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# The Spatial Logic of Mamluk Madrassas: Readings in the Geometric and Genotypical Compositions

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**Abstract** This paper looks at the spatial development of Mamluks' educational buildings *(madrassas)* throughout the Bahri and Burji periods (1260–1517 A.D.). The lines of inquiry aim at investigating diachronically the degree by which madrassas can demonstrate the idea of a single configurationally dominant genotype. Madrassas are scrutinized according to their geometric and spatial attributes; their spatial structure is described according to their patterns of permeability, and interpreted using geometric-syntactic and statistical analysis. Despite the variability of the madrassas' footprints, this research highlights the conventions essential in stabilizing the madrassa as a building type and identifies the regional 'court' and the local 'Jerusalem' genotypes. While the results for the first identify an integrated central zone with segregated outer environments, those of the second identify a centrifugal-extroverted plan that tries to expand its circle of presence, and maximize its opportunities of encounter.

**Keywords** Mamluk Madrassa · Court genotype · Jerusalem genotype · Educational building · Iwan · Madrassas · Space syntax

## Introduction

*Mamluk sultans* were great art and architecture patrons. They ordered the construction of an enormous number of buildings that fulfilled the people's social and religious needs and that expressed the power and prestige of the Mamluk sultans' reigns (Grabar 1984). As an institution, the *madrassa* evolved in the eleventh century as a synthesis of both the mosque, which has always been the

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centre of Islamic education, and the khan, which provided a resting place for travelling traders. The fundamental Islamic sciences comprised the curriculum, and the study of law usually covered all four schools of Sunni Islam (Mahamid 2011). The madrassa is a congregational space, a study area, a locus for communal readings of the Quran, social meetings, learning, and listening. The patron's mausoleum is usually associated with the madrassa (Malhis 2016). Responding to the size and location of the madrassa, the designers might provide rooms for the students and novices, and a residence for '*shiq*'.

The madrassa has a four-iwan plan in which one *iwan* (a rectangular hall which is typically walled on three sides and opens at one end) is situated on each of the four sides of a rectilinear courtyard, with one iwan always functioning as a mosque (Fig. 1). The court acts as a provisional spatial extension for the iwans and creates a distinguished spatial and visual expression. The madrassa is functionally constructed to serve its short-term visitors, long-term students, and caretakers (Newhall 1987). The wide variety of buildings that this civilization produced represented a varied repertoire of styles reflective of Mamluk architectural development.

Published work on Mamluk *madrassas* (plural) has moved in several directions. The first surveys madrassa types and discusses madrassas in the context of the evolution of the geometric and stylistic shapes of the open court and its four iwans (Parker 1985). The second explores how Mamluk architecture represented itself by discussing monuments in the greater Islamic world. At the morphological level, studies either used a narrative approach to describe how Mamluks located their buildings or presented morphological investigations that addressed the geometry of form without casting a wider net to interpret the layouts in which wider cultural expression has been preserved (Eilouti and Al-Jokhadar 2007; Rabbat 2010). In their drive for either precision, historical and comprehensive narrative or stylistic and geometric definition, these studies overlooked certain subtleties of the architecture of the four-iwan madrassas and the details of their configuration.

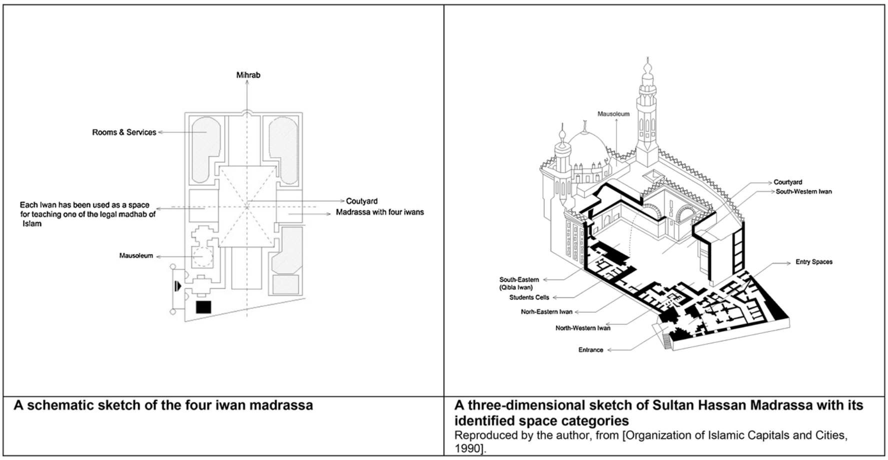


**Fig. 1** Sketches and images Mamluk madrassas

This paper aims at investigating madrassas throughout the Bahri, 1260–1382 A.D., and the Burji, 1382–1517 A.D. To achieve this goal, the following two questions are examined: (1) How have the four-iwan madrassas shaped their functions over time and are there any compositional rules that govern those formations? (2) What is the impact of programmatic and location challenges on the nature of the developed spatial patterns, and what is the degree by which madrassas can demonstrate the idea of a single configurational genotype? The sample includes every madrassa that marked the beginning and end of the Bahri and Burji periods, along with examples of protagonist sultans and long reigns (Table 1). When the sample was examined, a gap in the chronological order was noted; therefore, documented madrassas from the Levant (M3, M4, and M5) and Cairo (M12) were added to reflect the actual spread of the Sultanate's monuments and homogenize the chronological gap. The cases selected are represented by twelve madrassas in Cairo, Jerusalem, and Aleppo. Through their innovative or repetitive repertoire, they demonstrate the influence of location, the reign's limited or generous funding, and the chronological era (Fig. 2; Table 2). The sources of the plans were the collected sets of measured architectural drawings published in several recent studies (Organization 1992; Abouseif 1992). Based on these drawings, a new plan for each madrassa was prepared and marked with a standard set of abbreviations. While the layouts of some madrassas were altered since being built, the version of the madrassa analysed here is the original.

Taking these grounds as points of departure, this paper engaged two sequential methods of analysis crossed by historical and contextual debates: formal-geometric on one hand and morphological-syntactic related to *space-syntax* theory on the other. This paper consists of an introduction, three main parts, and a conclusion. In the first part, layouts are analysed by distinguishing their geometric characteristics and a brief proposal is given to clarify how the geometric rules are employed on the

**Table 1 Madrassas' sample**

| No. | Madrassa | Abbreviation | Year A.D. | location | Built up Area $M^2$ |
|---|---|---|---|---|---|
| Bahri Period (1260–1382 A.D.) | | | | | |
| 1. | Sultan Qalawan | M1 | 1284–1285 | Cairo | 1375 |
| 2. | Um Sultan Shaban | M2 | 1369 | Cairo | 1250 |
| 3. | Tashtamar | M3 | 1377 | Jerusalem | 350 |
| 4. | Saffaheya | M4 | 1377 | Aleppo | 1175 |
| 5. | Baldya | M5 | 1380 | Jerusalem | 895 |
| 6. | Sultan Hasan | M6 | 1356–1362 | Cairo | 9600 |
| Burji Period (1382–1517 A.D.) | | | | | |
| 7. | Zahir Barquq | M7 | 1384–1386 | Cairo | 2600 |
| 8. | Ashraf Barsbay | M8 | 1425 | Cairo | 1550 |
| 9. | Sultan Inal | M9 | 1451–1456 | Cairo | 960 |
| 10. | Sultan QaitBay | M10 | 1472–1474 | Cairo | 756 |
| 11. | Sultan Guri | M11 | 1504–1505 | Cairo | 2390 |
| 12. | Amir Karkamas | M12 | 1506–1507 | Cairo | 2170 |

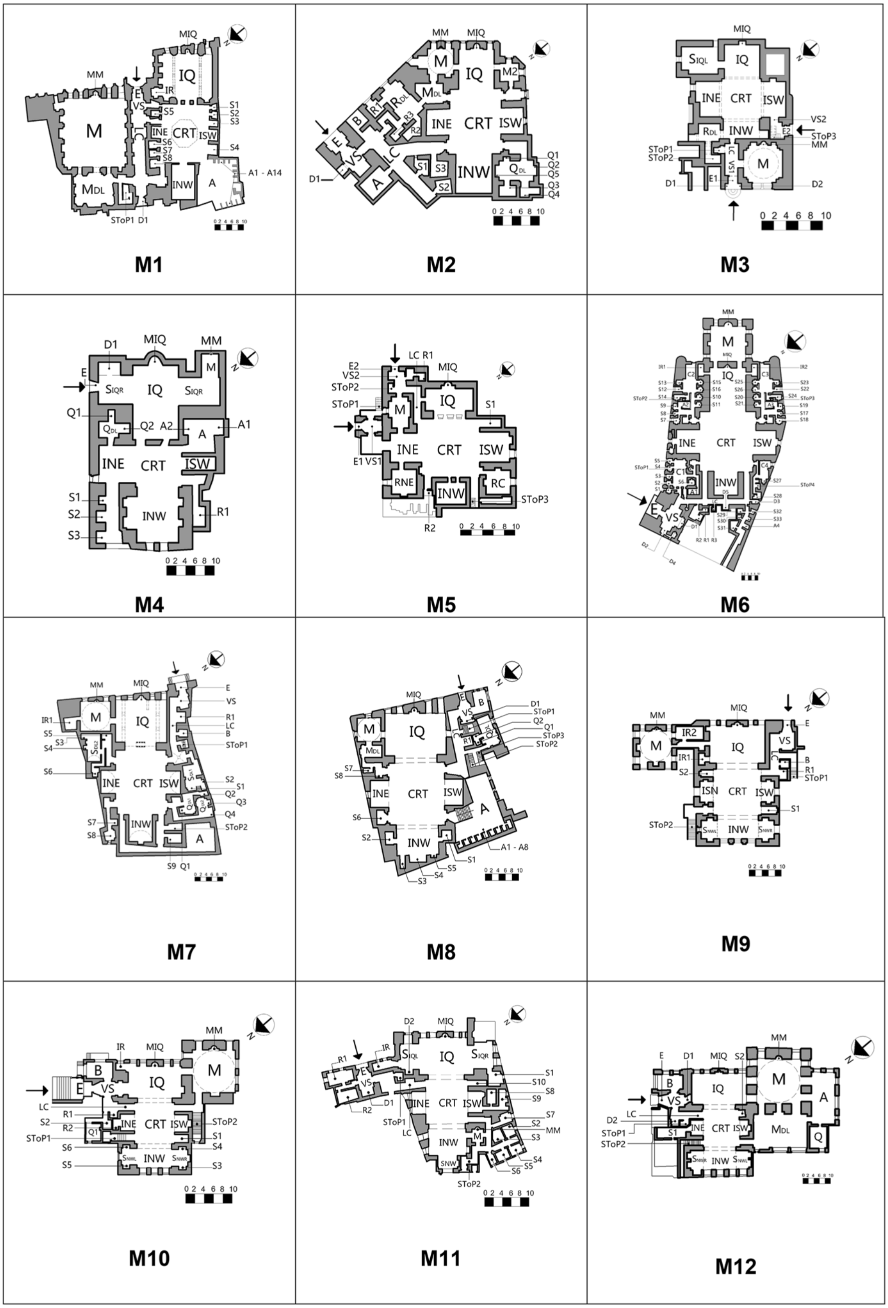


**Fig. 2** Madrassas layout. Reproduced by the author, from (Organization of Islamic Capitals and Cities, 1990)

**Table 2** Madrassas' floor layouts labels' legend

| Abbreviations | | | | |
|---|---|---|---|---|
| CRT: Court | IQ: Qibla-iwan | INW: North-western-iwan | ISW: South-western-iwan | INE:North-eastern-iwan |
| M: Mausoleum | MIQ: Qibla-iwan mihrab | E: Entrance | VS: Vestibule | S1-33: Student room |
| MM: Mausoleum mihrab | LC: Long corridor | STOP1:Stairway to Kuttab | Stop2-4: Stairway to Mezzanine | D1: Dead-end space for keeping holy books |
| R1-R3:Novices' room | A: Ablution | B: Sabil | Q1-6: Shiq room | IR1-2:Imam room |
| QDL: Shiq distributing lounge | SNWR: Sadla at the right of north-western-iwan | SNWL: Sadla at the left of north-western-iwan | SIQL: Sadla at the left of qibla-iwan | PDL: Private distributing lounge |
| E2: SECOND ENTRANCE | VS2: Second vestibule | M2: Second Mausoleum | RNE: Room attached to north-eastern-iwan | RC: room attached to the court |
| C1-C4: Sub-courts | A1-14: Ablution spaces | | | |

buildings' layouts. In the second, the configurational properties of the madrassas are examined by considering their morphological and functional patterns, and a quantitative picture of their spatial organizations is presented. In the third, a functional and a statistical account is attempted for the sample overall, and a genotypical account about the twelve-Madrassas sample is identified. The conclusion provides new readings of Mamluk designs that are grounded in design choices.

Given the complexity of Mamluk architecture and its significant architectural and stylistic innovations, this study is limited to providing new readings into the spatial morphology of Mamluk madrassas without relating their configurational relationships to the stylistic compositions of the madrassas' forms. Although the element of indoor-outdoor transition of Mamluk buildings demonstrated special urban attention in Mamluk inner-city innovations, and together they imposed an urban dialogue across the street, the sample included here is limited to considering the interior spaces of the Madrassa without including the complex urban outdoor spaces surrounding it.

## Madrassas Layouts

An initial examination of the madrassas layouts reflected varieties in how the spatial and geometrical architectonics of boundaries dissolved in favour of the continuity of each example. It showed that there is a high degree of variability in terms of the characteristics of the madrassas' basic building footprints. By following the street alignment and modifying the depth of the walls, designers were able to position their buildings along variously oriented portals. The literature showed that patrons of spaces produced their work by confronting four location challenges: confining the building's outline to the allocated land, aligning the sanctuary and its *mihrab* towards Mecca (*Qibla*), situating the building's entrance at street level, and locating the tomb chamber of the patron on the street side of the edifice. One can argue that the detected irregularities reflect the architectural and urban aspects of Mamluk history.

By examining what is happening geometrically inside the madrassas, one would suggest that there are clear and simple rules (Fig. 3). First, all iwans have a parallel and directional relationship to the court. Although the geometric cross-shape rule applies, the proportions and metric distances of the iwans are mutable. Second, the mausoleum and the cross-shape are geometrically in parallel alignment to one another. Third, in nine cases (with the exceptions of M1, M3, and M11) the rectilinear mausoleum is adjacent to qibla-iwan. Although the clear geometric order indicates some logical methodology at work, it is impossible to precisely describe how the cross-shape links to the rest of the composition. As the interpretation of the mausoleum located at the left side of the qibla-iwan suggests—as M7 shows—a direct/single connection, the interpretation of M5, although displaying a similar alignment, reveals different connections. The relationship between the entrance and the centre demonstrates another perplexing case and there are also variations in how

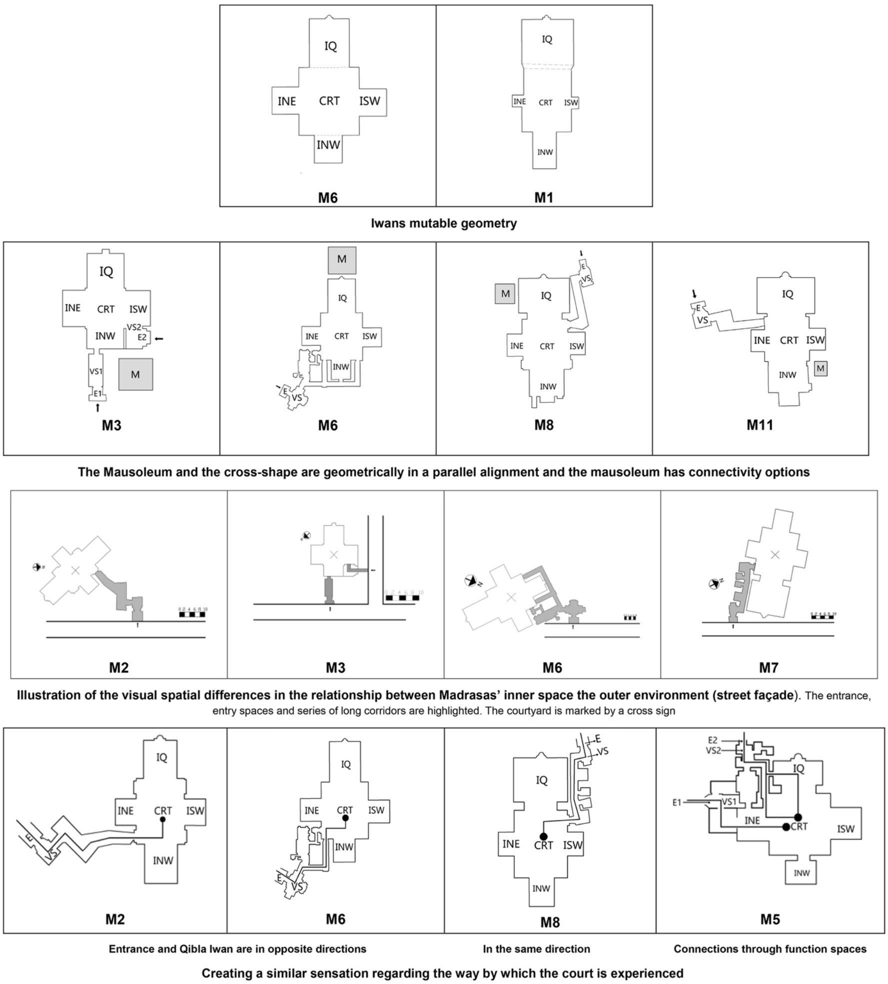


**Fig. 3** Geometric rules

madrassas functions are augmented. It is clear that the framework of the iwans/court rules strongly deviate outside of the iwans' borders.

If one examines these variations more closely, some experiential rules emerge. There is a trend to create a similar sensation with respect to how the court is experienced: the best criterion seems to appear when the entrance and the qibla-iwan are in opposite directions (M2 and M6). In this instance, the visitor approaches the courtyard through a series of transitional corridors, which locates the visitor at a point that facilitate both visualizing the beauty of the court and confronting the qibla-iwan. In the cases in which the entrance and the qibla-iwan are not in opposite directions (M8), the approach is altered by creating transitional corridors and reversing the journey's orientation. When this criterion was difficult to achieve, the visitor passed through actual functional spaces where the experience is diluted (M5).

## A Quantitative Picture

Although the initial visual inspection of madrassas compositions elucidates some obscured rules, it falls short of providing insight into the range of possibilities for arranging the programmatic spaces within the madrassa. It is time to ask whether the Mamluk efforts to adhere to a site and street pattern affected the spatial and functional structure of these madrassas and whether these levels of irregularity have remained permissible and reflective of a single functional type. The knowledge of such working structure, according to space-syntax comprehension, is embedded within the building itself (Hillier et al. 1987).

Space-syntax is a set of techniques that represents and quantifies spatial patterns. It is realized by focusing on spatial adjacencies and permeabilities. In its conception architecture is seen as a social interface through space that elaborates on two sets of social relationships: between the groups within the building, and between those groups and the visitors or the public from outside. To obtain a visual representation of these relationships, a two-dimensional convex structure is first created by depicting the least number of convex spaces that fully cover a particular plan. An abstracted justified graph then demonstrates how the organization of convex spaces (nodes) and connections (lines and rings) regulate both access and choice. Depth reveals the number of steps one should take to reach a particular space and is used in calculating the measure of integration that indicates the relative depth of a certain space. Looking at the building with and without the exterior helps in understanding how the building unfolds as a justified graph and allows investigation of the interior-exterior relations and their impact on the overall space configuration and its resultant social interface. Depthmap software facilitates the representation of the buildings as convex maps that can be processed to demonstrate the integration values of each functional space (Pinelo and Turner 2010; Varoudis 2014). Whereas the most integrated spaces are assigned the highest values, the most segregated spaces are assigned the lowest values. If the numerical differences in the functions are in consistent order across the sample, then this ‘type of consistency in spatial patterning [is termed] an inequality genotype’ (Hillier et al. 1987: 364). Although this dominant genotype is sometimes strongly attained by having all of its spatial-functional themes present across the sample, in many instances it is more weakly realized by having some of its themes present and some missing, showing itself under various ‘phenotypical’ arrangements. To evaluate the strength of these inequalities, space-syntax developed the measure of difference factor (BDF). It quantifies the degree of difference among the integration values of any three spaces. Despite the abilities of space-syntax in quantitatively expressing a building’s spatial qualities, it abstracts their three-dimensional perceptual capabilities. In spite of this limitation, it remains powerful in fulfilling the gap in the spatial comprehension of Mamluk madrassas.

One major discretionary element in space-syntax is the actual delineation of the spatial system considered, as the decisions chosen have direct impact on the syntactical results (Malhis 2016). In this research, the following decisions were made. First, outer courts were not considered as part of the spatial system. Second, the main floor is only considered because it housed all of the essential functions and because it is usually available in the literature. Third, each iwan is considered as a single space regardless of its size, because the detection of its size does not affect the dynamics of its use, which involves groups of learners spreading throughout its boundaries. In contrast, bent corridors that followed the angled entrance to the madrassa have been treated as equivalent to several spaces. Fourth, the decorative niches were not reflected as functional spaces; conversely, deep, functional niches were considered. Fifth, the stairway at the entry to the madrassa is identified throughout the analysis because it leads to the *Kuttab* space (for teaching children), which is usually squeezed in the mezzanine. Sixth, although the extra-awkward rooms that extended 'into the masonry behind the apex of the muqarnas hood' were not considered, the 'steps… accommodated within bent passage[s] cut through the thickness of [the] wall[s]' were identified to indicate these rooms (Burgoyne 1987: 472).

The following paragraphs aim at underlining the spatial characteristics present within the madrassa and across the sample. The topological structure of each madrassa's spatial configuration is represented by a justified permeability graph (Figs. 2, 4, 6, 7) and by considering its spatial pattern in terms of the rank order of

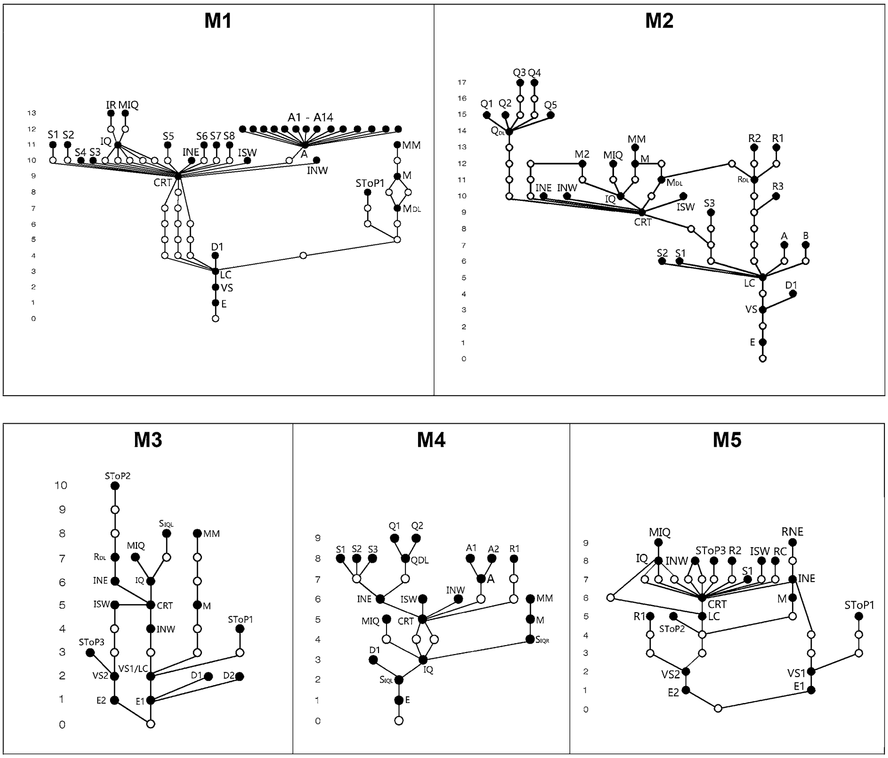


**Fig. 4** Bahri madrassas justified graphs (*M1–M5*). To distinguish between the transitional corridors, usually bent spaces, and the other functional spaces, such corridors were left unhatched

**Table 3** Order of Integration values of the sample's functions without exterior

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bahri Period (1260–1382 A.D.)* | | | | | | | | | | | | | | | | | | | |
| M1: Sultan Qalawan-25 function space: | | | | | | | | | | | | | | | | | | | |
| CRT (1.54) | > | LC (1.11) | = | INW (1.11) | > | ISW (1.06) | = | INE (1.06) | = | S4 (1.06) | = | S3 (1.06) | > | IQ (0.91) | > | A (0.86) | >, | | |
| VS (0.85) | > | D1 (0.84) | > | S8 (0.82) | = | S7 (0.82) | = | S6 (0.82) | = | S5 (0.82) | = | S1 (0.82) | = | S2 (0.82) | > | A1-14 (0.69) | >, | | |
| E (0.68) | > | MIQ (0.60) | = | IR (0.60) | > | MDL (0.58) | > | SToP1 (0.45) | = | M (0.45) | > | MM (0.36) | | | | | | | |
| M2: Um Sultan Shaban-29 function space: | | | | | | | | | | | | | | | | | | | |
| CRT (1.05) | > | IQ (0.89) | > | INE (0.81) | = | ISW (0.81) | = | INW (0.81) | = | MDL (0.81) | > | LC (0.77) | > | M (0.69) | > | R1 (0.63) | =, | | |
| R2 (0.63) | = | RDL (0.63) | = | S1 (0.63) | = | S2 (0.63) | > | S3 (0.60) | = | MIQ (0.60) | = | M2 (0.60) | > | VS (0.57) | > | B (0.54) | =, | | |
| A (0.54) | > | QDL (0.53) | > | MM (0.50) | > | R3 (0.49) | = | D1 (0.49) | > | Q2 (0.46) | = | Q5 (0.46) | = | Q1 (0.46) | > | Q3 (0.41) | >, | | |
| E (0.39) | > | Q4 (0.37) | | | | | | | | | | | | | | | | | |
| M3: Tashtamar-19 function space: | | | | | | | | | | | | | | | | | | | |
| INW (0.86) | > | CRT (0.85) | > | VS1/LC (0.81) | > | ISW (0.71) | > | INE(0.70) | > | IQ (0.69) | > | E1 (0.64) | > | MIQ (0.55) | > | D1 (0.54) | =, | | |
| D2 (0.54) | > | M (0.53) | > | SToP1 (0.51) | > | RDL (0.49) | > | SIQL (0.46) | > | VS2 (0.44) | > | E2 (0.38) | = | SToP3 (0.38) | > | SToP2 (0.36) | >, | | |
| MM (0.34) | | | | | | | | | | | | | | | | | | | |
| M4: Saffaheya-22 function space: | | | | | | | | | | | | | | | | | | | |
| CRT (1.49) | > | INE (1.19) | > | IQ (1.10) | > | ISW (0.95) | = | INW (0.95) | > | SIQR (0.83) | > | SIQL (0.81) | > | A (0.77) | > | QDL (0.68) | >, | | |
| S1 (0.66) | = | S2 (0.66) | = | S3 (0.66) | > | M (0.65) | > | E (0.62) | = | D1 (0.62) | > | MIQ (0.61) | > | A1(0.60) | = | A2(0.60) | >, | | |
| R1 (0.58) | > | Q1 (0.54) | = | Q2 (0.54) | > | MM (0.44) | | | | | | | | | | | | | |

**Table 3** continued

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M5: Baldya-20 function space: | | | | | | | | | | | | | | | | |
| CRT (1.24) | = | INE (1.24) | > | IO (0.93) | > | S1 (0.88) | > | M (0.82) | > | LC (0.74) | > | MIQ (0.71) | > | INW (0.70) | > | ISW (0.69) =, |
| RC (0.69) | = | SToP3 (0.69) | = | RNE (0.69) | = | R2 (0.69) | > | E2 (0.68) | > | VS2 (0.62) | > | SToP2 (0.57) | > | VS1 (0.55) | = | E1 (0.55) >, |
| R1 (0.39) | > | SToP1 (0.36) | | | | | | | | | | | | | | |
| M6: Sultan Hasan-66 function space: | | | | | | | | | | | | | | | | |
| CRT (1.01) | > | INW (0.88) | > | LC (0.87) | > | IQ (0.86) | > | ISW (0.84) | = | INE (0.84) | > | D3 (0.74) | = | D5 (0.74) | > | MIQ (0.73) >, |
| R3 (0.64) | = | VS (0.64) | = | D4 (0.64) | = | M (0.64) | > | C1 (0.63) | = | IR1 (0.63) | = | IR2 (0.63) | = | IR1 (0.63) | = | IR2 (0.63) >, |
| R1 (0.57) | = | R2 (0.57) | = | D1 (0.57) | = | D2 (0.57) | > | SToP1 (0.55) | > | MM (0.51) | > | S2 (0.50) | = | S3 (0.50) | = | S4 (0.50) =, |
| S5 (0.50) | = | S6 (0.50) | = | S1 (0.50) | > | A2 (0.49) | = | A3 (0.49) | > | E (0.47) | = | A1 (0.47) | = | S28 (0.47) | = | A4 (0.47) =, |
| S27 (0.47) | = | SToP2 (0.47) | > | C2 (0.46) | = | C3 (0.46) | > | S9 (0.45) | = | S19 (0.45) | = | S8 (0.45) | = | S11 (0.45) | = | S21 (0.45) =, |
| S10 (0.45) | = | S18 (0.45) | = | S20 (0.45) | = | S7 (0.45) | = | S17 (0.45) | = | S33 (0.45) | > | S32 (0.44) | > | SToP3 (0.42) | = | SToP4 (0.42) >, |
| S31 (0.41) | = | S30 (0.41) | = | S29 (0.41) | > | S15 (0.39) | = | S13 (0.39) | = | S12 (0.39) | = | S25 (0.39) | = | S23 (0.39) | = | S22 (0.39) >, |
| S24 (0.36) | = | S14 (0.36) | = | S16 (0.36) | | | | | | | | | | | | |
| *Burji Period (1382–1517 A.D.)* | | | | | | | | | | | | | | | | |
| M7: Zahir Barquq-35 function space: | | | | | | | | | | | | | | | | |
| CRT (1.16) | > | INE (0.89) | = | INW (0.89) | = | ISW (0.89) | > | IQ (0.79) | > | LC (0.62) | > | M (0.58) | = | QDL2 (0.58) | > | S5 0.57) >, |
| MIQ (0.56) | > | SToP2 (0.55) | = | S9 (0.55) | > | R1 (0.53) | > | SToP1 (0.52) | > | Q4 (0.50) | = | Q3 (0.50) | > | S8 (0.48) | = | S7 (0.48) =, |
| VS (0.48) | > | B (0.47) | > | SDL1 (0.45) | = | SDL2 (0.45) | = | QDL1 (0.45) | > | MM (0.44) | = | A (0.44) | = | IR1 (0.44) | > | D1 (0.42) >, |
| Q1 (0.41) | > | S1-S4 (0.40) | = | S6 (0.40) | > | E (0.38) | > | Q2 (0.37) | | | | | | | | |

**Table 3** continued

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M8: Ashraf Barsbay-30 function space: | | | | | | | | | | | | | | | | | |
| CRT (1.12) | > | LC (0.88) | > | INE (0.85) | = | ISW (0.85) | > | INW (0.76) | > | SToP1 (0.71) | > | R1 (0.70) | > | IQ (0.69) | > | VS (0.63) | =, |
| S4 (0.63) | = | S5 (0.63) | = | S3 (0.63) | > | SToP2 (0.62) | > | S6 (0.58) | > | M (0.54) | = | SToP3 (0.54) | > | S1 (0.53) | = | S2 (0.53) | =, |
| D1 (0.53) | > | A (0.52) | > | S8 (0.51) | = | S7 (0.51) | > | MIQ (0.50) | > | MDL (0.48) | = | QDL (0.48) | > | B (0.46) | = | E (0.46) | >, |
| A1-8 (0.45) | > | Q1 (0.43) | > | Q2 (0.38) | | | | | | | | | | | | | |
| M9: Sultan Inal-21 functions space: | | | | | | | | | | | | | | | | | |
| CRT (1.31) | > | LC (0.95) | > | IQ (0.91) | > | INE (0.89) | = | ISW (0.89) | = | S1 (0.89) | = | S2 (0.89) | > | VS (0.75) | > | INW (0.73) | >, |
| B (0.71) | = | R1 (0.71) | > | IR1 (0.69) | > | IR2 (0.59) | > | SNWR (0.57) | = | SNWL (0.57) | > | SToP2 (0.56) | > | MIQ (0.55) | > | M (0.51) | >, |
| SToP1 (0.48) | > | E (0.42) | > | MM (0.38) | | | | | | | | | | | | | |
| M10: Sultan QaitBay-26 functions space: | | | | | | | | | | | | | | | | | |
| CRT (1.46) | > | LC (1.10) | = | INE (1.10) | > | IQ (1.08) | > | ISW (0.99) | = | S1 (0.99) | > | INW (0.89) | > | VS (0.85) | > | R1 (0.81) | >, |
| MIQ (0.80) | > | SToP1 (0.76) | > | S2 (0.72) | > | SNWR(0.70) | = | SNWL (0.70) | = | M (0.70) | > | SToP2 (0.67) | > | IR (0.64) | > | R2 (0.58) | =, |
| Q1 (0.58) | > | MM (0.57) | = | S3 (0.57) | = | S4 (0.57) | = | S5 (0.57) | = | S6 (0.57) | > | B (0.55) | = | E (0.55) | | | |
| M11: Sultan Guri-31 function space: | | | | | | | | | | | | | | | | | |
| CRT (1.32) | > | LC (1.09) | > | INW (1.02) | > | ISW (0.97) | > | INE (0.93) | = | S10 (0.93) | > | M (0.85) | > | IQ (0.81) | > | S6 (0.79) | >, |
| SNW (0.77) | > | SToP1 (0.71) | > | VS (0.67) | > | S2 (0.65) | = | S3 (0.65) | = | S4 (0.65) | = | S5 (0.65) | = | SIQR (0.65) | > | SIQL (0.64) | =, |
| S7 (0.64) | > | S9 (0.61) | = | S8 (0.61) | > | MM (0.56) | > | D1 (0.55) | = | SToP2 (0.55) | > | MIQ (0.54) | = | S1 (0.54) | = | IR (0.54) | =, |
| D2 (0.54) | > | E (0.47) | > | R1 (0.42) | = | R2 (0.42) | | | | | | | | | | | |

**Table 3** continued

| M12: Amir Karkamas-23 function space: | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CRT (1.47) | > | LC (1.21) | > | INE (1.01) | > | ISW (0.97) | = | S2 (0.97) | = | MDL (0.97) | > | SToP1 (0.85) | = | D2 (0.85) | > | VS (0.79) | >, |
| INW (0.78) | > | IQ (0.76) | > | SToP2 (0.73) | > | M (0.63) | = | A (0.63) | > | SNWR (0.61) | = | SNWL (0.61) | > | S1 (0.60) | = | MIQ (0.60) | >, |
| B (0.52) | = | D1 (0.52) | = | MM (0.52) | = | E (0.52) | > | Q1 (0.44) | | | | | | | | | |

the integration values of its various functions and of how its functions fit into the spatial pattern as a whole (Tables 3, 4).

### Bahri Madrassas

M1 plan has a long corridor that regulates the arrangement of the memorial and educational functions at the sides of the entrance. Its justified graph shows that the court links to several trivial circulation rings (a trivial ring is one which connects the same pair of spaces twice), and leads to the iwans, ablution space, and study rooms. In contrast to the court and corridor, most of madrassa's spaces are endpoints. The court is the most integrated space at 1.54 followed by the corridor. The Mausoleum's mihrab is the most segregated at 0.36 and the exterior is largely segregated. All of the educational iwans are on the integrated side of the mean integration and the rest of the functions, including the entrance, are on the segregated side (Table 3).

To comprehend how the various functions are spatialized, it is useful to examine the degree of differentiation among the integration values of the different functions. Table 4 tabulates these relationships along three sets. The first examines the differentiations across the major educational and memorial functions and their relationships to madrassas' inner parts and outer edges. The second examines the individualized functions of novices, students and shiqs and how they relate to the court, the entrance and each other. The third examines particular detected adjacencies noted in the earlier geometric investigation. A review of M1's results shows that whereas the M, E and CRT, are strongly differentiated at the difference factor values (BDF) of 0.391 and 0.446 without and with the exterior (mean integration is 0.888 and 0.887), the three main educational iwans are weakly differentiated, with a BDF value of 0.996 with and without the exterior and a mean integration value of 1.080. M1 is a madrassa in which the court is the most integrated space: it is deep from the exterior, it lies on trivial rings, and it structures and links a homogenized and separated set of functions. The syntactical-configurational role of the corridor in distinguishing the 'rectangular mass' of the mausoleum and separating it from the rest of the madrassa's complex is seen in literature as a symbolically indicative gesture (Alsayyad 2011). It is interesting to see the extent to which these results are produced in the other madrassas.

M2's court lies on four non-trivial circulation rings; its qibla-iwan lies on three and branches into two separate rings. In contrast to the highly segregated mausoleum of M1, M2's mausoleum is on the integrated side and is much more homogenized. Whereas (CRT, IO, M) are weakly differentiated in M2 at 0.944, they are well structured in M1 at 0.707. Although the differentiation among (M, E, and CRT) is strong in M2 at 0.627, it is less pronounced in M1 at 0.391. Despite these differences, its iwans are, like M1, weakly differentiated, the entrance and exterior are on the segregated side, and the court remains the most integrated space. It plays a role in structuring the relationship among the madrassa's individualized functions and holds them apart at different branching.

M3 from Jerusalem is the smallest in the sample with double entrances. It has one external ring that connects its entrances, vestibules, two iwans and the court. M3

**Table 4** Difference Factor BDF for main spaces

| Madrasas | | Major functions | | | | | Individualized functions | | | Detected adjacencies | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Swings | | | | | Swings | Swings | Swings | | | |
| | | M, E, CRT | ISW, INW, ISE | CRT, IQ, M | Exterior, E, Court | IQ, E, CRT | S, E, CRT | Q, E, CRT | Q, R, S | LC, M, CRT | INW, M, CRT | E, INW, M |
| M1 | NC | 0.391 | 0.996 | 0.707 | | 0.739 | 0.776 | | | 0.424 | 0.424 | 0.745 |
| | C | 0.446 | 0.996 | 0.714 | 0.590 | 0.768 | 0.802 | | | 0.454 | 0.447 | 0.755 |
| M2 | NC | 0.627 | 1 | 0.944 | | 0.675 | 0.599 | 0.571 | 0.975 | 0.961 | 0.965 | 0.883 |
| | C | 0.664 | 1 | 0.945 | 0.346 | 0.706 | 0.644 | 0.613 | 0.972 | 0.964 | 0.967 | 0.892 |
| M3 | NC | 0.956 | 0.968 | 0.933 | | 0.99 | | | | 0.944 | 0.941 | 0.898 |
| | C | 0.969 | 0.961 | 0.952 | 0.992 | 0.994 | | | | 0.953 | 0.962 | 0.919 |
| M4 | NC | 0.573 | 0.997 | 0.841 | | 0.749 | 0.577 | 0.471 | 0.973 | | 0.755 | 0.911 |
| | C | 0.657 | 0.999 | 0.849 | 0.541 | 0.803 | 0.650 | 0.556 | 0.974 | | 0.786 | 0.925 |
| M5 | NC | 0.759 | 0.866 | 0.952 | | 0.781 | 0.774 | | | 0.928 | 0.915 | 0.976 |
| | C | 0.951 | 0.867 | 0.982 | 0.910 | 0.949 | 0.944 | | | 0.973 | 0.943 | 0.987 |
| M6 | NC | 0.782 | 0.995 | 0.933 | | 0.821 | 0.717 | | | 0.957 | 0.957 | 0.888 |
| | C | 0.789 | 0.995 | 0.934 | 0.648 | 0.826 | 0.771 | | | 0.957 | 0.957 | 0.890 |
| M7 | NC | 0.383 | 1 | 0.882 | | 0.531 | 0.355 | 0.289 | 0.989 | 0.785 | 0.858 | 0.819 |
| | C | 0.584 | 1 | 0.885 | 0.298 | 0.692 | 0.563 | 0.513 | 0.989 | 0.80 | 0.864 | 0.860 |
| M8 | NC | 0.603 | 1.004 | 0.870 | | 0.693 | 0.645 | 0.406 | 0.904 | 0.843 | 0.825 | 0.909 |
| | C | 0.671 | 1.004 | 0.881 | 0.551 | 0.749 | 0.572 | 0.501 | 0.904 | 0.862 | 0.847 | 0.914 |
| M9 | NC | 0.183 | 1 | 0.806 | | 0.519 | 0.508 | | | 0.696 | 0.615 | 0.899 |
| | C | 0.317 | 1 | 0.814 | 0.104 | 0.598 | 0.592 | | | 0.721 | 0.645 | 0.910 |
| M10 | NC | 0.516 | 1.001 | 0.869 | | 0.671 | 0.653 | 0.408 | | 0.837 | 0.798 | 0.932 |
| | C | 0.594 | 1.001 | 0.876 | 0.386 | 0.725 | 0.708 | 0.501 | | 0.859 | 0.818 | 0.943 |

**Table 4** continued

| Madrasas | | Major functions | | | | | Individualized functions | | | Detected adjacencies | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Swings | | | | | Swings | Swings Swings | | | | |
| | | M, E, CRT | ISW, INW, ISE | CRT, IQ, M | Exterior, E, Court | IQ, E, CRT | S, E, CRT | Q, E, CRT | Q, R, S | LC, M, CRT | INW, M, CRT | E, INW, M |
| M11 | NC | 0.585 | 0.990 | 0.939 | | 0.567 | 0.467 | | | 0.963 | 0.96 | 0.872 |
| | C | 0.637 | 0.990 | 0.940 | 0.269 | 0.623 | 0.553 | | | 0.964 | 0.961 | 0.884 |
| M12 | NC | 0.361 | 0.996 | 0.819 | | 0.471 | 0.327 | 0.092 | | 0.774 | 0.676 | 0.943 |
| | C | 0.458 | 0.997 | 0.826 | 0.249 | 0.557 | 0.433 | 0.223 | | 0.785 | 0.695 | 0.950 |

The values shown underlined have distinct BDF results iwans are distinguished by their permeabilities and by controlling the route to the madrassa. Its north-western iwan is the most integrated space followed by the court. The mean integration value for the madrassa is 0.527 without the exterior. In an unusual manner, the entrance (E1) that used to occupy the lower band of integration values becomes the fourth most integrated with the exterior included and moves over to the integrated side with the exterior excluded. The mausoleum's mihrab and the stairway that leads to mezzanine rooms are the most segregated spaces at 0.34 and 0.36, respectively.

When the exterior is included, the integration values of several spaces develop. The exterior appears on the integrated side of the mean integration. The vestibule becomes the most integrated, followed by the north-western iwan. A look at the distribution of the integration values reveals that the integrated central zone is pushed towards and around the north-western edge of the building into the outside. In contrast to the previous examples, BDF results suggest a weakly differentiated (M, E, and CRT) at 0.956 with the exterior and 0.969 without. More significant is the undifferentiated and largely homogenized (exterior, E, CRT) result at a BDF value of 0.992. Similarly homogenized are (E, INW, M) at 0.898. These BDF results are remarkable because it is uncommon to find such syntactic similarities between a madrassa's diverse functions, and their exterior.

Burgoyne argues that there are certain urban characteristics that Mamluks considered when they chose the location of their madrassas. Because Haram al Sharif symbolizes Jerusalem's sacredness to Islam, Mamluks intended to place their madrassas at the section nearest to the Haram (Fig. 5). 'The mausoleum, the most important building unit… was placed… at the juncture of two urban thoroughfares… where the stream of passers-by was dense and continuous. [Such an architectural setting] aims at providing a physical link with the passer-by and… is an indication of the ardent medieval… aspiration for beneficent divine influence… derived from the blessings invoked by passer-by on the tomb' (Burgoyne 1987: 468–469). These demands juxtaposed with the orientation challenges to Mecca, seem to have forced the builders to compromise the functionality of the madrassa.

Madrassa M4, from Aleppo, is the fourth-smallest madrassa. Most unusually, its qibla-iwan precedes the court and forms its entry space. Two of its iwans are permeable, and its exterior is on the segregated side of the mean integration. The mean integration value of M4's complex is 0.757, which is among the highest in the sample. In contrast to M3, north-western iwan does not play any major structuring role. Despite these variances, the syntactic and difference factor results show that M4 resembles other examples in terms of how its educational and individualized functions are spatialized.

M5 is another Jerusalem madrassa, which is tightly squeezed within the desired Mamluk block. It is the second-smallest madrassa, and the most permeable. The court, which lies on all of the trivial and non-trivial rings, is the most integrated space, followed by the north-western iwan. The mausoleum and its second entrance (E2) are on the integrated side of the rank order of integration values both with the exterior excluded or included. When the exterior is considered, the north-eastern iwan becomes as integrated as the court, followed by the mausoleum. Most notable is the exterior being on the side of the mean integration of the sample. In its

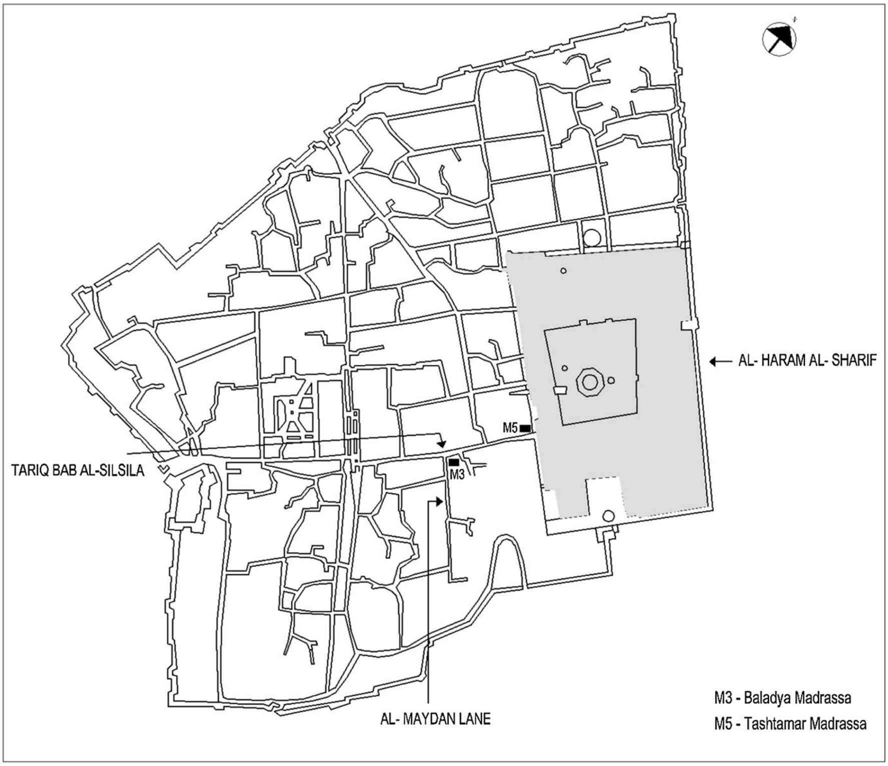


**Fig. 5** Jerusalem madrassas located on the Jerusalem map

syntactic unconventionality, the distribution of M5's integration values is similar to that of M3. M5 has a mean integration value of 0.602 with the exterior considered: its exterior's integration value is at 0.680 and the integration values of its two entrances are 0.625 and 0.809. All of which suggest that these madrassas have extroverted plans.

M6 is the largest in the sample (Fig. 6). Although most of its functional labelling is familiar, it introduces some new features in its spatial patterning which include: a clear division between the sets of students' cells, new sets of functions that appear in the deep branching of M6's justified graph (sub-courts C1-4, ablution spaces A1-4 and stairways SToP1-4), and an abundant number of splits both at the long corridor and the court. Five of the branches at the court penetrate deep in the system without deeper rings connecting them.

In M6 each iwan, at the corner of the layout, 'is devoted to one of the four Sunni rites of jurisprudence; the south-western-iwan was reserved for the sessions of the Hanbali school, the north-western for the Hanafi school … the north-eastern for the Maliki school' and qibla-iwan for Shafi (Al-Harithy 2001, pp. 74–75). It is beyond the sub-courts of these iwans that M6 began to expand. Despite these variances, the court remains the most integrated space, and the study rooms are the most segregated. The integration mean of this huge madrassa is the lowest across the sample. Its difference factor results did not register eccentric values. Although the literature had always described the unorthodox placement of M6's mausoleum 'behind the Qibla wall and its projection outside the main block of the complex … [as] the most symbolically charged gesture,' its syntactical results and the manner in which it is syntactically spatialized do not reflect this perceptual heterodoxy (Al-Harithy 2001, p. 76).

## Burji Madrassas

M7 has a justified graph that has some resemblance to M9, M8 and M2 in terms of how divisions among the various users of the madrassa develop. The divisions occur in the sequence of entry for the novices and later on for the kuttab and sabil. The literature shows that Sabil-Kuttab is a charitable Burji common duality; whereas the sabil on the main floor provides fresh water for passersby, the kuttab on the upper level teaches children. M7 and M9 are also similar in terms of how their mausoleum branches from qibla-iwan, without the mausoleum having any alternative entry approach. Although M2 and M8 are similar to M7 and M9 in how their mausoleums are linked to the qibla-iwan, the mausoleums of M2 and of M9 are set on a ring that connects to the court (Fig. 7).

In all of these Burji madrassas, the most integrated space is the court, followed by the long corridor. The iwans are on the integrated side of the mean integration value and the mausoleum on the segregated side. Student rooms range on the two sides of the mean according to their location. The entrance is amongst the most segregated poles, and the exterior is the first or the second most-segregated space. The madrassas' mean integration values are 0.631, 0.644 and 0.684 and decrease when

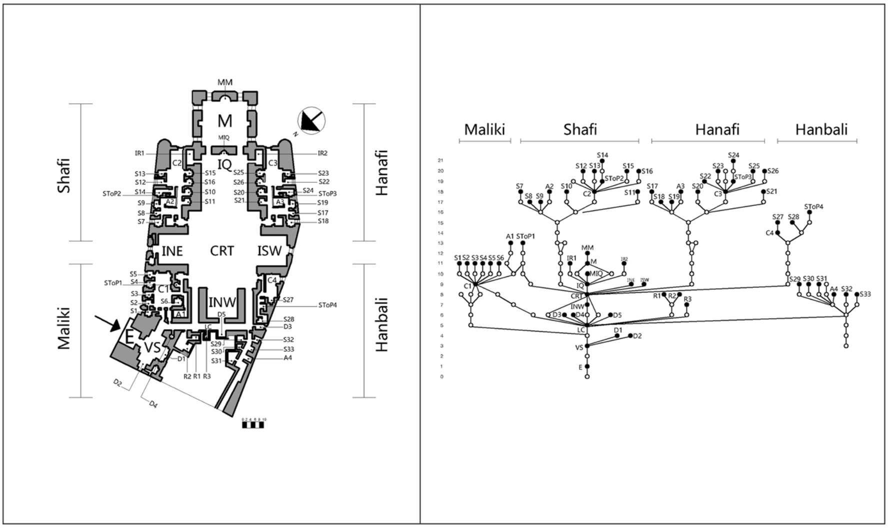


**Fig. 6** Bahri madrassa plan (M6) and its justified graph

the exterior is considered. The comparative difference factor results for the main spaces of these madrassas highlight, albeit at various degrees of strength, similar differentiating tendencies. The BDF results for M, E, CRT for the madrassas, for example, are (0.383, 0.603, 0.183); for their exterior, E, CRT are (0.298, 0.551, 0.104); and for their IQ, E, CRT are (0.531, 0.693, 0.519). The effect of their configuration reveals that the court draws the entire configuration together and structures the relationship between the two segregated poles of the entrance and the

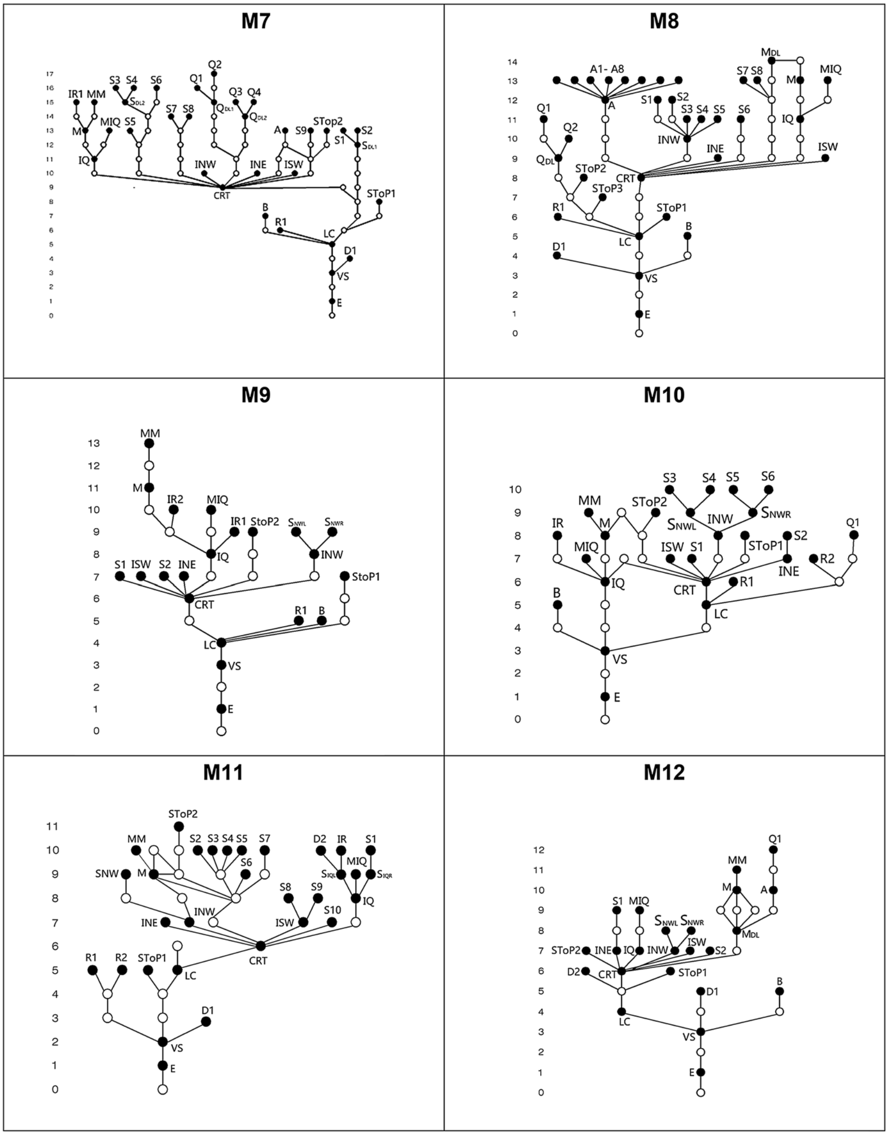


**Fig. 7** Burji madrassas justified graphs (*M7–M12*)

**Table 5** Review of the sample with each function's space number of occurrences, integration, and depth

| Sample | | | | | Bahri period | | | | Burji period | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Without exterior | | | With exterior | | Without exterior | | With exterior | | Without exterior | | With exterior | |
| Functional space | No. of cases | Integration | Integration | Depth | No. of cases | Integration | Integration | Depth | No. of cases | Integration | Integration | Depth |
| Exterior | 12 | | 0.484 | | | | 0.549 | | | | 0.418 | |
| CRT | 12 | 1.252 | 1.224 | 6.920 | 6 | 1.198 | 1.183 | 7.00 | 6 | 1.307 | 1.266 | 6.830 |
| IQ | 12 | 0.868 | 0.861 | 8.170 | 6 | 0.897 | 0.896 | 7.83 | 6 | 0.839 | 0.826 | 8.500 |
| INW | 12 | 0.865 | 0.857 | 7.920 | 6 | 0.886 | 0.885 | 7.50 | 6 | 0.844 | 0.830 | 8.330 |
| ISW | 12 | 0.885 | 0.875 | 7.920 | 6 | 0.845 | 0.841 | 8.00 | 6 | 0.926 | 0.910 | 7.830 |
| INE | 12 | 0.958 | 0.945 | 7.920 | 6 | 0.972 | 0.962 | 8.00 | 6 | 0.944 | 0.927 | 7.830 |
| M | 12 | 0.633 | 0.645 | 9.330 | 6 | 0.630 | 0.661 | 8.00 | 6 | 0.636 | 0.628 | 10.67 |
| MIQ | 12 | 0.612 | 0.603 | 9.800 | 6 | 0.634 | 0.624 | 9.33 | 6 | 0.591 | 0.581 | 10.17 |
| E | 12 | 0.513 | 0.563 | 1.000 | 6 | 0.558 | 0.633 | 1.00 | 6 | 0.468 | 0.493 | 1.000 |
| VS | 11 | 0.675 | 0.706 | 2.640 | 5 | 0.652 | 0.77 | 2.40 | 6 | 0.694 | 0.652 | 2.830 |
| S1 | 11 | 0.792 | 0.786 | 9.800 | 5 | 0.748 | 0.744 | 8.40 | 6 | 0.829 | 0.820 | 8.670 |
| MM | 10 | 0.461 | 0.467 | 9.800 | 5 | 0.429 | 0.446 | 10.0 | 5 | 0.493 | 0.489 | 9.600 |
| LC | 10 | 0.936 | 0.956 | 4.300 | 4 | 0.874 | 0.896 | 3.75 | 6 | 0.978 | 0.997 | 4.670 |
| SToP1 | 10 | 0.591 | 0.608 | 7.000 | 4 | 0.468 | 0.513 | 7.50 | 6 | 0.672 | 0.672 | 6.670 |
| SToP2 | 9 | 0.535 | 0.556 | 10.00 | 3 | 0.466 | 0.476 | 11.33 | 6 | 0.569 | 0.596 | 9.330 |
| D1 | 9 | 0.61 | 0.624 | 2.560 | 5 | 0.628 | 0.653 | 2.200 | 4 | 0.589 | 0.587 | 3.000 |
| R1 | 8 | 0.601 | 0.607 | 10.57 | 4 | 0.521 | 0.532 | 8.250 | 4 | 0.681 | 0.682 | 8.000 |
| A | 7 | 0.595 | 0.608 | 5.670 | 4 | 0.595 | 0.659 | 9.500 | 3 | 0.508 | 0.541 | 12.00 |
| B | 6 | 0.542 | 0.546 | 5.670 | 1 | 0.541 | 0.545 | 7.000 | 5 | 0.542 | 0.546 | 5.400 |
| Q1 | 6 | 0.507 | 0.505 | 11.50 | 2 | 0.568 | 0.562 | 12.00 | 4 | 0.477 | 0.476 | 11.25 |
| IR1 | 6 | 0.592 | 0.591 | 11.00 | 2 | 0.618 | 0.617 | 12.00 | 4 | 0.579 | 0.578 | 10.50 |

**Table 5** continued

| Sample | | | | | Bahri period | | | | Burji period | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Without exterior | | | With exterior | | Without exterior | | With exterior | | Without exterior | | With exterior | |
| Functional space | No. of cases | Integration | Integration | Depth | No. of cases | Integration | Integration | Depth | No. of cases | Integration | Integration | Depth |
| QDL | 4 | 0.568 | 0.564 | 11.75 | 2 | 0.605 | 0.598 | 11.50 | 2 | 0.531 | 0.529 | 12.00 |
| SNWR | 4 | 0.665 | 0.657 | 8.750 | 0 | | | | 4 | 0.665 | 0.657 | 8.750 |
| SNWL | 3 | 0.630 | 0.623 | 8.670 | 0 | | | | 3 | 0.630 | 0.623 | 8.670 |
| SIQL | 3 | 0.639 | 0.647 | 6.330 | 2 | 0.637 | 0.652 | 5.000 | 1 | 0.644 | 0.638 | 9.000 |
| MDL | 3 | 0.691 | 0.682 | 9.670 | 1 | 0.58 | 0.584 | 7.000 | 2 | 0.747 | 0.731 | 11.00 |
| SIQR | 2 | 0.740 | 0.744 | 6.500 | 1 | 0.831 | 0.845 | 4.000 | 1 | 0.650 | 0.644 | 9.000 |
| PDL | 2 | 0.572 | 0.575 | 6.500 | 2 | 0.572 | 0.575 | 6.500 | | | | |
| E2 | 2 | 0.530 | 0.733 | 1.000 | 2 | 0.53 | 0.733 | 1.000 | | | | |
| VS2 | 2 | 0.531 | 0.687 | 2.000 | 2 | 0.531 | 0.687 | 2.000 | | | | |
| M2 | 1 | 0.598 | 0.592 | 12.00 | 1 | 0.598 | 0.592 | 12.00 | | | | |
| RNE | 1 | 0.692 | 0.689 | 8.000 | 1 | 0.692 | 0.689 | 8.000 | | | | |
| RC | 1 | 0.688 | 0.689 | 7.000 | 1 | 0.688 | 0.689 | 7.000 | | | | |
| C1 | 1 | 0.630 | 0.660 | 9.000 | 1 | 0.628 | 0.663 | 9.000 | | | | |
| A1- | 1 | 0.467 | 0.447 | 11.00 | 1 | 0.467 | 0.447 | 11.00 | | | | |

various sets of individualized rooms. As Table 4 shows, M9 has the most structured relationship in the entire sample in terms of its mausoleum, entrance, and court relationship (BDF values at 0.183 and 0.317 without and with exterior).

M10 is distinguished by its largely permeable functional spaces, and by its mean integration value, which is the highest in the sample. Its rings around the qibla-iwan, the mausoleum, the distributing transitional spaces, and the court facilitate a high degree of choice in moving around the madrassa. M11 is also distinguished by its ring that links the north-western-iwan, mausoleum, court, and branches into several rooms. Despite these characteristics, the syntactic results of these madrassas do not depart from Burji's sample results. Like all madrassas, the court of M12 is where multiple branching occurs. Apart from the three adjacent iwans, which are strongly homogenized, the spatial configuration of M12, the last built Mamluk madrassa, is strongly differentiated.

## Incorporating an Inequality Genotype

The madrassa-by-madrassa review highlighted the individuality of each madrassa. However, when the spatial and functional properties of the sample were compared, we saw that madrassas appear to mutate a limited number of functions in different ways. These functions appear to be variations on a particular conception rather than profoundly different ways of organizing the madrassa.

The degree to which the sample can demonstrate the idea of a single, configurational, dominant genotype, is now investigated. Table 5 shows each main type of functional space, showing the number of times that it occurs, its era, its mean integration and its mean depth. This shows that although some of the functions appeared consistently in almost all madrassas, others were less frequent. To form a deeper understanding, the functions that appeared fewer than seven times were revisited. In most of those instances, the table shows that these labels are not exclusive to any particular era. However, sabils are more apparent in the Burji period; sadlas (SNWR and SNWL) are exclusive to the Burji period; and the second entrance and the vestibule are exclusive to Jerusalem madrassas. Whereas the sadlas are decorative static spaces that became popular in the Burji period to expand iwans, the second set of entrances to Bahri Jerusalem is a dynamic addition that influences the functionality and spatiality of the madrassa.

The table also reflects that there are strong across-the-board variations in the manner in which these functions are spatialized. Courts occur in the sample with a mean integration value of 1.252 (1.224 with exterior) and a mean depth of 6.92; qibla-iwans occur with a mean integration value of 0.868 (0.861 with exterior) and a mean depth of 8.17; the other three educational iwans have mean integration values ranging between 0.865 and 0.958 without exterior (0.857–0.945 with exterior) and a mean depth of 7.92; mausoleums occur with a mean integration value of 0.633 (0.645 with exterior) and a mean depth of 9.33. Entrances are both the shallowest and amongst the most segregated, except for M3 and M5; in contrast, courts are both located at an intermediate depth level and are the most integrated space with and without exterior except for M3 and M5 where they become the second. These

**Table 6** A spatial grouping of the proposed genotypes

| The 'Jerusalem' genotype | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| M | Mean integration | | Most integrated space | | | | Most segregated spaces | |
| | Without exterior | With exterior | | Without exterior | | With exterior | Without exterior | With exterior |
| M3 | 0.527 | 0.602 | INW | 0.86 | LC/VS1 | 0.95 | MM, SToP2, SToP3,E2 | StoP2,MM,SIQL, Stop3 |
| M5 | 0.608 | 0.657 | CRT | 1.24 | INE/CRT | 1.22 | SToP1,R1,E1,Vs0 | SToP1, R1, SToP2, RNE |
| Average | 0.568 | 0.630 | | | | | | |
| The 'Court' genotype | | | | | | | | |
| M | Mean integration | | Most integrated space | | | | Most segregated spaces | |
| | Without exterior | With exterior | | Without exterior | | With exterior | Without exterior | With exterior |
| M1 | 0.776 | 0.771 | CRT | 1.54 | CRT | 1.51 | MM, M, SToP1, MDL | MM,M,SToP1,Exterior |
| M2 | 0.577 | 0.570 | CRT | 1.05 | CRT | 1.03 | Q4,E,Q3,Q1 | Exterior, Q1, E, Q4 |
| M4 | 0.757 | 0.749 | CRT | 1.49 | CRT | 1.45 | MM, Q2,Q1, R1 | MM,Exterior, Q1-2, R1 |
| M6 | 0.426 | 0.426 | CRT | 1.01 | CRT | 1.01 | Sx, SToPx, Cx, Ax | Sx Rx, SToPx, Exterior |
| M7 | 0.631 | 0.596 | CRT | 1.16 | CRT | 1.14 | Q2,E,R2, Sx | Exterior, Q2,Sx,R2 |
| M8 | 0.644 | 0.639 | CRT | 1.12 | CRT | 1.08 | Qx, A, B, E | Qx, Exterior, A, B |
| M9 | 0.684 | 0.666 | CRT | 1.31 | CRT | 1.25 | MM, E, SToP1, M | MM,Exterior, E, SToP1 |
| M10 | 0.829 | 0.815 | CRT | 1.46 | CRT | 1.42 | E, B, Sx, MM | Exterior, B, Sx, E |
| M11 | 0.725 | 0.711 | CRT | 1.32 | CRT | 1.29 | Rx, E, D, IR | Exterior, Rx, E, MIQ |
| M12 | 0.759 | 0.744 | CRT | 1.47 | CRT | 1.42 | Qx, E, MM, D,B | Qx, Exterior, MM, B |
| Average | 0.681 | 0.669 | | | | | | |
| Integration average | | | | | | | | |
| Sample | | | | | 0.662 | | | 0.662 |
| Bahri period | | | | | 0.612 | | | 0.629 |
| Burji period | | | | | 0.712 | | | 0.695 |

variations are adequate to give a difference factor of 0.795 for the means of the court, mausoleum, and entrance, which are very strong, resulting in a difference factor of 0.908 for the means of the court mausoleum and the qibla iwan, which is strong in the sample. In addition, there is a difference factor of 0.994 for the means of the court, the qibla iwan and north-western iwan, which is very weak.

With respect to the transitional spaces, the long corridor is a common feature that is relatively shallow and strongly integrated. It occurs with a mean integration value of 0.936 (0.956 with exterior) and a mean depth of 4.3. The stairways that lead either to the kuttab or to the mezzanine are usually segregated at a mean integration value of 0.591 (0.608 with exterior) and have a mean depth of 7; SToP2 is much deeper at a mean depth of 10 and a mean integration value of 0.535 (0.556 with exterior). The different sets of individualized functions (students, shiq, novices) are common and rank among the least integrated spaces. When the base difference factor was examined, it became clear that these spaces are not differentiated among themselves but are held apart.

If spaces are 'shallower when the exterior participates in the configuration, then they can be considered extroverted, but if they are more integrated without the exterior, this suggests that they are more closed and inward looking' (Orhun et al. 1995: 33–34). The sample shows that those spaces that belong to the educational zone have a mean integration that is slightly more integrated without the exterior. However, the mausoleum, sabil, novices' rooms, corridor, entrances and vestibules are less integrated. These general tendencies are indicative of a delicate dominant spatial culture that articulates itself through systematic variations in spatial investment across the range of madrassa functions. Although it maintains several of its themes across the sample, some of these themes are particularly lost in M3 and M5.

The issue we need to investigate now relates both to the degree of difference of the spatial organization between Jerusalem madrassas and the rest of the sample, and the degree of similarity between the madrassas of the one hypothesized genotype. Table 6 divides the sample into two types. The mean integration of the Jerusalem sample is 0.568 without exterior and 0.630 with. Jerusalem madrassas are more integrated with the exterior and more segregated without it, leading to the likelihood that these madrassas are more extroverted. The mean integration of the ten-madrassa-sample is 0.681 without exterior and 0.669 with. While the court is the most integrated space with and without the exterior for the ten madrassas, it switches its rank in the Jerusalem sample to become the second with the exterior included. Its position is occupied by the vestibule/long corridor in M3 and by the north-eastern-iwan in M5. Whereas the exterior has always been amongst the most segregated, it became in Jerusalem madrassas on the integrated side. In contrast to the segregated entrances of the whole sample, Jerusalem madrassas' additional entrances became on the integrated side of the mean. These deviations of the Jerusalem sample are also echoed by peculiar BDF results; always occupying an extreme. A look at the values of M, E, CRT; Exterior, E, CRT; E, INW, M or CRT, IQ, M confirms this atypical trend (Table 4). Although the Aleppo madrassa is regional, its syntactic results are not as exclusive to suggest genotypical shifts.

The question now: what is the degree of strength by which the ten madrassas demonstrate the idea of a single configurational dominant genotype? Table 3 shows that the integration values of the court have the highest integration values in all ten cases; the long corridor is the second most-integrated space in six out of twelve cases, the north-eastern iwan is the second most-integrated space in two cases; the north-western and qibla-iwans have one case each; three of the four iwans always occupy the second, third, and fourth ranks and their integration values are very analogous to one another, homogenizing them and making them spatially interchangeable. The position of the last of the fourth iwans differs in response to its connectivity to other functions. Although the distribution does not show an unequivocal pattern, the rank order makes it clear that iwans occupy a middle tier. Also notable is the similarity of the functions that occupy the end tier of ranks and the small range of variation in their integration values. Although the entrance, for example, is the most segregated, occupying first place in one out of ten cases, second in five cases, and third to fifth in four cases, its location is interchangeable with the almost similarly segregated individualized quarters, mausoleums-mihrab, or ablutions and sabils, where these exist.

These vigorous tendencies through the sample however, are solid indications of an underlying spatial culture asserting itself through the spatial form of the madrassas. However, the various inversions notable here assert that there are several phenotypical expressions in this genotype. The number of spaces in these madrassas create a vast number of possible combinations of numerical sequences, to a point where finding a recurrent visual pattern seems less possible unless the relationship between spatial uses is so robust that it overcomes the changes at the level of building patterns. The variations in their consequent permeabilities have thus affected both their ranks and reduced the similarities in their clustered differentiations, particularly when entrances and mausoleums are considered. According to Hillier and Leaman, no builders or designers working with a tradition truly work with a clean slate of existing patterns: they always modify (Hillier and Leaman 1974). When such conditions are confronted, genotype could be looked at, not as ‘a given rank order of labelled spaces, but *a statistically stable pattern of variation* of those’ (Bafna 2001: 9). One can suggest that most madrassas belong to the spatial grouping from which the hypothesized ‘court’ genotype is theoretically derived (Ostwald 2011).

Although M1 and M6 owned some of the characteristics that categorized them within the court-genotype, these two madrassas remained phenotypically individualized. While M1 showed that each of its educational and memorial spaces is assigned a distinguished spatial identity shaped through separation and registered several BDF swings, M6 introduced new spatial complexity. Whether these two madrassas should be isolated as non-genotypes, or had their seeds established in the preceding eras or continued in later ones, is not clear and requires separate research.

## Conclusions

The initial reading of the spatial qualities of Mamluk madrassas highlighted the irregularities in the madrassas' forms and questioned their impact on the homogeneity of the actual syntax of space. The madrassa-by-madrassa review has suggested a dominant trend based on the existence of a court with several properties. Analyses show that there are two clear spatial genotypes. One dominant variant centres around an integrated court and segregated exterior. In this 'court-genotype' and its phenotypical variations, the integrated central zone is edged by segregation that spreads around individualized spaces, through the entrance and towards the outer-environment, separating and distancing by such the educational core from the busy exterior. The different filters and corridors come to regulate the dynamics of the madrassa and to separate its highly integrated, weakly differentiated educational inner parts from the outer busy environment.

The other variant, which is exclusive to Jerusalem, although keeping the court within the integrated core, brings some new themes into play. While the exterior has always been amongst the most segregated, it becomes on the integrated side of the mean integration value. The court of these tight-permeable madrassas switches its rank to second with the iwans and transitional spaces taking its position. The integrated core now spikes its focus towards the entrances, and relates the core and the context of the mausoleum to the exterior. In contrast to the earlier genotype, the madrassas are more centrifugal and of extroverted plans. The madrassa-mausoleum in this case tries to expand its circle of presence, reach the outer environment and maximize the opportunities of encounter. The visitors to the larger educational, holy, Jerusalem who cross the sought-after Mamluk block are now more homogeneous and thus are more welcome in the context of the madrassa than they were in the other localities.

While this underlying spatial 'Jerusalem genotype" is associated with the locality of Jerusalem, the second "court genotype" does not seem to be associated with the size, era, or locality of the madrassa as noticed by the stability of the integration values across the Bahri and Burji sample. Although the mean integration value slightly increased in the Burji period, it is not significant to suggest any genotypical turns. Analysis shows that the Bahri period is the period that witnessed the emergence of the spatial organizations of genotypes, and suggests that the madrassas over the Burji period have become more subtly composed.

While space syntax presents a quantitative picture that echoes the madrassas' geometric rules, its ability to capture the perceptual capabilities of the layouts remains arguable. While it mathematically discerned the symbolically charged Mamluk gesture that heightened M1's mausoleum by separation, it failed to detect the unorthodox placement of the M6 mausoleum behind the Qibla wall. A result that directs attention to space-syntax limitation and its plausibility in detecting combined syntactical-geometric and perceptual impacts.

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## References

Abouseif, Doris. B. 1992. *Islamic Architecture in Cairo: An Introduction*. Netherlands: Brill.

Al-Harithy, Howayda. 2001. The Concept of Space in Mamluk Architecture. *Muqarnas* 18: 73–93.

Alsayyad, Naser. 2011. *Cairo: Histories of a City*. Cambridge: The Belknap Press of Harvard University Press.

Bafna, Sonit. 2001. Geometrical Institutions of Genotype. *Proceedings, 3rd International Space-syntax Symposium in Atlanta*, Vol. 1, 20.1–20.15.

Burgoyne, Michael. 1987. *Mamluk Jerusalem: An Architectural Study*. Northampton: Interlink Publishing.

Eilouti, Buthayna and Amer Al-Jokhadar. 2007. A Generative System for Mamluk Madrasa Form-making. *Nexus Network Journal* 9 (1): 7–29.

Grabar, Oleg. 1984. Reflections on Mamluk Art. *Muqarnas* 2: 1–12.

Hillier, Bill and Adrian Leaman. 1974. How is Design Possible? *Journal of Architectural Research* 3 (1): 4–11.

Hillier, Bill, Julienne Hanson, and Heather Graham. 1987. Ideas Are in Things: An Application of the Space-syntax Method to Discovering House Genotypes. *Environment and Planning B: Planning and Design* 14: 363–385.

Mahamid, Hatim. 2011. Curricula and Educational Process in Mamluk Madrasas. *Education Research Journal* 1 (7): 141–151.

Malhis, Shatha. 2016. Narratives in Mamluk Architecture: Spatial and Perceptual Analyses of the Madrassas and Their Mausoleums. *Frontiers of Architectural Research* 5 (1): 74–90.

Newhall, Amy. W. 1987. The Patronage of the Mamluk Sultan Qa'it Bay, 872–901/1468–1496, Published Ph.D. thesis. Harvard: Harvard University.

Organization of Islamic Capitals and Cities. 1992. *Principles of Architectural Design and Urban Planning During Different Islamic Eras*. Cairo: Organization of Islamic Capitals and Cities.

Orhun, Deniz, Bill Hillier, and Julienne Hanson. 1995. Spatial Types in Traditional Turkish Houses. *Environment and Planning B: Planning and Design* 22: 475–498.

Ostwald, Michael. J. 2011. A Justified Plan Graph Analysis of the Early Houses (1975–1982) of Glen Murcutt. *Nexus Network Journal* 13 (3): 737–762.

Parker, Robin. 1985. *Islamic Monuments in Cairo*. Cairo: The American University in Cairo Press.

Pinelo, Joao and Alasdair Turner. 2010. *Depthmap 10* (Computer Program). London: UCL.

Rabbat, Nasser. 2010. *Mamluk History Through Architecture: Monuments, Culture and Politics in Medieval Egypt and Syria*. London: I.B. Tauris.

Varoudis, Tasos. 2014. *Depthmap X* (Computer Program). London: UCL.

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