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Original Research Article

Examining the Connection Between the Configuration of In-between Spaces and the Quality of Flexibility by Focusing on Adaptability in Seljuk Grand Mosques

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Abstract

Problem statement: Flexibility is considered one of the aspects of sustainability in buildings, as flexible spatial structure and configuration are required to meet their variable needs. Mosques, as one of the most significant spaces for the presence and collective activities of people, have always been used in different cultures and generations and accepted by various social activities. The main structure of Iranian mosques was formed during the Seljuk era, and they have kept this pattern until the present. The in-between spaces are one of the most important features of this structure, which have central roles in providing spatial organization and qualities.

The question raised here is as follows:What connection is established between the spatial quality and the configuration components of the in-between spaces on the one hand, and the quality of flexibility on the other hand by considering the quality of adaptability in the Seljuk mosques?

Research objectives: The research aims to signify the in-between spaces, their spatial definition, characteristics, and place in providing the quality of flexibility in the Grand Mosques of the Seljuk era.

Research method: This research is descriptive-interpretive with a quantitative-qualitative approach and inferential reasoning. The research statistical population includes all Grand Mosques that belong to the Seljuk era based on the ideas of relevant experts and researchers.

Conclusion: The spatial flexibility of the mosques in the Seljuk era was investigated based on the quality of spatial integration. The results were evaluated and compared by using two indicators of 'spatial connection and integration. The research outcomes showed that there are some factors including spatial characteristics and the quality of layout, besides the area factor, that affect the mean-value of spatial integration and connectivity in the Grand Mosques of the Seljuk era. The more in-between spaces (the central courtyard, porch, and entrance space), the higher the spatial integrity and better quality of flexibility.

Keywords: *Spatial Integrity, Central Courtyard, Porch/Iwan, Entrance Space, Space Syntax, In-between spaces.*

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Introduction

The factor of flexibility is considered one of the main aspects of sustainability. One of the key challenges in the discipline of architecture is the building's adaptability to quick changes in requirements. Buildings are required to have flexibility both in structure and spatial configuration to meet continuously changing needs (Estaji, 2017, 37). In this regard, (Bentley, 2006) believe that flexibility is one of the physical factors that creates a sense of place and an environment responsive to the individual needs, which is a key factor in creating harmony between the person and his environment, which leads to better use of it, user satisfaction, and ultimately a feeling of belonging to the environment for their continuous presence. This issue emphasizes the necessity of knowing the flexible spaces and the effective factors in creating this kind of quality in these environments.

A gathering place for the performance of congregational prayers of their followers is one of the key features of major religions. The social and political aspects of religion besides their spiritual aspect, can be manifested in the gatherings of their followers. In the religion of Islam, the mosque, as the most public and available place for daily gatherings, manifests the Muslim union, where their followers besides worshiping and praying, perform various political-social functions. Mosques have always been one of the major places for the presence of the Muslim people and the performance of their collective activities for many years in different cultures and over generations, which have been receptive to diverse social activities. This social stability has partially depended on its spatial and physical flexibility.

At present, making new religious spaces responsive to diverse activities and being able to attract different members of society requires knowledge about the spatial characteristics of their successful counterparts in past times. Therefore, to comprehend the physical characteristics of these architectural environments, it is required to know that architecture does not deal with a simple form but, beyond this, is an entity that represents the quintessence of that space; thereby, architecture should be considered a discipline that establishes a set of relationships between the components and makes spatial organization in which the in-between spaces play a key role in integrating elements. These interspaces, by having communicative features, can establish double-sided or multi-sided connections between the surrounding spaces, as they can convert the differences of various conditions to different relations of spatial hierarchies, which arise from their different constructive concepts due to their communicative pattern that governs spatial connections, which ultimately leads to the organization of space (Balilan Asl & Sattarzadeh, 2015, 173). In architectural settings, some connections establish a purposeful order between areas besides making in-between features, which can provide a more coherent presentation or integration of the surrounding spaces. Due to their characteristics in determining both the connection patterns and the order governing relations, they can form the surrounding spaces to make the possibility of spatial connection and continuity, besides dividing space (Torkaman & Soheili, 2021, 226). Since, the structure of Iranian Mosques was established in the Seljuk era and continued later, knowing the architecture of these mosques as a characteristic of the architecture of Iranian mosques is required. One of the significant developments in the design of mosques during the Seljuk era was the creation of four porches or Char-īwān and the placement of its dome facing toward the Qiblah. This kind of design became one of the most constant architectural designs of religious and public buildings (Soltanzadeh, 2019, 50). According to the available resources investigation, the first Char- īwān mosque was built in this era, (Hillenbrand, 2004, 97-98). From this time onwards, the main architectural structure of the Iranian mosques in most of the cases were founded based on a spatial organization of Char- īwān mosques equipped with domes (ibid.). This research aims to

know the quality of in-between spaces, space syntax, special place, and their characteristics in providing flexibility in the Grand Mosques of the Seljuk era. The main research question arising here is to address the relationship between the spatial quality and the structural components of in-between spaces with flexibility by focusing on adaptability in Seljuk mosques.

Research Background

The characteristic of flexibility has had a definite existence in the discipline of architecture since the beginning of this field, but it entered the modern style of architecture in place of a conscious concept in the 1950s (Ćetković, 2012, 213). Following this time much research has been conducted around it. Most of these researches have addressed the definitions and concepts of this qualification and some have even dealt with solutions and ways for achieving flexibility. For instance, (Kim, 2013) in the first group believes that the multifunctional and multi-potential spaces are two dominant strategies for achieving flexibility, however, he argues that these two approaches contradict each other.

The characteristic of multi-functionality is dependent on changing environments, but flexibility relies on various potential user interpretations, which cannot be anticipated. In this research, to overcome this contradiction, a solution based on textual relations is proposed. Unlike the features of multi-functionality and multi-potential that create flexibility by changing the characteristics of each space, changing the textual relations of a building, not merely a single room brings flexibility. In the second group, the researchers (Schneider & Till, 2008) have used "flexible housing" in their book to cover issues related to flexibility and adaptability. This compatibility includes the possibility of adopting different arrangements of housing during the lifetime and the ability to use new technologies over time relevant to family growth. Considering the flexibility, these researchers introduced two strategies of soft and hard type in their book. Given the domestic studies, the research of Gharavi-Al Khansari in the field of principles and solutions of flexible housing design in Iran is noticeable. In his article "Analysis of Potentials in Architectural Flexibility", he has classified flexibility from three aspects 1. Soft connection, 2. Diversity and multiplicity of places, and 3. Multi-functional places. According to the first, second, and third capabilities, 1. The way of communication, 2. The number and scale of spatial domains, and 3. The internal capabilities of these spatial areas have been addressed respectively. The researcher in a similar study in 2018 introduced the following items, according to the basic rules of flexibility by indicating "soft communication of spaces" including 1. Open plan, 2. Prefabricated or built-in modules, 3. Similar spaces, 4. Expandable units, 5. Attaching or separating the adjacent units, 6. Common space between adjacent units, 7. Portable walls, and 8. Folding furniture in a multi-functional space, which all are indicative of the mentioned three principles. Some other studies in the country have measured flexibility in existing buildings. For example, (Kiaee, Soltanzadeh, & Heidari, 2019) have evaluated and compared the flexibility of houses in Qazvin city in three types of traditional, traditional-contemporary, and contemporary patterns of housing using the space syntax method. In their research, the expandability and the ability to change, which means the possibility of joining or splitting space due to the existence of in-between spaces, to be able to turn into a larger or smaller space, is equal to the concept of spatial integration in the space syntax method. Their results showed that the effect of spatial order in creating flexibility in traditional houses is higher compared to the other two counterparts, traditional-modern and contemporary houses. This key role in contemporary houses is given to semi-constant (furniture) and non-constant elements (activity systems). Moreover, they have shown the effect of area on the flexibility of traditional houses, while it did not influence the flexibility of two other housing styles (Mohseni & Kharabati, 2021). in

a similar study have emphasized the significance of this quality in educational spaces and indicated the ignorance of this effect in newly built schools. They have pointed out that the flexible elements of traditional schools as key indicators are required to be considered in the architecture of newly built schools as well. To deal with this, they have reviewed the quality of flexibility in traditional schools from the Seljuk to Qajar era. Their results showed that the quality of flexibility in traditional schools has gradually increased during the mentioned time.

Not much research has been done in the field of in-between spaces, especially on historical buildings, contrary to flexibility. According to international research in the field of architecture, the in-between spaces have been proposed as a quality belonging to the architecture of the present era which has been established initially based on the ideas of Bernard Tschumi. In his book, "Tschumi Le Fresnoy: Architecture In/Between". Tschumi, considers these spaces as the place where the old and new buildings cross over (Tschumi et al., 1999). Similarly, Park, in an article entitled "A Study on the Meaning of In-between space in Sou Fujimoto and Bernard Tschumi's Architecture" argues that these spaces belong to a quality related to contemporary architecture. They are spaces placed between old and new spaces that create a special quality and identity of synchronicity which causes complexity in the space (Park, 2015).

In many recently published articles in the field of urban planning, this expression refers to empty spaces between cities. According to this opinion and definition, the space in-between is not considered as a positive quality, but rather as an abandoned and residual space that needs to be revived. For example, (Rembeza & Sas-Bojarska, 2022) in their article entitled "The Changing Nature of In-Between Spaces in the Transformation Process of Cities" have discussed reviving empty and abandoned urban spaces, which are called in-between spaces, to give them a new identity; They have suggested solutions for reusing these abandoned spaces to preserve the continuity and cohesion of the cities. In domestic studies, the in-between space has been discussed as a space with positive and valuable qualities. The most extensive and intensive research on this concept has been done by Lida Balilan Asl. In her PhD thesis (Balilan Asl, 2008), entitled "The Influence of In-between Spaces in the Spatial Continuity of Architectural and Urban Elements in Iran, A Case Study of Tabriz City" in the Islamic Azad University [of] Science and Research Branch two articles were published under the titles of "The Role of In-between spaces in identifying the spatial extent of Iran's historical textures" in 2011 and "The place of in-between space in the spatial organization of architectural and urban elements in Iran, a case study of Shahre Tabriz in the Qajar period" in 2015. According to the results of the first study (Balilan Asl, Etesam & Islami, 2009) the in-between spaces have a key role in organizing the components and elements in building structures and urban spaces, to represent a context for various functions. These spaces are considered as a process and the product of the process as well, as they can rate and adjust various concepts. The authors in the second research (Balilan Asl & Sattarzadeh, 2015) claimed that connecting spaces were more involved in the spatial organization of architectural and urban complexes of the past styles as a major characteristic for connecting spatial elements with a unique identity. They finally concluded that in-between spaces have a quality of receiving interpreting, verifying, transforming, and developing signals like a cell membrane due to their dynamic nature and showing high flexibility in the historical context of Tabriz city.

Considering the significance of in-between spaces in the traditional style of Iranian architecture and their mediating role in organizing and connecting spaces with various characteristics and qualities in representing various spaces and providing spatial verification. This characteristic has a significant contribution to "soft communication between spaces" to meet flexibility. Given that urban study is the main field of in-between spaces, they are not

regarded in any other disciplines. Moreover, the characteristic of flexibility has not been studied in mosques, especially historical grand mosques.

Finally, considering the special place of in-between spaces in the architecture of mosques and their contribution to giving flexibility, a study for analyzing this quality by focusing on these spaces is demanding. To do this, space syntax emphasizing the layout and inter-spatial connections is a proper tool for measuring the "flexibility in textual connections".

Theoretical Foundation

• The concept of in-betweenness

According to the comprehensive Persian Lexicon (Dehkhoda), the word "between" means separation and connection, which is a contronym word. It is used for separating or connecting two objects and for representing distance and separation as well. It might also refer to a time/place container and sometimes is used as a noun. Depending on the context, it can also refer to synonym words of 'between', 'middle', 'mid', 'in', 'between two things', and also as outer limits. The word 'intermediate' or 'in-between' is also used as a compound adverb, which is referred to as something between good and bad, neither good nor bad (Dehkhoda, 1984). Different meanings have been proposed for the concept of 'Interstitial' or 'In-between' in various disciplines including physics, linguistics, philosophy, and architecture. Shaygan, Roland Barthes, Julia Kristeva, Hegel, Derrida, Venturi, Eisenman, and Daneshmir have presented definitions regarding this concept. According to the opinion of Shaygan, the concept of in-between and those referred to as border identities includes the intermingling areas that are created from the cultural and social intersections (Shayegan, 2001, 104).

• The in-between space

The term in-between with its Persian definition, Beinabein initially described by Loukaitou Sideris in 1996 for spaces (Rembeza & Sas-Bojarska, 2022, 33). According to the 'Metapolis Dictionary of Advanced Architecture', This space continuously moves which is spatially ambiguous, confused, with fusion, and indefinite characteristics. The in-between space is not merely a vacant space or a remaining space. rather, it has converted into a stable place based on a complex geometry, with simultaneous ambiguities, which never splits spaces, but always joins them. This space represents the architecture of connections, contacts, as tangent spaces are preferable places for this type of architecture. The In-between architecture attracts everything applicable to the construction of this space (Cros, 2003). Jan Gehl, calls these spaces intermediate spaces that have a double function, with no independent shape and character, that its border is determined by its adjacent spaces. It is a place between other spaces with various identities and characteristics that is created to organize and connect the spaces (Sasani, Einifar & Zabihi, 2016, 70). These spaces represent liminal characteristics and are known as border spaces (Carmona, 2010, 126), which are associated with the concept of porous architecture, and are perceived with essential qualities to be adopted to the complexity of urban spaces. They can be applied by layering fusion of spaces, faded borders, and ambiguity of liminal spaces. This concept is considered one of the essential elements of architecture, to be adopted to the complexity of today urban spaces (Wolfrum et al., 2018, 9-10).

• In-Between spaces in Grand Mosques

The various relationship are classified into four categories as follows:

A- Adjacent spaces

B- A space within a space

C- Interlocking spaces

D- Spaces linked by a common space (Ching, 2003, 195-203). The in-between spaces are formed by combining three out of the four types of spatial connections.

- Central courtyard, is an enclosed space which is formed When an unlimited open space is placed inside an enclosed space of an enclosed space of Shabestan.

Porch or Iwan, is a semi-open space, which is created when a closed space of Shabestan and the enclosed open space of the central courtyard are interlock.

Entrance space, is a spatial interface which is placed between the urban context and the mosque to connect these two spaces. The types of in-between spaces in grand mosques and their architectural characteristics are shown in Fig. 1.

- **Flexibility**

Flexibility (Enetaf-Paziri) according to the Persian lexicon of Dehkhoda originated from (Attf) means bending, which refers to something that accepts twisting and turning (Dehkhoda, 1984). According to another comprehensive Persian lexicon, called Moein, this word means eligible to harmonize with any situation and environment (Moein, 2007). In architecture and environmental design, it is defined as the potential ability of a building to be modified and reorganized to adapt to growing requirements (Einifar, 2013, 66). The term "flexibility" refers to the function of a space and the way of using it by its definite users (Kim, 2013, 192). It can also be considered the potential of a space to present various options, diverse configurations, and customizations. It is a space with multiple capacities that offers various functions without changing the form, which finally generates the best solution (De Paris & Lopez, 2018, 81). According to (Kronenburg, 2007), and Schneider and Till (2008), there is a potential response to a change, while they believe that flexibility must be achieved in an organized process, otherwise it may lead to a disorder condition (Gharavi al-Khansari, 2017, 122). The researchers and architects usually apply the term "Flexible" for physical changes and "Adaptable" for non-physical variations. Steven Groák (1992) suggested that there should be a distinction between these two terms. According to his opinion, "adaptability is the capability of different social uses", while flexibility refers to "the capability of different physical arrangements". According to his definition, adaptability refers to using space in different ways without making physical changes while, flexibility is achieved by modifying the physical form of the building by joining, splitting, extending, and merging spaces (Estaji, 2017, 37). Based on the results of some researches, flexibility contains non-physical changes as well. In these theories, there are three concepts for flexibility 1) Expansibility, which is a spatial flexibility to adapt to growth through expansion. 2) Convertibility, which is spatial flexibility by changing space settings. 3) Versatility, which is multipurpose spatial flexibility (Aliyah, Setioko & Pradoto, 2017, 42). Therefore, the first two concepts emphasize the possibility of physical changes, while the third concept emphasizes the multi-capacity use of space without physical changes. There are justifications for the multi-functionality of the room both simultaneously and at different times. Many theorists emphasize the third concept. According to Venturi, a multi-functional room probably provides a more feasible answer to the concerns of a modern architect about flexibility. A room with a common sense or inherent feeling rather than a specific one, and using movable furniture instead of movable partitions, promotes perceptual flexibility rather than physical one, which has the potential to create a valuable ambiguity (Soheili & Bashirzadeh, 2015, 70). In addition, (Hertzberger, 2008) preferred multi-purpose spaces that were clearly defined, which were open enough for different uses. According to Lynch, no matter how much flexibility is used and cited, still, no one gets its true meaning and does not use it correctly (Lynch, 1984, 68). Although in

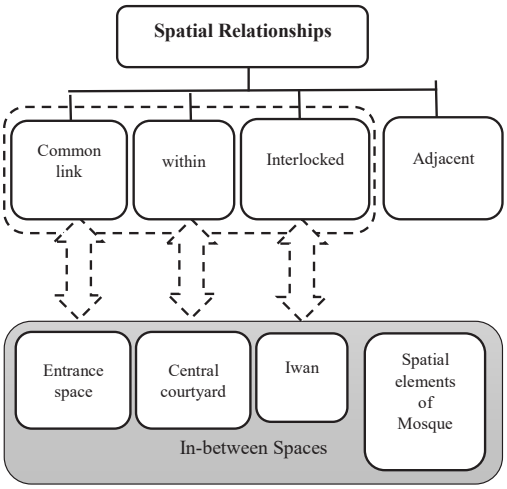


Fig. 1. The types of in-between spaces in Grand Mosques. Source: Authors.

many private spaces such as housing architecture, it is possible to consider all aspects of flexibility, but in public spaces and religious places such as mosques (especially historical mosques), the priority is on the characteristic of multi-functionality of the space without interfering the space, which is called adaptability. For this reason, this research aims to measure adaptability in Grand Mosques during the Seljuk era. Flexibility is considered from two aspects 1. The user and structures and 2. Innovative design, which includes four main subjects in this field: 1. Structural system, 2. Service spaces, 3. Architectural layout and furniture for flexible use (Ćetković, 2012, 213). Given that space arrangement is one of the topics in the field of flexibility, the method of space syntax can be used to measure this area of flexibility.

- **Space Syntax**

Space Syntax includes a set of techniques for presenting and describing spatial patterns in two-dimensional structures (Orhun, Hillier & Hanson, 1995, 476). The basis of this theory indicates that space is the initial main core for the occurrence of social and cultural events (Sheikhakbari, Soheili & Armaghan, 2022, 82). Connection and integrity are two major components in the space syntax method.

Theoretical Framework

To summarize the issues raised in the theoretical foundations, it can be mentioned that adaptability or versatility includes the potential to perform various activities in the space without interfering with it, which is the most adopted characteristic among the three concepts defined for flexibility in the historical Grand Mosques. The space layout is one of the four areas of flexible spaces that can be measured by using space syntax. Therefore, in this study, this method has been applied to measure flexibility based on the approach of adaptability in the Grand Mosques of the Seljuk era. According to the physical structure idea, adaptability is defined as spatial integration. When the spatial organization is more integrated, it creates a high level of flexibility to cover different functions (Arsalan & Uraz, 2017, 58). By having an integrated spatial organization, wide flexibility would be achieved in an overlapped status of various functions. An integrated setting is created when direct spatial communication between adjacent spaces is possible in spatial configuration by keeping individual characteristics. Based on the space syntax method, this concept can be evaluated by measuring connectivity (Kiaei et al, 2018, 67).

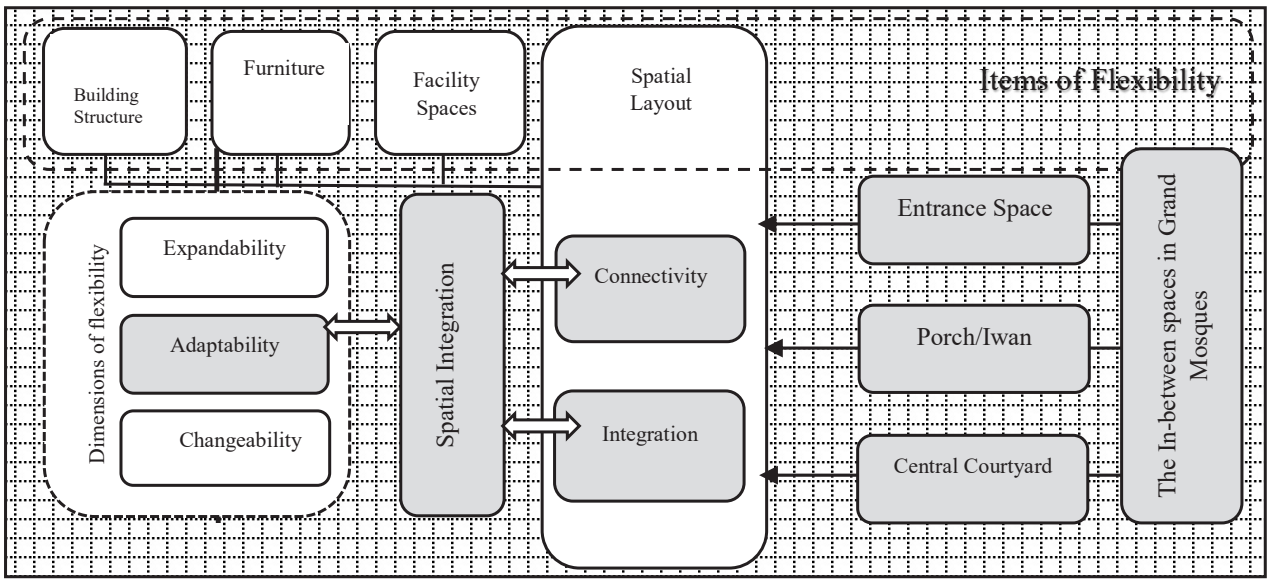


Fig. 2. The Research Conceptual Model. Source: Authors.

Therefore, in this research, by using the space syntax method and connectivity, spatial flexibility has been measured based on adaptability and focusing in-between in the grand mosques of Seljuk era. The relevant conceptual model is shown in Fig. 2.

Methodology

The current research is a descriptive-interpretive study and mixed method research including both quantitative and qualitative data, in which a conclusion was drawn based on the inferential reasoning method. The study addressed the relationship between the configuration of the in-between spaces and the quality of flexibility in the Seljuk Grand Mosques. The statistical population included all the Grand Mosques that were attributed to the Seljuk era, 14 mosques, based on the opinions of experts. Data gathering was based on a library and reliable resources by using computer simulation.

For performing quantitative analysis, the data was extracted from the graphs of Depth Map X software. By acquiring the normal distribution of the variables, the Kolmogorov–Smirnov test was applied to study the relationship between them. Other tests including the Pearson correlation test, Levene's test, one-way ANOVA, T-test Welch and Brown-Forsyth (BF), and Tukey's HSD (honestly significant difference) test in SPSS 24 software were also applied, and the obtained data were analyzed by using the qualitative reasoning (QR) method. All these steps are presented in Fig. 3.

Discussion

Initially, considering the area factor as an intervening variable in the process of space syntax, all 14 mosques were categorized into five classes. Based on the presence of courtyards in mosques as a distinct factor, the first category includes mosques

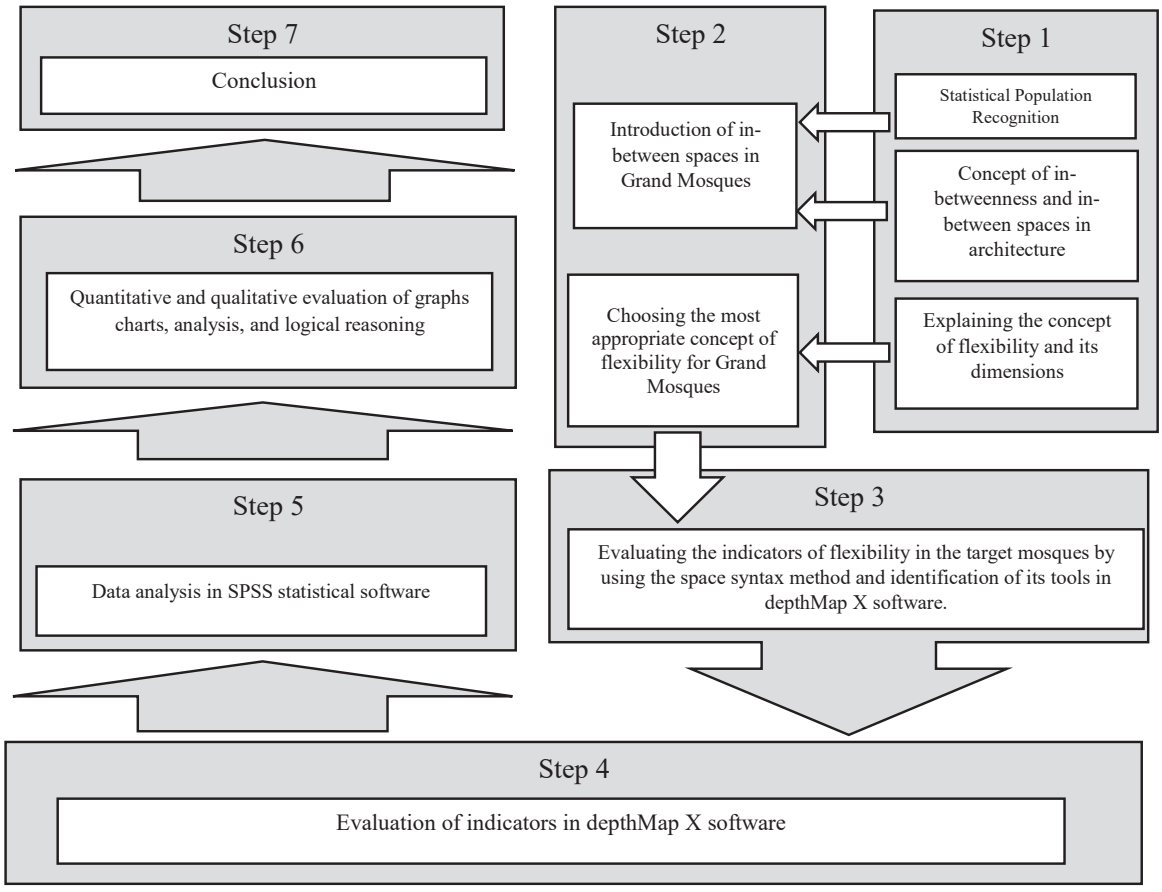


Fig. 3. Diagram of Research Steps. Source: Authors.

with no courtyards which have an area of less than 1000 square meters (m^2), the second group which has an area of more than 1000 square meters (1000-4000 m^2) with a length of mostly three thousand meters. The third category includes mosques with an area of 4000-70000 square meters (m^2), the fourth category mosques have an area of 7000-10000 m^2, and finally the fifth category mosques have an area of more than 10000 thousand square meters. Due to the limited number of samples, none of the Seljuk mosques were placed in the fourth category, so this category was excluded from the study. Therefore, four classes of the area were considered. Moreover, given the central courtyard is the most significant courtyard in the grand mosques, the ratio of the area of this space to the total area of the mosque was also measured. The results from the total area and the data acquired by the software Depth Map X have been shown in order (Table 1).

According to the output of the Klomogrof-Smirnov test, the variables had a normal distribution, and there was a high positive correlation between area factor and connectivity (%0.85) based on the results of the Pearson correlation test (Table 2), which

Table 1. The quantitative data of mosques (space and numerical outputs of space syntax). Source: Authors.

No.	The Name of the Grand Mosques	Total Area Area of Central Courtyard	The area of the central courtyard (%)	Space syntax data	Mean Value	Min.	Max.	Standard Deviation
1	Gherveh	146	-	Connectivity	369.614	116	426	57.533
		-		Integration	104.572	8.042	884.689	131.389
2	Barsian	205	-	Connectivity	507.889	7	589	136.741
		-		Integration	33.003	1.976	51.960	12.897
3	Ardabil	702	-	Connectivity	695.486	20	1203	312.492
		-		Integration	13.691	3.666	25.588	4.298
4	Urmia	1150	-	Connectivity	735.03	15	1086	220.741
		-		Integration	8.560	3.495	12.425	1.951
5	Zavareh	1340	22	Connectivity	1109.56	12	2268	614.175
		297		Integration	12.391	4.492	20.241	3.641
6	Borujerd	2335	24	Connectivity	1508.04	3	3452	879.73
		581		Integration	10.804	3.857	17.909	3.112
7	Golpayegan	2840	31	Connectivity	1815.05	7	4353	1197.87
		884		Integration	9.634	3.993	16.999	2.999
8	Ardestan	3122	16	Connectivity	1258.9	3	3607	1006.12
		510		Integration	7.563	2.496	13.078	2.45
9	Ferdows	3680	18	Connectivity	1279.23	24	3787	951.316
		688		Integration	7.102	3.008	10.720	1.604
10	Damghan	4200	16	Connectivity	1705.01	11	4036	1053.65
		698		Integration	7.217	2.669	11.390	2.028
11	Qom	4830	27	Connectivity	2028.86	18	4689	1272.94
		1331		Integration	7.8949	2.731	12.710	2.179
12	Historic Mosque of Saveh	5530	35	Connectivity	2189.99	25	5024	1533.41
		1990		Integration	7.652	2.861	12.327	2.169
13	Ancient Mosque of Qazvin	12935	37	Connectivity	2524.61	6	5024	1657.99
		4882		Integration	4.362	1.551	7.641	0.554
14	Isfahan	17650	20	Connectivity	1876.56	2	5024	1348.69
		3560		Integration	3.943	0.315	4.048	0.441

indicates a strong relationship between these two variables; The 'correlation squared' showed a 'shared variance' of 72.25%, in other words, the area of the Grand Mosques in the Seljuk era showed nearly 72% variance of connectivity. Moreover, there was a high correlation between connectivity and area ratio of central courtyards (0.79%), as the related 'correlation squared' showed a shared variance of 62.41%. The other characteristics have also been shown in Figures 4 & 5 as follows: The configuration comparison, analysis, and evaluation of the total ratio value of the central courtyard to the entire structure of the mosque, and the mean value for connectivity and integration or spatial coherency together with the relevant data variation related to the area of the mosques.

The output of Levene's test for each of the variables (connectivity and integration) relevant to the area factor showed the homogeneity of variance for connectivity and the inhomogeneity of variance for integrity. Therefore, one-way analysis of variance (One-Way ANOVA) and Tukey HSD post-hoc tests were used for analyzing connectivity variables, and Welch and Brown-Forsyth ANOVA were used for measuring the variable of integration. The results of these tests are presented in Tables 3 to 5.

By analyzing the value of variance, it can be seen that the numerical difference of connectivity in various areas had a significant level of 0.05. In other words, the contribution of the area factor in the level of connectivity was confirmed. According to the result that the area difference in Tukey's test in the 1st and 2nd categories was significant compared to other categories (a significant level of 0.05), it can be confirmed that the area factor is involved in the mean value of connectivity in these two categories. Therefore, the factor of connectivity in the target mosques was required to be compared and analyzed separately for each category. However, the area of mosques in the 3rd and 4th categories was not significant at the 0. 05 level of significance, and in other words, in mosques with an area of more than four thousand square meters, the area factor was not effective, thereby these mosques were compared to each other. Given the results of the Welch and Brown-Forsyth test for the area and integration were not significant at the $0.^{05}$ level, it can be concluded that the area factor does not influence integration.

The results of the statistical studies showed the influence of the area factor on connectivity in the Seljuk mosques with areas less than 4,000 meters. However, in mosques above this amount, the effect of this factor was not significant, and the area factor did not have much effect on integration. In the following, the diagram analysis of the target mosques together with other physical factors affecting connectivity and integrity have been discussed and investigated (Table 6)

Analyzing the Connectivity Level of the Grand Mosques in the Seljuk Era

According to Fig. 6, by increasing the area in the Seljuk mosques, the connectivity level of the spaces increases. Moreover, in these mosques, the physical characteristics, proportions, and spatial organization

Table 2. The correlation between variables using the Pearson correlation test. Source: Authors.

Total Area of Mosques	Area of Courtyard (%)	Integration	Connectivity		
**0.858	**0.791	-0.533*	1	Correlation	Connectivity
0.000	0.006	0.05	-	Statistical Significance level	
-0.434	-0.092	1	-	Correlation	Integration
0.121	0.801	-	-	Statistical Significance level	
0.345	1	-	-	Correlation	Area of Courtyard (%)
0.329	-	-	-	Statistical Significance level	

P<0.01** P<0.05*

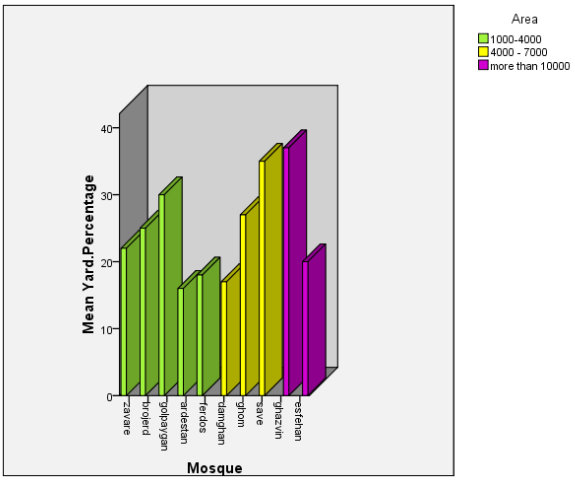


Fig. 4. The percentage of the area of the central courtyard to the total area of the Grand Mosques. Source: Authors.

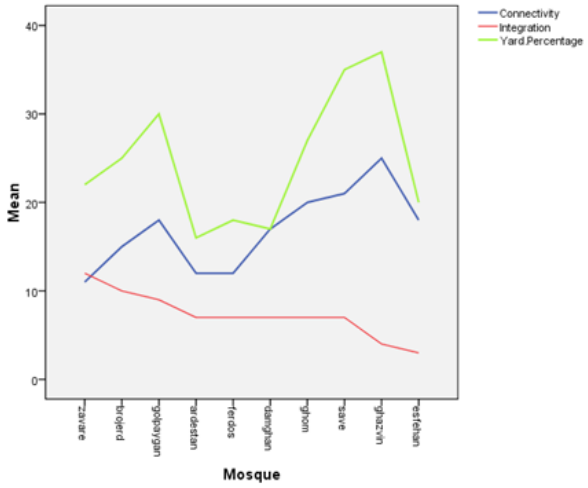


Fig. 5. The data flow of the ratio for the area of the central courtyard and the components of space syntax relevant to the total area of mosques. Source: Authors.

Table 3. The Levene's test for measuring equality of variances and one-way ANOVA test to check the equality of mean variables. Source: Authors.

One-Way ANOVA Test						Levene's Test		
Sig.	F	Mean Square	df	Sum of Squares		Sig.	Levin Statistic	Connectivity
0.00	23.25**	155.722	3	467.167	Between Groups Variance	0.111	2.592	
			6.697	10	66.966	Within Groups Variance		
				13	534.133	Total		

Note: P<0.05* P<0.01**

Table 4. Tukey's post hoc test to assess the significance of mean differences between groups. Source: Authors.

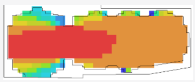
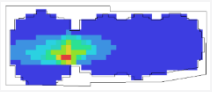
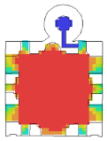
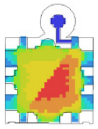
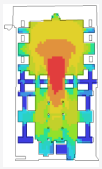
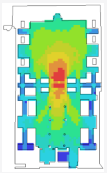
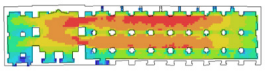
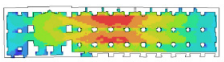
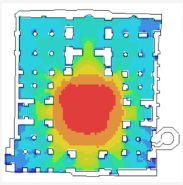
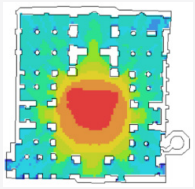
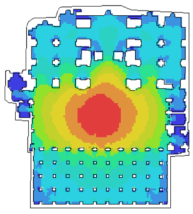
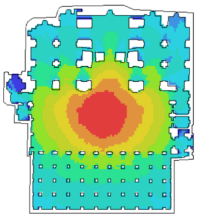
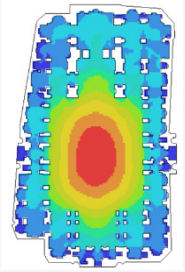
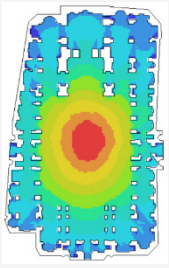
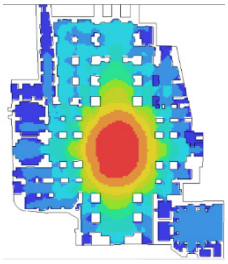
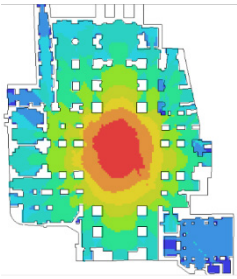
0.95 Confidence Interval		Sig.	Std. Deviation	Mean Difference (MD)	Area		
	Upper Bound	Lower Bound					
-2.382	-13.003	0.006	1.735	-7.693**	1000-4000	1000≤	Connectivity
-7.448	-19.541	0.00	1.976	-13.495**	4000-7000		
-8.898	-22.611	0.00	2.241	-15.755**	10000<		
-0.020	-11.583	0.049	8.889	-5.802**	4000-7000	1000-4000	
-1.438	-14.685	0.017	2.165	-8.062*	10000<		
4.967	-9.485	0.776	2.362	-2.260	10000<	4000-7000	

Table 5. Levine's test for equality of variances and Welch and Brown-Forsyth's statistics to check the equality of mean variables. Source: Authors.

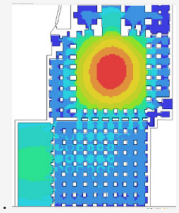
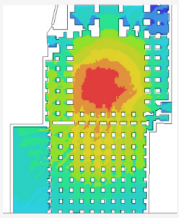
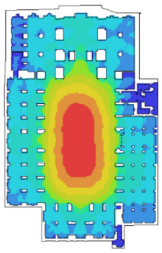
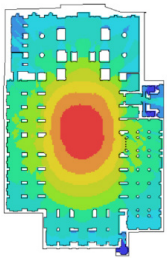
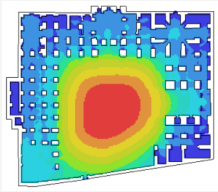
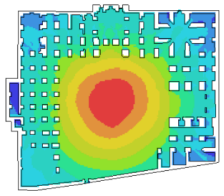
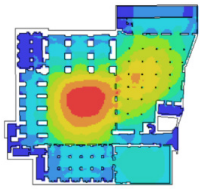
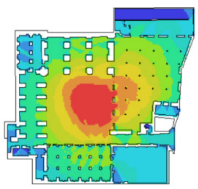
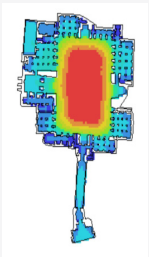
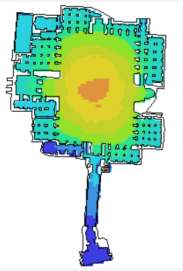
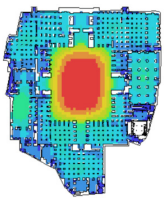
Welch and Brown-Forsyth's Test					Levine's Test		
Sig.	df 2	df 1	df1		Sig.	Levine's Statistics	Integration
0.116	5.809	3	41.416	Welch	0.018	5.417*	
0.276	3.014	3	2.120	Brown-Forsyth			

of spaces, especially semi-open spaces including the central courtyard, porches (Iwans), and entrance spaces, influence this process. It has been shown that the connected spaces are higher in mosques with courtyards than those lacking it, as, can be seen in 'Central Mosque Golpayegan' which is also known as 'The Grand Mosque of Golpayegan', with a small area in the second category, is comparable to those

Table 6. The diagram analysis of the target mosques. Source: Authors.

Grand Mosque	Connectivity	Coherency	Comments
Gherveh/Ghorveh			The high level of connectivity in this mosque can be seen in the opening area of the dome and the Shabestan. The highest level of coherency has been found in this area, while other parts showed a low level of this characteristic.
Barsian			This mosque simply represents a dome space (Gonbad-Khaneh) as the high level of connectivity in all parts of this mosque is due to the presence of a single space and the convex shape of the dome. The difference in the diameter of its dome is due to the presence of a minaret staircase placed in the side space.
Ardabil			The highest level of connectivity and coherency has been seen in the opening area between the dome and the porch (Iwan). It seems that the level of coherency in the dome space is higher than porch (Iwan). The Iwan of this mosque has been turned into Shabestan after closing the opening space.
Urmia			The highest level of connectivity and coherency can be seen in the main and expanded eastern part of Shabestan. The small size of the opening space to the eastern and western parts of Shabestan has reduced the connectivity level between the dome space and the western area of Shabestan.
Zavareh			There are no parts with a low level of connectivity or coherency in the plan of this mosque. The courtyards and porches showed a high degree of connectivity and coherency, while the Shabestan area showed a moderate level of these two characteristics.
Borujerd			The second highest level of connectivity and coherency after the central courtyard can be seen in the single porch, which has a wide opening area compared to the courtyard and the small areas of Shabestan. The porch (Iwan) has raised the connection level between the dome and the adjacent Shabestans The openings adjacent to the central courtyard in the North Shabestan also have an acceptable connection. Its indirect and meandering entrance elite shows the least spatial connection and interconnection.
Central Mosque Golpayegan			The second highest level of connectivity and coherency after the central courtyard is allocated to the north and south Iwans of this mosque, which have wide openings and large dimensions compared to the shabestan, the courtyard, and its adjacent spaces. The entrance spaces have spatial hierarchies, but without moving and visual obstacles, and there is not much decrease in the level of connectivity and coherency compared to the entrance spaces of other mosques.
Ardestan			The highest level of connectivity and coherency is seen in the central courtyard, the four Iwans, and the adjacent shabestans. However, there are many parts with very little connection in this mosque, most of them are related to entrance corridors, and other parts are located in areas far from balconies; However, the connectivity level of most of these areas is at medium and acceptable level.

Rest of Table 6.

Grand Mosque	Connectivity	Coherency	Comments
Ferdows			The highest level of connectivity can be seen in the main central courtyard and the Iwan area, and next in the side courtyard. The single Iwan of this mosque, with its rather wide opening, has provided the possibility of significant connectivity and entrance from the open space to the closed areas; however, the highest connectivity level is observed in the central courtyard close to the Shabestan, which is also integrated with the side courtyard. There are not enough connected spaces in the areas of Iwan and the surrounding spaces
Qom			The highest level of connectivity after the central courtyard is seen on the main porch (qibla) of this mosque. Other Iwans, with very low depth and openings similar to the adjacent shabestans, have not contributed to the level of connectivity in these spaces. Also, the lowest level of connectivity is seen in indirect entrances and its visua, moving barriers, and visual intrusion. Moreover, after the central courtyard, the Iwan-qibla in this mosque, the adjacent shabestans, and then the three Iwans and their shabestans have an acceptable level of connection.
Historic Mosque of Saveh			After the central courtyard, the highest level of connectivity and spatial integration can be seen in the western Iwan. The Iwan in the southern part, with its small dimensions and opening, does not let entry into the dome space and the shabestans.
Damghan			After the courtyard, the highest level of connectivity and coherency can be seen in the connected western shabestan. The twisting entrance corridors have reduced the connectivity level; the separate and isolated single Iwan has no contribution to the level of connectivity compared to the general plan; however, this Iwan, with its high opening space, has a high level of connectivity compared to the adjacent spaces.
Ancient Mosque of Qazvin			The rather wide Iwans in this mosque and the adjacent shabestans show a lot of connectivity but little cohesion. The long entrance hall of this mosque, due to the spatial presentation through the portico (Jelo-khan) and the northern area of Iwan facing the courtyard, has not lowered that much the connection of spaces, however, there is a low level of coherency.
Isfahan			The first and the second highest levels of connectivity and cohesion can be seen in the main central courtyard and Iwans and then in the adjacent courtyard. The depth of the Shabestan, which is far from the courtyard and Iwans, shows a low level of connectivity but has an acceptable level of coherency.

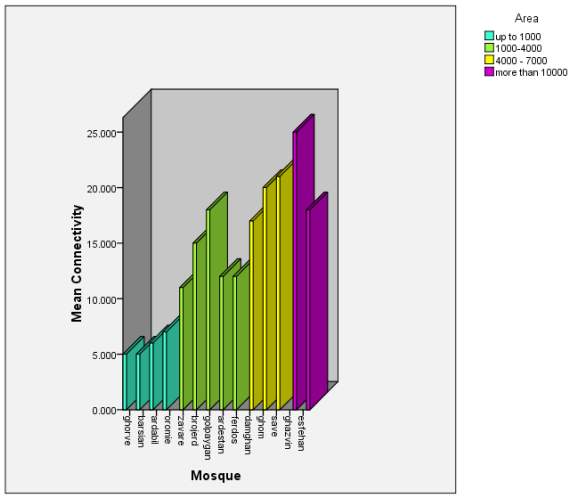


Fig. 6. The average level of connectivity (mean value) in mosques according to area-based classification. Source: Authors.

mosques of the third and fourth groups due to its connected spaces, and is also comparable to Grand Mosque of Isfahan. It seems that this high level of connectivity in mosques with four Iwans is due to the following reasons: 1. The high proportion of the central courtyard to closed spaces (shabestans), 2. The regular and symmetrical spatial organization, 3. The symmetrical position of the entrance spaces, and their access to the adjacent shabestans, 4. The absence of visual and moving barriers while providing spatial hierarchy and finally 5. The special position of Iwans. For those located in the north and south parts, which, by having the suitable opening space and proper spatial depth, allow the courtyard to enter the dome space and shabestans to create a high level of connectivity.

According to the third and fourth categories of mosques the Ancient Grand Mosque of Qazvin with a large area, a definite main entrance with all spatial hierarchy, four Iwans adjacent to a large courtyard, and a high ratio of in-between and open spaces to closed spaces has placed at the top of the diagram of connectivity. The Grand Mosque of Qom is at the second level with two definite entrance spaces and four Iwans with different proportions to each other. In this mosque, only the main Iwan (Qibla), which is distinct from the other three ones, in case of depth and dimensions, which is greater others represents an Iwan, while the other three porches do not represent it according to the spatial definition of a porch except that they are taller than the openings around them only in terms of height. The entrance spaces also have visual and moving barriers to create a quiet and obedient entry and represent a spatial hierarchy.

The Grand Mosque of Isfahan is placed at the next level due to the following characteristics, despite having a large area: 1. numerous and scattered entrance spaces, 2. spatial complexity and more asymmetric arrangement of spaces compared to the previously mentioned mosques and the 3. Increase in the ratio of closed to semi-open and open spaces. In this mosque, the porches/Iwans have little level of entry to the closed spaces, and in other words, the interfering of open and closed spaces in the semi-open space of the Iwan is at the low level, as there is no possibility for a suitable spatial transmission from the central courtyard to the space of shabestans.

The Grand mosque of Damghan with high degrees of inconsistency in the building plan, is placed in the last order, even after the Jame Mosque of Golpayegan (which has 2nd place in the area-based category) due to the following characteristics: 1. A very small space in the central courtyard compared to the entire spaces of the mosque, 2. A single Iwan and an entrance corridor 3. An indirect and circulated entrance. In the second category of grand mosques, Borujerd Jame Mosque has the second most connectivity level after Jame Mosque of Golpayegan, due to having a specified single porch, and a symmetrical plan much simpler than other mosques, with less spatial complexity and variety. This porch/Iwan has provided a high spatial entrance from the courtyard to the dome space and the shabestan area.

At the next level, Ardestan and Ferdows Jame Mosques with small central courtyards are placed (Fig. 7). The Ardestan Jame Mosque, despite having four Iwans, has little connectivity due to its long entrance corridors and the asymmetrical and irregular spatial organization. The Ferdows Jame Mosque with its simpler spaces and single

porch/Iwan is at the same level of connectivity as Ardestan Jame Mosque, and it seems that what has caused Grand (Great) Mosque of Zavareh to present the least spatial connection despite the acceptable ratio of open and semi-open spaces to closed spaces, is arising from its large difference in area compared to other Great Mosques. Although this mosque is placed in second place, it is close to the first category in terms of area, especially the Grand Mosque of Urmia. It seems that the presence of a central courtyard and four symmetrical and regular Iwans around it with a proper entry into the space of the shabestans and two regular and symmetrical entrance spaces are the main factors of the unexpected increase in connectivity level of this mosque compared to the first group mosques.

In the first group of mosques, the connectivity is dependent on the area factor as the diagram shows, and it seems that in the Gherveh Grand Mosque, the opening area above the shabestan and dome space has created a high level of connectivity, similar to the single space of the Barsian Mosque (dome space/Gonbad-Khaneh). The connectivity level between the Iwan and the adjacent shabestans has been compared in two samples of the grand mosques (Fig. 7 & 8).

Analysis of the Level of Integration in the Seljuk Mosques

Generally, the level of integrity decreases by increasing the area factor in these mosques this decreasing flow from mosques without courtyards to those with central courtyards shows an increase. It seems that the central courtyard is a significant factor in increasing the factor of integration. The gradient of the integration in the first group mosques is much higher than in other groups as the diagram shows (Fig. 9).

This finding shows that the effect of area on integrity in mosques with low areas is stronger than those with high areas. According to his figure the integration in courtyard mosques from the Grand Mosque of Zavareh to the Grand Mosque

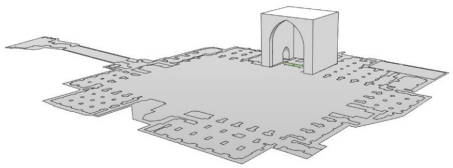


Fig. 7. The Iwans connection and opening area to the space of shabestans in the Borujerd Jame Mosque. Source: Authors.

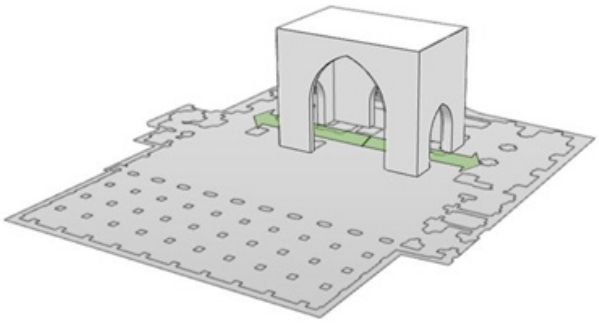


Fig. 8. The spatial disintegration of Iwan with shabestan in Ancient Jameh Mosque of Qazvin. Source: Authors.

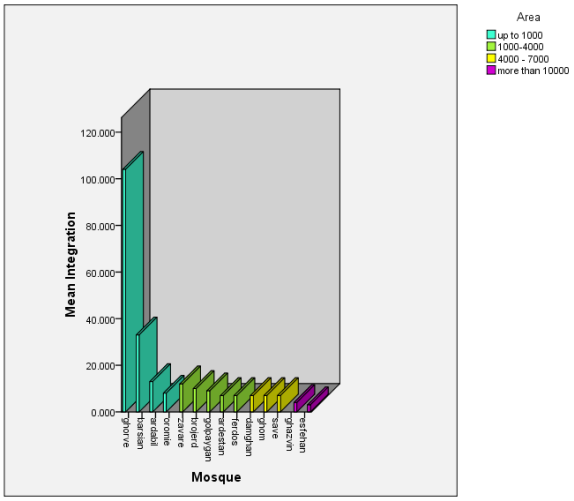


Fig. 9. The mean value for connectivity factor in mosques according to area-based classification. Source: Authors.

of Ardestan is decreasing while from this mosque to the Grand Mosque of Damghan has a constant gradient Considering a rather equal area difference between the mosques of these two parts of the diagram, it seems that the physical characteristics of these mosques have influenced the gradient of the diagram. The graph moves downward again from the Grand Mosque of Damghan to the Grand Mosque of Isfahan.

The details of the difference in the degree of integration factor in the spaces of these mosques have been studied and analyzed for each sample

in Table 6. It shows that the Grand Mosques of Gherveh, Barsian, and Ardabil have a very small area compared to other mosques with one or two simple and convex spaces, and it seems that this high difference in integration level is caused by these two mentioned issues, however, Grand Mosque of Zavareh, despite its area close to Grand Mosque of Urmia, shows a much higher spatial integrity. This mosque has the highest level of integrity among the other mosques with courtyards due to having the following characteristics 1. A symmetrical plan, 2. A small central courtyard, 3. Four Iwans with relatively wide dimensions around it and 5. Two symmetrical, simple, and short entrance spaces. In this mosque, the opening spaces of the Iwans compared to the adjacent shabestans have created an integration unity and prevented the spatial interruption of the shabestans besides its contribution in creating the convex shape of spaces. On the next level, the Grand Mosques of Golpayegan and Borujerd are placed, which have regular entrance spaces, central courtyards, wide Iwans with a special position, and a spatial connection with the adjacent shabestans and dome spaces. Despite having more area compared to Grand Mosque of Urmia, they are more integrated than this mosque. At the entrance spaces of Grand Mosques of Golpayegan, the spatial discontinuity or disintegration between the entrance space and the areas of shabestans is at its lowest level compared to the other mosques. Despite having a hierarchical spatial design, these entrance spaces provide an integrated space and spatial continuity with the spaces of shabestans due to their wide opening areas. After Grand Mosques of Golpayegan, the following mosques are placed in order: 1. Grand Mosques of Qom with four integrated Iwans, spatial opening compared to the surrounding shabestans, a long courtyard, and a narrow space of shabestans; 2. Historic Grand Mosque of Saveh with two Iwans and a wide courtyard and 3. Grand Mosque of Ardestan with four Iwans, and numerous irregular, long, and corridor entrance areas. It seems that the reason for the reduction of integration in this mosque compared to the other mentioned mosques with a larger area (Qom and Saveh) is arising from its 1. Location, layout, and form of entrance areas, 2. Spatial multiplicity, complexity and disintegration, and finally 3. The lower level of symmetry and organization.

Despite deep penetration of the Iwan space in the Grand mosques of Saveh, Ardestan, Qom, and Damghan, the spatial expansion inhibits the spatial disruption in shabestans, but the grand mosques of Ferdous and Damghan due to having a single deep Iwan, which is enclosed and separated from shabestans are placed in the next stage after the mosques of Saveh and Qom despite having a smaller area. The lowest level of integration was seen in the grand mosques of Qazvin and Isfahan. Considering the large difference in the area of these two mosques, compared to the previous ones, it seems that this decrease in the mean value of integration is due to the high area of these mosques. Moreover, in these mosques, especially in the Grand Mosque of Isfahan, in addition to having large areas, more spatial complexity can be seen, and there are irregular spaces with less organization around the central courtyard. In these two mosques, due to the deeply expanded Iwans with physical enclosure and the presence of closed walls compared to the adjacent shabestans, the spatial connection between the shabestan spaces has been disintegrated, which caused spatial concavity and the decrease of integrity among the spaces. The various types of entrance spaces have been compared in these mosques (Figs. 10-12).

Conclusion

After explaining the concept of "in-betweenness" and its manifestation in architecture, these spaces were introduced in the target Grand Mosques.

Moreover, the qualities affecting the environment flexibility were identified by applying the adaptability approach, and its relevant measuring and evaluation tools, including connectivity and integration factors. After selecting the statistical population and dividing

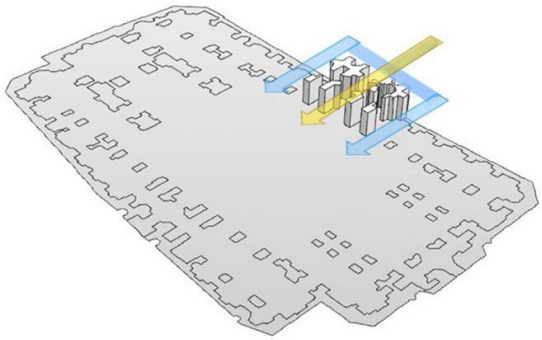


Fig. 10. The entrance space in the Central Mosque of Golpayegan (there is a connection and integrity with the surrounding shabestans and the possibility of visual penetration from the entrance space to the central courtyard). Source: Authors.

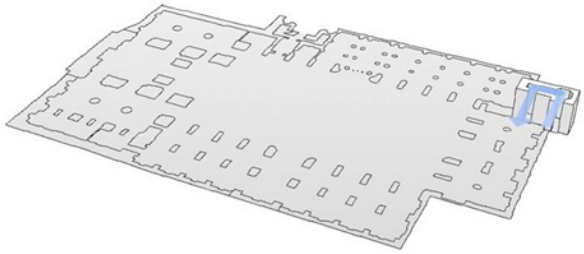


Fig. 11. The entrance space of Grand Mosque of Qom (90-degree spatial turn and twist without visual intrusion into the interior spaces). Source: Authors.

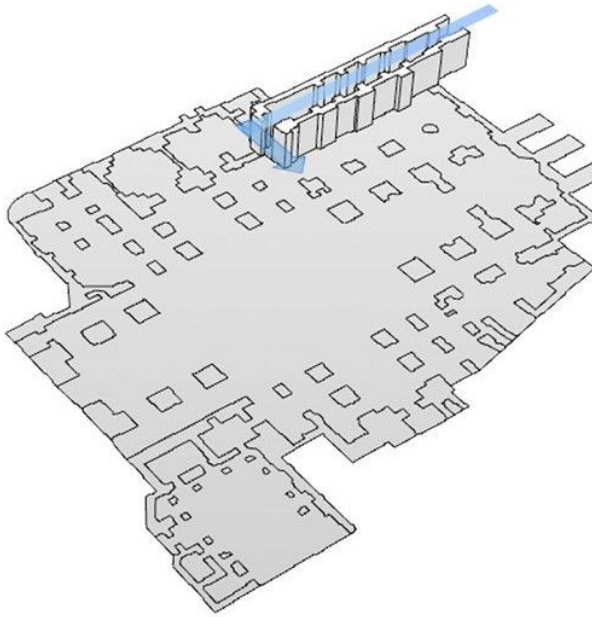


Fig. 12. The entrance space of Grand Mosque of Ardestan (corridor entrance without visual penetration into the interior space. Source: Authors.

it into five categories of areas, the data acquired by the depthMap X software were analyzed in SPSS statistical software to measure the normal distribution. The results of the statistical analysis showed the influence of area factor on the level of connectivity in Seljuk mosques with an area of less than 4,000 m2, while, this factor had no significant effect in mosques above this area.

Moreover, according to the results, the area factor did not affect the integration, and finally, the output graphs from the software were analyzed based on two factors of shape and physical characteristics with special attention to the in-between spaces. The analysis of tables, diagrams, and graphs related to the space syntax indicates that the layout quality of in-between spaces is effective both on the mean value of integration and connectivity in the grand mosques of the Seljuk era and the quality of their adaptability.

By comparing the connectivity and integration diagrams, it can be concluded that the effect of the area factor on integrity is less than its effect on the connectivity of spaces. According to the results (tables, diagrams, and graphs of the space syntax) and considering the overall plan of the Seljuk mosques, it can be mentioned that the following factors increase the spatial connectivity and integration, and subsequently the quality of adaptability in the target mosques: 1. symmetrical organization in the whole plan of the building 2. Low level of complexity 3. Low level of spatial diversity and 4. Higher level of spatial simplicity. Given the layout of the three in-between spaces (the central courtyard, Iwan, and the entrance spaces) the following items were concluded:

Central courtyard: The central courtyard and its proportion to the entire area of the mosque, is the most important in-between space in connecting the spaces and increasing the integration level. The space layout around the central courtyard affected the average connectivity of the spaces. The mosques with elongated shapes and enclosed spaces (shabstans) around the rectangular central courtyards represented the highest level of space connectivity. By decreasing the courtyard ratio to enclosed spaces and being separated from the courtyard wall, this factor had a less increasing effect on space connectivity. Moreover, in mosques

with two courtyards, the second side courtyard increased the integrity and connectivity levels of the spaces.

Porch/Iwan: Iwan as a spatial intermediate space between two open (courtyards) and closed (shabestans) spaces is the meeting place of these two areas, which is required to have the properties of both areas in equal proportion to be able to connect them, otherwise, it turns into one of them and loses its function as an in-between space, similar to what happened in Grand Mosque of Qazvin, in which the Iwans had little connection with the shabestan space due to the spatial enclosure of walls and the expanded openings compared to the courtyard which become part of the courtyard. The example of an integrated connection of Iwans with both open and closed spaces can be seen in Grand (Great) Mosque of Zavareh, which created the highest level of integration. It should be indicated that the decrease in the average level of connectivity in this mosque compared to other mosques is arising from the effect of the area factor on the connectivity of spaces. Therefore, the higher regular organization of Iwans around the central courtyard and appropriate spatial depth compared to closed spaces, provide a more possibility of integration in open and closed spaces; As, due to having no physical enclosure to cause spatial discontinuity in the adjacent spaces of shebastans, a sufficient expansion and subsequently a higher level of integration between the surrounding spaces presented. The spaces with these characteristics provide a higher performance of in-between spaces which increases the spatial convexity, adoption, and integration level. Therefore, the increased number of Iwans brings a higher level of spatial integration and connectivity in four Iwan mosques. By increasing the number and ratio of Iwan's area (by having optimal characteristics of in-between spaces) to the total area of the mosque, a higher level of connectivity was provided in the target mosques in the Seljuk era.

Entrance Spaces: These spaces are among those areas with in-between characteristics that affect the average level of connectivity and integration in grand mosques. Therefore, the following characteristics have increased the average level of connectivity and integration: The presence of in-between spaces, regular and symmetrical placement of entrance areas, no long corridors, simple design, and finally spatial integration besides respecting a kind of hierarchy have increased the quality of adaptability. Therefore, according to what was mentioned earlier, the in-between concept has shown a great contribution in elevating the quality of adaptability in the mosques of the Seljuk era. Moreover, based on the results of this study, the higher level of characteristics relevant to the in-between spaces (central courtyard, Iwan, and entrance spaces) leads to more spatial integrity and the quality improvement of adaptability.

Conflict of Interest

The authors of this study declare that there was no conflict of interest.

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