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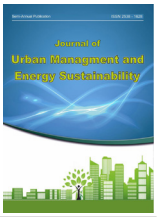

CASE STUDY RESEARCH PAPER

Recognition and analysis of the spatial configuration of traditional schools during the Safavid period (Case study: Traditional schools in Isfahan city)[1]

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ABSTRACT

Traditional schools in historical periods have played a significant role in education and the advancement of various sciences. Notably, during the Safavid era, remarkable examples can be observed in important cities like Isfahan. Given the political and economic conditions of Iran during this period, the traditional schools of Isfahan also played a crucial role in stabilizing the Safavid state and shaping the cultural identity of Iranians. Recognizing the formative spaces within the conceptual framework of spatial configuration can lead to strategies for designing contemporary schools. The research methodology of this study is applied in terms of purpose and combines descriptive and logical reasoning methods regarding its nature and approach. Data collection is primarily library-based, and regarding primary data on spatial arrangement methods, the research sample studies have been gathered through document studies and articles. The case studies consist of various types of schools from the Safavid era in Isfahan, including six schools: Jaddeh Bozorg, Jaddeh Koochak, Chaharbagh, Molla Abdullah, Kaseh Garan, and Nimaavard. In the analysis part, the spatial arrangement method is initially used to call up maps and analyze the spatial parameters of the schools in the software environment. This involves connectivity and readability using the analytical graph system. The findings indicate that the parameters of connectivity, readability, and the connection relate to the form of the floor plan, access from the courtyard to public and private spaces, and the degree of visual depth in the way spatial connections are configured. Consequently, during the Safavid era, due to the existence of cohesive architectural patterns and the creation of modular and spatially compact, symmetrical structures with central courtyards, these schools are considered outstanding examples in the history of Iranian architecture.

Running Title: The spatial configuration of traditional schools during the Safavid period

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11

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1. *This paper is taken from Raziyeh Ghanbari Safdar's Ph.D. thesis entitled "Physical typology and spatial configuration of traditional schools to achieve a suitable model for contemporary school design (Case study of Safavid schools in Isfahan)" which is about to be conducted under the guidance of Dr. Hasan Sajadzadeh and advice of Dr. Saeid Salehi Marzijarani at Faculty of Art and Architecture of Islamic Azad University, Arak Branch.*

INTRODUCTION

Traditional schools during the Safavid period in Isfahan are considered some of the most prominent examples of educational centers in the history of Iran. These schools were recognized not only as educational institutions but also as cultural and social centers. In fact, with the establishment of the Safavid capital in Isfahan, considerable efforts were made for scientific and cultural development, leading to the formation and flourishing of traditional schools. One of the notable features of Safavid schools was their attention to architecture and design. During this period, schools were designed inspired by Islamic architecture, utilizing beautiful elements suited to the region's climate. The structure of educational buildings included central courtyards, classrooms, and places of worship, which helped maintain the scientific and religious spirit among students. For example, the Chaharbagh School, one of the most recognized schools in Isfahan, with its beautiful architecture and striking domes, was a center attracting students and scholars from various parts of the country (Hosseini, 2017). The Safavid period is particularly known for the increasing growth of Islamic and human sciences. Scholars of this era, such as Mulla Sadra and Allameh Majlisi, taught and conducted research in these schools. These schools also served as a venue for the exchange of ideas and thoughts among scholars and philosophers. The education of great scholars who contributed to the development of science and knowledge in Iran was one of the most significant achievements of these schools (Tazikov, 2014). Safavid schools also functioned somewhat as social institutions. In addition to education, subjects such as ethics, social rights, and religious responsibilities were taught. Consequently, students were educated not only as religious scholars but also as responsible citizens (Amini, 2021). Another characteristic of the traditional schools in Isfahan was the diversity of educational disciplines. In these schools, various sciences, including jurisprudence, Quranic interpretation, philosophy, mathematics, astronomy, and literature, were taught. This multidimensional approach to education enabled students to acquire skills in various scientific and cultural fields, contributing to their social development (Pirnia, 2010). Considering the political and economic situation in Iran during this period, the traditional schools of Isfahan played a crucial role in stabilizing the Safavid state and the cultural identity of Iranians. These schools were centers of science and culture, laying the groundwork for the stability of the Safavid system and the strengthening of Shia Islam in Iran. Additionally, the educational programs of these schools provided a platform for intellectual and theoretical frameworks that continued into later periods (Sadeghi, 2019). Studying in these schools was considered a significant privilege, especially for religious and influential families, and it helped in the social advancement of individuals. Students became acquainted not only with deep religious knowledge but also with social and cultural skills. As a result, many graduates of these schools achieved high positions in religious and social spheres (Ebrahimi, 2016). Despite their outstanding features, traditional schools in Isfahan faced challenges. These challenges included inefficient educational systems and social limitations on the admission of students from lower classes. These issues hindered access for many individuals who had academic merit and potential talents (Rajabi, 2020). Ultimately, the legacy of the traditional schools of Isfahan during the Safavid period had a profound impact on the history of education in Iran. These schools not only contributed to the formation of Iranian cultural identity, but also played a fundamental role in the improvement and advancement of society through the production of knowledge (Moradi, 2022). Thus, the traditional schools of Isfahan during the Safavid era are recognized as effective institutions in the cultural and scientific formation of Iran, and their impacts on the history of education in this land remain evident.

MATERIALS AND METHODS

The spatial configuration or spatial organization of Isfahan's traditional schools during the Safavid era was one of the most important architectural and educational features of these institutions. Due to their specific design and construction features, the schools of this era had a great impact on the learning process and social interactions of students. In the following, we will examine the different dimensions of the spatial configuration of Isfahan's traditional schools:

Central courtyard: The central courtyard was a key element in the design of Isfahan's traditional schools. As the main core of the building, this space provided a space for students and teachers to gather and interact. The courtyard was usually decorated with gardens and trees, and social and educational activities were carried out there (Khalili, 2016). Classrooms: Classrooms were usually located around the central courtyard. (Razavi, 2021) These classrooms were designed in such a way that they received sufficient natural light through openings and windows and had proper ventilation. In some schools, classes were organized according to the level of education and the type of lesson (Golestani, 2019). Use of arches and various sizes: Beautiful arches and different sizes of spaces were well used in many Safavid schools. These elements not only enhanced the aesthetics of the building but also helped facilitate the flow of air and light (Ahmadi, 2020). Public and private spaces: In addition to classrooms, traditional schools also had public and private spaces. Spaces for students to study were considered, as well as places for rest and social interactions. (Esmaili, 2022) These factors helped create an environment that encouraged learning (Rezaei, 2021). Libraries: Libraries were an integral part of traditional schools and served as centers for students' study and research. These spaces were usually located in the main school building and close to the classrooms to be easily accessible to students (Seyed Alavi, 2018). Decorative facades: Islamic schools in Isfahan are known for their beautiful decorations of manuscripts and tiles. These beautiful elements helped to form the cultural and artistic identity of these schools and positively influenced the visual experience of students (Nasr, 2015). Spatial separation of men and women: In many schools, educational spaces for men and women were designed separately to allow girls to study, considering the social context of the time. This design helped balance the learning process (Kazemi, 2020). Teachers' rooms: These schools usually had special rooms for teachers, which allowed them to interact more with students and review the course content in that space. These rooms were usually designed to allow easy access to the classrooms (Mohammadi, 2022). Use of light and shade: Schools were designed to allow light to best penetrate the interior spaces through windows and canopies. Light and shade, as two design elements, played a fundamental role in facilitating learning (Faraji, 2023). Connections with religious spaces: The proximity and connection of schools to mosques or other religious places were also prominent features of these schools. This connection provided students with an opportunity to participate in religious activities and strengthen the spiritual and moral dimension of education (Zamani, 2019). A conceptual model for the spatial configuration of traditional schools in Isfahan during the Safavid period can include the details and key elements of this design. In the following, a model is presented that examines the main components and their relationships.

Therefore, the spatial configuration features of these schools can be presented in the form of a table:

The model and its features can be analyzed as follows:

- The central courtyard, as the core of the school, affects all social and educational activities.
- The teacher or classrooms and public and private spaces contribute to learning and social interactions.
- Libraries and teachers' rooms also contribute to improving the teaching and learning process.

- Environmental factors and connections to religious spaces will also help strengthen its spiritual and social dimensions.

Finally, this spatial organization doesn't only affect the educational process but also leads to the refinement of the cultural and social spirit of scholars and students. The spatial configuration of traditional schools, especially in the Safavid period, was formed under the influence of numerous factors, including cultural, social, political and economic, and has also experienced changes in subsequent historical periods. These changes are notable in Isfahan, as one of the important centers of science and culture in Iran. Next, we will examine the changes in the spatial configuration of traditional schools during the Afshari, Qajar, and Pahlavi periods.

Methodology

Research Methodology The present study is applied in terms of its purpose and is a combination of descriptive and logical reasoning in terms of its nature and method. The method of collecting information is library-based, and the primary data on the spatial arrangement method and the research study samples were collected through the study of documents and articles. In the process of conducting the research, computer simulation, comparison of samples, and finally logical reasoning were used. The study samples are also from different types of schools related to the Safavid era in Isfahan, including six schools: Jaddeh Bozorg, Jaddeh Kuchak, Chaharbagh, Mulla Abdullah, Kase Garan, and Nimavard. In the analysis section, first, based on the spatial arrangement method, a map was called up and through this, the spatial parameters of the schools' dump maps were analyzed in the connectivity, integration, and readability software environment using justification graph analysis systems. The collected characteristics of the schools, such as flexibility, are examined through the relationship varies in the visibility graph analysis system. In order to analyze accessibility, the connectivity variable is also applied in these schools. In the visual structure, the visual connection and the visual and physical step are also examined. Next, the models proposed in the field of school plans are explored in the context of case studies with a descriptive-analytical approach, and the type of spatial configuration

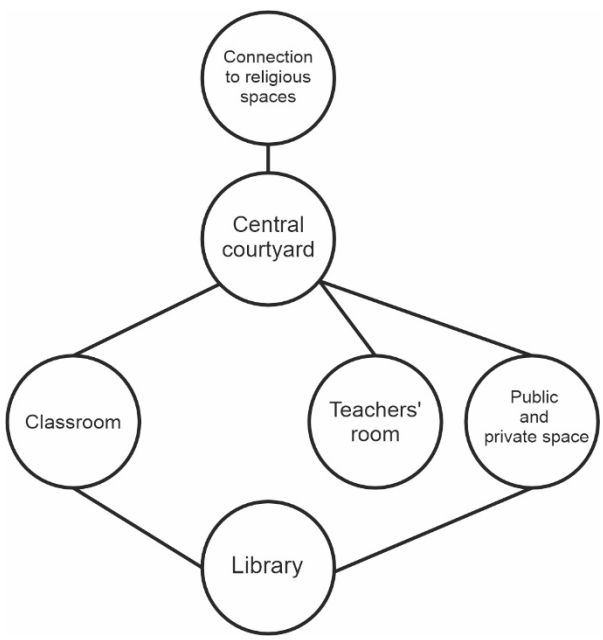


Figure 1: Conceptual model of the spatial configuration of traditional Safavid schools in Isfahan

for each case is explained. Finally, by adapting the findings with the logical reasoning method, the results are expressed and spatial configuration patterns are presented. Finally, the spatial parameters of each school can be interpreted and concluded by adapting and calibrating them with the main features of the research structure.

DISCUSSION AND FINDINGS

Case study analysis

To examine the samples required for the research, six schools in the Safavid historical period in the city of Isfahan, corresponding to the period from 1501 to 1736 AD, the Safavid ruling dynasty of Iran, were selected. (Table 2)

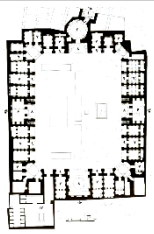
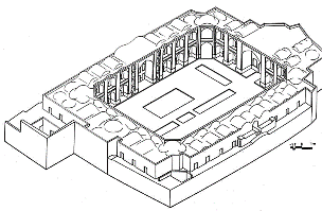
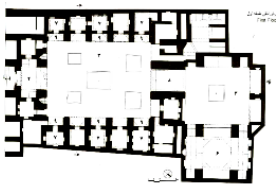
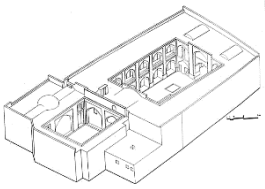
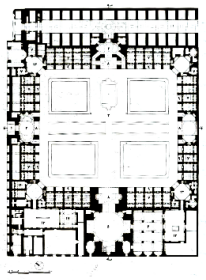
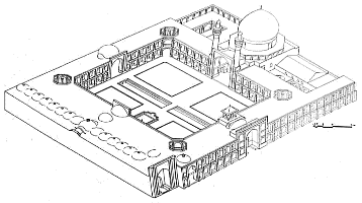
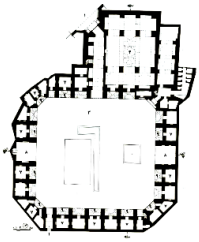
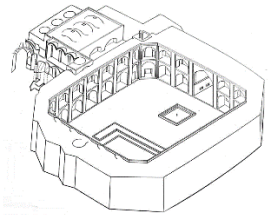
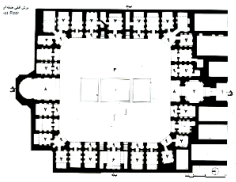
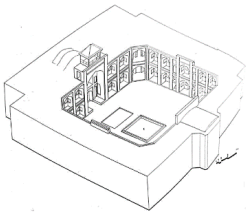
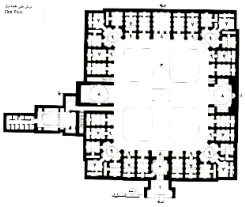
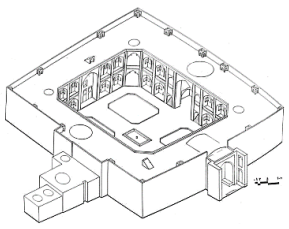
Space Syntax Method

One of the methods that was born in the form of a formalist perspective and in line with understanding the structures, invisible systems and systems behind architectural forms and phenomena is the spatial arrangement method. This method was founded in 1984 by Hillier and Hanson (1977). (Hillier and Hanson, 1984; quoted in Bahreini and Taghabon, 2011). The spatial arrangement method, with the help of connected graph representation, models and analyzes the spatial configuration or the arrangement of urban and architectural spaces together (Jamshidi, 2003). The syntax of space recalls spatial characteristics in the form of spatial configura-

Table 1: Characteristics of the spatial configuration of traditional schools in the literature

Space name	Feature	Description	Reference
Central courtyard	Sociability	The central courtyard in traditional Iranian schools serves as a gathering space for scholars, students, and teachers. This space is usually decorated with gardens, ponds, and ornamental trees and is designed to provide a sense of calm and coolness for its users.	Khalili (2016)
Class	Readability	The classroom or lecture hall is designed to ensure natural light and proper ventilation. Often, these classrooms are decorated with arches and domes, helping to enhance the aesthetics and learning atmosphere.	Golestan (2019)
Public and private space	Flexibility	These spaces include study rooms for scholars and students, relaxation areas, and spaces for social activities. This design facilitates teamwork and social interactions.	Rezaei (2021)
Library	Flexibility	Libraries are usually located close to classrooms and provide a space for study and research. These spaces allow scholars and students to access various resources and carry out their research projects.	Seyed Alavi (2018)
Teachers' room	Flexibility	Teachers' rooms are designed close to classrooms so that teachers can easily access students and scholars. These spaces are usually used for educational meetings and lesson planning.	Mohammadi (2022)
Environmental factors	Environmental comfort	The spaces are designed to make optimal use of natural light and shade. The use of local and sustainable materials in these schools helps create a pleasant and pleasant atmosphere.	Faraji (2023)
Connecting to religious space	Accessibility	Many traditional schools in Isfahan are close to mosques and religious sites. This proximity allows scholars and students to participate in religious activities and practice religious values in their daily lives.	Zamani (2019)
Social role	Communitarianism	Traditional schools also function as community centers, educating responsible citizens in society. These institutions emphasize social and moral values while teaching various sciences.	Kazemi (2020)
Use of architectural style	Aesthetics	The different arches and heights in traditional schools have a significant impact on the aesthetics of the spaces and help improve the social and classroom life of students.	Ahmadi (2020)
Use of light and shadow	Climatic comfort	The design of schools is such that natural light enters the interior spaces well through windows and openings, and appropriate shades help reduce the ambient temperature and create a pleasant atmosphere.	Sadeghi (2019)

Table 2: Sample of schools studied in the study, indicating type, construction period, and documentation

School name	School type	Construction period (H.Q.)	Construction description	Main plan	3D Image
Jaddeh Bozorg	Central courtyard	1058	This school was built on the orders of a lady named Houri, the great-grandmother of Shah Abbas II. (Jaberi, 2009)		
Jaddeh Kuchak	Central courtyard	1056	This school was also built during the reign of Shah Abbas II at the request of Delaram Khanum Jaddeh, or the Shah's grandmother. (Riahi, 2012)		
Chahar-bagh	Central courtyard	1116-1126	This theological school (known as Madar Shah Mosque) was established during the reign of Shah Sultan Hussein. (Graber, 2009)		
Mull Abdolah	Central courtyard	1088	Mullah Abdullah School is a residential school built in Isfahan in the 11th century AH by order of Shah Abbas I for the teaching of Maulana Abdullah Shushtari (Honar Far, 2010).		
Kase Garan	Central courtyard	1105	The founder of this school is Hakim al-Molk Ardestani and it was built during the reign of King Suleiman. (Imrani, 2005)		
Nima-vard	Central courtyard	1117	Zainab Begum built the Nimavard School in 1117 during the reign of Shah Sultan Hussein. (Sultanzadeh, 1364)		

tion and presents ideas in line with the impact of spatial characteristics of the environment on the formation of social behaviors. (Nazarpour et al., 2011) Researchers have concluded that the spatial arrangement method is an effective method for predicting the movement of people in space. (Abbas Zadegan, 2002; Bahreini and Taghabon, 2011). Spatial organization can strengthen desirable social interactions and also have a direct impact on creating desirable privacy. In fact, through appropriate organization of spaces and spatial layout, an appropriate level of communication and desired privacy can be achieved in accordance with the activities of the desired spaces (Varmaghani, 2021). Privacy and social communication are among the most important activities carried out in the classroom and affect the learning process.

Spatial configuration in traditional schools

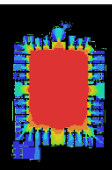
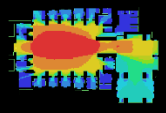
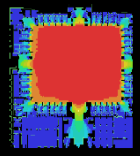
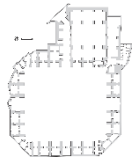
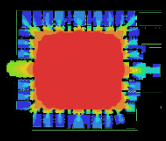
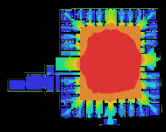
Spatial configuration refers to the spatial organization and structure of an environment, which includes the distribution and arrangement of elements and spaces in a specific area. This concept is particularly considered in architecture, urban planning, and interior design, and it examines how the designed space affects human behavior and social functions. In the following, some basic aspects and importance of spatial configuration are mentioned. (Setaysh, 2021) Spatial configuration refers to the structure and distribution of space that encompass various applications. This term refers to the arrangement of spaces, rooms, corridors, and other elements of the environment that affect how people use that space. In other words, spatial configuration determines how humans interact in the designed space and what kind of experience they gain in that space (Habraken, 1998). Proper arrangement of space can lead to productivity, comfort, and social amenities related to the environment. For example, in educational environments, the layout of classrooms, courtyards, and social spaces can influence learning and social interactions (Alexander, 1979). This includes elements such as volume and scale, which express the relationship between the size of spaces and their function, light and ventilation, which indicate the effect of natural light and ventilation on the comfort of the space, and finally flow of movement, which are patterns that facilitate movement and use of space (Gehl, 2010). In particular, spatial configuration is a key tool for understanding and improving the quality of educational spaces in traditional schools (Rogers, 1997). The spatial configuration study in the Depths-Map software provides various results, including the depth of interconnection of various visual and physical features in the form of numbers and graphs. By analyzing and evaluating each of these parameters alone and in some cases, evaluating the overlap of two or more of these parameters, it is possible to understand the architectural qualities in examining the existing state of the spaces and also predict how these qualities will be if designed in new spaces. In this part of the study, after evaluating the ground floor plans of 6 traditional schools built during the Safavid period in Isfahan, the general results can be examined and studied in two categories. The first category is the evaluation of convex spaces and the connections between them, and the second category is information related to the visual features of these spaces. In the first part and in Table 3, the average output of the interconnection parameters and the depth of space resulting from the examination of the convex shapes of the plans of these schools is shown.

Table 3: Results of the evaluation of the spatial configuration of traditional schools of the Safavid period in Isfahan

	Nimavard	Mulla Abdulah	Kase Garan	Chaharbagh	Jaddeh Kuchak	Jaddeh Bozorg
Connectivity	2.0978	2	1.9062	2.0952	1.9393	1.974
Integration [HH]	1.4586	1.5915	1.5713	1.6289	1.6945	1.6104
Step depth	4.7282	7.8142	4.1875	4.5238	2.3636	4.6233

According to Table 3, the values obtained from the software evaluation for these plans, it can be seen that there are significant differences in each of the output parameters among the 6 schools studied, especially while there is no significant difference in the connection and interconnection parameter. This indicates that in both small and large schools, issues such as connecting spaces to each other and linking these spaces well and correctly and at a close level have been considered by designers and architects, and in practice, this quality has been implemented in the construction of these schools. However, regarding the significant difference in depth that is seen between the schools, it is due to the existence of hidden spaces in some of these schools, such as Mulla Abdullah School. In the following, each of these parameters will be studied and examined separately.

Table 4: Results of evaluating the connection parameter in spatial arrangement by Depth-Map

School name	Value		Plan	Connectivity
Jaddeh Bozorg	Min.	1		
	Average	1.974		
	Max.	28		
Jaddeh Kuchak	Min.	1		
	Average	1.9393		
	Max.	18		
Chaharbagh	Min.	1		
	Average	2.0952		
	Max.	50		
Mulla Abdullah	Min.	1		
	Average	2		
	Max.	33		
Kase Garan	Min.	1		
	Average	1.9062		
	Max.	25		
Nimavard	Min.	0		
	Average	2.0978		
	Max.	28		

Communication (Connectivity)

To examine the relationship between spaces in these schools, the values obtained for the connection parameter were used in this study. In Table 4, the minimum, average, and maximum values of the connection parameter for each of the schools, as well as the software output graphics for this parameter, have been examined for each of the schools.

As shown in Figure 2, comparing the average connection parameter for each school, Nimavard School and Chaharbagh School have the highest connection between spaces. Kaseh Garan School has the lowest spatial connection. This indicates that the quality of the connection between spaces in this school is higher than in other schools studied. It is quite clear in the graphic analysis that the schoolyard space has the highest connection with all spaces and micro-spaces. However, in schools such as Jaddeh Kuchak, Molla Abdullah, and Nimavard, the orange spectrum around the red spot of the schoolyard is more intense and more intense. Even in Jaddeh Kuchak School, we see a significant yellow border around the orange spectrum, which indicates a decrease in the connection between spaces. The center of the parabola is moving towards the walls and corners. Of course, this can also be analyzed and examined from another perspective and by considering the structural dimensions of the schools. In this case, Jaddeh Kuchak School has the smallest spatial dimensions and Chaharbagh School has the largest scale among the schools studied, which is an indication of the provider is one of the causes of the inconsistency of the quantities obtained from school evaluations.

Accessibility (Integration)

The connectivity quantity is another parameter obtained from the evaluation of these schools in the software environment. In this study, this quantity was used to study the quality of access among school spaces, meaning that spaces with high connectivity are more accessible and provide better and higher usability. Table 5 shows the values obtained from examining the connectivity parameter of spatial configuration in the software environment.

In the study of the quality of access between school spaces, which was based on the connectivity parameter, according to Figure 3, the highest level of this parameter belongs to the Jaddeh Kuchak School, and the Nimavard School shows the lowest level of connectivity between spaces. The other 4 schools are located in close proximity to each other and with a slight difference from each other. A graphic study of the level of connectivity in schools shows that in square-shaped

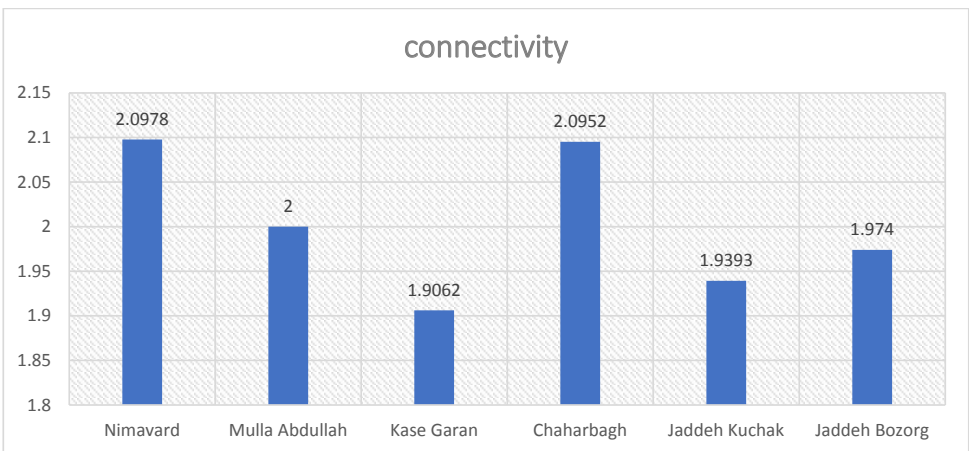


Figure 2: Comparison of the average connectivity parameter of schools in spatial layout

Table 5: Results of evaluating the correlation parameter in spatial arrangement by Depth-Map

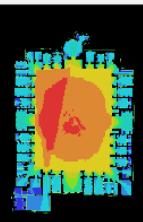
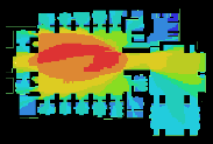
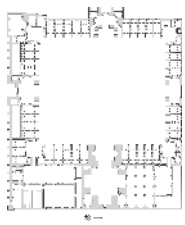
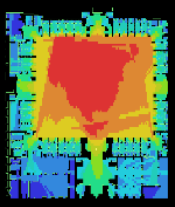
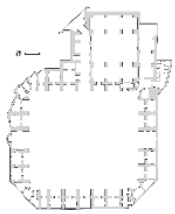
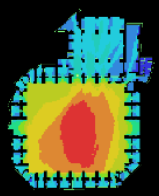
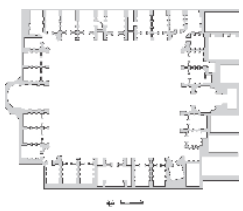
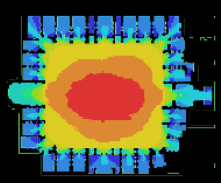
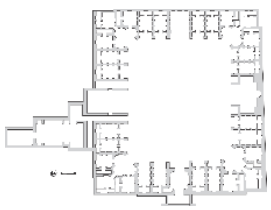
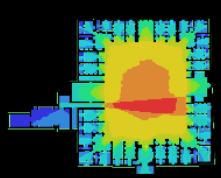
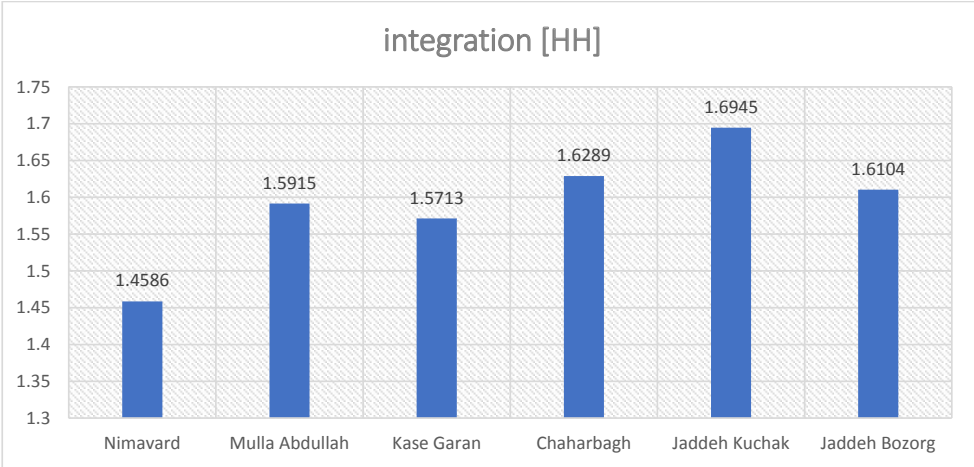
School name	Value		Plan	Integration
Jaddeh Bozorg	Min.	0.694		
	Average	1.6104		
	Max.	4.4207		
Jaddeh Kuchak	Min.	0.8496		
	Average	1.6945		
	Max.	5.6641		
Chaharbagh	Min.	0.8917		
	Average	1.6289		
	Max.	4.0789		
Mulla Abdullah	Min.	0.5155		
	Average	1.5915		
	Max.	4.1859		
Kase Garan	Min.	0.972		
	Average	1.5713		
	Max.	4.9549		
Nimavard	Min.	0.697		
	Average	1.4586		
	Max.	3.8638		

Figure 3: Comparison of the average integration parameter of schools in spatial arrangement



plans that have less depth and spatial hierarchy, there is a low level of connectivity in the space close to the parabolic walls, but in plans that are longer, such as the Jaddeh Bozorg and Jaddeh Kuchakschools, and the main axis of the design is located on the longer side of the plan, and also in a plan like the ChaharbaghSchool, which has a higher spatial hierarchy, more micro-spaces, and a higher depth of space, the graphics resulting from the connectivity assessment show a more favorable distribution of this quality in the main space of schools and, consequently, in the connection to the micro-spaces.

Physical depth (sub-base)

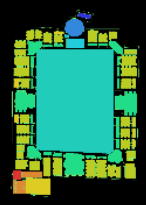
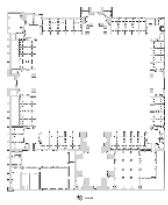
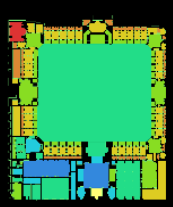
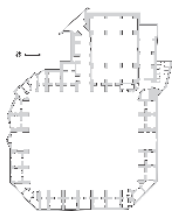
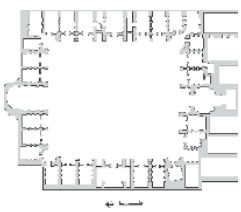
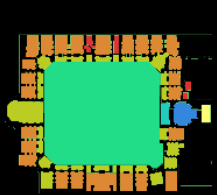
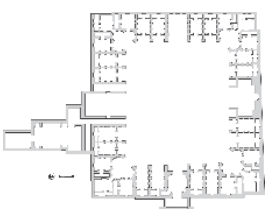
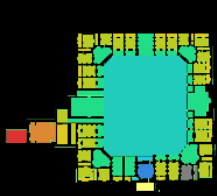
As mentioned, the evaluation in the space layout method is carried out in two main modes: the evaluation of convex spaces and the visual quality within the space. In this section, the physical depth of the spaces that make up the school plan is determined by considering each of the spaces as a separate space and establishing connections between these spaces. The steps to access each of the spaces are defined by considering the entirety of the spaces, starting with the main entrance. Table 6 shows the values of the physical depth parameter for each of the schools.

By examining the parameter of physical depth of space, in Figure 4, Mulla Abdullah School has the highest level of this parameter by far, and Jaddeh Kuchak School is located with a level close to half of the physical depth of the other 4 schools that are located in a close range. Examining the graphics resulting from this evaluation shows that the warmer the color of the school yard space as the main existing space is and the more it tends to yellow or orange, which is the case in Mulla Abdullah School compared to other schools, the spaces that make up the plan of this school have greater spatial depth. On the contrary, the more the color of this space tends to blue and cold, the lower and less spatial depth is in this plan, which is clearly evident in the school graphics.

Visual depth (Visual step-depth)

The visual depth of the overall school space was discussed in the first case of the study in the previous sections, and it is clear that in calculating the visual depth, it is necessary to specify the observer's point of view, and in the plan of the schools under study, this point is considered from the exit of the vestibule or the main porch of the entrance to the school courtyard, and the visual depth of the space from that point to all the spaces and micro-spaces of the school plan has been evaluated. Table 7 shows the results of the evaluation of the visual depth of space parameter.

Table 6: Results of evaluating the depth parameter of space in spatial layout by Depth-Map

School name	Value		Plan	Space depth
Jaddeh Bozorg	Min.	0		
	Average	4.6233		
	Max.	8		
Jaddeh Kuchak	Min.	0		
	Average	2.3636		
	Max.	4		
Chaharbagh	Min.	0		
	Average	4.5238		
	Max.	7		
Mulla Abdullah	Min.	0		
	Average	7.8142		
	Max.	12		
Kase Garan	Min.	0		
	Average	4.1875		
	Max.	6		
Nimavard	Min.	0		
	Average	4.7282		
	Max.	8		

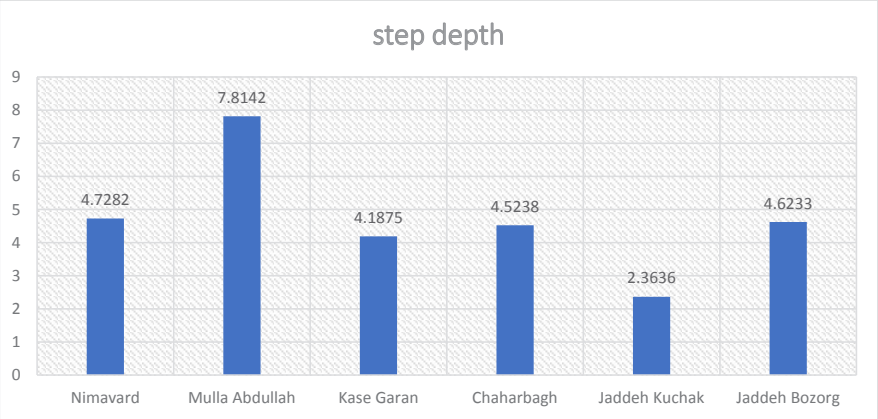
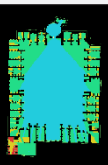
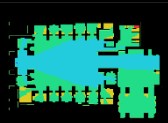
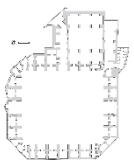
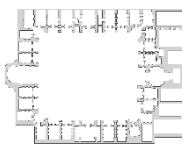
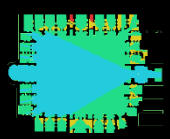
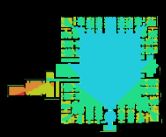


Figure 4: Comparison of the average physical depth parameter of schools in spatial layout

Table 7: Results of evaluating the depth of space parameter in spatial layout by Depth-Map

School name	Value		Plan	Visual depth
Jaddeh Bozorg	Min.	0		
	Average	1.69204		
	Max.	5		
Jaddeh Kuchak	Min.	0		
	Average	1.701		
	Max.	6		
Chaharbagh	Min.	0		
	Average	1.5794		
	Max.	4		
Mulla Abdullah	Min.	0		
	Average	1.8688		
	Max.	6		
Kase Garan	Min.	0		
	Average	1.6495		
	Max.	4		
Nimavard	Min.	0		
	Average	1.5325		
	Max.	4		

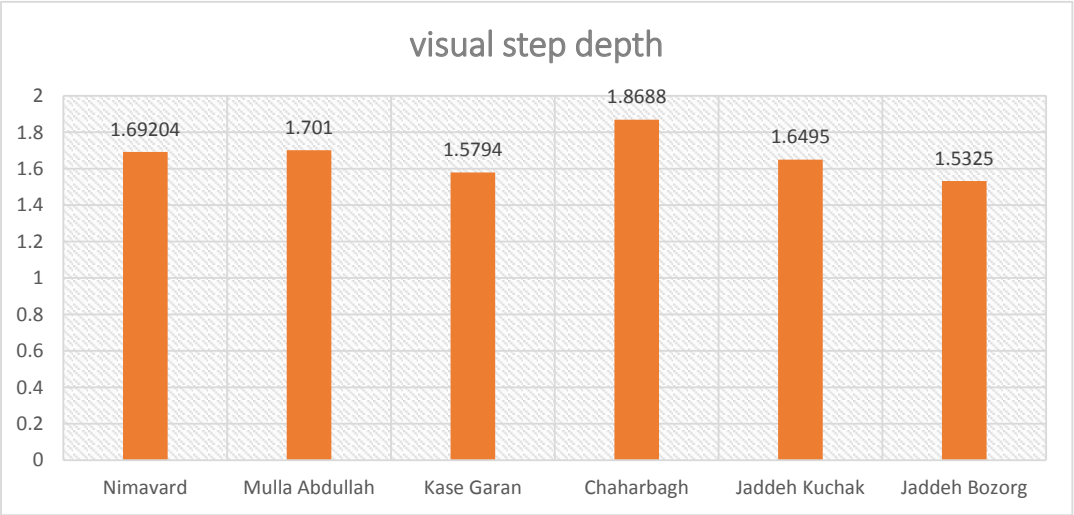


Figure 5: Comparison of the average visual depth parameter of schools in spatial layout

By studying the results shown in Figure 5 and Table 7, the Jaddeh Bozorg School has the lowest visual depth among the schools studied, while the Chaharbagh School has the highest value of this parameter. The Mulla Abdullah and Nimavard schools have almost the same visual depth, and the Jaddeh Kuchak and Kase Garan schools are at a lower level than the two with a slight difference from each other. A graphic study of this parameter also indicates that in the parts where we see blue and colder colors, we see a greater and higher visual depth of space. The highest value of this parameter is seen in the two Jaddeh Kuchak and Mulla Abdullah schools, and the Jaddeh Kuchak, Jaddeh Bozorg, Kase Garan and Nimavard schools graphically show similar and close values to each other. This result is due to the shape of the plan of the site area, as well as the type and manner of opening the main porch to the school courtyard, which are among the factors affecting the visual depth of these spaces.

Readability (overlapping connections and visual Integration)

In this study, two methods have been used to examine the quality of readability for the schools studied. In the first method, the correlation of two parameters of visual connection and coherence was used, and in the second method, the ranking of schools was used according to the unscaled values of three connection parameters of visual depth, coherence, and readability. Tables 8 and 9 show the correlation diagram of the main parameter X for each of the schools. In the readability diagram, the line R2 is related to the coefficient of linear correlation of two values of coherence and communication.

The graphs in Table 8 show the level of correlation. By studying the graphs, it becomes clear that this correlation is visible at a desirable and acceptable level in almost all schools, because in all graphs the regression line or the level of correlation is drawn with a slope of 45 degrees and in the positive direction, which indicates the existence of readability quality in these spaces. Therefore, the distance from zero to the origin of the regression line in each of the graphs is not completely the same. This value in the correlation graph of Chaharbagh School has the greatest distance from zero, and in Mulla Abdullah School it shows the closest distance. Also, the width from the origin of the correlation in the Jaddeh Kuchak School shows that in this school, in addition to the values of

coherence and connection, other parameters also play a role in the level of readability. In contrast, the dispersion and width from the origin of the correlation in the graphs of other schools show that the readability of the space of these schools is greatly influenced by their spatial configuration and the parameters of coherence and connection.

Table 8: Correlation diagram of two parameters of visual connectivity and integration of schools

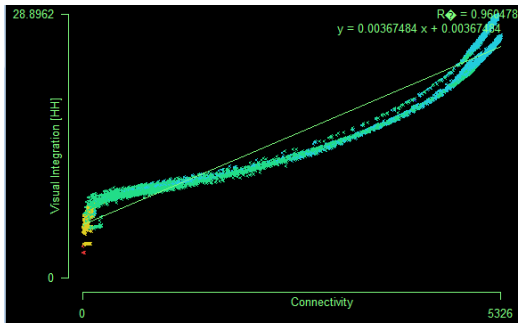
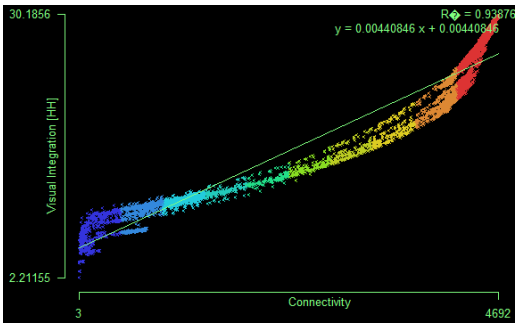
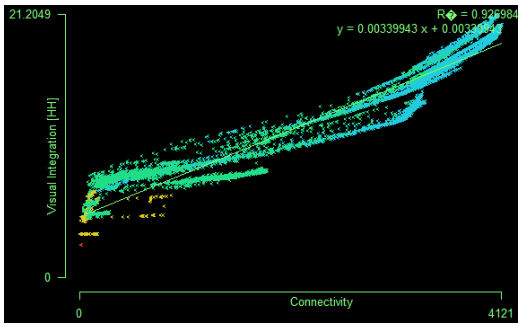
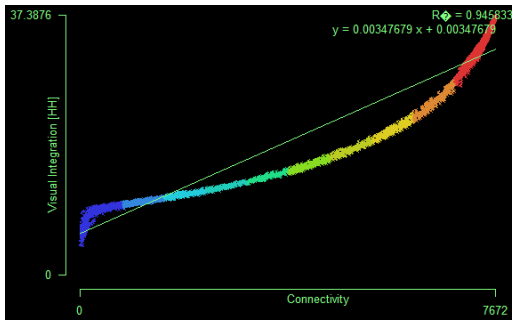
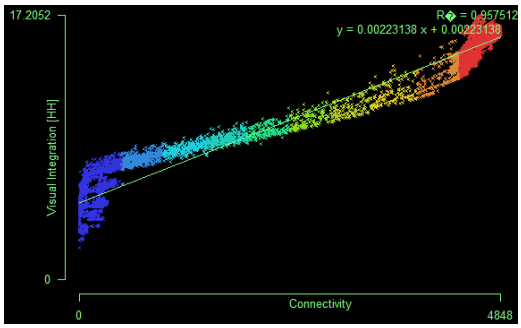
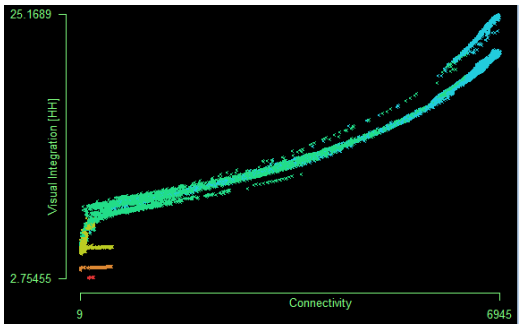
Visual connection and integration correlation	
	
Jaddeh Bozorg	Mulla Abdullah
	
Jaddeh Kuchak	Kase Garan
	
Chaharbagh	Nimavard

Table 9: Evaluating readability quality by examining visual integration and connectivity correlation

School name	R2 Correlation Value
Jaddeh Bozorg	0.960478
Jaddeh Kuchak	0.926984
Chaharbagh	0.957512
Mulla Abdullah	0.93876
Kase Garan	0.945833
Nimavard	0.956389

The R2 value among the studied schools in all 6 cases with values close to one generally confirms the significance of this correlation and the effect of the two parameters of visual connectivity and integration on readability in the studied school space, which the radar chart shows the final status of the six schools in the final parameters. (Figure 5)

Table 10: Results of the evaluation of the visual configuration of traditional schools of the Safavid period in Isfahan

	Nimavard	Mulla Abdullah	Kase Garan	Chaharbagh	Jaddeh Kuchak	Jaddeh Bozorg
connectivity	3883.48	2887.48	4973.16	2609.59	2202.08	3321.82
visual integration	14.3847	17.9835	23.0768	10.7678	12.3437	17.9272
visual step depth	1.69204	1.701	1.5794	1.8688	1.6495	1.5325

Table 11: Scale-free values of the results of the visual configuration evaluation of traditional schools of the Safavid period in Isfahan

	Nimavard	Mulla Abdullah	Kase Garan	Chaharbagh	Jaddeh Kuchak	Jaddeh Bozorg
connectivity	0.1954	0.1453	0.2502	0.1313	0.1108	0.1671
visual integration	0.1491	0.1864	0.2392	0.1116	0.1279	0.1858
visual step depth	0.1688	0.1697	0.1576	0.1864	0.1646	0.1529

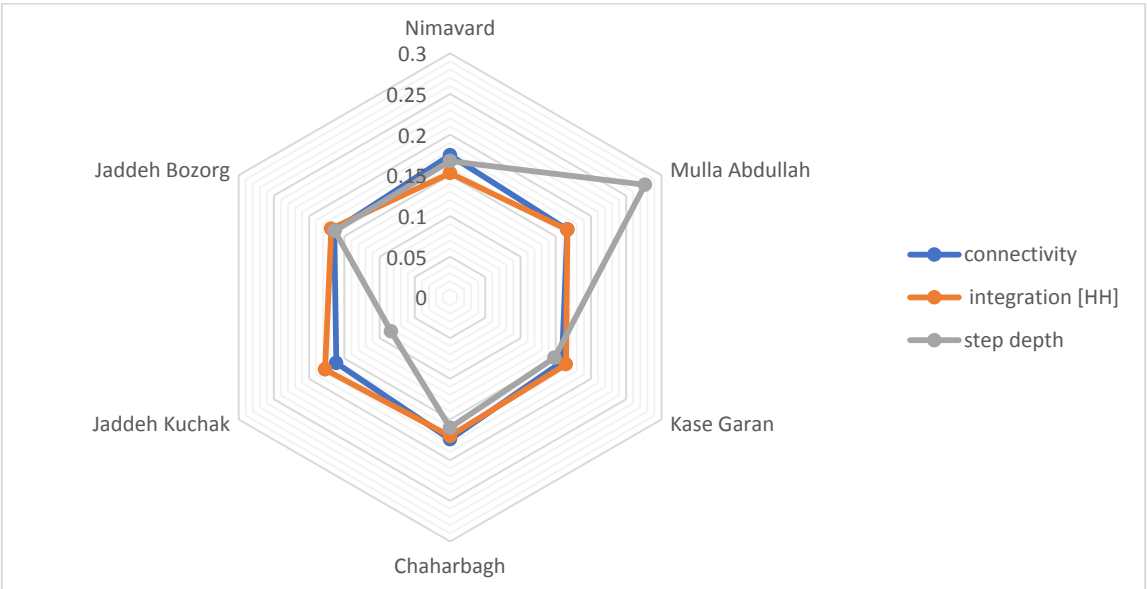


Figure 6: Radar sample of spatial configuration parameters of the studied schools

RESULT AND CONCLUSION

Based on the findings of the research, the following results can be presented:

1. Based on the plans of all six schools studied, it can be concluded that the qualitative level of the parameters under study in the formation of a convex space based on the presence of symmetry and compactness with a central courtyard is maximum when the level of access and connection is the same from the center of the courtyard, in which case the squarer the plan form is, the more it can help with spatial legibility. In this regard, the plan of Mullah Abdullah School has different qualities due to the connection of a public space such as the Shabestan on the northern front of the complex and also the Jaddeh Kuchak School.
2. The connection parameter in all six schools in one direction has numerical values close to each other because spatial organization is based on a specific pattern in traditional school architecture. Among them, Nimavard and Chaharbagh schools have the highest numerical values with approximate numerical values of 0.167 and 0.174.
3. In the connectivity parameter, the schools under study have corresponding and almost close numerical values due to the type of spatial organization in the form of a main configuration.
4. In the readability parameter, however, the main difference can be stated in the six samples under study with this structure:

- Mulla Abdullah School, with a numerical value of 0.276, has the highest parameter value, which is due to the high depth of the public space on the northern front of the complex from the central courtyard, which, by moving from the room space on the southern front to it, provides the audience with the largest cone of vision.
- Jaddeh Kuchak School, with a numerical value of 0.083, has the lowest parameter value, which is due to the shape of the building and the rectangular form of the plan and the short distance in access from the center of the courtyard or central habitat to the surrounding spaces. In this school, the public space on the eastern and southeastern fronts has created a distance from its connection to the other side on a main axis, creating a visual break. In addition, for spatial legibility, two examples of private space such as a room on the same front and also the corridor itself connecting to that space have created a visual derivation between the public and private space.
- All four schools of Kase Garan, Nimavard, Chaharbagh and Jaddeh Bozorg, due to their compact form and almost symmetrical central courtyard pattern, creating almost consistent access from the center of the courtyard to public and private spaces, have a numerical value between 0.142 and 0.160 of the parameter value.

Consequently, it can be acknowledged that the spatial configuration in the schools studied in Isfahan during the Safavid period mainly has almost identical values and is clearly highly interconnected and connected, and this amount changes only when the building changes direction in connection to another public space, which is the product of renovation and sometimes additions from other periods.

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