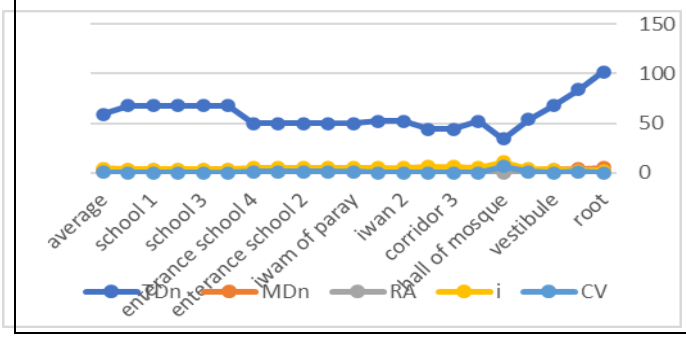
Table (6) data analysis of : **El Sultan Hassan mosque**

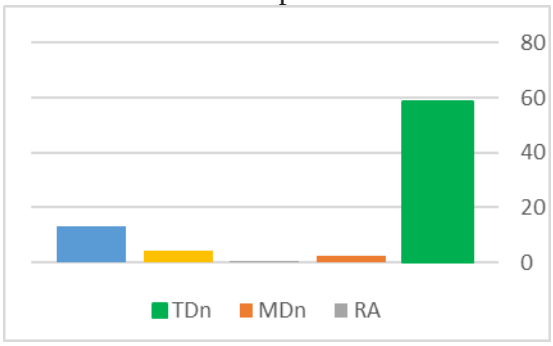
depth from root | integration absolute | integration relative | control value

	space	TDn	MDn	RA	i	CV
0	root	102	5	0.42	2	0
1	main entrance	84	4	0.32	2	1
2	vestibule	68	3	0.21	3	0
3	corridor 1	54	2	0.11	4	1
4	hall of mosque	34	1	0	11	6
5	Iwam 1	52	2	0.11	5	0
6	corridor 3	44	2	0.11	6	0
7	corridor2	44	2	0.11	6	0
8	iwan 2	52	2	0.11	5	0
9	iwan 3	52	2	0.11	5	0
10	iwam of paray	50	2	0.11	5	1
11	enterance school1	50	2	0.11	5	1
12	enterance school2	50	2	0.11	5	1
13	enterance school3	50	2	0.11	5	1
14	enterance school4	50	2	0.11	5	1
15	school 4	68	3	0.21	3	0
16	school 3	68	3	0.21	3	0
17	school 2	68	3	0.21	3	0
18	school 1	68	3	0.21	3	0
19	tomp	68	3	0.21	3	0
	average	58.8	2.5	0.16	4.45	0.65



The total number of spatial levels is 8



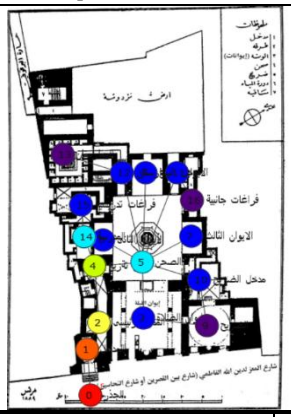
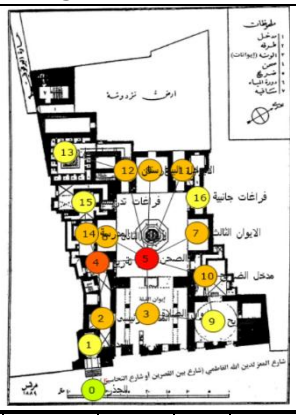
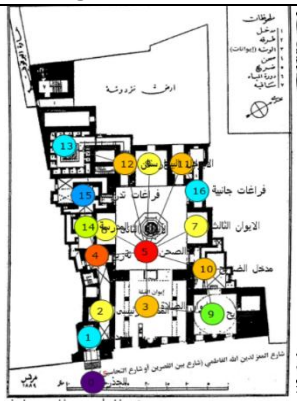
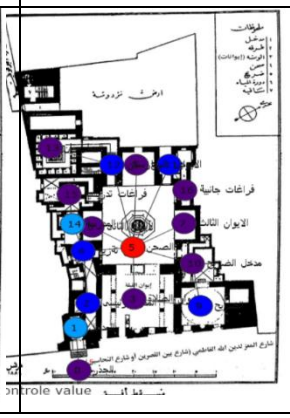


the indicators of the important place

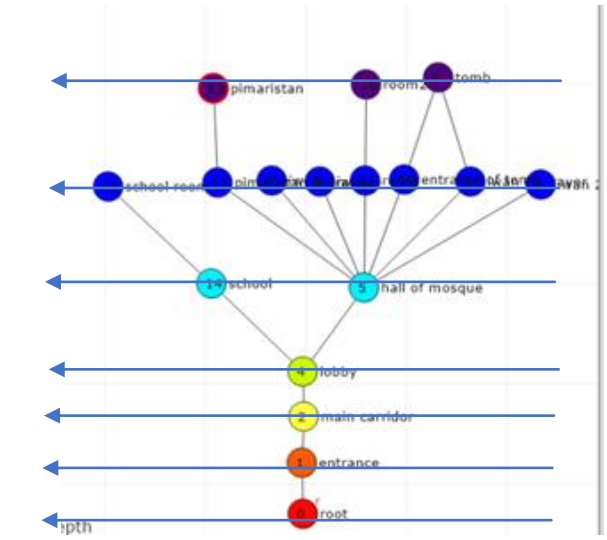
The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 6, which resulted in a large amount of connectivity of 11, Iwans came in second place with less functional efficiency, despite being the main space for prayer However, the prayer iwan is distinguished from the rest of the iwan in functional efficiency according to the previous indications

Table (7) data analysis of : Mosque of Sultan Barkouk

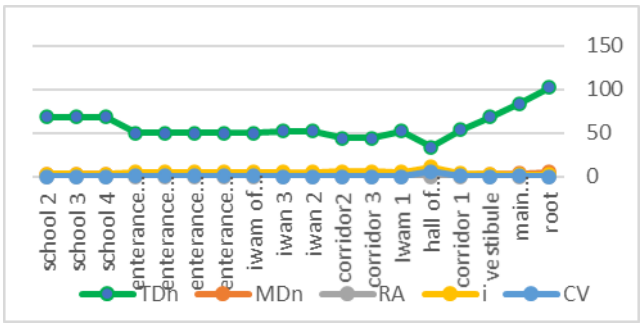
depth from root	integration absolute	integration relative	control value

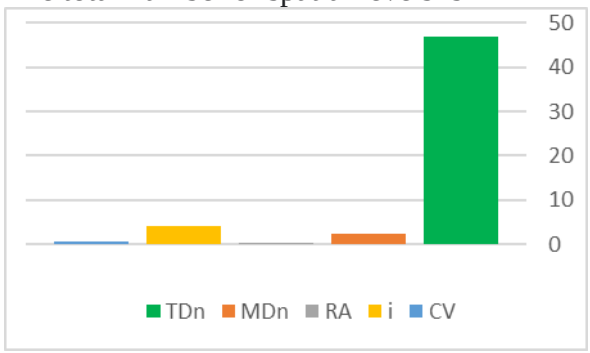





spaces		TDn	MDn	RA	i	CV
0	root	72	4	0.38	2	0
1	Main entrance	57	3	0.25	2	1
2	corridor	44	2	0.13	4	0
3	Iwan of prayer	41	2	0.13	4	0
4	lobby	33	2	0.13	7	1
5	Hall of mosque	28	1	0.00	10	5
6	Iwan 2	43	2	0.13	4	0
7	Iwan 3	43	2	0.13	4	0
8	iwan 4	43	2	0.13	4	0
9	tomb	54	3	0.25	3	1
10	Entrance of tomb	41	2	0.13	4	0
11	Room	41	2	0.13	4	1
12	Bimaristan entrance	41	2	0.13	4	1
13	Bimaristan	56	3	0.25	3	0
14	school	46	2	0.13	4	1
15	School room	61	3	0.25	2	0
16	Room2	56	3	0.25	3	0
average		47.0	2.35	0.17	4	0.6



The total number of spatial levels is 7





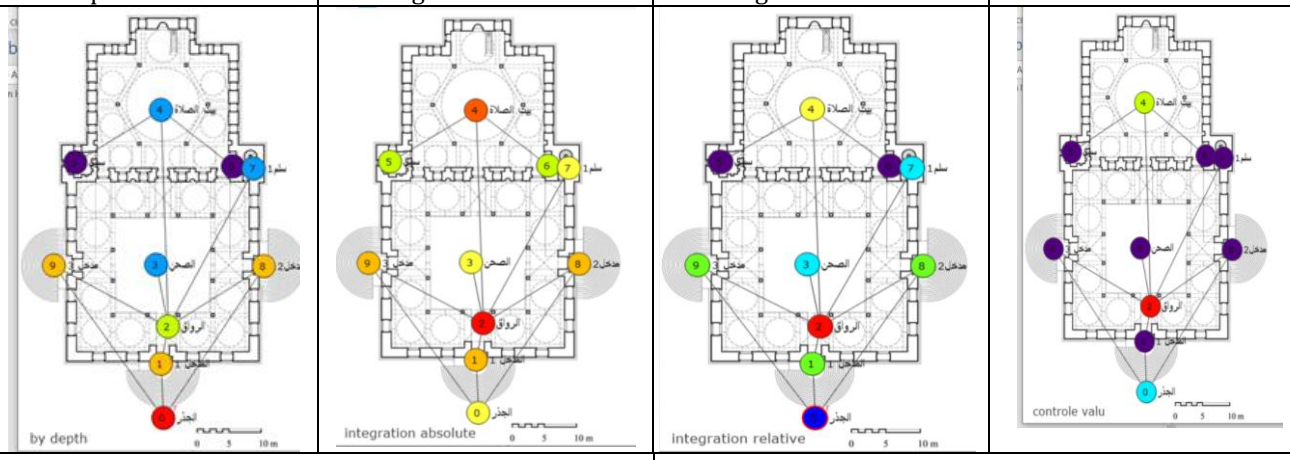
The indicators of the important place

The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 5, which resulted in a large amount of connectivity of 10, Iwans came in second place with less functional efficiency, despite being the main space for prayer However, the prayer iwan is distinguished from the rest of the iwan in functional efficiency according to the previous indications

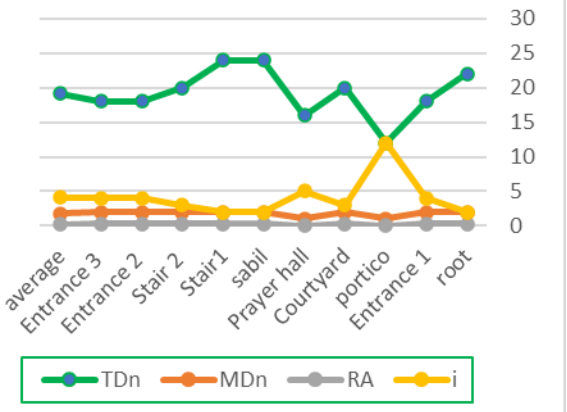
The Third style (centrally planned mosque)

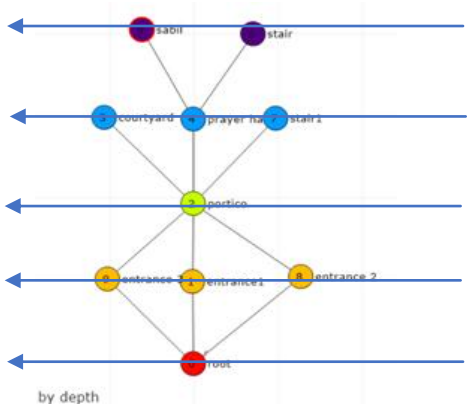
Table (8) data analysis of : al-Malika Safiyya mosque

depth from root	integration absolute	integration relative	control value

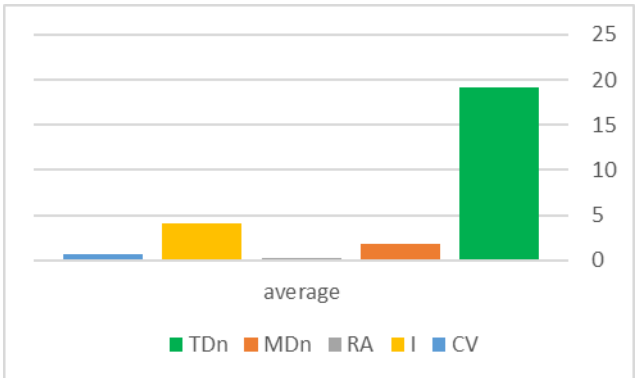


		TDn	MDn	RA	i	CV
0	root	22	2	0.29	2	1
1	Entrance 1	18	2	0.29	4	0
2	portico	12	1	0.00	12	3
3	Courtyard	20	2	0.29	3	0
4	Prayer hall	16	1	0.00	5	2
5	sabil	24	2	0.29	2	0
6	Stair1	24	2	0.29	2	0
7	Stair 2	20	2	0.29	3	0
8	Entrance 2	18	2	0.29	4	0
9	Entrance 3	18	2	0.29	4	0
	average	19.2	1.8	0.23	4.1	0.6





The total number of spatial levels is 5

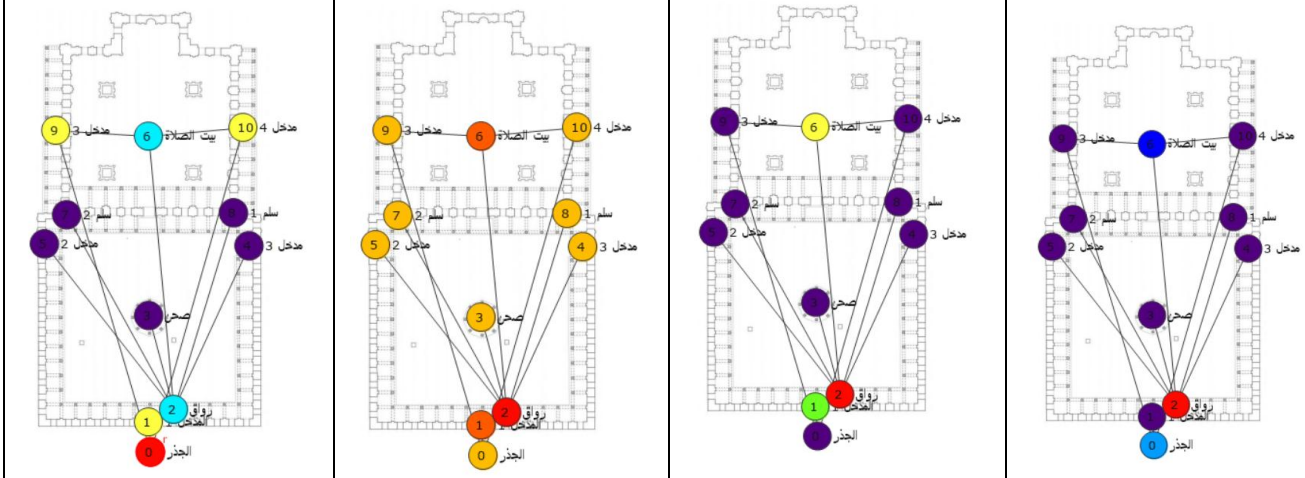


The indicators of the important place

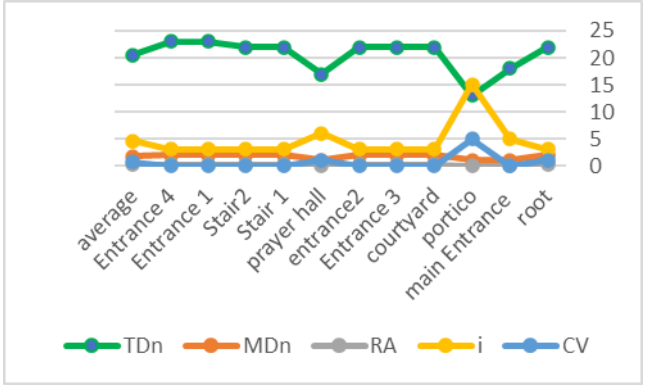
The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 3, which resulted in a large amount of connectivity of 12 hall prayer came in second place with less functional efficiency, despite being the main space for prayer

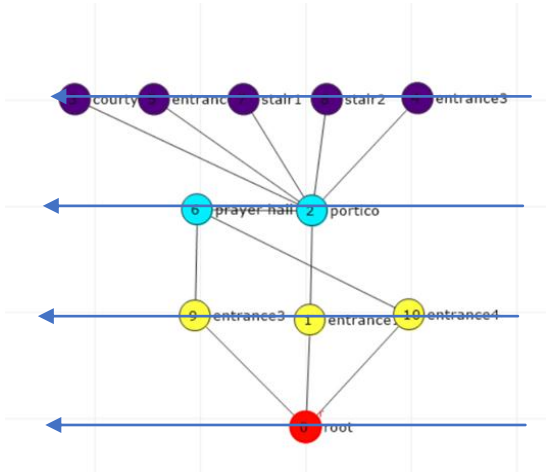
Table (9) data analysis of : Mohamed ali mosque

depth from root	integration absolute	integration relative	control value

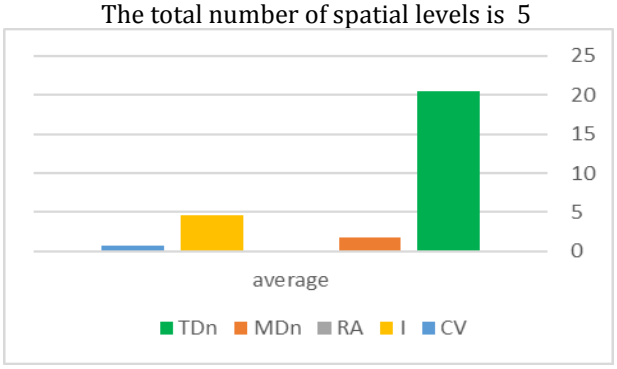


		TDn	MDn	RA	i	CV
0	root	22	2	0.25	3	1
1	main Entrance	18	1	0	5	0
2	portico	13	1	0	15	5
3	courtyard	22	2	0.25	3	0
4	Entrance3	22	2	0.25	3	0
5	entrance2	22	2	0.25	3	0
6	prayer hall	17	1	0	6	1
7	Stair 1	22	2	0.25	3	0
8	Stair2	22	2	0.25	3	0
9	Entrance1	23	2	0.25	3	0
10	Entrance4	23	2	0.25	3	0
average		20.5	1.7	0.18	4.5	0.6





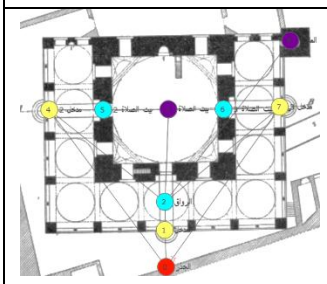
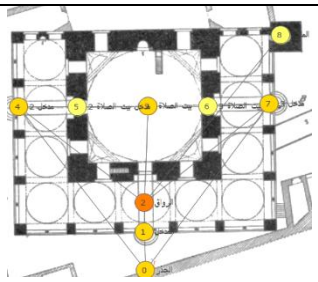
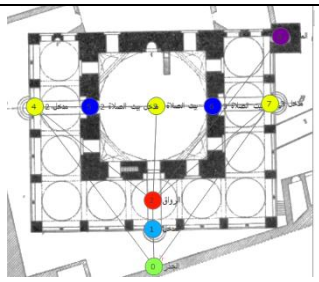
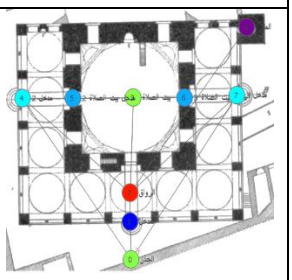
The total number of spatial levels is 5



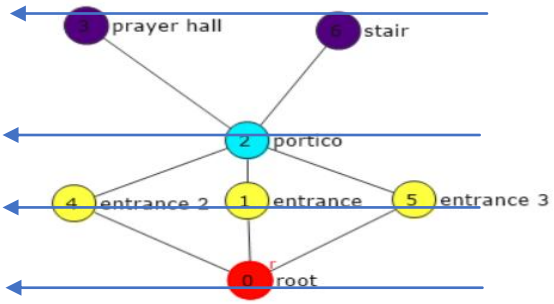
The indicators of the important place

The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 5, which resulted in a large amount of connectivity of 15 hall prayer came in second place with less functional efficiency, despite being the main space for prayer

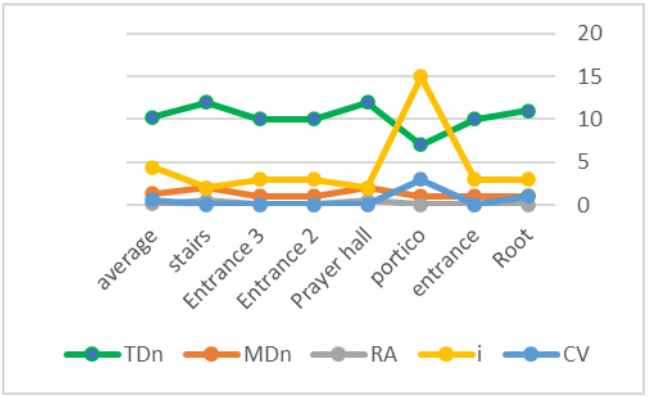
Table (10) data analysis of : Abu dahab mosque

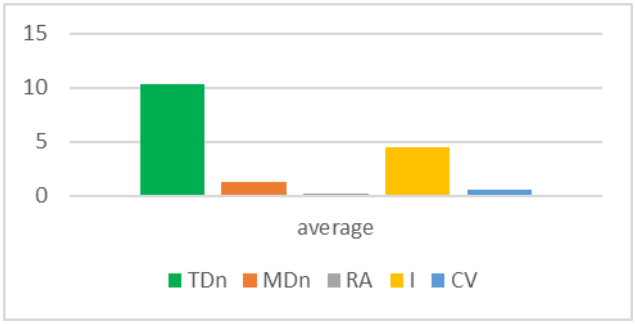
depth from root	integration absolute	integration relative	control value
			

		TDn	MDn	RA	i	CV
1	Root	11	1	0	3	1
2	entrance	10	1	0	3	0
3	portico	7	1	0	15	3
4	Prayer hall	12	2	0.5	2	0
5	Entrance 2	10	1	0	3	0
6	Entrance 3	10	1	0	3	0
7	stairs	12	2	0.5	2	0
average		10.2	1.2	0.14	4.4	0.57



The total number of spatial levels is 4

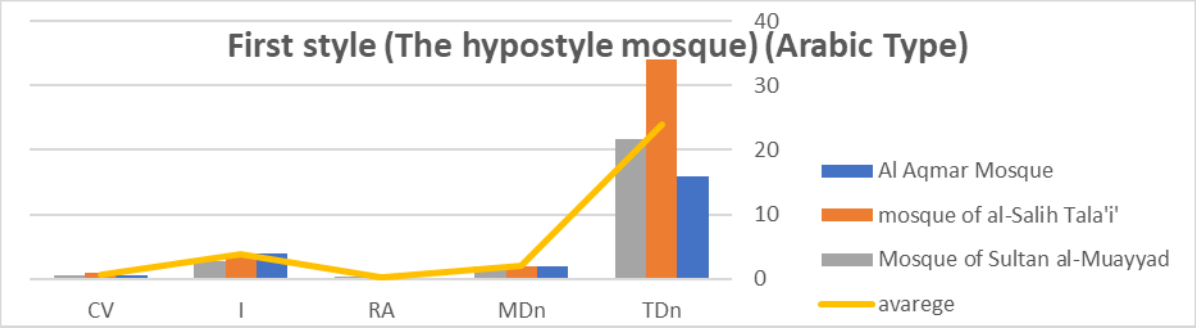




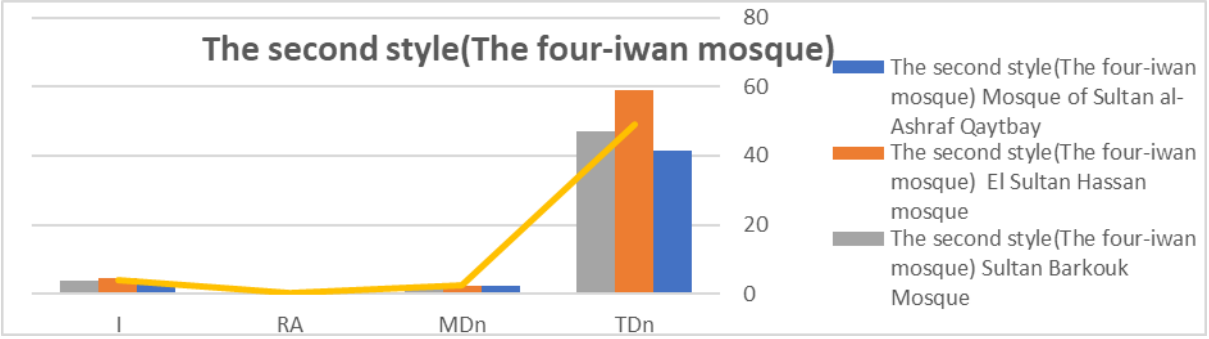
The indicators of the important place

The indicators showed that the prayer portico had the highest functional efficiency, as its depth index was the lowest value among the organizing spaces, which reached 1, as well as the relative asymmetry index, which reached 0.0, which necessarily means giving a high integration index (inverse relationship), while the control indicators showed high values. It reached 3, which resulted in a large amount of connectivity of 12 hall prayer came in second place with less functional efficiency, despite being the main space for prayer

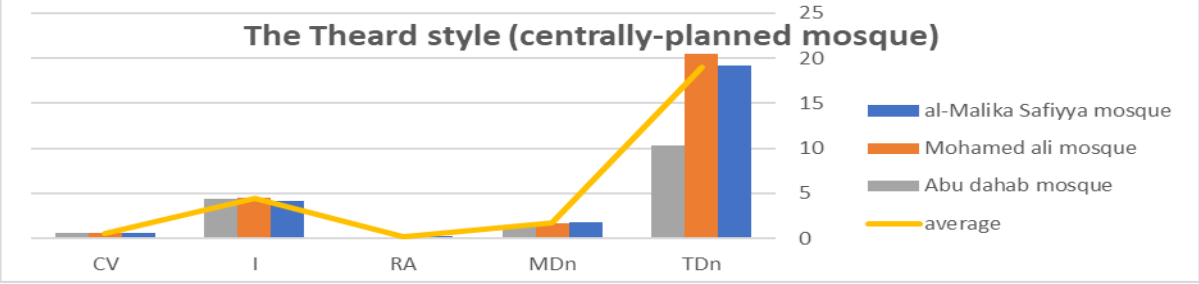
First style (The hypostyle mosque) (Arabic Type	TDn	MDn	RA	I	CV
Al Aqmar Mosque	16	2	0.2	4	0.6
mosque of al-Salih Tala'i'	34	2	0.17	4	1
Mosque of Sultan al-Muayyad	21.6	2	0.3	2.8	0.5
avarege	23.9	2	0.2	3.8	0.7



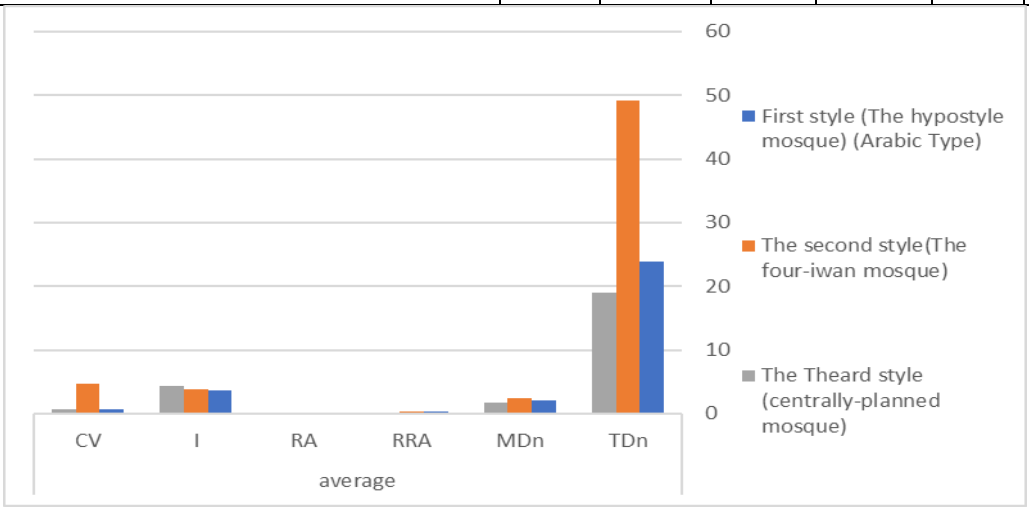
The second style(The four-iwan mosque)	TDn	MDn	RA	I	CV
Mosque of Sultan al-Ashraf Qaytbay	41.6	2.5	0.3	3.2	0.6
El Sultan Hassan mosque	58.8	2.5	0.16	4.45	0.65
Mosque of Sultan Barkouk	47.0	2.35	0.17	4.0	0.65
laverage	49.15	2.45	0.22	3.9	4.75



The Third style (centrally planned mosque)	TDn	MDn	RA	I	CV
al-Malika Safiyya mosque	19.2	1.8	0.23	4.1	0.6
Mohamed ali mosque	20.55	1.73	0.18	4.55	0.64
Abu dahab mosque	10.29	1.29	0.14	4.43	0.57
average	19.0	1.7	0.2	4.4	0.6



the Average of main indicators	average					
	TDn	MDn	RRA	RA	I	CV
First style (The hypostyle mosque) (Arabic Type)	23.9	2	0.28	0.2	3.6	0.7
1) The second style(The four-iwan mosque)	49.15	2.45	0.26	0.22	3.88	4.75
2) The Theard style (centrally-planned mosque)	19	1.7	0.23	0.2	4.4	0.6



Results

The results of the visual analysis using (Justified Graph) of the mosques study subjects highlighted the primary features of the contrast between the three styles in terms of spatial organization, which showed that all the plans are in a tree shape where all the spaces are close to the outer space (root)

First: Application results

The numerical results obtained from the Agraph program highlighted The values of the depth and integration indices for each of the three types appeared within the selected samples for analysis in a way that gave the possibility of dealing with these indicators and making use of them in the functional analysis of the mosque system

The space organization of the mosques in the three styles is characterized by a tree shape despite the difference in space syntax structure and a low depth rate for most models, which gives the first impression about their functional success despite the different levels of depth.

Second: Depth levels

The depth levels in the mosques ranged between 4-8 levels

1. the First type

The depth levels in the first model (The hypostyle mosque) ranged between 4-5 levels, with an average relative depth ratio of 2, which was reflected in the asymmetry index, reaching 0.25, and an integration rate of 3.8, the indicator that reflects the high functional efficiency of the first model.

1.1. the indicators of the most important place

The three models selected for the first model reflected the indicators of the more important place, as the three models agreed that the space of (prayer portico) is the most important, as it was characterized by the lowest average depth and the lowest value of asymmetry between the spaces, which made it the highest integration and thus the highest efficiency, which is agreed with the main function of the mosque

2. The second type

The depth levels in the second type (mosques with iwans) ranged between 7-8 levels, with an average relative depth rate of 2.45, which was reflected in the asymmetry index, reaching 0.21, and an integration rate of 3.9.

2.1. the indicators of the most important place

The three models selected for the second model reflected the indicators of the more important place, as the three models agreed that the space of (prayer hall) is the most important, as it was characterized by the lowest average depth and the lowest value of asymmetry between the spaces, which made it the highest integration and thus the highest efficiency, which contradicts the basic function of the mosque, which is prayer, as the space of the iwans came second in importance

3. The third type

The depth levels in the third type (The centrally planned mosque) ranged between 4-5 levels, with an average relative depth of 1.8, which was reflected in the asymmetry index, reaching 0.2, and an integration rate of 4.4,

3.1. the indicators of the most important place

the indicator that reflects the high functional efficiency of the third type.

The indicators showed that the space of(portico) was distinguished by the highest functional efficiency, as the depth index was the least valuable among the organizational spaces, as well as the low values of the relative asymmetry index. Which necessarily means giving a high integration index and came in second place the Central Prayer House with less functional efficiency, despite it being the main space for prayer according to the previous indicators.

Third: Average modified relative asymmetry (RRA)

The average relative asymmetry changed during the three models, as it reached 0.2 in the first model, 0.22 in the second model, and 0.2 in the third model. The results are as follows

the average of the modified relative asymmetry changed during the three models, as it reached 0.28 in the first style, 0.26 in the second style, and 0.23 in the third type, which indicates that the more functional competence is represented in the third type, which are the mosques with a central dome, which confirms the research hypothesis in terms of the change in the design entailed an increase in the overall functionality of all system spaces.

It remains to be noted that the first type (The hypostyle mosque) outperformed in terms of the relative importance and functional efficiency of the main prayer space, followed by the centrally planned mosque and then the mosques with iwans.

Conclusion

1. . The spatial organization of mosques is characterized by a large spread, a small number of levels of depth, a low rate of depth, and a high integration, and these characteristics are related to the tree shape of this organization

2. The most important void in mosques is characterized by being located close to the outer space (the root) and at a lower rate of depth than the rest of the spaces where the higher degrees of control appear in

- Control is concentrated in the (prayer hall), then in the courtyard, in the hypostyle mosque
- Control is concentrated in the courtyard in the mosques with iwans
- Control is concentrated in the hallway and the prayer house in the centrally planned mosque

Which was confirmed by the most important emptiness indicators

3. result of a change in the architectural style

4. The development of mosque designs has increased the functional efficiency of all system spaces in general

5. Rising functional efficiency of the spaces of the mosque, in general, does not mean that the most important vacuum is the house of prayer

6. The study emphasized that the main goal of it is to determine the highest functional model and build on it. The indicators of the most important vacuum in mosques (prayer house) are identified and linked to the basic function of prayer, which showed that mosques with a central nave are of the highest functional efficiency.

7. The study recommends making audio and visual analyzes (visibility) of mosques to complete the study of the general features of mosques and enrich the course on history and theories of architecture.

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