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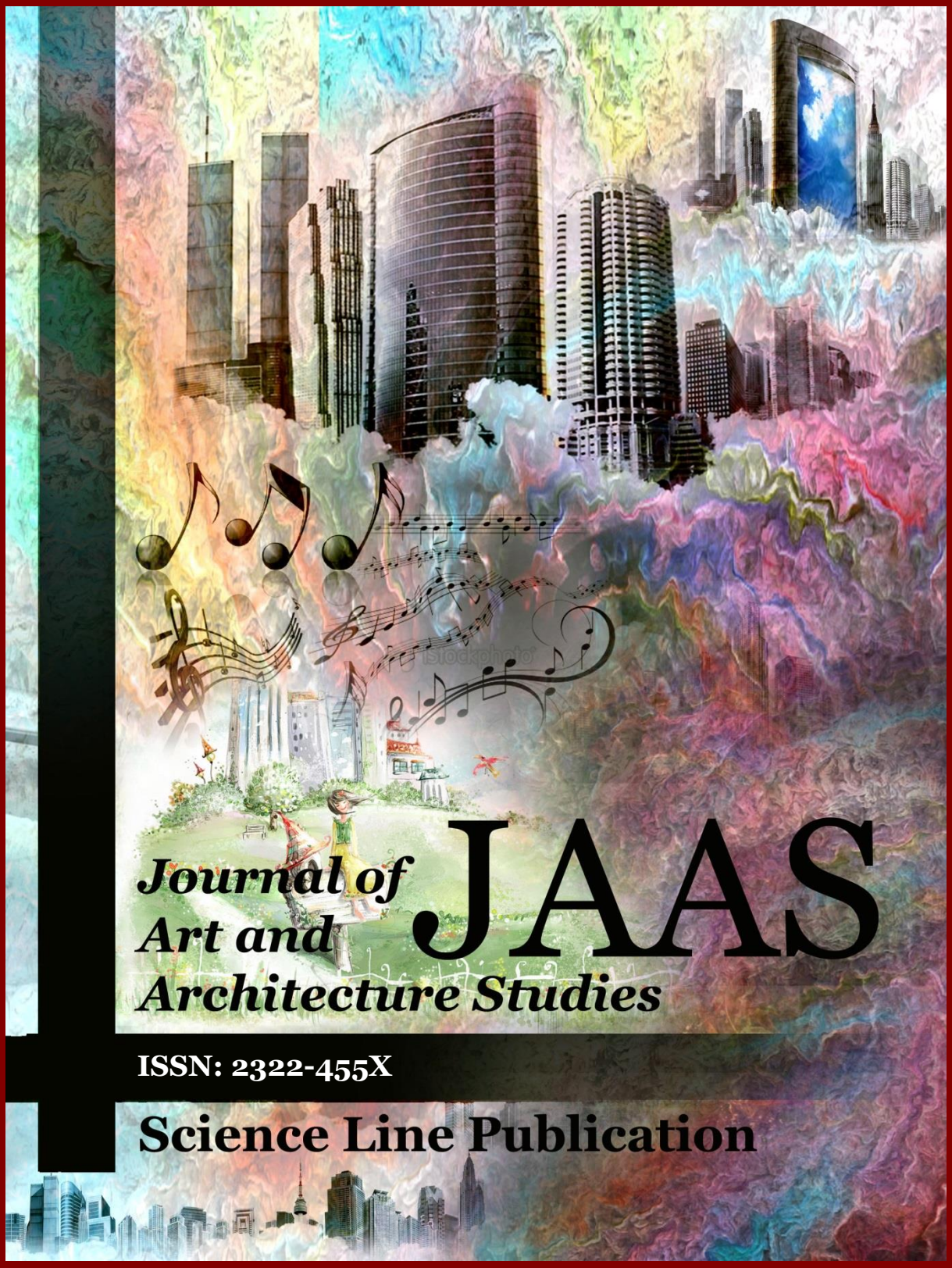

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Volume 14 (1); June 2025

Research Paper

Procedural interplay of art and technology in Seljuk mausoleum across empire phases: a chronological and comparative analysis

Nazer Z and Rabb P.

J. Art Arch. Stud., 14(1): 01-12, 2025; pii:S238315532500001-14

DOI: https://dx.doi.org/10.54203/jaas.2025.1

ABSTRACT

This study examines the dynamic interplay between artistic expression and structural technology in Seljuk mausoleum across the Early (1037–1063 CE), Middle (1063–1100 CE), and Late (1100–1194 CE) phases of the empire, extending into their Post-Seljuk legacy. Through a chronological and comparative analysis of key examples from Persia and Anatolia—such as Gonbad-e Qabus, the Kharāqan Towers, the Mausoleum of Sultan Sanjar, the Tomb of Mama Hatun, the Melik Gazi Tomb, and the Hüdavend Hatun Tomb—we demonstrate how Seljuk architects integrated ornamentation and structure as interdependent elements. Our findings revealed an evolution: the Early phase used material-driven ornamentation, the Middle phase advanced craft-based techniques, and the Late phase achieved a complex synthesis of form and decoration with regional variations. Shaped by cross-cultural influences from Persian, Byzantine, Armenian, Central Asian, and Turkic traditions, this process left a lasting impact on Islamic architecture. We conclude that this procedural interplay, rooted in Tektonik and material poiesis, not only defined Seljuk architectural innovation but also offers a framework for analyzing integrated design in broader architectural contexts.

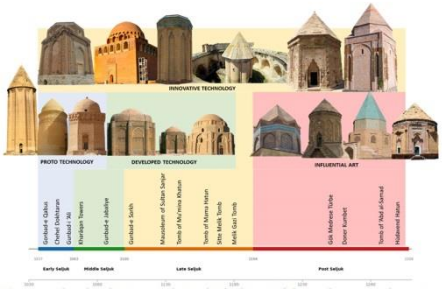

Figure 12. Chronological interaction of art and technology in Seljuk mausoleum case studies, (source: Authors).
Nazer Z and Rabb P (2025). **Procedural interplay of art and technology in Seljuk mausoleum across empire phases: a chronological and comparative analysis** *J. Art Arch. Stud.*, 14 (1): 01-12. DOI: https://dx.doi.org/10.54203/jaas.2025.1

Keywords: Seljuk mausoleum, Ornamentation, Geometric Patterns, Medieval Architecture, Chronological Analysis, Cross-Cultural Transmission, Procedural Design, Architectural Tectonics, Material Poiesis

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Research Paper

Understanding the role of architectural design in enhancing place attachment for senior citizen cases of senior living communities in Ahmedabad, India

Patel Y and Raval P.

J. Art Arch. Stud., 14(1): 13-19, 2025; pii:S238315532500002-14

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ABSTRACT

India, like many other countries worldwide, is experiencing a significant demographic shift. The aging of its population in India is expected to grow substantially in the coming years, leading to increased demands for specialized senior living environments. As the elderly face unique physical, emotional, and social challenges, the role of architecture in enhancing their well-being and fostering a sense of placement becomes crucial. In senior living developments, design interventions can be incorporated to increase accessibility, safety, comfort, social interaction, and a sense of identity and belonging. According to research, social isolation and loneliness in senior citizens are linked to poor health and mental performance. The relationship between place attachment and the well-being of senior citizens in India is significant and multi-faceted. Some key aspects of defining the relationship are emotional well-being, sense of identity and purpose, social support, and interaction with familiarity and comfort. Creating supportive and age-friendly environments that foster attachment and enhance the quality of life becomes essential.

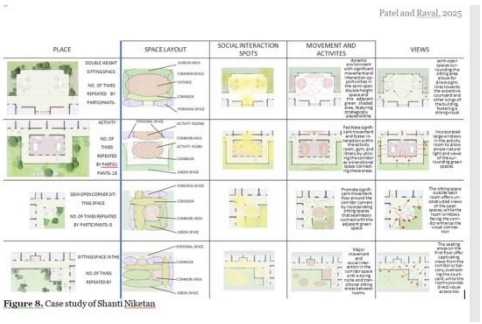

Figure 8. Case study of Shanti Niketan

Keywords: Place attachment, Senior living, Place identity, Sense of Place, Senior citizens, Architectural features.

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Review

Garden of philosophy: a nature-oriented idea of university, a cross-cultural review

Ahmadimoghaddam A and Khaghani S.

J. Art Arch. Stud., 14(1): 20-33, 2025; pii:S238315532500003-14

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ABSTRACT

Figure 4. The cloister at the centre of the Abbey of Santo Domingo de Silos, an example of the practice of garden making in the centres of learning throughout medieval Europe [32].

Ahmadimoghaddam A and Khaghani S (2025). **Garden of philosophy: a nature-oriented idea of university, a cross-cultural review.** *J. Art Arch. Stud.*, 14 (1): 20-33. DOI: https://dx.doi.org/10.54203/jaas.2025.3

This review article explores the significance of gardens as landscapes for contemplation and education across various cultures, including Iran, Greece, Japan, and medieval Europe. Through a cross-cultural and historical analysis of existing literature, it examines examples of the interaction between philosophy and gardens, such as court gardens and cloister garths of madrasas and early universities, where the garden served as an active participant in the educational experience. Additionally, it investigates the influence of gardens on culture, literature, philosophy, and language, revealing how these spaces shaped modes of thought and reflection. The article argues that gardens were not merely physical environments but philosophical spaces rooted in the affinity between humans and nature, places where intellectual and spiritual growth took place. It also highlights their potential contribution to sustainable development goals in education and urban well-being. The study advocates recognising gardens as vital spaces for intellectual and spiritual growth in modern education. This knowledge could help develop landscapes fostering thinking and debate in schools and universities, where communication between students, thinkers, and scholars reflects the enduring legacy of gardens as sources of inspiration and creativity.

Keywords: Garden, Educational Spaces, Islamic Madrasas, Cultural Gardens, University, Sustainable Urban Practices.

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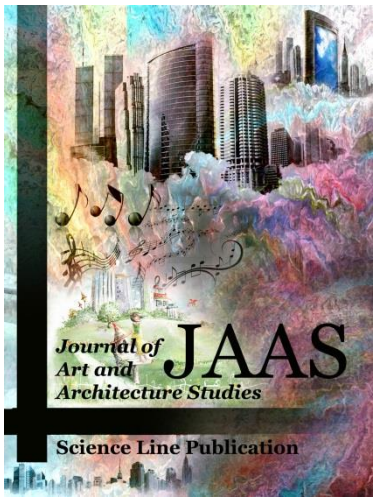

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Emails: administrator@science-line.com; saeid.azar@atauni.edu.tr

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PROCEDURAL INTERPLAY OF ART AND TECHNOLOGY IN SELJUK MAUSOLEUM ACROSS EMPIRE PHASES: A CHRONOLOGICAL AND COMPARATIVE ANALYSIS

Zeynab NAZER and Péter RABB

Department of History of Architecture and Monument Preservation, Faculty of Architecture, Pál Csonka Doctoral School, Budapest University of Technology and Economics, Budapest, Hungary

Research Article

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E-mail: nazer.znb@gmail.com

ABSTRACT: This study examines the dynamic interplay between artistic expression and structural technology in Seljuk mausoleum across the Early (1037–1063 CE), Middle (1063–1100 CE), and Late (1100–1194 CE) phases of the empire, extending into their Post-Seljuk legacy. Through a chronological and comparative analysis of key examples from Persia and Anatolia—such as Gonbad-e Qabus, the Kharāqan Towers, the Mausoleum of Sultan Sanjar, the Tomb of Mama Hatun, the Melik Gazi Tomb, and the Hüdavend Hatun Tomb—we demonstrate how Seljuk architects integrated ornamentation and structure as interdependent elements. Our findings revealed an evolution: the Early phase used material-driven ornamentation, the Middle phase advanced craft-based techniques, and the Late phase achieved a complex synthesis of form and decoration with regional variations. Shaped by cross-cultural influences from Persian, Byzantine, Armenian, Central Asian, and Turkic traditions, this process left a lasting impact on Islamic architecture. We conclude that this procedural interplay, rooted in Tektonik and material poiesis, not only defined Seljuk architectural innovation but also offers a framework for analyzing integrated design in broader architectural contexts.

KEYWORDS: Seljuk mausoleum, Ornamentation, Geometric Patterns, Medieval Architecture, Chronological Analysis, Cross-Cultural Transmission, Procedural Design, Architectural Tectonics, Material Poiesis

INTRODUCTION

The Seljuk empire (1037–1194 CE) produced remarkable architecture by combining artistic vision with technical skill, particularly in its mausoleum across Persia, Anatolia, and Central Asia. These structures went beyond their role as tombs, serving as expressions of dynastic power, religious devotion, and cultural identity across a vast region. Scholars have widely explored their styles, forms, and regional differences. However, the process of how art and technology were united in their design and construction has received less focus. This study fills that gap by arguing that ornamentation in Seljuk mausolea was not a separate layer but an essential part of their structure, planned and built as one. To analyze this, we propose the concept of "procedural interplay," grounded in Tektonik (the science of construction) and material poiesis (the expressive potential of materials), as a new framework to interpret this architectural evolution. This framework shows how Seljuk design principles balanced aesthetic innovation with structural integrity, leaving a lasting mark on Islamic architecture and extending into Post-Seljuk adaptations, such as the Hüdavend Hatun Tomb. We use Tektonik—where form and structure align—and material poiesis—where materials shape design—to trace this process. From the Early phase's material focus to the Late phase's detailed designs, and across Persia and Anatolia, we reveal an approach that was both innovative and influential. This work explains Seljuk architecture and provides insights for studying design processes in other settings.

Historical and architectural context: cross-cultural synthesis and material tectonics

The Seljuk period marked a key moment in Islamic architecture. It blended influences from Persian, Byzantine, Armenian, Central Asian, and early Turkic traditions into a unique style [1]. This style featured large buildings, skilled brickwork, vaulted structures, and detailed ornamentation. Mausolea were not just burial sites; they symbolized Seljuk power, faith, and goals across the empire. Nazer et al. [2] showed how these structures (cylindrical towers or domed chambers) stood as lasting signs in their landscapes. Their effect came from a process where art and structure were planned together.

Critically, the profound aesthetic impact of Seljuk mausoleum emerged organically from a deeply ingrained procedural integration of artistic and technological considerations from the

conceptual genesis of design and throughout the complex construction process. As Oleg Grabar astutely observed, Seljuk architecture strategically deployed decoration to articulate and accentuate underlying structural forms [3]. This inherent procedural interaction, therefore, is not merely a stylistic preference, but a fundamental organizing principle, signifying a deliberate design ethos rooted in Tektonik principles.

The material landscape profoundly shaped Seljuk architectural expression. The Iranian Plateau's scarcity of timber elevated brick to a primary building material, stimulating exceptional brick quality and innovative vaulting techniques [3]. Brickwork became a sophisticated medium for decorative articulation, imbued with poiesis. Seljuk architects masterfully utilized varied bonding patterns, glazed tiles, stucco, plaster, and muqarnas to create rich decorative surfaces and spatial effects. In Anatolia, dressed stone predominated, leading to regional adaptations in material and decorative styles, while still reflecting the overarching Seljuk design ethos of integrated art and technology.

Literature review

Addressing the gap in procedural analysis of Seljuk mausoleum

Seljuk architecture has been thoroughly studied, with mausolea recognized as key examples of technical and artistic success in Islamic research. Scholars like Ettinghausen et al. [4] and Bloom [5] have detailed their forms, materials, styles, and cultural ties (Table 1). Yet, the step-by-step integration of art and technology in these buildings is less examined. Often, ornamentation is seen as an end step, not part of the construction process. The current study aimed to address that with “procedural interplay,” a concept showing how structure and decoration were connected from the beginning. Hence we break this into four stages (proto technology, developed technology, innovative technology, and influential art) to follow its growth. Based on Tektonik and material poiesis, this approach looks at the methods behind Seljuk design, adding a fresh view to past studies.

Table 1. Summary of key literature on Seljuk mausoleum

Author(s)/Year	Title/Publication	Focus	Period Addressed	Key Contribution	Relevance to Study
Ettinghausen et al. [4]	Islamic Art and Architecture 650-1250	Early Islamic architecture, Persian traditions	Early	Describes Gonbad-e Qabus as structurally focused with minimal ornamentation	Supports Proto Technology as the initial stage
Pope and Ackerman [6]	A Survey of Persian Art	Persian architectural history, brickwork	Early	Emphasizes structural clarity in early brick mausolea	Connects form to ornamentation in Early phase
Komaroff & Carboni [7]	The Legacy of Genghis Khan	Central Asian influences on Islamic art	Early	Links simplicity to nomadic traditions	Explains cultural roots of Early Seljuk design
Tabbaa [8]	The Transformation of Islamic Art	Sunni revival, geometric ornamentation	Middle	Examines brick patterns as craft in Kharāqan	Highlights Developed Technology’s craft focus
Makovicky [9]	Tomb Towers and Minarets	Technical analysis of Kharāqan	Middle	Details planned brick ornamentation	Reinforces focus on embedded decoration
Bloom [5]	The Minaret	Structural evolution, vaulting techniques	Middle	Studies octagonal forms and vaulting advances	Adds structural insight to Middle phase
Gharipour and Blessing [10]	Mausoleums of the Islamic World	Sultan Sanjar's design and decoration	Late	Shows brick and tile integration	Evidence for Innovative Technology’s synthesis
Pancaroğlu [11]	The Seljuks of Anatolia	Mama Hatun, geometric stone carving	Late	Details geometric precision on stone surfaces	Supports Anatolian innovation in Late phase
Blessing [12]	Rebuilding Anatolia after the Mongol Conquest	Post-Seljuk Anatolian architecture	Post-Seljuk	Views Gök Medrese and Doner Kumbet as Seljuk continuations	Defines Influential Art as legacy
Öney [13]	Anadolu Selçuklu Mimari Süslemesi	Anatolian Seljuk ornamentation	Post-Seljuk	Documents Hüdavend Hatun's figural designs	Shows post-Seljuk adaptation of Seljuk ideas

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METHODOLOGY

We used a case study approach, analyzing selected Seljuk mausoleum from the Early (1037–1063 CE), Middle (1063–1100 CE), Late (1100–1194 CE), and Post-Seljuk periods. This timeline helps us see changes over the empire's history. We chose examples from Persia and Anatolia, using research like Hillenbrand [14] and Blair [15]. These mausolea were picked for their architectural importance, historical value, and good documentation. Our main idea, "procedural interplay," means art and technology were blended during design and construction. Based on Tektonik and material poiesis, this makes ornamentation and structure work together. We divided this into four stages:

A) Proto technology (structure shapes decoration): Early phase where the structure itself is the ornamentation, using materials directly.

B) Developed technology (craft builds art): Middle phase where decoration is built into the structure through skilled work.

C) Innovative technology (form and art unite): Late phase where structure and decoration fully merge, varying by region.

D) Influential art (legacy guides design): Post-Seljuk phase where Seljuk ideas shape later buildings.

For each mausoleum, we looked at the structure (form, materials, techniques), ornamentation (patterns, tiles, carvings), and how they fit together, showing the process behind their unity.

Analysis: procedural evolution across Seljuk periods

This section looks at the mausolea by period to show how art and technology changed over time and across regions.

1. Early Seljuk period (1037–1063 CE): Proto technology - structural form as ornament in Persia

In the Early phase, Proto Technology used structural form as ornamentation. Gonbad-e Qabus has a cylindrical tower, decagonal plan, and conical roof in plain fired brick. Buttresses and a Kufic inscription blend into the structure, relying on material texture for effect. Gunbad-i 'Ali, a cylindrical tower with a conical roof, uses brick texture and minimal inscriptions the same way. This approach focuses on structural clarity and material use.

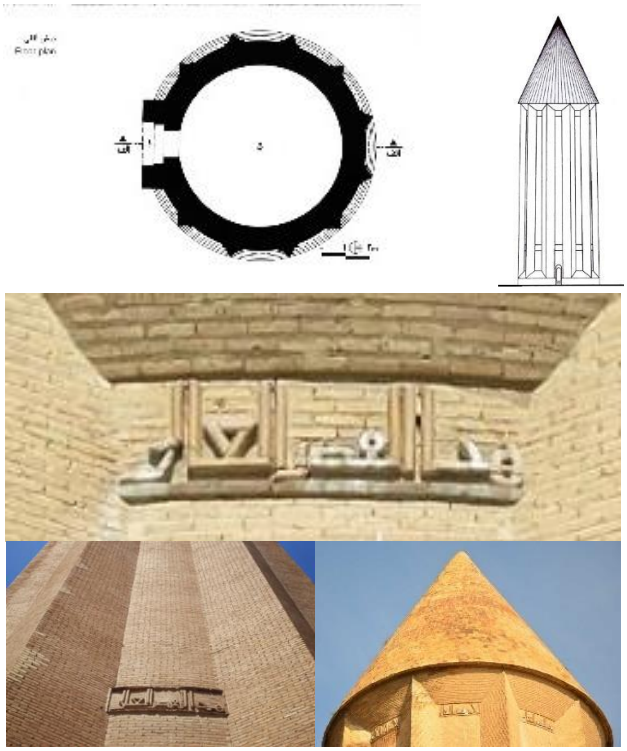

Figure 1. Gonbad-e Qabus represents Proto Technology, where the decagonal plan and plain brickwork form the ornamentation, reflecting a basic tectonic approach. (Photos: authors' archive).

Figure 2. Gunbad-i 'Ali refines Proto Technology, with its cylindrical tower and conical roof in plain brick, enhanced by texture and Kufic inscriptions, emphasizing material and form (Photos: authors' archive).

2. Middle Seljuk period (1063–1100 CE): developed technology - craft-integrated ornament in Persian brickwork

The Middle phase, Developed Technology, added ornamentation into construction. The Kharāqan Towers have octagonal brick forms with

double conical roofs. Polygons and strapwork are carved into the brick as it's built, making craftsmanship artistic. Gunbad-e Jabaliye, with an octagonal stone base and domed roof, uses geometric brick patterns in stucco, showing more complexity. This phase relies on skill to join structure and decoration.

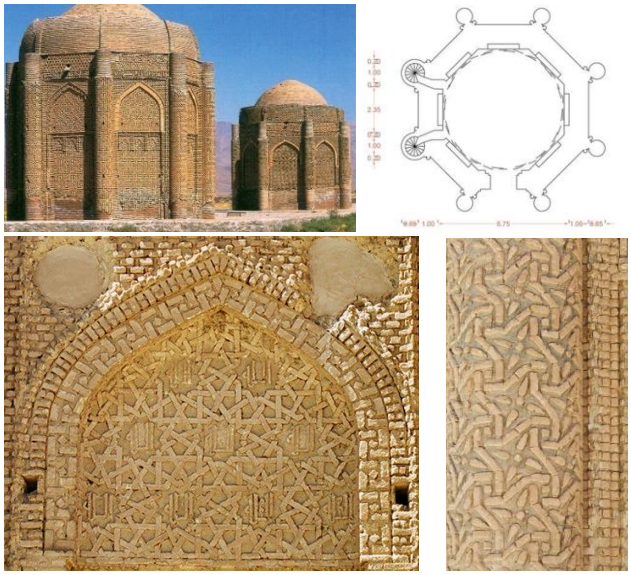

Figure 3. Kharāqan Towers detail shows developed Technology, with geometric patterns carved into brickwork, turning structure into an artistic medium through material poiesis (Photos: authors' archive).

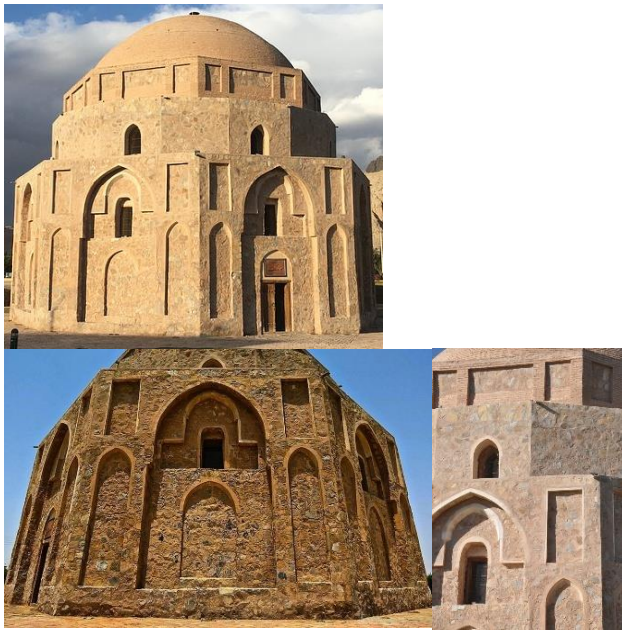

Figure 4. Gunbad-e Jabaliye reflects developed Technology in stone, its octagonal form and domed roof with brick patterns in stucco adapting brick techniques. (Photos: authors' archive).

3. Late Seljuk period (1100–1194 CE): innovative technology - symbiotic art & structure and regional diversification

The Late phase, Innovative Technology, fully united structure and ornamentation. The Mausoleum of Sultan Sanjar mixes Hazārbāf brickwork, turquoise tiles, and interior painting into one design, boosting both form and meaning. In Anatolia, the Tomb of Mama Hatun has geometric stone carvings on a curved drum, while the Sitte Melik tomb uses turquoise tile revetment as its main ornamentation. This phase shows advanced methods and regional styles.

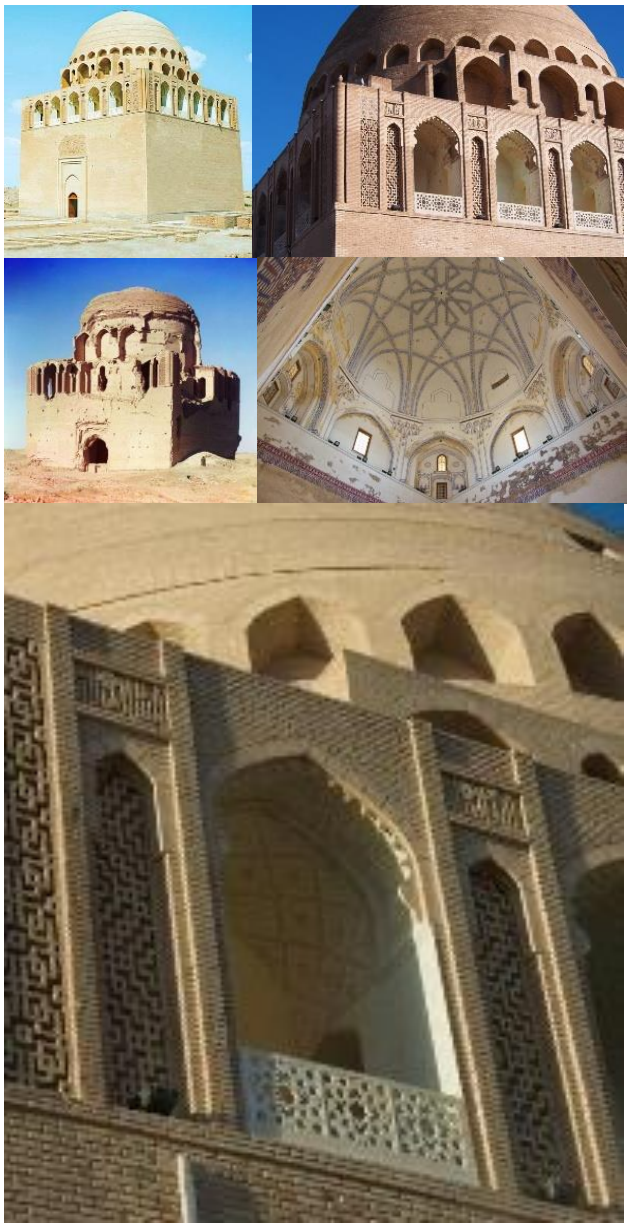

Figure 5. Mausoleum of Sultan Sanjar reflects innovative technology, integrating Hazārbāf brickwork, tile revetment, and painting into a unified structure with symbolic depth. (Photos: authors' archive).

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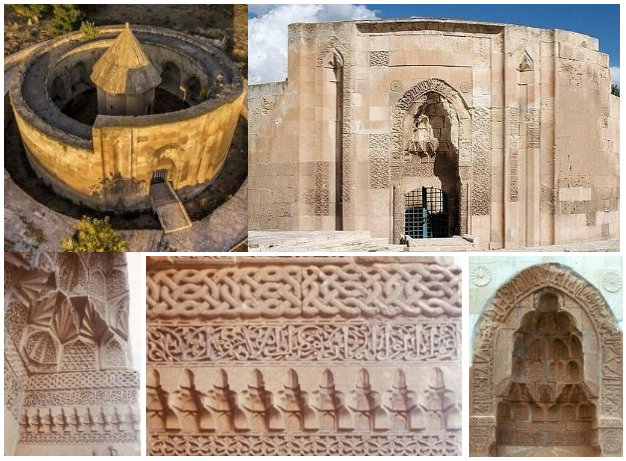

Figure 6. Tomb of Mama Hatun shows innovative technology in Anatolian stone, with geometric carvings on curved surfaces highlighting regional skill (Photos: authors' archive).

Figure 7. The Sitte Melik tomb (c. 1190–1200 CE) demonstrates innovative technology, with its octagonal base, cylindrical drum, and conical roof showcasing intricate stone carvings and geometric patterns that integrate structure and ornamentation in Anatolian Seljuk design (Photos: authors' archive).

4. Post-Seljuk period (Post-1194 CE): influential art - legacy design principles and adaptation

In the Post-Seljuk phase, influential art kept Seljuk ideas alive. Gök Medrese Türbe has an octagonal stone form with a conical roof, using turquoise tiles and geometric carvings. Doner Kumbet, a dodecagonal two-story structure, has carvings and tile traces, continuing Seljuk principles. This phase shows how Seljuk methods lasted and changed.

Figure 8. Gök Medrese Türbe reflects influential art, maintaining Seljuk style with octagonal stone, tiles, and carvings aligned with the form (Photos: authors' archive).

Figure 9. Doner Kumbet shows influential art, its dodecagonal two-story form with carvings and tile traces extending Seljuk design. (Photos: Authors' Archive).

RESULTS AND DISCUSSION

This section synthesizes our findings to elucidate the evolution and variation of procedural interplay in Seljuk mausolea, contextualizing them within prior scholarly work.

Procedural interaction types in Seljuk mausoleum

Our analysis identifies four distinct types of procedural interplay, each corresponding to a specific period:

Proto technology (Early Seljuk Period, 1037–1063 CE): Characterized by minimal ornamentation where the structure itself serves as the decorative element, relying on material texture and form, as seen in Gonbad-e Qabus. Ettinghausen et al. [4] note that early Seljuk mausolea, like Gonbad-e Qabus, prioritized structural clarity with minimal applied decoration, aligning with our observation of form-driven ornamentation in this phase.

Developed technology (Middle Seljuk Period, 1063–1100 CE): Ornamentation is embedded into the structure through skilled craftsmanship, as exemplified by the Kharāqan Towers' carved brick patterns. Makovicky [9] emphasizes the planned integration of geometric brickwork in the Kharāqan Towers, reinforcing our finding that craft became a medium for artistic expression during construction.

Innovative technology (Late Seljuk Period, 1100–1194 CE): A seamless blend of structure and complex ornamentation, with regional variations, as seen in the Mausoleum of Sultan Sanjar and Tomb of Mama Hatun. Gharipour and Blessing [10] highlight the sophisticated integration of brick and tile in Sultan Sanjar's mausoleum, supporting our conclusion that this phase achieved a symbiotic unity of form and decoration.

Influential art (Post-Seljuk Period, Post-1194 CE): Seljuk principles guide later designs, as in Doner Kumbet, where geometric carvings and tile traces extend the Seljuk legacy. Asefi et al. [16] discuss historical architectural globalization, which parallels our conceptualization of this phase as a continuation of Seljuk design ethos in adapted forms. These four types illustrate a progressive sophistication in integrating art and technology, evolving from material-based simplicity to a refined legacy. This evolutionary framework aligns with Asefi et al.'s [16] analysis of art-technology interactions across Islamic and Christian contexts, but our study extends this by focusing specifically on the procedural methodologies of Seljuk mausolea.

Framework for evolution of procedural interaction in Seljuk mausoleum

Our framework, detailed in Tables 2 and 3 and Figures 10–12, tracks the progression of procedural interplay across shape, motif, and color. From Proto Technology's reliance on structural geometry to Influential Art's refined form-surface harmony, this framework moves beyond stylistic analysis to uncover the deliberate design ethos of Seljuk architects. Bloom [5] notes the evolution of vaulting techniques and geometric forms in Middle Seljuk architecture, which supports our observation of increasing structural complexity in the Developed Technology phase. Similarly, Pancaroğlu [11] details the geometric precision of Anatolian stone carvings in the Late phase, corroborating our findings of regional diversification in Innovative Technology. This framework provides a robust tool for analyzing procedural integration, offering insights applicable to broader architectural studies.

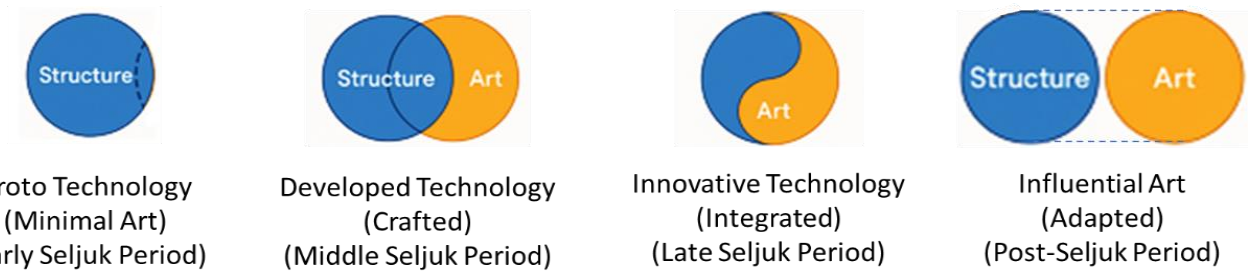

Figure 10. Schematic evolution of procedural interplay; structure and art interaction across Seljuk phases (source: Authors inspired by Asefi et al. [16]).

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Table 2. Procedural interaction types in Seljuk mausoleum (source: Authors)

	Mausolea-Date (CE)	Region	Structural Design	Ornamentation	Procedural Interaction Type	Description
Early	Gonbad-e Qabus 1006-07	Persia (Iran)	Cylindrical tower, decagonal plan, conical roof	Plain fired brick, buttresses, Kufic band	Proto technology: structure shapes decoration	Geometry (decagonal plan) and brick texture define decoration without applied elements.
	Chehel Dokhtaran c. 1055	Persia (Iran)	Cylindrical tower, conical roof	Plain brick, Kufic inscription, subtle brick texture	Proto technology: structure shapes decoration	Brick texture and Kufic band enhance structural form with minimal ornamentation.
	Gunbad-i ‘Ali 1056	Persia (Iran)	Cylindrical tower, conical roof	Plain brick, minimal texture, Kufic inscription	Proto technology: structure shapes decoration	Brick texture and inscriptions enhance structural clarity with minimal ornamentation.
Middle	Kharāqan Towers 1067 & 1093	Persia (Iran)	Octagonal brick, double conical roofs	Carved brick (polygons, strapwork), inscriptions	Developed technology: craft builds art	Patterns carved into bricks during construction, merging art and structure.
	Gunbad-e Jabaliye c. 1080–1090	Persia (Iran)	Octagonal stone, domed roof	Geometric brick patterns, minimal stucco	Developed technology: craft builds art	Brick patterns integrated into stone structure, marking transitional complexity.
Late	Gunbad-e Sorkh 1147	Persia (Iran)	Square brick, conical roof	Brick strapwork, early muqarnas, inscriptions	Innovative technology: form and art unite	Brick strapwork and early muqarnas enhance square form, reflecting advanced synthesis.
	Mausoleum of Sultan Sanjar 1157	Persia (Turkmenistan)	Domed square, large single dome	Hazārbāf brick (chevron, diaper), tile, interior paint	Innovative technology: form and art unite	Brick, tile, and interior paint symbiotically enhance structure and spatial symbolism.
	Tomb of Mu’mina Khatun 1186	Persia (Azerbaijan)	Decagonal brick, domed roof	Brick strapwork, early muqarnas, inscriptions	Innovative technology: form and art unite	Brickwork and muqarnas amplify structural geometry in a refined synthesis.
	Sitte Melik Tomb c. 1190–1200	Anatolia (Turkey)	Octagonal base, cylindrical drum, conical roof	Turquoise tile revetment, geometric patterns	Innovative technology: form and art unite	Turquoise tile revetment enhances structure as primary ornament, reflecting regional style.
	Tomb of Mama Hatun c. 1191–1192	Anatolia (Turkey)	Curved stone drum, squinch, column	Geometric stone carving (hexagonal, dodecagonal), muqarnas	Innovative technology: form and art unite	Geometric carvings on curved stone integrate form and decoration via advanced techniques.
	Melik Gazi Tomb c. 1196–1197	Anatolia (Turkey)	Square with muqarnas, tripartite elevation	Brick muqarnas hoods, decorative bonds	Innovative technology: form and art unite	Brick muqarnas articulate structure, reflecting Iranian influence in Anatolian context.
Post-Seljuk	Gök Medrese Türbe c. 1270	Anatolia (Turkey)	Octagonal stone, conical roof	Turquoise tile, geometric stone carvings	Influential art: legacy guides design	Tile and stone carvings harmonize with octagonal form, continuing Seljuk traditions.
	Doner Kumbet 1276	Anatolia (Turkey)	Dodecagonal, two-storey, conical roof	Geometric carvings, turquoise tile traces	Influential art: legacy guides design	Dodecagonal form and carvings/tile traces harmonize, extending Seljuk principles.
	Tomb of ‘Abd al-Samad c. 1299	Persia (Iran)	Octagonal brick, domed roof	Glazed tile, geometric brickwork, stucco	Influential art: legacy guides design	Tile and stucco refine octagonal form, evolving Seljuk decorative systems.
	Hüdavend Hatun 1312	Anatolia (Turkey)	Octagonal stone, pyramidal roof	Stone carvings (geometric, figural), muqarnas	Influential art: legacy guides design	Octagonal form with geometric and figural carvings evolves Seljuk style into a new synthesis.

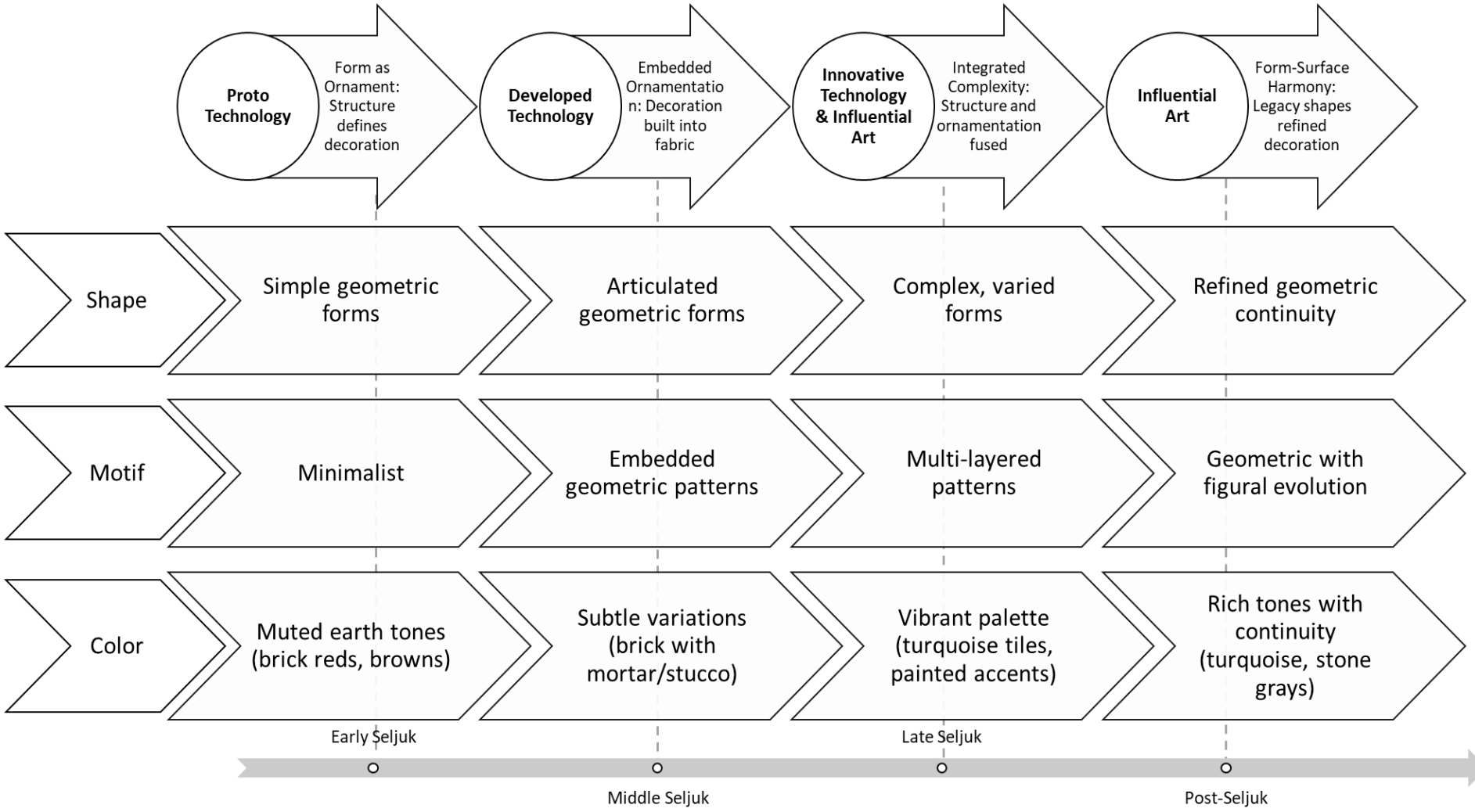

Figure 11. Conceptual diagram of procedural interaction evolution in Seljuk mausoleum (source: Authors)

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Table 3. Conceptual framework for evolution of procedural interaction in Seljuk mausoleum (source: Authors)

Visual Representation	**Early-Seljuk**	**Middle-Seljuk**	**Late-Seljuk**	**Post-Seljuk**
	Proto Technology	***Developed Technology***	***Innovative Technology***	***Influential Art***
Shape	Simple, bold geometric forms	More articulated geometric forms	Highly complex and varied forms	Refined geometric continuity
	Gonbad-e Qabus: Cylindrical tower, decagonal plan	*Kharāqan Towers*: Octagonal with double conical roofs	*Sultan Sanjar*: Large domed square	*Gök Medrese Türbe*: Octagonal stone
	Chehel Dokhtaran: Plain cylinder	*Gunbad-e Jabaliye*: Octagonal stone base	*Mu'mina Khatun*: Decagonal dome	*Doner Kumbet*: Dodecagonal two-storey
	Gunbad-i 'Ali: Plain cylinder		*Gunbad-e Sorkh*: Square with conical roof	*Hüdavend Hatun*: Octagonal with pyramidal roof
			Mama Hatun: Curved stone drum	
			Sitte Melik: Octagonal with cylindrical drum	*'Abd al-Samad*: Octagonal brick
			Melik Gazi: Square with tripartite elevation	
Motif	Minimalist design	Interwoven geometric patterns embedded in brick or stone	Intricate, multi-layered patterns	Geometric with evolving figural and refined synthesis
	Gonbad-e Qabus: Kufic band, buttress light-shadow interplay	*Kharāqan Towers*: Polygons, strapwork in brick	*Sultan Sanjar*: Chevron, diaper brick, tile, star-painted interiors	*Gök Medrese Türbe*: Tile, geometric stone carvings
	Chehel Dokhtaran: Kufic band, subtle brick texture	*Gunbad-e Jabaliye*: Geometric brick patterns	*Mu'mina Khatun*: Strapwork, early muqarnas	*Doner Kumbet*: Geometric carvings, tile traces
	Gunbad-i 'Ali: Basic brick texture, Kufic inscription		*Gunbad-e Sorkh*: Strapwork, early muqarnas	*Hüdavend Hatun*: Geometric and figural carvings
			Mama Hatun: Hexagonal, dodecagonal stone carvings	*'Abd al-Samad*: Glazed tile, geometric brickwork
			Sitte Melik: Turquoise tile geometric patterns	
			Melik Gazi: Brick muqarnas hoods	
Color	Muted, earthy tones reflecting material honesty	Subtle variations—earthy tones with mortar/stucco contrast	Rich, vibrant palette	Sustained rich tones with continuity
	Gonbad-e Qabus: Brick reds, browns	*Kharāqan Towers*: Brick tones, mortar grays	*Sultan Sanjar*: Turquoise tiles, brick reds, painted yellows	*Gök Medrese Türbe*: Turquoise tiles, stone grays
	Chehel Dokhtaran: Brick reds, browns	*Gunbad-e Jabaliye*: Brick with stucco grays	*Mu'mina Khatun*: Brick reds	*Doner Kumbet*: Turquoise hints, stone grays
	Gunbad-i 'Ali: Brick reds, browns		*Gunbad-e Sorkh*: Brick reds	*Hüdavend Hatun*: Stone grays
			Mama Hatun: Stone grays	*'Abd al-Samad*: Turquoise tiles, brick tones
			Sitte Melik: Turquoise tiles, brick undertones	
			Melik Gazi: Brick reds	
Key Characteristic	Form as Ornament	Embedded Ornamentation	Integrated Decorative Complexity & Regional Diversification	Form-Surface Harmony
	Emphasis on structural geometry and material expression as primary decoration	Decoration integrated into construction, bricklaying as craft	Seamless synthesis of structure and elaborate ornamentation with regional adaptations	Refined legacy of Seljuk principles shaping design

Chronological evolution and regional divergence of procedural harmony

The chronological analysis reveals a clear trajectory from structural ornamentation to a sophisticated synthesis of form and decoration. In Persia, brick-based patterns dominated, as seen in the Hazārbāf brickwork of Sultan Sanjar's mausoleum, while Anatolia favored stone and turquoise tiles, as in the Tomb of Mama Hatun. This regional divergence, driven by material availability and cultural preferences, is consistent with Blair and Bloom's [1] observation of cross-cultural synthesis in Islamic architecture, where Persian, Byzantine, and Turkic influences enriched Seljuk designs. Despite these variations, the core principle of procedural integration remained consistent, as evidenced by the shared emphasis on harmonizing art and technology across both regions. Ettinghausen et al. [4] further note the adaptability of Seljuk architecture to local materials, which aligns with our finding that regional styles did not dilute but rather enhanced the unified Seljuk design ethos. Cross-cultural transmission, as discussed by Asefi et al. [16], played a pivotal role in this process, with Seljuk architects creatively adapting diverse influences to create a rich and varied architectural language.

In summary, our results demonstrate that the procedural interplay of art and technology in Seljuk mausolea evolved through distinct phases, shaped by technical advancements, material poiesis, and cross-cultural exchanges. By comparing our findings with prior studies [1, 4, 5, 9, 10, 11, 16], we affirm that this interplay was not merely stylistic but a fundamental design principle, offering a new lens for understanding Seljuk architectural innovation and its lasting influence.

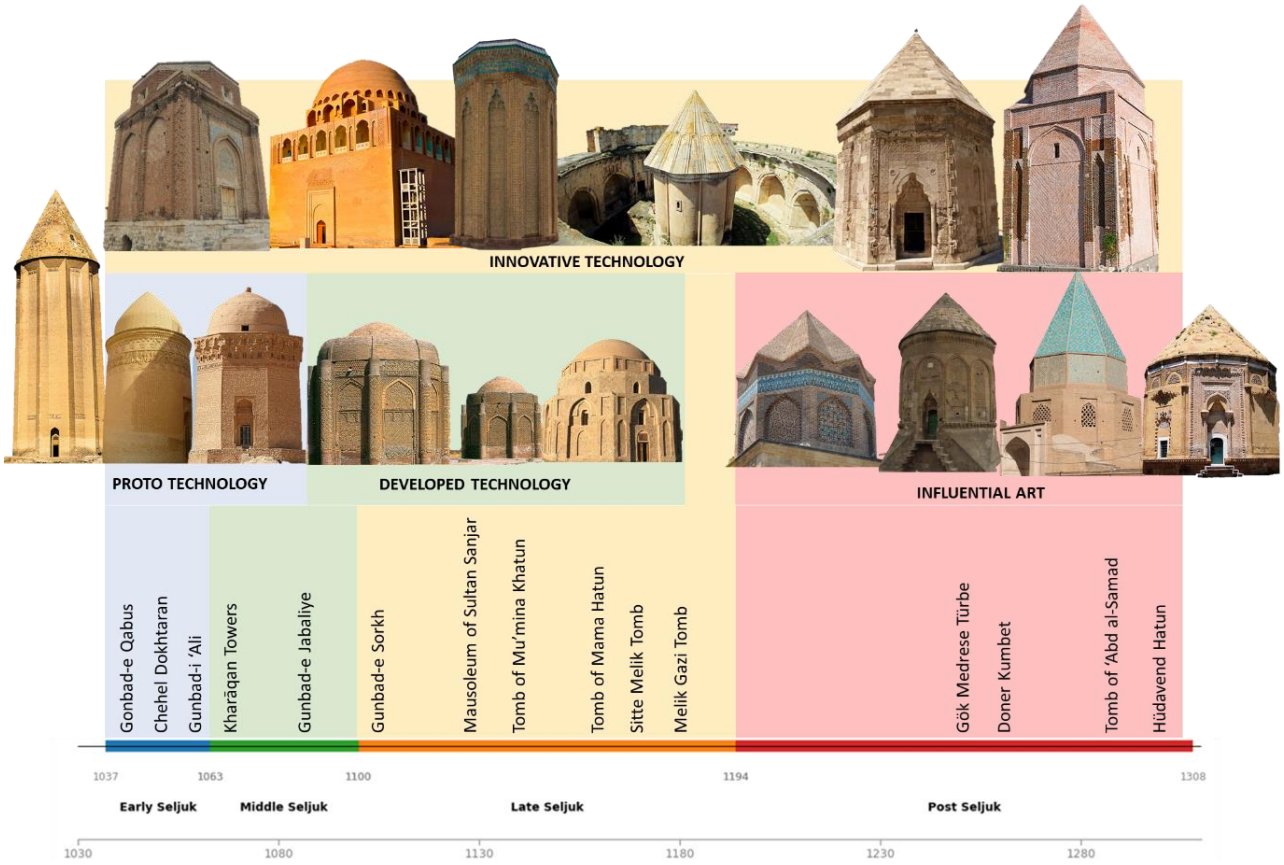

Figure 12. Chronological interaction of art and technology in Seljuk mausoleum case studies, (source: Authors)

CONCLUSION

This study establishes that the integration of artistic expression and structural technology was a defining feature of Seljuk mausolea throughout their development across the Early (1037–1063 CE), Middle (1063–1100 CE), and Late (1100–1194 CE) phases, with its influence persisting into the Post-Seljuk period. Our chronological and comparative analysis of key examples—Gonbad-e Qabus, Kharāqan Towers, Mausoleum of Sultan Sanjar, Tomb of Mama Hatun, Melik Gazi Tomb, and

Hüdavend Hatun Tomb—reveals a clear evolution in this process. In the Early phase, as seen in Gonbad-e Qabus, ornamentation relied on the structural form and material texture, using minimal elements like Kufic inscriptions and brick patterns to enhance clarity. The Middle phase, exemplified by the Kharāqan Towers, shifted to a craft-driven approach, embedding geometric patterns into brickwork during construction, showing increased technical and artistic skill. By the Late phase, structures like the Mausoleum of Sultan Sanjar and Tomb of Mama Hatun achieved a sophisticated balance, fully uniting complex ornamentation—such as Hazārbāf brickwork, turquoise tiles, and stone carvings—with structural design, tailored to regional materials and styles. This trajectory continued into the Post-Seljuk period, where mausolea like Hüdavend Hatun Tomb adapted Seljuk principles, blending geometric and figural carvings with traditional forms.

This evolution reflects a consistent design approach where art and structure were not separate but worked together, rooted in Tektonik and material poiesis. Tektonik ensured that form and construction aligned, while material poiesis allowed materials like brick and stone to express both function and beauty. This method went beyond decoration, embedding it into the building process to strengthen both visual impact and symbolic meaning—whether dynastic power, religious devotion, or cultural identity. Cross-cultural influences from Persian, Byzantine, Armenian, Central Asian, and Turkic traditions enriched this approach, making Seljuk mausolea adaptable and diverse across Persia and Anatolia. The result was an architectural legacy that shaped Islamic design and influenced later periods, as seen in Post-Seljuk examples.

The concept of "procedural interplay" introduced here offers a new way to understand this integration. It highlights how Seljuk architects balanced innovation with stability, creating mausolea that stood as both technical achievements and artistic statements. This framework is not limited to Seljuk architecture; it can help analyze how art and technology merge in other times and places, offering a tool for broader studies in medieval and Islamic architecture. Looking ahead, future research could dig deeper into the geometric and mathematical basis of Seljuk patterns, explore the social and political factors behind this design approach, or trace its influence on later architectural traditions in greater detail. For now, this study positions Seljuk mausoleum as a powerful example of how art and technology can combine, leaving a lasting mark on architectural history and providing lessons for design today.

DECLARATIONS

Corresponding author

Correspondence and requests for materials should be addressed to Zeynab Nazer, E-mail: nazer.znb@gmail.com; ORCID: 0000-0002-0945-1348

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Authors' contribution

Z. Nazer: Conceptualization, methodology, computational analysis, data curation, formal analysis, validation, writing – original draft, review, and editing. P. Rabb: Conceptualization, methodology, art historical validation, supervision, project administration, resources, writing – review and editing, and validation.

Competing interests

The author declares that there is no competing interest.

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UNDERSTANDING THE ROLE OF ARCHITECTURAL DESIGN IN ENHANCING PLACE ATTACHMENT FOR SENIOR CITIZEN CASES OF SENIOR LIVING COMMUNITIES IN AHMEDABAD, INDIA

Yashvi PATEL and Pooja RAVAL

Institute of Architecture & Planning, Nirma University, India

Research Article

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Corresponding author:
E-mail:
pooja.raval@nirmauni.ac.in

ABSTRACT: India, like many other countries worldwide, is experiencing a significant demographic shift. The aging of its population in India is expected to grow substantially in the coming years, leading to increased demands for specialized senior living environments. As the elderly face unique physical, emotional, and social challenges, the role of architecture in enhancing their well-being and fostering a sense of placement becomes crucial. In senior living developments, design interventions can be incorporated to increase accessibility, safety, comfort, social interaction, and a sense of identity and belonging. According to research, social isolation and loneliness in senior citizens are linked to poor health and mental performance. The relationship between place attachment and the well-being of senior citizens in India is significant and multi-faceted. Some key aspects of defining the relationship are emotional well-being, sense of identity and purpose, social support, and interaction with familiarity and comfort. Creating supportive and age-friendly environments that foster attachment and enhance the quality of life becomes essential.

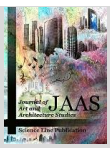
KEYWORDS: Place attachment, Senior living, Place identity, Sense of Place, Senior citizens, Architectural features.

INTRODUCTION

Human experiences are informed and influenced by the environment built around them; that is why emotional experiences, social interactions, and general quality of life are so closely tied to the built environment. For an elderly population, especially those living in senior communities, architecture is more than just a living place; it is also about building place attachment, which is described by Altman and Low [1] as the emotional and psychological bonds individuals make with their lived places. The increase in elderly people worldwide has emphasized the need for better senior living environments that offer greater comfort, security, and a sense of belonging. It is important to note that Ahmedabad, a fervently urbanizing Indian city, provides a unique example of the relation between architectural design and place attachment in senior living communities because it has a culturally rich, changing urban landscape and a growing elderly population. Even with the increasing focus on the architecture of the elderly, much-existing literature still focuses on the emotional and psychological aspects of architectural spaces [2] along with universal design, accessibility, and physical comfort needs. Place attachment is about remembering space, identity, social experience, and multi-sensory engagement [3]. Ahmedabad's heritage-inspired architecture, climate-responsive designs, and increasing demand for senior-friendly housing provide a compelling landscape to explore how architectural interventions shape emotional belonging. Senior living communities in the city exhibit varying design approaches, from institutionalized settings to more community-oriented, interactive spaces. This study examines the role of spatial organization, aesthetics, nature integration, and social spaces in influencing seniors' attachment to their environment. Through case studies, interviews, and spatial analysis, the research seeks to establish a framework for designing emotionally responsive senior living spaces that go beyond mere accessibility compliance to nurture a sense of belonging and identity actively.

Thus, this study is premised on the argument that place attachment is not an incidental outcome of architectural design but a fundamental objective in designing senior living communities. By critically analyzing design strategies that enhance familiarity, engagement, and sensory comfort, the research aims to contribute to an evidence-based approach to senior housing design. Ultimately, fostering place attachment in senior living environments is not just about creating age-friendly spaces but about ensuring that seniors feel emotionally rooted, socially connected, and psychologically secure in their living environments—a crucial factor in healthy aging and well-being.

Citation: Patel Y and Raval P (2025). Understanding the role of architectural design in enhancing place attachment for senior citizen cases of senior living communities in Ahmedabad, India. *J. Art Arch. Stud.*, 14 (1): 13-19. DOI: https://dx.doi.org/10.54203/jaas.2025.2



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Background

According to research, senior persons frequently suffer changes in their interactions with others and housing circumstances as they age. This adjustment can result in fewer social interactions, feelings of loneliness, and a drop in general well-being. Place attachment, which reflects the emotional link that people have with their physical surroundings, has been identified as an important part of well-being in a variety of circumstances. A strong feeling of place attachment can improve senior citizens' quality of life, sense of belonging, and general contentment with their living environment.

Architectural design shapes the built environment and has the potential to improve place attachment for senior adults. Architects and designers may positively influence the physical and psychological well-being of elders by building age-friendly settings that are accessible, safe, comfortable, and socially engaged. Design interventions that include elements like easy navigation, plenty of natural light, well-designed common areas, and chances for social interaction can help senior adults feel at home. This study intends to investigate the relationship between architectural design and attachment among older adults in India through extensive research that includes literature reviews, case studies, and surveys. The findings will help architects, designers, and politicians build effective strategies that prioritize the requirements and well-being of the aging population, resulting in the establishment of more inclusive and supportive living environments.

Selection of case study:

i. Shantiniketan Senior Living is a well-known senior living community in Adalaj, a peaceful neighborhood in Ahmedabad, Gujarat. It benefits from its strategic location in a peaceful and attractive setting. The neighborhood is located within beautiful green surroundings, giving inhabitants a tranquil and revitalizing environment. The location is convenient to key facilities such as hospitals, retail centers, and recreational areas, providing seniors convenience and comfort.

ii. Jeevan Sandhya Old Age Home is a residential community that caters to senior citizens who require assisted living or nursing care. The facility's architecture is focused on providing a safe and comfortable environment for the elderly residents.

METHODOLOGY

•The survey analysis will provide a comprehensive understanding of the range of experiences and perspectives of senior citizens regarding the role of architectural design in enhancing place attachment.

•To understand the level of place attachment among the seniors from the PPP theory of place attachment using Likert scale.

•Synthesize the findings from the literature review, case studies, and survey data to provide insights on how architectural design can enhance place attachment among senior citizens in elderly housing.

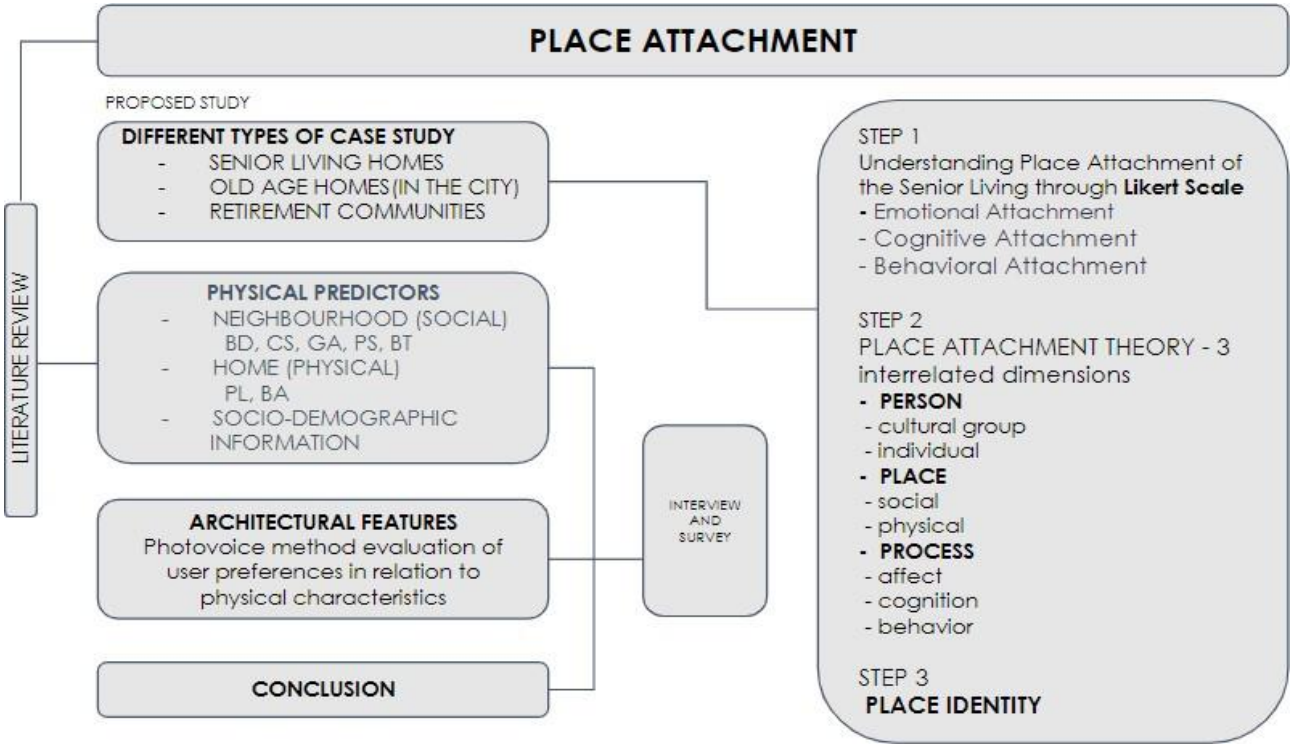

Figure 1. Research methodology.

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Based on the PPP framework, the following is a proposed Likert scale for understanding place attachment of senior citizens in the context of architectural design in their living environment.

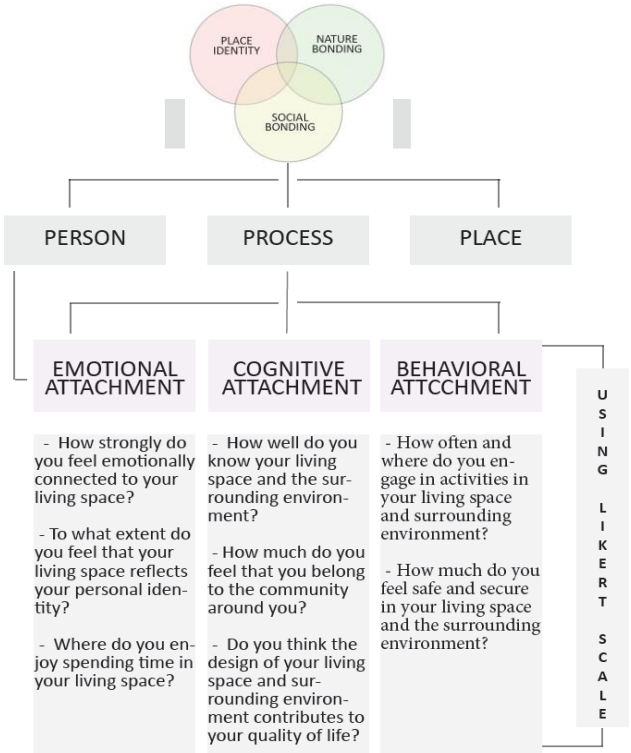

Figure 2. Research analysis framework

4. Literature Review

Sense of place

The subjective and emotional ties that people have with a specific environment or area are referred to as a sense of place. It includes people's emotions, meanings, and attachments to a place, which can influence their behavior, perceptions, and general well-being. Understanding the feeling of the place is critical in architectural design, especially for elderly persons, because it plays an important role in improving their quality of life and establishing a sense of belonging and identification within their living situations. For senior citizens, a feeling of place is critical because it can significantly impact their physical, emotional, and social well-being. Individuals' movement and everyday activities may become more constrained as they age, making their local surroundings, such as their living community or senior living facility, much more important. A strong sense of place can give elders a sense of security, familiarity, and comfort, allowing them to feel linked to their surroundings and encourage a pleasant living experience. Architectural design is critical in creating environments that foster a strong feeling of place for senior adults. The architectural elements and features used in the built environment can significantly impact how elders perceive and interact with their surroundings. Accessibility, safety, comfort, aesthetics, and social contact are all important considerations in creating a feeling of place for elders.

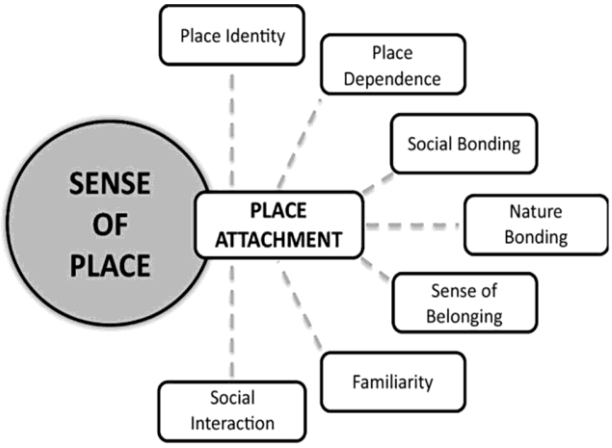

Figure 3. Sense of place with place attachment. Source Steele [4]

Place Identity

Place identity is the process by which individuals establish a feeling of self and belonging in relation to a given location or environment. Individuals' subjective and personal attachment to a particular place impacts their identity, values, and experiences. Place identity is important in architectural design for elderly adults since it improves their well-being, sense of belonging, and general quality of life. The formation of a strong place identification is critical for senior persons since it adds to their emotional and psychological well-being. Individuals may change their responsibilities, relationships, and physical abilities as they age, impacting their sense of self and purpose. For example, senior living communities and retirement homes can serve as a basis for their place identity, offering security, continuity, and meaning. Architectural design is critical in shaping senior citizen's sense of place. The physical characteristics and architectural features included in the built environment can impact how elders perceive and relate to their living situations. Architectural style, spatial layout, interior design, and incorporating personalized and recognizable aspects are all important components in establishing place identity. Spatial structure and function also play an important part in developing senior folks' sense of place. Space layout, circulation patterns, and accessibility elements should be developed to accommodate their everyday activities, needs, and preferences. Designing settings that encourage freedom, mobility, and personalization can empower elders and increase their sense of identity within their living environments. Incorporating community and shared areas into the design can help to build a place's identity. Providing opportunities for social interaction, communal activities, and shared

amenities helps elderly residents feel a feeling of belonging and community. These common places become an extension of their identity, contributing to a sense of connection and involvement with their surroundings. Following that, place identity is an important part of senior citizen architectural design. Architects and designers can develop surroundings that foster a strong sense of place identification for elderly persons by considering architectural style, spatial arrangement, interior design, personalization, and the integration of community areas. Understanding seniors' specific needs, preferences, and personal histories is critical in designing environments that promote their well-being, foster a feeling of belonging, and improve their overall quality of life.

Importance of place attachment for senior citizen

The sense of home is composed of different scale levels, from the connection with the outdoors to the quality of furniture and architectural layout of the room. It is considered significant for the aging process [5, 6]. According to Relph [7], place attachment is a fundamental human need, and there is agreement in the literature about the reciprocal relationship between the wellness of older persons and their ability to feel place attachment [1, 8]. According to Rubinstein and Parmelee [9], the three reasons why place attachment was crucial for older people were to maintain a sense of continuous capacity and autonomy, consistency and continuity during times of transition, and to keep the past alive. Place attachment can help with age-related adaptations by creating a sense of home and assisting the older adult in maintaining self-identity [10]. More broadly, location attachment provides meaning, value, and relevance to people's lives [11]. Sugihara and Evans [12] surveyed 67 older persons at a Continuing Care Retirement Community (CCRC) in the United States to explore an affinity between place attachment and design elements and discovered that it played a mediating role in the social milieu. Their research discovered that the proximity of a local gardening area, the possibility of spontaneous social contacts, and a short walking distance from the residence to the main activity center improved social interaction and participation and consequently contributed to place attachment.

Factors affecting place attachment in senior living communities

Place attachment to a space is influenced by various elements contributing to occupants' emotional connection, contentment, and sense of belonging to their living environment. The physical environment of senior living communities is important in determining place connection. Architectural design, building aesthetics, layout, and accessibility have all been shown to influence tenants' connection to their living spaces. Demographic factors include attributes such as age and marital status. Different demographic groups can have diverse requirements and preferences with respect to their living environment, which in turn can impact place attachment. Having family around to offer presence and support is an important aspect of the senior living community, and building meaningful relationships with one's family while staying active in the community can foster feelings of belongingness to the place. The quality & accessibility of public facilities & infrastructure plays a crucial role in determining the physical factors within senior-living communities. A built environment's physical design and spatial configuration significantly impact place attachment [13]. Individuals' interactions and movements within a space are affected by building form, spatial organization, and room configuration [14].

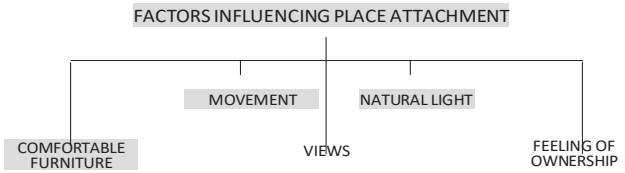

Figure 4. Factors affecting place attachment

Analysis of the case studies

The parameters for conducting analysis have been derived from the background study and theories related to the topic. These parameters are important in analyzing as they serve as factors for studying a particular senior living in detail, to understand the socio- cultural factors, the lifestyle of the community, and built form. For this study, the parameters have been divided into 4 main categories: spatial organization, accessibility and movement, natural environmental integration, and social interaction spots.

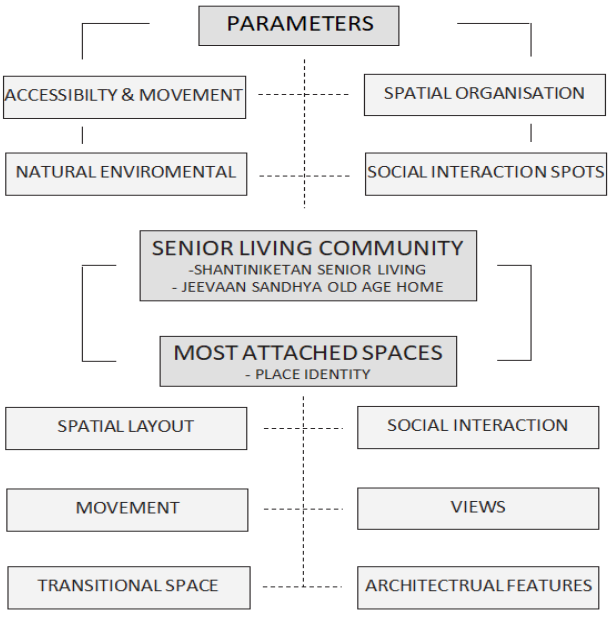

Figure 5. Framework for analysis

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5. Area of study

Assisted Living Houses: With the advancement of age, senior citizens require constant medical attention and aid. Assisted living houses are a concept that allows the elderly to live with an assistant, including a family member or a medical nurse or helper. Such assisted living houses are comparatively a newer concept in India but will likely pick up shortly. The advantage of having medical assistance is that it cuts out any traveling time to hospitals, making such homes quite useful for people with medical issues and other disabilities.

Recognizing the decrease in physiological capability in all design features

1. Privacy: Older people require their own space. We must consider resident living routines, preferences, and privacy while designing senior housing.

2. Social interaction: Since older people need social interaction, being alone is highly bad for their physical and mental health. As a result, when considering the inhabitants, there should be room for social contact and resident exchanges.

3. Direction and logo system: The elderly requires a setting with clear direction and a readable marking system to direct them to event areas due to identification issues and memory decline.

4. Safety and comfort: All designs for the elderly must offer a secure interior environment that satisfies their needs for physical and psychological comfort.

5. Disability design: Indoor areas for senior activities must be well-designed for accessibility.

6. Familiarity and continuity: Senior housing designs should incorporate regional customs and provide residents with personal decorating areas to display cherished mementos from their past, such as photos.

7. Light Ventilation issues: Require sufficient light and ventilation in the residential design elements for the elderly.

Shanti Niketan senior living, Ahmedabad

The layout of Shantiniketan Senior Living is designed to prioritize ease of access and create a welcoming and functional environment for senior citizens. The community consists of two identical floors, with each floor housing 40 individual room units. The rooms are big and well-designed, with a small pantry and individual bathroom. At the entrance, a common double-height space welcomes residents and visitors, creating a sense of grandeur and warmth. The community's large corridors connect diverse sections, providing seamless mobility and easy navigation. To ensure the safety of senior citizens, especially those with limited mobility, these corridors are well-lit and barrier-free. The huge central courtyard, which acts as a focal point and gathering space for residents, is a significant aspect of the layout. The activity and dining halls have been planned to ensure all rooms have easy access. The property has two floors. The ground floor and the first floor are identical. All the administration and activity rooms with 30 private rooms are on the ground floor while there are only private rooms and semi-open terraces on the first floor.

BEHAVIORAL ATTACHMENT

Behavioral Attachment					
Likert Scale Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
How often do you engage in activities in your living space and surrounding environment?	8	4	7	14	7
How much do you feel that your living space and surrounding environment are convenient and accessible for your daily activities?	3	6	5	17	9
How much do you feel safe and secure in your living space and surrounding environment?	2	4	11	18	6

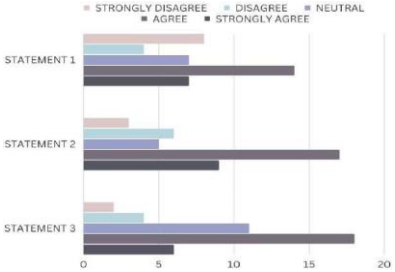

Figure 6. Field survey of behavioural attachment

EMOTIONAL ATTACHMENT

Emotional Attachment					
Likert Scale Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
How strongly do you feel emotionally connected to your living space?	2	4	7	12	15
To what extent do you feel that your living space reflects your personal identity?	3	5	10	11	12
How much do you enjoy spending time in your living space?	1	6	11	14	9

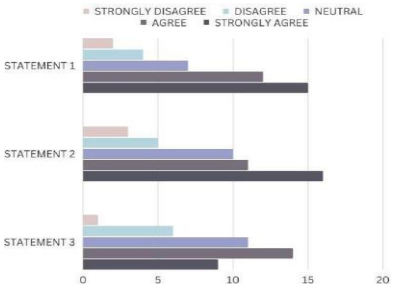

Figure 7. Field Survey of place attachment

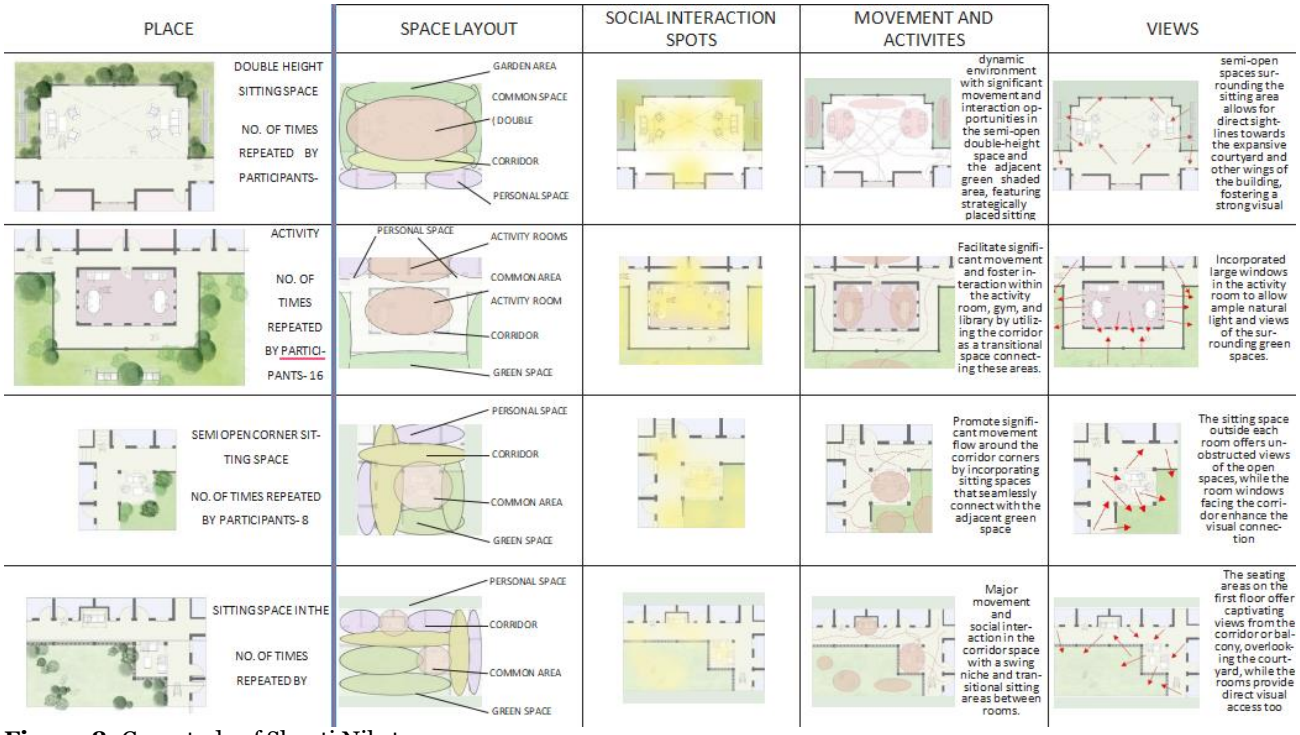

Figure 8. Case study of Shanti Niketan

CONCLUSION

As populations' age and urbanization accelerates, senior living communities are increasingly being designed as holistic environments that go beyond accessibility and functionality. While much of geriatric-focused architecture emphasizes universal design principles, this research underscores the importance of emotional and psychological engagement with space. The findings indicate that place attachment is a fundamental factor influencing seniors' mental health, social connectedness, and overall quality of life. Seniors develop deep emotional ties with their living spaces, shaped by memory, familiarity, cultural identity, and opportunities for social interaction.

Key findings and contributions

Spatial organization and familiarity:

Architectural design should emphasize clear, intuitive spatial layouts that enhance wayfinding, security, and comfort.

Small-scale, home-like environments with familiar cultural and regional elements foster a sense of continuity and place attachment.

This research highlights that place attachment should be a fundamental objective in designing senior living communities, rather than an incidental outcome. Architects, urban planners, and policymakers must recognize the multidimensional role of architecture in shaping experiences of aging. Designing spaces that encourage emotional connections, social engagement, and personalized interactions will help transform senior housing into environments that foster dignity, autonomy, and a sense of home.

Future research and design initiatives should focus on:

- Longitudinal studies on how architectural features influence long-term place attachment.
- Exploring innovative, flexible housing models that accommodate diverse senior needs.
- Sustainable, climate-responsive designs that integrate traditional and contemporary elements.
- Policies that prioritize mental and emotional well-being in geriatric housing development

DECLARATIONS

Corresponding author

Correspondence and requests for materials should be addressed to Pooja RAVAL; E-mail: pooja.raval@nirmauni.ac.in; ORCID: https://orcid.org/0009-0003-3744-1184

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Competing interests

The author declares that there is no competing interest.

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GARDEN OF PHILOSOPHY: A NATURE-ORIENTED IDEA OF UNIVERSITY, A CROSS-CULTURAL REVIEW

Ali AHMADIMOGHADDAM[1] and Saeid KHAGHANI[2]

[1]*Master's student in Architecture, School of Architecture, College of Fine Arts, Tehran University, Tehran, Iran*
[2]*Associate Professor, School of Architecture, College of Fine Arts, Tehran University, Tehran, Iran*

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Corresponding author:
E-mail: ali.ahmadi.mo@ut.ac.ir

ABSTRACT: This article explores the significance of gardens as landscapes for contemplation and education across various cultures, including Iran, Greece, Japan, and medieval Europe. Through a cross-cultural and historical analysis of existing literature, it examines examples of the interaction between philosophy and gardens, such as court gardens and cloister garths of madrasas and early universities, where the garden served as an active participant in the educational experience. Additionally, it investigates the influence of gardens on culture, literature, philosophy, and language, revealing how these spaces shaped modes of thought and reflection. The article argues that gardens were not merely physical environments but philosophical spaces rooted in the affinity between humans and nature, places where intellectual and spiritual growth took place. It also highlights their potential contribution to sustainable development goals in education and urban well-being. The study advocates recognising gardens as vital spaces for intellectual and spiritual growth in modern education. This knowledge could help develop landscapes fostering thinking and debate in schools and universities, where communication between students, thinkers, and scholars reflects the enduring legacy of gardens as sources of inspiration and creativity.

KEYWORDS: Garden, Educational Spaces, Islamic Madrasas, Cultural Gardens, University, Sustainable Urban Practices.

INTRODUCTION

Gardens have long represented the cultivation of both nature and the self, a concept explored in literature and philosophy throughout history [1]. These spaces have served as environments for intellectual engagement, philosophical reflection, and cultural exchange, shaping the way societies think, learn, and grow. In 1625, Francis Bacon, a philosopher advocating for mastery over nature, referred to gardens as the "purest of human pleasures" and a "refreshment for the spirit" [2]. Like art, gardens are cultural expressions designed to enhance both human character and the environment. The relationship between gardens, philosophy, and intellectual reflection has played a crucial role in shaping each other's development over time [1].

Gardens are deeply rooted in the cultural and philosophical worldviews of the societies that created them. Persian gardens, for example, evoke an image of paradise, with the centre symbolising a cosmic focal point that connects the individual to the world's four corners and the realms beyond, where the finite and infinite, human and divine, Earth and Heaven converge [3]. Similarly, Zen gardens hold significant meaning in Japanese culture and spiritual thought. Gardens also appear prominently in literature and poetry, such as in the works of Persian poet Saadi, whose *Bustan* and *Gulistan* (The Orchard and The Rose Garden) are iconic texts. Furthermore, garden design has influenced philosophical thought, as seen in Plato's Academy in ancient Athens, which was likened to a garden, or in Iran, where gardens and court gardens were seen as spaces for contemplation and meditation. As natural interfaces, gardens offer individuals a chance to reconnect with nature, providing respite from the chaos of urban life and fostering a deeper understanding of the environment [4]. This integration of green spaces and reflective environments into everyday life not only contributes to individual well-being but also enhances the quality of public spaces, fostering the creation of more sustainable and inclusive communities [5]. From their ancient origins to contemporary innovations, gardens continue to inspire individuals across cultures, standing as enduring symbols of humanity's profound connection to the natural world [6]. The role of gardens as spaces for reflection and metaphors for philosophical ideas underscores their significance across cultures and periods. Their presence within learning environments, whether historical madrasas or modern universities, reflects their potential to enrich educational experiences by cultivating spaces that support both critical thought and emotional balance. Today, modern learning environments, such as universities and schools, could benefit from incorporating the subtle, contemplative qualities of gardens to enrich their educational atmosphere. These gardens provide opportunities for social interaction, community engagement, and interdisciplinary learning.

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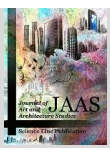

Furthermore, integrating community gardens into educational settings can offer students a holistic learning experience by exposing them to healthier behaviours, fostering a sense of connection to nature, and providing practical, hands-on opportunities [7]. As Karl Jaspers [8] emphasised, universities are communities where scholars and students engage in the pursuit of truth, not just places of instruction. Gardens, with their reflective atmosphere, can enhance communication between thinkers, fostering a deeper exchange of ideas. As Olivadese and Dindo [4] point out, gardens in modern urban life encourage a heightened awareness of one's surroundings, much as libraries inspire intellectual thought through books; gardens foster contemplation through nature [2]. By integrating gardens and natural landscapes in a new format into educational institutions and learning spaces, societies can take meaningful steps toward achieving United Nations sustainable development goals (SDGs) such as higher-quality education and more sustainable, inclusive urban communities [9]. This integration not only enhances students' cognitive and emotional well-being but also promotes environmental awareness and social cohesion within communities. For example, short-term contact with green spaces on university campuses has been shown to significantly enhance students' psychological well-being and reduce mental fatigue [10]. Additionally, inclusive green public spaces can serve as platforms for intercultural dialogue and community engagement, contributing to urban resilience and equity [9].

This study explores the relationship between nature, philosophical thought, and learning across various historical contexts, including Japan, Iran, ancient Greece, and medieval Europe. By examining how gardens functioned as spaces for contemplation and intellectual exchange, this research provides valuable insights for modern educational institutions. The research emphasizes the historical role of gardens as vital spaces for learning, education, discussion, reflection, and the cultivation of knowledge and building on this historical perspective, it aims to inform contemporary educational institutions on how integrating natural landscapes into university campuses can enhance the learning experience, merging historical wisdom with present-day academic needs and addressing the dual objectives of fostering intellectual growth and promoting well-being.

METHODOLOGY

This review aims to evaluate the role of gardens in spaces dedicated to learning, philosophy, education, and contemplation. It begins with a historical–analytical examination and a review of exemplary educational and contemplative landscapes in various civilisations. Representative examples from different cultural and historical contexts are selected to illustrate the interaction between gardens and educational or philosophical practices. These include Plato's Academy in ancient Greece, madrasas and court gardens in Islamic civilisation (with a focus on Iran), Zen gardens in Japan, and cloister gardens in medieval Europe. Selection criteria include their documented historical association with educational and contemplative activities, the presence of designed landscapes intended to facilitate reflection and intellectual exchange, and the availability of credible historical records, scholarly studies, and visual documentation. Data are collected from primary historical sources, such as architectural records, drawings, and written descriptions, as well as from secondary academic literature, including peer-reviewed journal articles, books, and research reports. Visual materials, such as site plans, reconstructions, and photographs, are also reviewed to support spatial and design analysis. The characteristics of these spaces are explored in detail, and their spatial, symbolic, and functional aspects are analysed. The study also offers a theoretical discussion on the role of gardens within intellectual and contemplative environments. By establishing the historical and cross-cultural significance of gardens in fostering thought and reflection, it argues that these principles can be applied to the design of modern educational spaces, including universities and schools. This demonstrates how lessons from past landscapes can inform the creation of sustainable, intellectually enriching, and contemplative environments in contemporary educational settings.

The historical background and literature review

Gardens have long been a fundamental aspect of human civilisation, playing a significant role in both the collective imagination and the cultivation of thought. The practice of cultivating gardens dates back to early human societies, with gardening traditions shared across diverse cultures worldwide. Gardens are human-made enclosures dominated by plants and defined by physical or symbolic boundaries. The earliest known depiction (circa 3000 BCE) shows such a space. While often bordered by walls or fences, gardens remain open to air, weather, and living beings, allowing the natural movement of seeds, plants, and animals—some welcome, others not. They embody a balance between "enclosure and openness Gardening reflects humanity's profound connection to the fundamental experience of life, or "lifeworld." Despite diverse garden styles and locations, it reveals our inability to fully "objectify" this lifeworld in its inexhaustible

entirety [2]. The writings of Plato and other Greek philosophers, combined with archaeological remains from antiquity, demonstrate a connection between gardens and other open public spaces. The gardens and court gardens played a significant role in the development of philosophy in the ancient world, and as Groening and Wolschke-Bulmahn [11] argue, the Greeks created the first gardens for schools and academics. Furthermore, the Athenian Agora was a centre where thinkers and philosophers gathered, and Socrates famously wandered the streets of Athens barefoot, asking questions [12]. In ancient Rome, environments such as forums, baths, and court gardens became hubs for discussion and thought exchange. Although the fall of Roman civilisation in the 5th century AD led to the decline of gardens and court gardens in Europe, the concept of court gardens and education both survived in monasteries and Christian churches. These monasteries preserved Greco-Roman and early Christian literary culture, serving as schools, self-sustaining communities, and production centres. By the 12th and 13th centuries, as society evolved, intellectual and religious life shifted to cities, spurring the rise of Europe's first modern universities [13].

Furthermore, the ancient Persian worldview and their approach to spatial planning are deeply interconnected with the nature and geographical conditions of their environment [3]. Throughout Iran, gardens with roses were built, called "pairidaeza," from which the English word "paradise" derives [11]. These gardens and court gardens, often built in arid landscapes, provided oases for reflection and meditation for thinkers, philosophers, and Sufis of the Islamic world. Furthermore, Madrasas, which were often inward-looking schools with court gardens at their centres, offered beautiful vistas from the students' rooms and a suitable space for the gathering of students and thinkers for learning, discussion, and exchange of ideas.

In East Asia, Zen gardens serve as spaces for deep contemplation, where natural elements reflect the impermanence of life, while their carefully cultivated forms symbolise the mind's constructiveness, creating a contrast that challenges the thinking mind. Beyond its surface beauty, the Zen garden invites a pause for reflection, guiding thoughts away from daily distractions and into a realm of profound introspection [14]. Applying Zen philosophical principles to the design of Zen-inspired landscapes, including temple gardens, was a crucial aspect of their creation [15], and a Zen garden was a place for reflection where the natural elements nourish the mind and body [16]. This approach to gardens and thinking, while different in many ways, underscores the importance of gardens in creating suitable spaces for meditation.

Studying these examples reveals that gardens were more than just physical spaces; they served as gathering places for philosophers and thinkers throughout history, where they shared ideas, exchanged thoughts, and cultivated intellectual growth. While thinkers and philosophers have used other spaces throughout the ages, gardens are an essential environment for the cultivation of thought and gathering of thinkers. This hidden potential of gardens as a landscape for contemplation and argument could be further utilised in the modern era and in the future to provide suitable outdoor landscapes for thinkers and students worldwide.

The historical development of universities and institutions of higher education is a reflection of the evolution of thought, culture, and society. These institutions have long served as epicentres of knowledge and intellectual growth, contributing to the shaping of civilisations. Understanding their origins and functions offers valuable insights into how education has been intertwined with cultural practices, including the cultivation of gardens, symbols of contemplation, beauty, and harmony. This literature review will begin with the critical role that nature has played in the educational environments of various cultures, starting with the significant contributions of Persian gardens in Iran and the Islamic world, followed by Japan's unique relationship between gardens and learning. It will then delve into the philosophical foundations laid by ancient Greece and the subsequent developments in Europe. Additionally, an exploration of the history of universities will highlight their pivotal role in shaping modern society, and attention will be drawn to modern universities that emphasise the importance of nature and contemplation in their educational practices.

Iran

The examination of landscape and architecture in Iran reveals a profound connection between culture and nature, which culminates in the creation of gardens. When people first settled on the Iranian plateau in the fourth millennium BCE, agriculture became the driving force of civilisation and in a relatively arid climate, trees, plants, and water were essential for life. As society stabilised, gardens evolved not only as sources of sustenance but also as representations of spiritual beliefs, symbolising the perfection of the universe, abundance, leisure, power, and protection [17]. Gardens held immense cultural and social significance in Iran's hot, dry climate, and many of their features, such as ponds, fountains, flowers, trees, and their enclosed structures, became intertwined with cultural values. The term *pairidaeza* signified a garden in Achaemenid times (550–330 BCE) and later gave rise to the Greek term *paradeisos*, the Latin *paradisus*, the Arabic *firdaws*, the modern Persian *Pardîs*, as well as the terms *paradis* (French) and *paradise* (English).

The centre of the gardens was conceptualised as a cosmic centre, interconnected not only with the four corners of the world but also with the beyond, serving as a point where Earth and Heaven, the

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human and the divine, the finite and the infinite converge [3]. The famous archetype of the Persian garden, the *charbagh* (four gardens), was closely associated with the image of paradise in religious and mystical texts [18], and the concept of the garden became a central cultural theme in Iran rather than a mere visual image [19]. Thus, Gardens became omnipresent symbols in Persian art, music, and literature, and wherever Persian art is found, traces of the garden are evident [20]. The influence of gardens on thinkers, mystics, and scholars of the time can also be found in famous works of literature. In poetry, for instance, the development of the garden as an expression of paradise resulted in a cultural synthesis, enabling thinkers and poets to refer to gardens literally and metaphorically [17]. The titles of Saadi's Golestan (The Rose Garden) and Bustan (The Orchard) both are references to the garden. The famous poet Mulavī (Rūmī) narrates the tale of an ant traversing the pages of a book, imagining itself in a rose garden, where words blossom like the flowers of this garden. This symbolism extends to the Persian language, where terms such as *chār-bahār* ("four-spring"; also, the name of a city in southeast Iran) and *hamīshe bahār* ("evergreen") symbolise the antithesis of destructive change and the anxiety produced by the unpredictability and impermanence of nature [19].

The earliest known gardens in the region were established in Mesopotamia. The Achaemenids (550–330 BCE) continued the tradition of garden-making, with Pasargadae (550 BCE) being the most notable example, which was created in an oasis surrounded by hills with a rectangular network of canals that formed a quadripartite layout, organising gardens, palaces, and pavilions [20]. The art of garden-making continued through the Parthian and Sassanid eras and during the reign of Shapur. The University of Gundishapur was established, where the favourable climate, fertile soil, abundant water, and the blend of Iranian and Roman influences created an ideal setting for discussions, teaching, and scholarly debates. This made it a suitable place for Greek and Roman philosophers and scholars, in addition to the learned individuals and intellectuals of Iran [21]. After the seventh century CE, large parts of the Sassanid and Byzantine empires were conquered by Muslim Arabs, leading to the spread of the Persian garden throughout the Islamic world [17], and the layout of Persian gardens influenced garden designs in other regions where Persian culture held sway [20]. During the Abbasid period, Islam experienced a renaissance in science, philosophy, literature, historiography, and religious studies as Baghdad and Khorāsān became centres where Greek philosophy, Gnostic mystical ideas, Indian medical science, and Persian governance converged [19].

In these vibrant environments, *madrasas* flourished as institutions for higher education. Evidence suggests that the "prehistory" of the *madrasa* can be traced back at least one and a half centuries before its official adoption by the Saljuq dynasty. These early *madrasas* were likely not substantial public buildings, and the foundations of this architectural typology should be understood within the context of a well-established tradition of building *madrasas* in the major cities of the eastern Iranian world and Khorāsān, such as Nishapur, where thirty-eight *madrasas* predate the renowned Nizamiya of that city [22]. Court gardens, which during this period were the central feature of most buildings, with all other spaces arranged around it [20], were adapted to *madrasa* design, and thus, the inward-looking garden became the primary structural element shaping the spatial organisation of these educational spaces. The importance of the madrasa as an educational institution, characterised by a courtyard adorned with trees and ponds, underscores the significance of gardens in designing spaces for contemplation and reflection [22] (Figures 1 & 2).

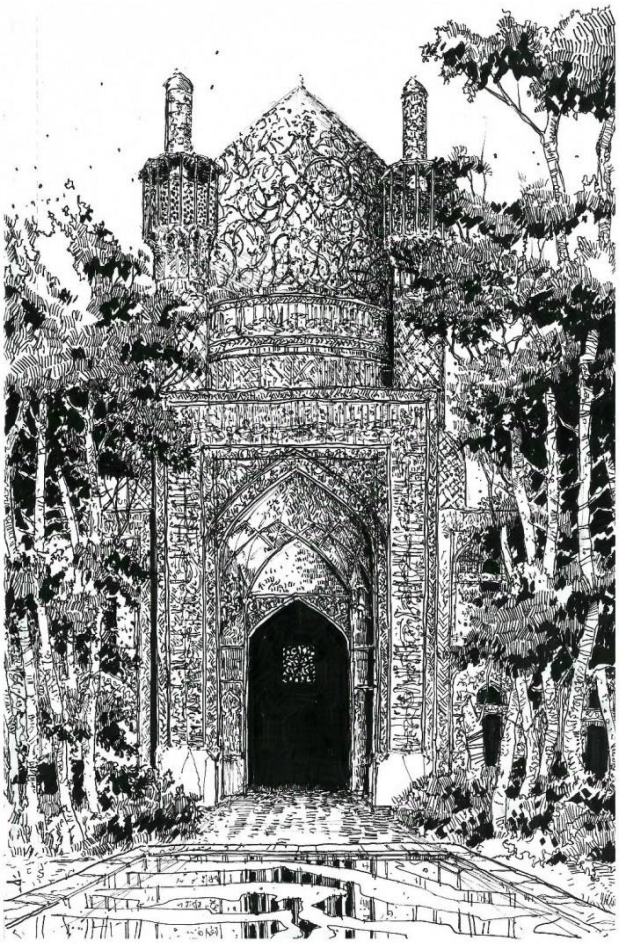

Figure 1. The view of the central court garden and main dome of the College of Mother of Shah Sultan Hussein, after passing through the entrance, provides a harmonious image between architecture and garden (Sketch by the Author)

During this period, Rabat Rashidi became a cultural and academic town where the greatest scholars of the era gathered from Eastern countries. It had a large library, and many plants were discovered and experimented upon in its gardens, leading to scientific discussions [23]. Rabat Rashidi exemplified the ideal of a harmonious society and became a significant centre for knowledge and culture during its time. Scholars and thinkers from diverse backgrounds convened here, fostering a spirit of collaboration and intellectual exchange. The university town of Rabat Rashidi provided a serene backdrop for intellectual engagement and symbolised the harmony between nature and knowledge.

This integration fostered an environment for thought and creativity, creating a space where ideas could flourish [24, 25].

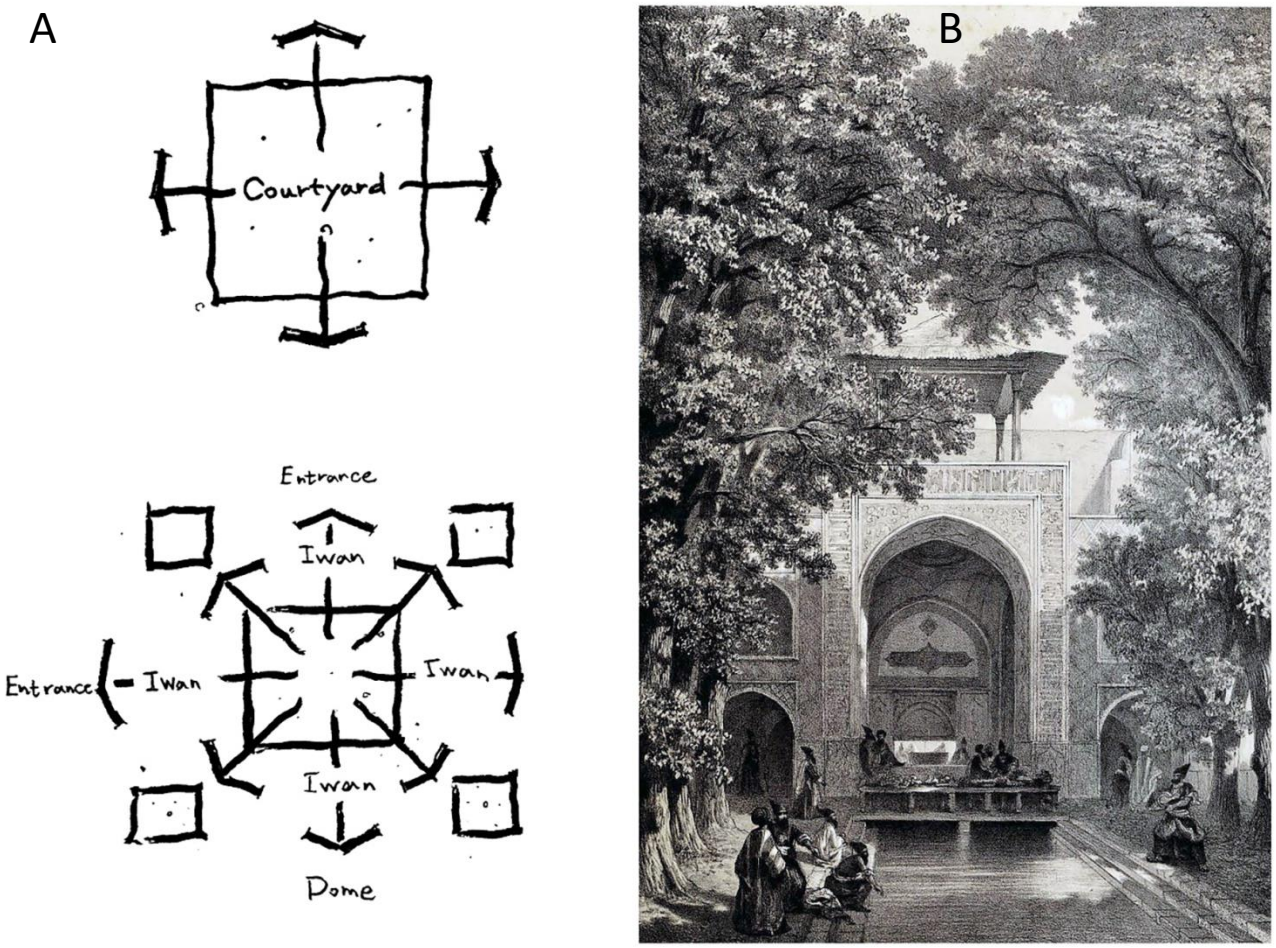

Figure 2. A) Placement of the courtyard at the heart of Madrasa not only provides access to the main areas of the school but also serves as the central hub for Engagement (Sketch by the Author) & B) Painting of the interior garden of the Mosque and College of Sultan Shah Hussein [26].

Japan

Japanese gardens hold a significant place in both individual and communal life, deeply intertwined with the culture, climate, and worldview of those who create them. To fully understand Japanese gardens, it is essential to first explore Zen philosophy. Zen is the discipline of enlightenment, which signifies emancipation. While freedom within the realm of relativity remains limited, absolute freedom is attained through enlightenment. Once this realisation occurs, external circumstances lose their hold, and one achieves inner liberation, a central tenet of Zen thought. Zen emphasises self-reliance and self-awareness, and peace, harmony, and beauty are the three fundamental elements that characterise the art of the Japanese Zen Garden. These gardens cannot be categorised under a single typology as they encompass a variety of styles, each with its own distinct and unmistakable form. The goal is to offer the observer a reinterpreted vision of reality where every element contributes to an immersive landscape [16]. Through symbolic allusions, Japanese gardens engage the mind on multiple levels, fostering both conscious reflection and subconscious thought. Over centuries, the Japanese garden evolved to aid meditation practitioners in achieving a desired mental state, encouraging both conscious and subconscious thought. The meanings and narratives embedded within the garden's elements enhance the quality of

the space, inviting interpretation rather than imposing fixed ideas. The most essential principle in Japanese garden design is ensuring that the viewer's imagination remains unrestricted by a singular theme. The beauty of Japanese garden symbolism lies in its abstraction and flexibility, allowing these landscapes to be appreciated across cultures, nations, and generations. A single, carefully placed rock can symbolise an island in the Sea of Japan or evoke the grandeur of Yosemite Valley in California. This interpretive flexibility is one of the reasons Japanese gardens leave such a profound and lasting impression on all who experience them [27].

Unlike Chinese gardens, which are designed to be walked through and offer a variety of spatial experiences, Japanese gardens are primarily visual and intended to be admired from within the home. Thus, they become an intrinsic part of interior space and are conceived as an extension of it, an open, roofless environment that seamlessly integrates with the residence. Serving as a continuous point of interaction with nature, Japanese gardens also embody the spiritual world of Shinto, which is believed to be inhabited by numerous spirits. In contrast to Western gardens, which often symbolise human activity and reflect ideals such as humanism, individualism, or specific ethical principles, Japanese gardens represent the broader natural world [27]. Rather than showcasing human control over nature, they embody a holistic philosophy in which the garden serves as a microcosm of natural harmony.

Over centuries, Japan has developed a diverse range of garden styles, varying in size and form, including tea gardens, residential gardens, Zen gardens, and stroll gardens. Despite their differences, all Japanese gardens share a profound connection to architecture, history, nature, culture, and philosophy [27]. Zen gardens—also referred to as Japanese karesansui- have long been used as spaces for meditation and contemplation. Through the careful arrangement of rocks, meticulously raked sand and gravel, and other minimal elements, these gardens seek to capture the essence of nature in its purest and most harmonious form [16] (Figure 3). A key shift in Japanese garden design occurred after the Heian period with the rise of Zen monastery gardens during the Muromachi period. Known as karesansui or dry landscape gardens, these emphasised minimalism and the symbolic representation of nature. The decline of the aristocracy, the spread of Zen Buddhism, and the rise of the samurai led to significant social change. The idealism of the Heian period gave way to an era focused on meditation, where the samurai's quest for meaning mirrored their pursuit of power. Zen monasteries became centres of learning, culture, and commerce, reinforcing the samurai's intellectual and martial development. Zen Buddhism, emphasising personal effort and oral transmission over scripture study, aligned with the values of the emerging warrior class [28]. Ashikaga Gakkō (足利学校, "Ashikaga School") is Japan's oldest standing academic building. Students from across the country were drawn to Ashikaga Gakko, where the curriculum centred on classical Chinese literature, Confucianism, *Laozi*, *Zhuangzi*, *Shiji*, *I Ching*, and Chinese medicine. Although the instructors were often Zen monks, the school primarily focused on Confucianism and secular education, with theological and Buddhist teachings explicitly excluded from the curriculum. Tuition was free, and students were expected to find accommodation at local private houses. The school featured a garden to grow its food and an herb garden to raise medicinal herbs, highlighting the significant role of nature in the learning environment [29].

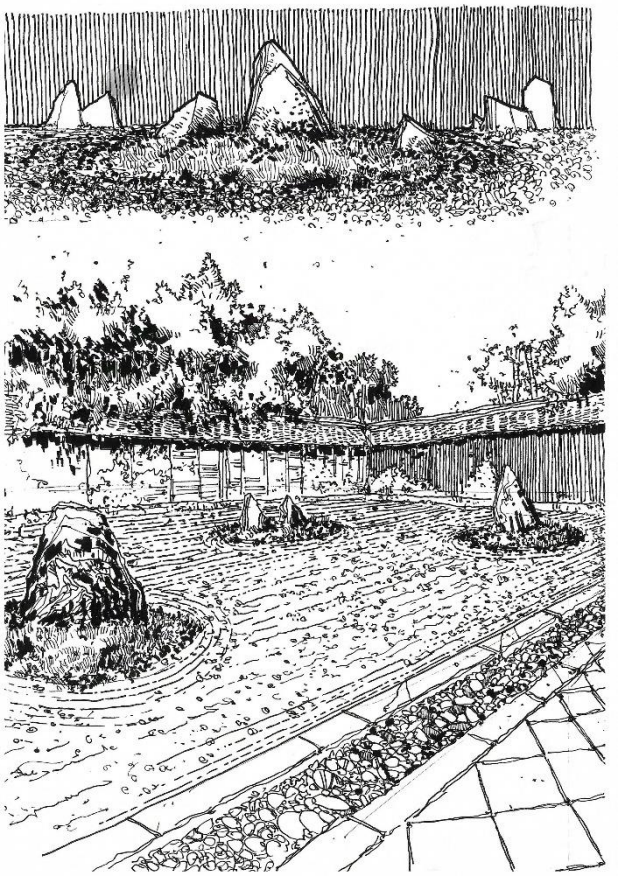

Figure 3. Tranquil and symbolic environment of Ryoan-ji Zen Garden, capturing the harmony of nature while allowing different interpretations of the landscapes by the viewer (Sketch by the Author)

The presence of these gardens not only provided practical resources but also served as an extension of the academic experience. The gardens offered students a tranquil environment for reflection and meditation, complementing their studies and encouraging a deeper connection to the philosophical teachings they engaged with. In a culture that values harmony with nature, the gardens at Ashikaga Gakkō facilitated a unique learning atmosphere where students could

contemplate the material learned in the classroom while immersed in the natural world.

Ancient Greece and Europe

The history of European academic institutions illustrates the pivotal role of gardens and gardening in spaces dedicated to thought and education. To understand this history, Plato's Academy must be examined first. Plato's Academy is considered the first institution of higher learning and stands as the most significant educational centre in ancient Athens. Philosophy, in its true sense, was established during Plato's time, and the Academy, where Plato and his students engaged in philosophical discussions within the Garden of Akademos, played a crucial role in this intellectual development [30]. All traditional academies of modern times trace their origins to the model of the *Academia Platonica*, which was established by Cosimo de' Medici in Florence in 1460, based on what he perceived to be the structure of Plato's Academy. The ancient Academy, on the outskirts of Athens, however, was not merely a school but resembled a public park or garden adorned with ancient trees. It was a sacred precinct dedicated to the Attic local divinity and hero, Akademos and the goddess Athena. Situated at the end of a ceremonial avenue and enclosed by a wall, it served as both a religious centre and a place for rest and recreation. Plato taught and lived in the Academy from around 387 BCE, which indicates his residence in the vicinity of this holy precinct, specifically in a garden plot that included a house. He conducted his beginners' courses in the gymnasium located within the holy precinct, while more advanced discussions took place in his garden and the house located in his garden [31]. The Academy continued to operate during the Hellenistic period but was shut down for four years during the First Mithridatic War. In 86 BC, the Romans besieged Athens, causing significant destruction and plundering the Academy, making its reconstruction nearly impossible. When Antiochus of Ascalon returned to Athens from Alexandria, the Academy resumed operation, but at the Lyceum instead of its original location. Cicero recalls visiting the Academy one afternoon when it was “quiet and deserted at that time of day”.

The Academy was finally closed in 529 AD by the Byzantine Emperor Justinian, after nearly 10 centuries of existence. Its legacy persisted in the following centuries, though it experienced periods of decline and renewal. According to Agathias, the remaining members of the Academy, including Siblikos, sought refuge in the courtyard of Khosrow I in Persia, bringing with them scrolls of literary, philosophical, and, to a lesser extent, scientific texts. Their safety was ensured with the Persian-Byzantine peace treaty in 532 [30].

Figure 4. The cloister at the centre of the Abbey of Santo Domingo de Silos, an example of the practice of garden making in the centres of learning throughout medieval Europe [32].

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After the fall of the Roman Empire and the onset of the Middle Ages, monasteries in Europe became almost the sole repositories of what remained of the literary culture of the Greco-Roman world and early Christianity, becoming both schools and self-sufficient communities [13]. The art of garden-making also thrived in these abbeys [33] and thus Monasteries became crucial centres for spiritual and mental healing, shaped by religious practices [34] (Figure 4). Monastery gardens are frequently mentioned in early monastic records. St. Anthony, who organised the first monastic communities in the fourth century, cultivated a garden. Two centuries later, St. Benedict, founder of the Benedictine order, emphasised the importance of gardens in monastic life, stating that monasteries should include essential features like a garden to prevent monks from leaving the enclosure, which he believed was harmful to their souls [35].

The earliest-known plans of monastery gardens are found in the St. Gall Plan, which includes several gardens vital to daily monastic life. These included the centrally located cloister garth, where monks could enjoy fresh air, the kitchen garden for vegetables and herbs, the infirmary garden for medicinal plants, and a cemetery garden with fruit and nut trees [36] (Figure 5). These gardens, often featured in medieval art and literature [35], had practical, religious, and cultural significance. Typically enclosed by walls or arcades, they were designed with symmetrical layouts, featuring quartered lawns and a central fountain [36].

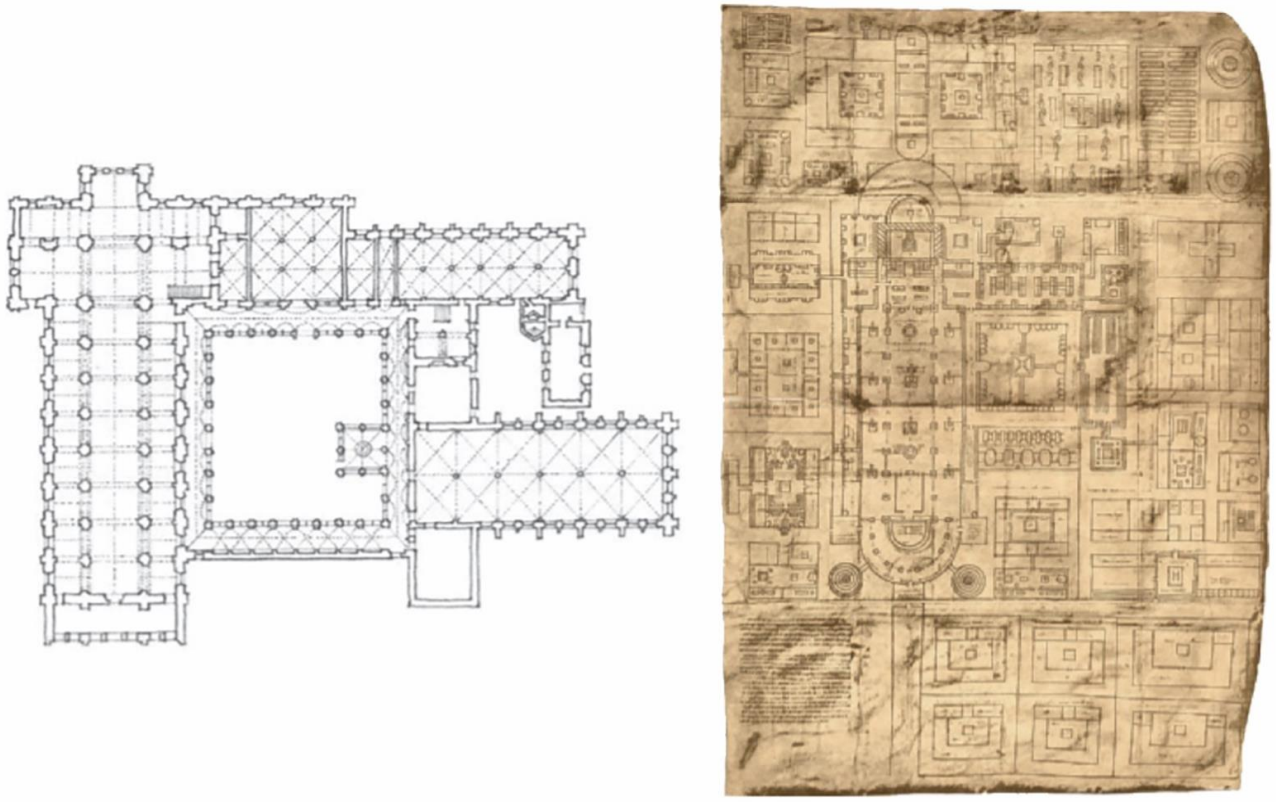

Figure 5. Plan of Fontenay Abbey showing a cloister at the centre of the complex [37], and a schematic plan of a 9th-century Saint Gall monastery, illustrating different spaces, including several types of gardens [13].

The influence of gardens in academic environments continued to evolve as European institutions of higher learning developed. The 12th and 13th centuries were a time of profound change in European society, and the focus of both intellectual and religious life shifted definitively from monasteries in the countryside to rapidly expanding cities. In these new urban centres, scholars founded the first modern universities [9]. Following the traditions set by monasteries and ancient academies, medieval universities in Europe embraced the idea of fostering spaces that encouraged intellectual growth. Among the earliest and most influential institutions were the University of Bologna and the University of Paris, which are regarded as the first true models of modern universities in Europe and beyond. Founded in 1088 in the Italian city of Bologna, Bologna University is often celebrated as the oldest in the Western world [38]. Bologna also holds the distinction of being the first to employ the term universitas to describe the collective body of students and masters that constitutes a university.

The University of Paris, also known as "Sorbonne," is one of the oldest and most prestigious universities in the world. Founded in the thirteenth century, particularly in the year 1200, it is recognised as a centre of scholarly and educational excellence in Europe. It is also famous for its green spaces and gardens, such as the Paris Botanical Garden, which are used as places for contemplation and study. The Botanical Garden is one of the most well-known green spaces at the University of Paris, serving as an educational and research centre in the fields of biological sciences and botany. The University of Paris features various green spaces that act as tranquil and inspiring locations for study and reflection. These areas are typically located near educational buildings and libraries, allowing students to engage in learning in a natural and pleasant environment. Similarly, the University of Oxford, another historic institution, is celebrated for its stunning gardens that enhance the campus's aesthetic while serving as vital environments for learning and reflection. These gardens are strategically located near classrooms and libraries, providing an environment that encourages scholarly engagement [39].

Garden and the idea of modern universities

In Western philosophy, Plato saw the purpose of higher education as the "cultivation of the individual for the sake of the ideal society," where personal fulfilment would contribute to a harmonious society with citizens fulfilling their roles [40]. Centuries later, Jaspers [8] argued that the university's primary function is the search for truth, achieved through systematic research. Teaching, as the transmission of this truth, forms the second purpose of universities. Jaspers [8] also highlights the cultural role of universities in fostering intellectual growth and societal development. Universities and institutions of higher education play a pivotal role in shaping modern society. By educating the next generation of decision-makers, they exert a profound influence on the decisions that shape the future of communities [41]. Throughout history, universities have not only been centres of higher learning but also spaces where intellectual development and community life converge. Following this, the history of modern universities and the vital role that gardens and nature play in educational environments will be explored.

The development of universities from their medieval origins to the present day represents an uninterrupted evolution, and one of the most significant achievements of the Middle Ages is considered the formal development of universities [42]. These institutions have grown from monasteries and schools to comprehensive hubs of research, science, and culture, influencing societies globally. The origin of universities, however, has long been debated. European scholars often point to medieval institutions such as the University of Bologna, established in 1088, and the University of Paris as the first models of modern universities. However, higher learning institutions existed long before Bologna in places like India, China, Africa, and the Middle East [43].

Though they may not have been called "universities" in the European sense due to linguistic and cultural differences, these institutions served a similar purpose, providing higher education and intellectual cultivation. For instance, as early as the 5th century BCE, centres of higher learning such as Thakshila in India functioned as international academic hubs [44]. In Southeast Asia, Egypt, and Turkey, educational institutions prepared young minds for civil service and societal roles [42]. In Iran, the Academy of Gondishapur, established between 246 and 287 CE, was one of the most prominent centres of learning in the ancient world, known for its advances in medicine, philosophy, and science. This institution attracted scholars from various parts of the world, particularly from Greece and India, and played a crucial role in preserving and expanding classical knowledge.

Universities in ancient and medieval times, whether in Europe, the Middle East, Africa, or Asia, interacted and influenced one another, ultimately shaping the European university model that later became the foundation for modern higher education worldwide [38]. Many of these institutions, along with the cultures that built them, were deeply connected to nature, often incorporating gardens as integral spaces for learning and reflection. This concept persists in some of the renowned modern institutions, where the presence of nature and gardens continues to play a significant role. For example, "The Green Heart" at the University of Birmingham, a leading institution in the marketisation of higher education in England, demonstrates this enduring connection. This expansive garden, surrounded by the university's most prominent new campus buildings, was designed as a multifunctional lounge area, conceptualised as a "social learning space" or "active learning space" [45]. The following table outlines the historical development of significant universities

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around the world, from ancient learning centres to the medieval institutions that laid the foundation for modern higher education (Table 1).

Table 1. History of ancient universities.

Higher learning institution	Location	Date of foundation	Notable characteristics
Shanghai "Higher School"	China	2257-2208 BCE	One of the earliest recorded institutions of higher learning in ancient China
Imperial Central School	China	1046-249 BCE	Established during the Zhou dynasty, this school was pivotal in educating officials for the Chinese imperial system.
Takshashila University, Taxila	Pakistan	7th century BCE	One of the oldest universities in the world, offering subjects like medicine, law, and military science.
Nalanda University, Bihar	India	5th century BCE	A major centre of Buddhist learning and one of the earliest residential universities, drawing scholars worldwide.
Library of Alexandria	Egypt	285–246 BCE	Famed ancient research institution, housing vast collections of scrolls and attracting scholars from across the world.
Plato's Academy	Greece	387 BCE	The first institution of higher learning in the Western world, founded by Plato, was centred on philosophy and dialogue.
Academy of Gundeshapur	Iran	242-272 AD	Renowned for its contributions to medicine, philosophy, and science, and a hub for scholars from diverse backgrounds.
Nanjing University	China	258 AD	One of China's oldest universities was originally established as a Confucian academy.
Ez-Zitouna University	Tunisia	732 AD	One of the oldest Islamic universities, focusing on religious studies, law, and the Arabic language.
Baghdad School	Iraq	Early 9th century	Known as the centre of the "Golden Age of Islam," this institution contributed significantly to philosophy and science.
Ashikaga Gakkō (Ashikaga School)	Japan	839 or 842 AD	An influential centre of Confucian and military learning during Japan's medieval period.
University of Salerno	Italy	9th century AD	One of the earliest European medical schools, known for its advancements in medical knowledge.
University of Qarawīyīn (al-Karaouine)	Morocco (Fez)	859 AD	The oldest existing university in the world, with a focus on Islamic studies and jurisprudence.

Al-Azhar University	Cairo	970 AD	A key centre of Islamic learning, it continues to be one of the most prestigious Islamic universities in the world.
Temple of Literature	Hanoi, Vietnam	1076	Vietnam's first national university was dedicated to Confucian education and the civil service.
University of Bologna	Italy	1088	Considered the oldest university in the Western world, a model for modern higher education institutions.
University of Paris	France	1150	Known for its theology faculty, this university became a model for later European institutions.
University of Oxford	England	1167	One of the oldest universities in the English-speaking world, influential in various fields of learning.
Sankore University	Timbuktu, Mali	12th century	A centre of Islamic and scholarly learning in West Africa, contributing to the spread of knowledge in the region.
University of Cambridge	England	1209	Known for its research and intellectual rigour, it grew into one of the most prestigious universities globally.
University of Salamanca	Spain	1218	One of the oldest universities in Spain, known for its contributions to law and the humanities.
University of Montpellier	France	1220	Renowned for its medical school, it became a leading centre of learning in medieval Europe.
University of Padua	Italy	1222	Famous for its law and medical faculties, it attracted students from all over Europe.
University of Naples	Italy	1224	Founded by Emperor Frederick II, it was one of the first public universities in Europe.
University of Toulouse	France	1229	Known for its law and theology faculties, Toulouse became a significant educational centre in France.
University of Coimbra	Portugal	1290	One of the oldest universities in Portugal is recognised for its contributions to law and the humanities.
Universidad Complutense de Madrid	Spain	1293	One of Spain's premier universities, known for its academic excellence in various fields of study.
University of Lleida	Spain	1300	An influential centre for learning in Spain during the medieval period, particularly in the field of law.
University of Rome La Sapienza	Italy	1303	One of the oldest and largest universities in Europe, still a prominent institution today.
Rashidiyya Quarter (Rashid al-Din's Educational Complex)	Iran	1306	A major intellectual and cultural complex in medieval Iran, fostering scholarly exchange and research.

Source: Authors

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CONCLUSION

While enclosed classrooms are ubiquitous in most universities, schools, and academies in contemporary conventional educational environments, a historical examination of the roots of education and educational institutions highlights the significance of gardens and open environments for thinking, learning, and intellectual discourse. From the inward-looking courtyards of Persian madrasas to the cloister garths of medieval European monasteries and the gardens of Plato's Academy in ancient Greece, gardens were far more than decorative or recreational spaces; they shaped the way thinkers and students engaged with knowledge, debate, and reflection. The central position of these gardens within educational institutions underscores their role in structuring the learning experience, providing an environment conducive to contemplation, dialogue, and intellectual exchange.

Examining the intrinsic relationship between the court garden and the madrasa shows that this central space was more than a mere open area; it played an active role in the education, debate, and daily life of students. Additionally, numerous references to gardens and gardening in Persian literature, intellectual discourse, and terminology emphasise this connection. A similar observation can be made in the English language, where words like "cultivation" simultaneously refer to both the preparation of land for agriculture and the development of skills or knowledge, reflecting the deep-rooted link between growth in nature and intellectual development.

In Iran, the integration of gardens into madrasas and educational complexes, such as Rabat Rashidi and the University of Gundishapur, facilitated not only meditation and reflection but also interdisciplinary discussions among scholars. Similarly, the Persian charbagh exemplifies how spatial arrangements and symbolic features created a microcosm of the universe, reinforcing a holistic understanding of the natural and metaphysical world. In Japan, Zen gardens functioned as structured landscapes for deep reflection, emphasising the cultivation of both mind and spirit. Likewise, ancient Greek philosophy flourished within gardens and court gardens, as well as in the agora and streets of Athens, where scholars engaged in discourse amid natural surroundings. These gardens and open environments were not merely tranquil retreats but active participants in the cultivation of thought, providing spaces where nature and intellect converged.

The analysis of these historical examples reveals a consistent principle: gardens serve as a bridge between nature and intellectual growth. In the modern era, recognising and harnessing the potential of gardens as spaces for intellectual and spiritual growth can foster creativity, reflection, and scholarly engagement in educational institutions. By acknowledging the historical role that gardens have played in shaping human thought and learning, we can create spaces that not only nurture knowledge and wisdom but also foster engagement and ensure more equitable, inclusive educational experiences. For example, the University of Birmingham's "Green Heart" demonstrates how central gardens can operate as active learning spaces, supporting both social interaction and academic discourse. Beyond individual learning, contemporary green spaces promote social cohesion and sustainable urban practices. Drawing inspiration from cloisters and courtyards, green spaces can also reduce the ecological footprint of built environments while benefiting the local ecosystem, mitigating urban heat, improving air quality, and cultivating favourable microclimates. These benefits collectively support the achievement of several United Nations Sustainable Development Goals (SDGs), including quality education, sustainable cities and communities, and climate action.

Overall, the evidence across cultures and historical periods supports a clear conclusion: gardens have been, and can continue to be, essential catalysts for intellectual growth, reflection, and education. The enduring legacy of gardens as spaces for inspiration, learning, and intellectual engagement is undeniable. Their historical role in shaping learning environments offers valuable lessons for modern educational design. By appreciating their historical role in shaping philosophical and educational traditions, we can better integrate them into modern contexts. The future of learning and contemplation may well depend on a return to these lasting principles, where nature and philosophy converge to inspire the next generation of thinkers. Such integration ensures that the tradition of contemplative, intellectually rich spaces persists, bridging the wisdom of the past with the educational needs of the present and future, while simultaneously advancing principles of sustainable development.

DECLARATIONS

Corresponding author

Correspondence and requests for materials should be addressed to Ali Ahmadimoghaddam; E-mail: ali.ahmadi.mo@ut.ac.ir; ORCID: https://orcid.org/0009-0008-7883-2532

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Authors' contribution

A.Ahmadimoghaddam contributed to the study conception, literature review, data collection, sketches preparation, and manuscript writing. S.Khaghani supervised the research and provided critical revisions.

Competing interests

The authors declare that there is no competing interest.

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THE SHAPE OF HERITAGE: MAINTAINING SPATIAL CONTINUITY IN COMMERCIAL CORRIDORS IN BANDUNG, INDONESIA

Husna IZZATI [1,2], Dwita Hadi RAHMI [3], and Syam Rachma MARCILLIA [3]

[1] *Architecture Study Program, Faculty of Science and Engineering, Universitas Faletehan, Bandung, Indonesia*
[2] *Doctoral Program, Department of Architecture and Planning, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia*
[3] *Department of Architecture and Planning, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia*

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Corresponding author:
E-mail: izzaa.husna@gmail.com

ABSTRACT: Braga Street is a commercial area and a popular tourist destination in the centre of Bandung. Known as "*De Meest Europeesche Winkelstraat Van Indie*" (the most European business street in the Dutch East Indies), it features a continuous row of colonial-era shop buildings with pedestrian pathways and distinctive architecture that is over 100 years old. Despite ongoing urban development and the commercialization of tourism, this corridor has managed to retain much of its spatial and visual character. This study aims to examine how the historical corridor of Braga Street maintains its distinctive morphological and visual identity amid contemporary urban transformations. It specifically addresses the question of how spatial and visual factors contribute to the corridor's ability to preserve its heritage values while accommodating modern functions. Using a qualitative method with a morphological approach involving historical overlay maps, figure-ground analysis, and enclosure evaluation across different time periods, the research identifies spatial and visual factors that support the corridor's endurance. The findings reveal a persistent spatial continuity reflected in consistent figure-ground and enclosure patterns, complemented by contextual architectural facades and supportive landscape elements that enhance pedestrian comfort. However, this continuity is not absolute, as adaptive reuse and new developments introduce partial ruptures in the urban fabric. The study's contribution lies in demonstrating how quantitative morphological indicators can inform strategies that balance conservation with contemporary urban needs.

KEYWORDS: Braga street, Bandung, Urban corridor, Figure-ground, Spatial enclosure.

INTRODUCTION

Cities can be viewed as architectural masterpieces that continuously evolve. Beyond their physical structures, they embody layered histories that connect memories with contemporary life. Examining this historical depth provides valuable insight into the complexity of urban space [1]. A city is a spatial system, with its layout and development axes reflecting unique characteristics that illustrate its historical trajectory.

Braga Street is situated in the centre of Bandung City, West Java, directly north of Asia-Afrika Street (formerly known as the Great Post Road during the Dutch colonial era), where the city's zero-kilometre point is located. In the Bandung City Spatial and Regional Plan (RTRW) for 2022-2042, the Braga corridor is designated as a strategic urban area for cultural heritage preservation and tourism development. However, population growth and urban expansion have increased demand for buildings and land in the city centre, creating development pressure along the Braga Street corridor.

Over time, the Braga Corridor has experienced both continuity and change. Many colonial-era buildings have deteriorated due to age, natural disasters, pollution, and inadequate maintenance [2]. In response, new constructions have emerged, some designed contextually, others diverging significantly from the corridor's architectural character. Despite these pressures, the Braga Corridor has largely retained its spatial structure and identity.

This study examines how the spatial and visual continuity of the Braga corridor has been maintained for over a century and identifies the factors that sustain this consistency. The findings are significant for preserving the identity of Braga Street as a historic commercial corridor and tourist destination. The Braga area of Bandung is a popular research site due to its distinctive colonial architecture and commercial character. Previous studies have examined various aspects, from regional-scale urban settlements to micro-scale

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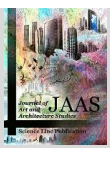

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architectural details. These works have primarily focused on architectural elements and functional adaptations that sustain Braga's role as a commercial and tourist hub. Several works have discussed contextual façade preservation [3], place meaning and functional continuity [4], and adaptive reuse as a strategy to balance commercial and heritage functions [5]. Other studies have focused on the typological continuity of building façades [6], thermal and visual comfort [7], and the colonial atmosphere's appeal for tourism and photography [8]. Recent research has also explored the interaction between nearby residential areas and tourist activities [9], revealing both potential and challenges in the government's tourist village initiative. However, few studies have examined how morphological changes and spatial proportions shape users' spatial experiences and contribute to the perception of comfort and continuity within the historic corridor. This perspective is crucial, as the concept of spatial enclosure connects physical form with experiential and heritage values. By investigating the historical development of Braga's morphological structure and its relationship with spatial enclosure, this study aims to contribute to broader debates on urban heritage preservation and sustainable urban identity in post-colonial contexts. It extends previous architectural analyses by situating Braga not only as a local tourism icon but also as a case that reflects global challenges in maintaining continuity within transforming historic urban landscapes.

Theoretical framework

Urban morphology: Urban development patterns are shaped by both planned design and historical evolution. The physical form of a city reflects its adaptation to natural surroundings and the social and economic changes that occur over time. Therefore, understanding urban morphology involves examining how historical, structural, and functional transformations interact within the city's spatial framework [10, 11]. Urban morphology refers to the configuration and organization of urban form and can be analysed structurally, functionally, and visually [12]. This study applies three theoretical approaches to interpret the spatial characteristics of the case area. Figure-ground theory reveals the relationship between solid and void spaces, highlighting the density and spatial continuity of the urban fabric. Linkage theory explains the connective elements, such as movement flows, axes, and building edges, that unify different components into a coherent spatial system. Place theory helps interpret the cultural and experiential dimensions of space, showing how social behaviour and collective memory shape urban form [13, 14]. A historical approach supports this morphological analysis by identifying how different spatial layers evolve. Traces of earlier developments, such as remaining building masses, extensions, and new infills, illustrate the transformation and continuity of urban form. Through this approach, linkage patterns and spatial layers are examined to understand how the area maintains its physical and visual coherence within a changing urban context [15].

Urban enclosure: The morphological structure of urban areas can be objectively identified through their physical attributes, which define spatial organization and visual orientation. Within the linkage system of urban morphology, spatial composition typically presents itself in three forms: boundary, enclosure, and domain. Boundaries mark the limits of space, either lateral, vertical, or overhead, and may be defined by building facades or vegetation [16] . The combination of these elements creates spatial enclosure, which determines how urban spaces are visually perceived.

In spatial enclosures, proportion and scale play crucial roles in shaping both subjective and objective experiences of space. Subjectively, enclosure ratios influence user emotional responses and sense of comfort, while objectively they are determined by the relationship between building height (H) and the distance between facades (D) [17]. Comfort in an urban environment is often experienced when the spatial scale aligns with human proportions, supported by symmetrical layouts and rhythmic repetition of architectural elements.

Scholars have proposed various interpretations of this relationship. Blumenfeld links the human scale as a reference in viewing urban scale and explains that spatial definitions weaken when the dimensions of mass and height of buildings decrease, while Ashihara uses the ratio of distance (D) and building height (H) to determine the proportion of road landscapes with spatial quality. McClauskey emphasizes the degree of sense of enclosure, where a narrow ratio indicates cramped space and a wide ratio emphasizes a lack of sense of enclosure [18]. Spatially, the ratio not only indicates the degree of enclosure but also reflects the height and width of urban space, where the sense of spatial comfort ranges from 1:1 to 1:2 [17]. A study by the Greater London Council [19] also suggested that

enclosure and comfort are determined by scale and proportion, with a minimum ratio of 1:1 and a maximum ratio of 1:2.5. However, more recent studies have refined this understanding, showing that the perception of comfort and enclosure varies depending on the context. Optimal ratios range between 1:1 and 1:3, or even beyond, and are influenced by lighting, visibility, and façade composition [20, 21].

METHODOLOGY

This study employs a qualitative method using a case study approach to highlight the phenomenon of continuity in historic commercial corridors. To provide context for the developments over time, a historical method is utilized. The base map was obtained from colonial archive maps downloaded from the KITLV digital collection website (1900s–1940s) and the Bandung Smart Map online spatial database. Street widths and building heights were obtained from field measurements and visual estimates based on facade proportions.

The analysis is conducted using a periodization approach, which systematically divides the time span, and an abductive framework, where observations from figure-ground and enclosure analyses were interpreted to generate plausible explanations about the persistence of morphological continuity. Rather than testing hypotheses deductively, the analysis seeks to infer the most likely causes of spatial consistency by iteratively comparing empirical patterns with existing morphological theories (see Figure 1).

The figure-ground and spatial enclosure approaches were applied by depicting the layers of morphological structure development from the early stages of Jalan Braga (early 1900s to 1920s), the modern colonial era (1920s to 1940s), and the contemporary era (2025). Two of the three street segments, each with several representative street sections, were selected based on their unique morphological characteristics: colonial, transitional, and contemporary blocks.

The mass of buildings and morphological structures was depicted using the figure-ground approach, while the height and distance of building masses were presented using the enclosure approach. A comparison between morphology and enclosure can reveal the relationship between visual characteristics and existing comfort ratios. These ratios are then presented in a data matrix to compare areas corresponding to the comfort ratios found in the Braga corridor. The enclosed area ratio is calculated by dividing the average building height (H) by the distance between opposite building facades (D) on the selected street segment.

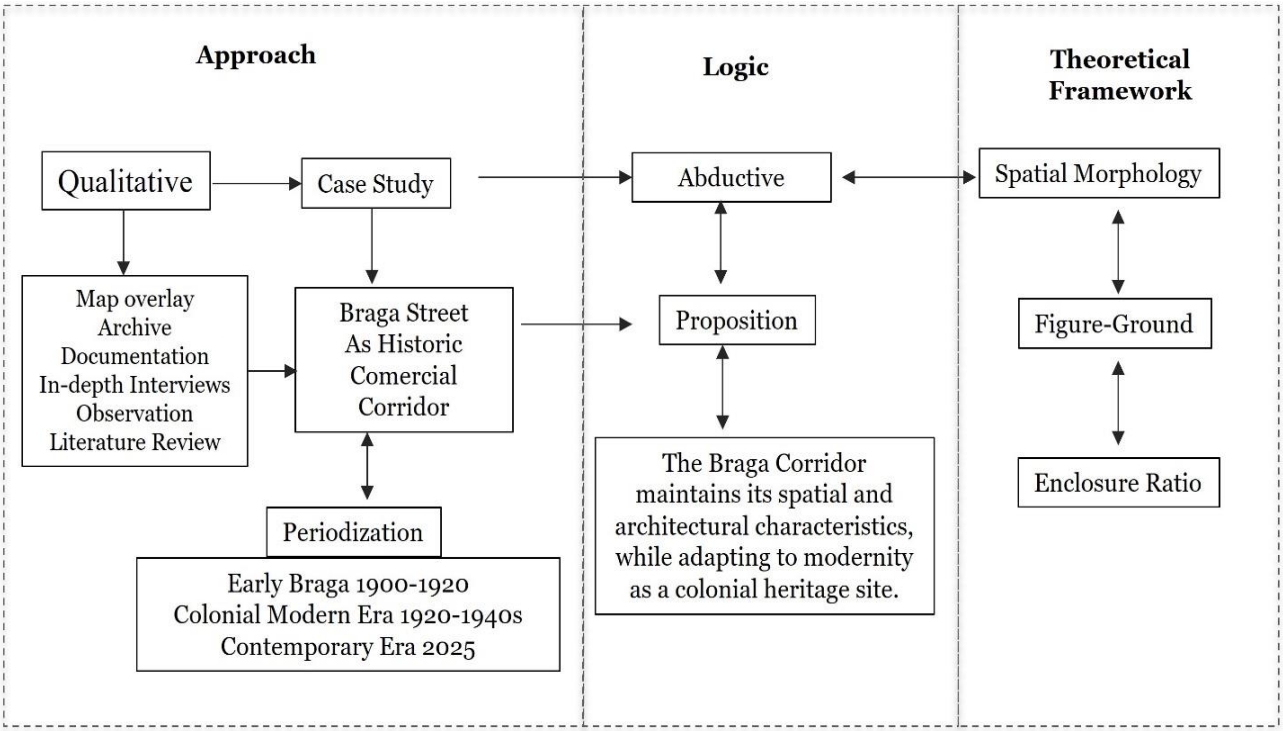

Figure 1. The connection between research methods and theoretical frameworks.

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Figure 2. Braga street's location as a field of study

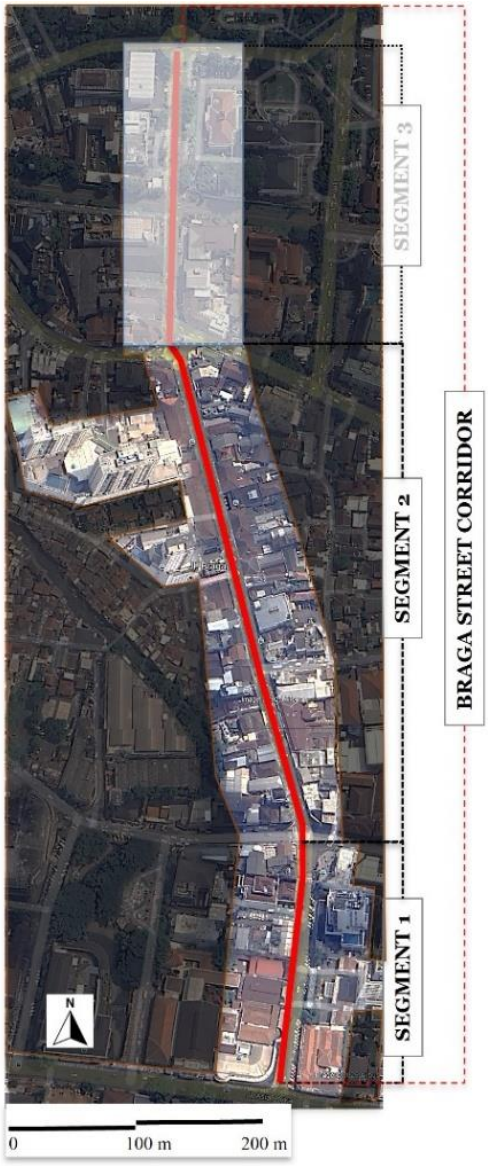

Figure 3. Street segments in the Braga corridor

Area of study

Braga Street, a cultural heritage area, exhibits the characteristics of a promenade. A promenade is a pedestrian-only zone where visitors can experience a unique spatial ambiance, with its own distinct theme, charm, and appeal [22]. The Braga Street corridor, located in the centre of Bandung (Figure 2), spans approximately 845 meters and is divided into three main segments. The northern segment stretches from Perintis Kemerdekaan Street to the junction of Suniaraja and Lembong Streets, the central segment extends to Naripan Street, and the southern segment reaches Asia-Afrika Street.

This study focuses on Segments 1 and 2, which correspond to the central and southern parts of the corridor. These areas represent the most historically intact sections of Braga Street, where the architectural and spatial continuity of the colonial-era promenade remains clearly visible. In contrast, the northern segment has experienced significant functional transformation and no longer reflects the original morphological character of Braga (Figure 3).

Background of the Braga street corridor

Bragaweg (in Dutch) is one of the earliest developed areas in Bandung, dating back to the early 1800s during the Dutch colonial period. According to Katam [23], the street initially functioned as a transport corridor for agricultural goods from the Coffee Warehouse in the north to *De Groote Postweg* (now Asia-Afrika Street) in the south, earning the name *Karrenweg* (in Dutch) or *Pedatiweg* (in the local language).

The opening of Priangan (the name before West Java Province) to European settlers in 1853, marking the era of economic liberalism in the Dutch East Indies, encouraged European plantation owners and traders to establish residences in [24]. According to Kustedja [25], since Bandung became the capital of the Priangan Residency in 1864, many Europeans settled around Alun-Alun (the local name for the city square), particularly north of *De Groote Postweg*, including the *Bragaweg* area. By the end of the 19th century, the corridor had developed from a residential to a mixed-use area, with small stalls and permanent European-style houses. The emergence of entertainment venues, notably *Societeit Braga* (later *Societeit Concordia*), at the southern end of the street fostered Braga's transformation into a social and cultural centre for Europeans. Concurrently, the quality of housing on

the Braga corridor improved, with the establishment of permanent homes and the development of road infrastructure, featuring wide sidewalks and shade trees lining both sides of the street. The establishment of the railway line to Bandung further accelerated population growth and urban development, attracting plantation owners and elites seeking European goods, dining, and leisure activities. *Societeit Concordia* became the focal point of upper-class entertainment, offering concerts, theatre performances, and dances, which positioned Bandung as one of the most modern cities in the Dutch East Indies [26]. Many plantation owners and elites from outside Bandung, especially from Batavia (now Jakarta), came to Bandung by train in the morning, spent their time enjoying entertainment in Bandung, and returned by train in the evening. According to Hardjasaputra [27], *Societeit Concordia* was one of the characteristics of Bandung's development as a modern city during the Dutch colonial period.

During the 1920s–1940s, Braga reached its peak as a commercial and cultural hub. The street evolved into *"De Meest Europeesche Winkelstraat van Indie"* (the most European shopping street in the Indies), lined with luxury shops, fashion boutiques, restaurants, banks, and automobile dealers catering to the European elite. The annual *Jaarbeurs*, a Dutch government trade fair held in Bandung each June or July, further stimulated commercial activity and tourism. Architectural regulations issued under the *Stadsvorming Ordonnantie*, with input from urban planner Thomas Karsten, guided the visual harmony of the corridor. Buildings were required to be continuous without front yards, have a maximum of two stories, and include adequate windows for lighting and ventilation[6] , shaping the cohesive urban character that defined Braga Street's identity as a symbol of colonial modernity

RESULTS AND DISCUSSION

The figure - ground and sense of enclosure of Braga Street

The development of the Jalan Braga corridor closely coincided with the establishment of Bandung as a new capital city. This study focuses on the period following the turn of the 20th century, highlighting the rapid transformation of the Jalan Braga corridor from an elite residential area into a commercial zone. The spatial and morphological development of the Braga Street corridor can be divided into three distinct periods: the early development period (1900-1920), the modern colonial period (1920-1940), and contemporary Braga as it stands today (2025).

During the early 1900s, Braga Street evolved from a mixed-use area of small detached buildings into a dense commercial corridor. Despite various architectural changes, the corridor continues to retain its original spatial layout and linear configuration. This transformation is illustrated in photographs showing the evolution of each street segment across three distinct periods (Figure 4). The relationship between enclosure and figure-ground defines the spatial morphology that characterizes the Braga Street corridor. The sense of enclosure emerges from the spatial proportion between building height and street width, shaping the perceived comfort and coherence of space. To analyse this relationship empirically, the patterns of enclosure in Braga Street corridor were examined by comparing the built mass to the open spaces in the figure-ground composition (Figure 5). This condition is further analysed through ten cross-sectional profiles representing variations in building height, setback, and façade continuity on both sides of the street. The results, presented in figure-ground and enclosure diagrams, illustrate how the corridor's three-dimensional character evolved across different historical periods while maintaining its urban rhythm and human-scale proportion.

During its early development, the Braga Street corridor exhibited a low level of spatial enclosure, as most of the building distances (D) exceeded twice the height (H) of the buildings. From the 1920s to the contemporary period in 2025, the ratio between height and width gradually became more proportional, suggesting an improved spatial balance.

The addition of new building heights was accompanied by increased spacing, as taller buildings were placed behind the older structures, maintaining the enclosure ratio within a consistent range. Several sections display similar distance and height proportions, as summarized in Table 1. According to the literature, the comfort-related enclosure ratio ranges from 1:1 to 1:2.5 (line highlighted in grey). The observed continuity of enclosure ratios from 1920 to 2025 indicates a stable spatial character. While this analysis demonstrates physical consistency that may support a perception of comfort, further observational or perceptual studies are needed to verify users' experiential responses to these spatial conditions.

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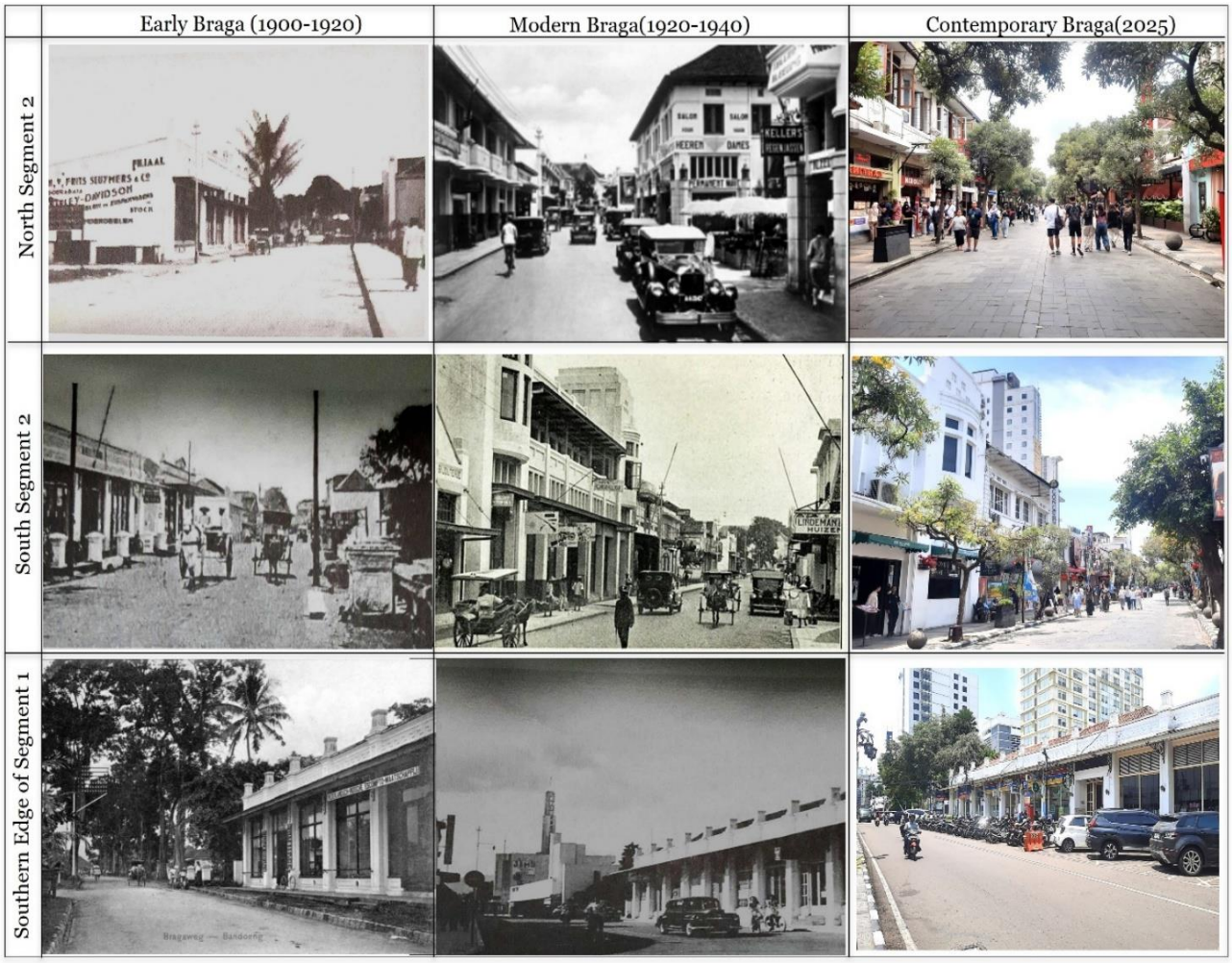

Figure 4. Development of the Braga Street corridor by periodization (Source: KITLV [28] & Author)

Figure 5. Analysis of the figure-ground relationship with the enclosure ratio of the Braga Street corridor

Table 1. Comparison of height and distance ratios of buildings on Braga Street

Section	Street Segment	West Height – Width - East Height Ratio (H-W-H)								
		1900-1920			1920-1940s			2025		
		H	W	H	H	W	H	H	W	H
10	Segment 2	1	3	1	1	3	1	1	3	1
9		1	3	1	1.6	2.4	1	1.6	2.4	1
8		1	4	0.8	2	2.4	2	2	2	1
7		1	3	1	1	1.6	1	1	1.4	1
6		1	2.4	1	1.6	2.4	1	1.6	2.4	1
5		1	2.4	1	1.2	2	1	1.2	2	1
4		1	4	1	1	2.4	1.6	3	2.4	3
3	Segment 1	1	3	1	1.6	2.4	1	2	2.4	1
2		1	5	1	2	3	2	2	3	1.6
1		1	2.4	1	1.6	2.4	1	2	2.4	1

The height–width–height (H–W–H) ratios of buildings along Braga Street from its early development (1900–1920) to the 1920–1940s period and the contemporary condition in 2025 are summarized in Table 1. The data were derived from direct field measurements and the analysis of historical maps and photographs to estimate building heights and inter-building distances. The comfort ratio was calculated by comparing the number of street segments with enclosure ratios between 1:1 and 1:2.5, an optimal range for pedestrian comfort according to enclosure theories, to the total number of observed segments.

During the early development of Braga in the 1900s, the comfort ratio was only 27 %, indicating that most sections of Braga Street lacked the desired enclosure and spatial comfort. By the 1920-1940s, this ratio increased significantly to 82%, suggesting a major morphological adjustment toward a more comfortable and human-scaled spatial form. In 2025, the comfort ratio remains at 82%, demonstrating a consistent preservation of these spatial proportions across a century of urban transformation.

The consistent closure along the Braga Street corridor not only reflects visual continuity but also compliance with theoretical comfort parameters for enclosure. However, this continuity should not be viewed solely as the result of organic spatial evolution. Alternative explanations, such as the enforcement of conservation regulations, restrictions on the height of heritage buildings, and tourism-oriented design controls, may also have contributed to maintaining the proportions of this corridor. This shows that the morphological persistence of Braga is shaped by both physical and policy factors.

From a broader perspective, the findings resonate with ongoing debates in heritage conservation and urban design regarding the role of spatial form in maintaining historical identity and experiential quality. The consistent enclosure ratio exemplifies how morphological continuity contributes to the preservation of the street's sense of place, while also supporting walkability and visual coherence within a heritage context. Nevertheless, the comfort ratio presented here is derived purely from morphological indicators and does not capture the subjective or psychological aspects of user comfort. Future studies could incorporate observational or survey-based data to understand how these spatial proportions are experienced by contemporary users and how perceptions of comfort relate to heritage ambiance and urban vitality.

CONCLUSION

Braga Street represents a historically significant urban corridor that continues to function as a lively commercial and tourist destination. The spatial analysis reveals a generally consistent enclosure pattern, formed through the interplay of colonial and contemporary buildings. This spatial continuity contributes to a comfortable pedestrian environment supported by well-designed pathways and landscape elements. However, the continuity is not absolute; several sections display ruptures and inconsistencies due to new developments and adaptive reuse interventions that have modified the original proportions. These changes reflect the

ongoing negotiation between heritage preservation and commercial pressures within the corridor. Rather than claiming a uniform spatial harmony, this study highlights how Braga Street's morphological persistence coexists with dynamic adaptation processes. This nuanced understanding underscores the need for design and policy approaches that balance conservation with contemporary urban needs. The findings provide a heritage-sensitive perspective on spatial comfort and enclosure, emphasizing how morphological metrics can inform strategies for preserving the experiential quality of historic streets.

The study's novelty lies in integrating figure-ground and enclosure analysis across multiple historical periods to interpret spatial comfort in a living heritage context. Methodologically, it demonstrates how quantitative morphological indicators can complement qualitative heritage assessments. Practically, the research offers insights for urban designers and policymakers seeking to maintain human-scale spatial structures while accommodating economic activity. Future studies could expand the analysis to adjacent streets and explore user perceptions to better capture the experiential and psychological dimensions of comfort within heritage environments.

DECLARATIONS

Corresponding author

Correspondence and requests for materials should be addressed to Husna Izzati; E-mail: izzaa.husna@gmail.com; ORCID: https://orcid.org/0000-0003-4532-5653

Data availability

The datasets and/or analyzed during the current study available from the corresponding author on reasonable request.

Authors' contributions

H. Izzati, D.H. Rahmi, and S.R. Marcillia = Preparation of article concepts .
H. Izzati = Data collection, data analysis, methods, and manuscript writing.
D.H. Rahmi, and S.R. Marcillia = Writing review and supervision

Competing interests

The authors declare that there is no competing of interests.

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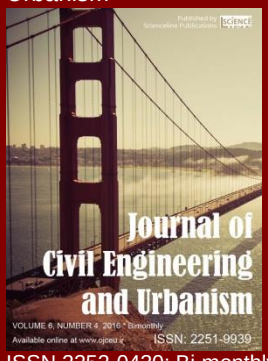

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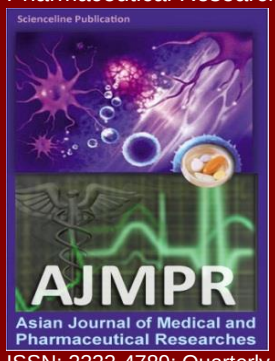

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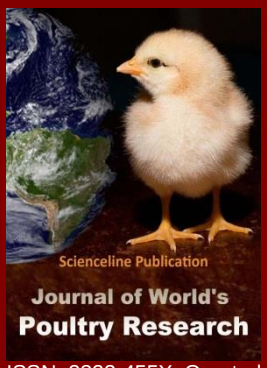

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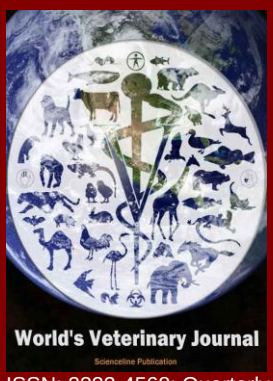

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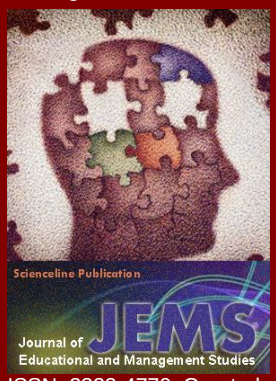

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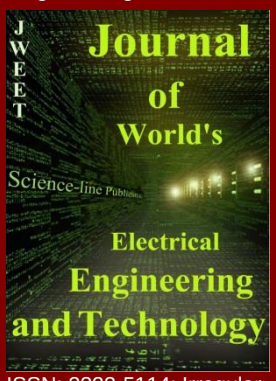

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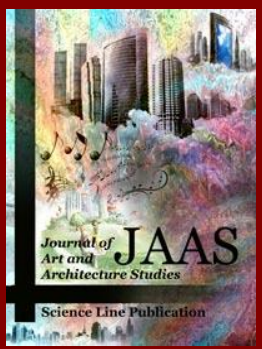

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