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Influence of Campus Outdoor Spaces on Students Behavior: Enhancing Social Interaction and Learning at An-Najah University

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Abstract: This study examines how the physical features of university campus outdoor spaces affect student behavior, aiming to promote social interaction and improve learning outcomes. Two central questions guide the research: how student movements relate to open space features, and how campus layout influences student circulation and interaction. By employing a mixed-method approach, including field observations and space syntax analysis, five areas at An-Najah University Campus are studied. The findings highlight the importance of these insights in urban design and planning, especially for teaching staff, students, and visitors. Results indicate that spatial layout and physical features significantly affect space usage, with students favoring areas with seating, shade, and social opportunities, adapting to informal setups when formal options are limited. Visibility is key, with students favoring spaces offering maximum visibility for seating. This understanding informs architects and planners in creating engaging campus environments for social interaction and learning.

Keywords: Space Syntax, Urban Open Spaces, University Campus, User Behavior, Urban Design.

INTRODUCTION

Human behavior is paramount to the usage, impact, and spaces value. This notion becomes vital for the perception of urban spaces in educational amenities, such as universities, as they gather distinctive experiences of teaching staff, students, and external visitors. Stressing the experience of students, the academic experience is not only built upon the use of campus buildings but also upon the use of spaces between the buildings, and most importantly the open spaces [1]. Open spaces in schools contribute significantly to the designed environment of universities, affecting students' academic experience and their general comfort levels [2]. This complements the scholars' efforts in approving the role of schools' infrastructure and environment to influence the behavior and health of students [3-4]. Thus, the interrelationship between universities' physical structure including open spaces' pattern, design, and students' activity patterns is important.

Studying educational campus is an extension of the research conducted in analyzing urban configurations. Over the years, numerous scholars in urban planning and design have undertaken empirical research activities focusing on the link of physical structure and usages of public and open spaces, employing various methodologies [5-6], and addressing several encounters [7]. These methods have encompassed techniques such as videotaping and activity mapping. As contemporary open spaces in cities evolve in response to technological advancements and evolving societal needs, there is a growing emphasis on exploring their changing nature and complexity in educational contexts in terms of servicing [8] and using. To address this, the usage of advanced methodologies is supported for the creation of spaces. One such analytical tool gaining prominence in planning practice is Space Syntax.

Various university campuses, plaza, labs, and studios were experimented using space syntax studies [9-11]. In regard to the liveliness of campus plazas, multiple syntax studies proved the significance of outdoor areas for students' satisfaction and social engagement [12-14]. Schwander, Kohlert, & Aras compared the spatial arrangements of two new campuses to gauge their efficacy in promoting communication [15]. Further studies have pushed forward optimizing campus space layouts and

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establishing post-evaluation systems based on syntax-related studies [11].

While various studies explored the influence of spatial organization on students' experiences, there is a particular scarcity of literature assessing and evaluating the quantitative qualities in educational amenities. Furthermore, while existing literature often emphasizes qualitative aspects of spatial design and user experience, this paper contributes by incorporating quantitative methodologies, such as space syntax theory and field observations, to provide a more rigorous analysis. This integration of theoretical frameworks and computational tools strengthens the credibility of the research findings, allowing for more precise assessments of open space utilization and social activeness. Thus, there is a need to bridge a significant research gap in understanding the relationship between spatial design, particularly open spaces, and human behavior within university campuses.

At the university campus level, there are diverse spatial designs, configurations, and uses of open spaces that may have a different impact on students. This paper aims to develop a comparative spatial analysis between different squares and spaces at the campus level. The research employs direct field observations and space syntax theory to identify the features and characteristics of each open space, examine the spatial configuration of university open spaces, and assess their utilization. The paper aims to answer two questions: What is the relation of the circulation of students and the spatial configuration of an open space? And what influence does the structure of the university campus on students' social activities? Answering these questions asserts the application and the understanding of urban design theories and practices, potentially inspires further research to enhance the design and utilization of existing and future open spaces, and leads to the formulation of the most suitable design guidelines for urban configuration and open spaces on campuses.

The paper's contribution lies in its holistic approach to filling the research gap of understanding the complex interplay between physical design, human behavior, and social interaction within university campuses. It establishes a methodology that integrates Whyte's (1980) approach, Golicnik's (2011) methods, and Space Syntax as tools in urban public space evaluation and analysis studies. By this means, the study contributes to a synchronized process of conceptualizing, designing, implementing, and operating open spaces on university campuses, where both physical and social attributes are considered. Additionally, by providing specific recommendations for optimizing open space layouts based on empirical data, the paper offers actionable insights for university administrators, urban planners, and architects seeking to create more vibrant and user-friendly campus environments.

MATERIALS AND METHODS

This study integrates qualitative and quantitative methods to allow a holistic understanding of spatial attributes and usage patterns in open spaces. By combining these approaches, the research mitigates the biases that could arise from relying on a single method and strengthens the validity of the findings through data triangulation. The research begins with data collection, focusing on social activities and behaviors within open spaces. This involves direct field observation to capture the movements and locations of students within designated areas, as well as gathering data on the characteristics of open spaces. In the data analysis phase, the study examines daily activity patterns and common locations for activities. This is complemented by using Space Syntax Theory, that assesses parameters such as visibility, accessibility, and enclosure. The analysis generates various Space Syntax metrics, including integration, choice, connectivity, intelligibility, clustering coefficient, isovist area, visual control, and visual integration. The results will feature mappings of social activities and space dynamics, which will be synthesized into a comprehensive social dynamics map of open spaces. This map, rooted in Space Syntax Theory, will reveal how various spatial configurations influence user behavior by analyzing movement patterns derived from space syntax analysis. This approach offers deeper insights into the dynamics of spatial utilization and how space influences social interactions. Finally, the study will offer recommendations to enhance the impact of open spaces on user behavior based on the findings (Figure 1).

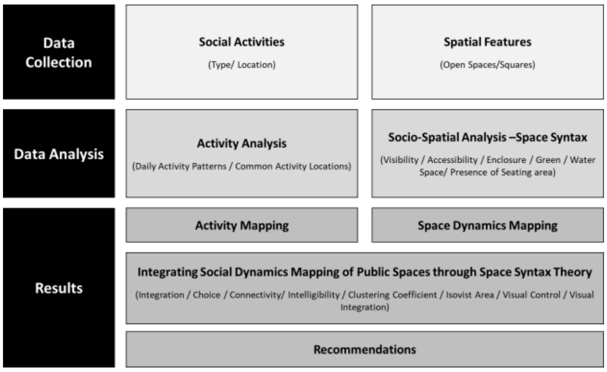


Figure (1): Research Methodology.

Data collection

The data collection phase is crucial for capturing social activities, behaviors, and the spatial characteristics of open spaces. This phase begins with the definition of typologies for each activity and physical design feature, ensuring that all observed data is systematically classified. These typologies, established prior to data collection, cover key elements such as activity levels, activity locations, and design features.

Data is gathered through direct field observation, meticulously recording the movements and locations of students within designated areas. Observations were conducted through photographing and walking. Static snapshots captured the usage buildings or open areas patterns in an urban setting. The photos collected during the fieldwork represent the general design of open spaces, landscape features, and their ambient environments. Additionally, the physical dimensions and features of these spaces are documented, guided by place-making principles. Key design elements such as green spaces, water features, and the overall layout of the square are used as selection criteria. This comprehensive approach ensures that both social activities and spatial characteristics are thoroughly captured for subsequent analysis.

Social Activities Data Collection

Before the formal data collection begins, a use case is defined, and a preliminary observation is used to distinguish active zones of the space. The space is then divided into primary areas, excluding regions with minimal activity. Each observation session is designed to cover all designated areas without overlap, ensuring a comprehensive capture of activities.

Data collection spans multiple observation sessions over several days and months, accounting for variations in weather and other temporal factors. Observers walk through each zone using a paper map, taking photographs to document activities. These maps are annotated to record activity types and locations, providing supplementary information. Each observation session reveals daily activity patterns, highlighting common locations, especially those frequently used by students. A floor plan is used for drafting social and physical activities at regular intervals throughout the day.

Spatial Features Data Collection

Spatial features data is collected through various sources, including the official plan of the study area, aerial photographs, and related geographic layers (e.g., streets, plazas, and open spaces) obtained from the Ministry of Local Government's Geospatial Portal (GEOMOLG), the official source of spatial data in Palestine. The objective is to document the physical dimensions and features of the spaces, applying spatial principles that emphasize key design elements like green spaces, water features, and the overall design layout within the square.

Data Analysis

Social Activities

This analysis focuses on understanding human behavior as how students use and move through spaces. Clear typologies were established for each activity, distinguishing between active and passive engagements (Table 1). Active activities include movements like walking or moving from one place to another, while passive activities involve standing or sitting. The analysis involves systematically tracking and mapping static activities, such as standing and sitting, alongside dynamic movements over time. This approach reveals spatial usage patterns and identifies areas where interactions naturally occur more frequently.

Table (1): Activity Classification.

Activity Level	Activity Type
Active	Walking around
	Moving from a place to another
Passive	Standing
	Sitting

Design features were categorized into four main typologies based on the existing physical elements within the space. This social analysis incorporates two of Lynch's (1960) five physical elements: edges and landmarks, while the space syntax analysis addresses the remaining three elements: paths, nodes, and districts. Edges, include the walls enclosing the space or steps on existing stairs, often serve as seating areas for students. Landmarks, along with urban furniture like benches and shade structures, are crucial design features that influence spatial use. Additionally, natural elements, including grassy areas and selected trees, were identified as key components of the space's design.

Space Syntax Analysis

The usages of space syntax have been valid for the schemes of spatial structures of contemporary cities. Proposed by Hillier and colleagues, space syntax theory studies the relationship between space configuration and social variables [16-18] which emphasizes how a space is defined and is integrated with other spaces influence social and informational interaction [19]. Syntax principles cover the investigation of spatial urban layout and architectural structure [20], and unfolds the spatial logic of street networks used to test urban ties in city, district, and community scales [21]. It measures two primary types of movement potential: to-movement, which considers the relation of each street segments [22], indicating location potential within the space, and through-movement, which gauges the movement potential of streets expected to have the highest foot traffic [23]. When such is observed, urban vitality and diversity become logical to the structure and the spatial wholeness of spaces, which assist in setting efficient planning and accessibility strategies that fulfil the community's distinctive needs [24].

Space syntax structures mathematical and substantial measures for findings about space usage [25]. The theory is established on dividing spaces into constituent elements, and investigating parameters to analyse spatial structures [26].

In this paper, space syntax analysis was conducted to study the campus spatial configuration and identify locations that encourage student interaction. This analysis examines the accessibility and attractiveness of various campus locations, particularly in terms of movement. This approach aligns with Lynch's perception of space by using his elements—such as paths, nodes, and districts—through space syntax analysis to detect students' social behavior. DepthmapX software was employed to perform axial line analysis, visibility graph analysis, and isovist generation. These techniques provided graphical representations and maps that visualize spatial connectivity and integration, where red shows the highest value and blue shows the least.

Several criteria were studied to link activities with different spatial settings, including space dimension, location of spaces within the campus, their connectivity, and the campus's spatial configuration. In this paper, the analysis was conducted in two phases: one including the entire campus and another excluding the amphitheater, as it is used only for special occasions and does not facilitate movement. The aim is to provide insights into movement patterns, helping to understand the dynamics of spatial utilization on campus.

The analysis focused on parameters such as integration, choice, connectivity, intelligibility, clustering coefficient, isovist area, visual control, and visual integration. The conception of each parameter is as follows:

Integration: Integration spatial hierarchy is about the ease of accessibility of users in a clear and connected spatial system [27-28]. It often refers to less private areas [29-30]. Integration generally refers to the tendency of space to be inhabited while co-presence of areas of social and retail activities [18]. The degree of integration measures accessibility, showing how well a line is reached without significant directional changes from the other axial lines in the system [31]. Local integration analysis embraces diverse regional urban centers and can be calculated using different radii, R3 being the most common.

Connectivity: Connectivity is about the connection of streets to each other [32]. It resembles the most localized property of the syntax of lines.

Choice: Choice is about the familiarity of users with the urban system [27], and about pedestrian preference pattern of movement [30]. It reflects the amount of movement flows through space [33].

Intelligibility: Intelligibility refers to the readability [28], the common use of a space [30], and how far one is capable of acquiring an understanding of the global structure from the local position [34]. It studies the relation between integration and connectivity.

Connectivity, choice, and integration parameters are integrated with spatial configuration analysis, which the latter develops into graphical representations and maps known as axial maps, convex spaces, and convex isovists [26-27] [35]. Axial lines represent movement properties [36], while convex spaces relate to the spatial experience within the system. The convex isovist is about the connection of points in an identified convex space [16].

Investigated parameters of connectivity, choice, and integration, using space syntax assists in understanding the performance of urban space [26][37] analysing spatial structures [38], allocating service allocations [39], accessibility [22] [40-41], and targeting challenges [42]. Many technological advancements of several software plug-in are adapting the methodology of space syntax [43]; visual analysis for instance is conducted on three-dimensional analysis using the generative computational tool of Grasshopper [44].

RESULTS

Study Area: An-Najah National University Campus

An-Najah National University, the largest Palestinian university, accommodates over 22,000 students across four campuses: the New Campus, Old Campus, Hisham Hijjawi College of Technology, and Khadouri Campus in Tulkarem. The New Campus, selected for this study, features a diverse landscape of buildings, paths, gardens, and parking areas, with various connected court spaces and corridors. The campus was divided into five main zones for observation: the Main Square (White Square), Science and Engineering Square, the area between Fine Art and Graduate Study College, the space in front of the Medical Colleges, and the area in front of the Engineering College (Figure 2).

Figure (2): Main Open Spaces at NNU University Campus.

Before data collection, an initial observation identified key activity zones, leading to the division of the campus into these five primary areas, excluding regions with minimal activity and spaces within specific college boundaries. Observation sessions were conducted from March to May 2016, during the midday break from 12 to 1 p.m., to capture a range of student activities in these areas.

Each of these defined open spaces has unique characteristics. The centrally located White Square, measuring 90 by 40 meters, is bordered by faculty buildings on the east and west, with open north and south ends. It features white stone flooring, benches, shading devices, and is connected to the main cafeteria via north stairs. The Science and Engineering Square, on the east side of the campus, consists of two connected squares, each 40 by 25 meters. The western square, enclosed by three-story buildings, offers a sense of privacy, while the northern square, featuring a small pond and palm trees, connects to the main cafeteria. The Fine Art Square, located on the west side, serves as a parking area surrounded by the library and Fine Art College, with terraces linking the square to the Medical Colleges. The space besides the Medical Colleges is more of a pathway than a square, bordered by the Medicine and Pharmacy Colleges and featuring a small cafeteria, mini-market, and seating. Lastly, the Engineering Square is primarily a parking area with greenery, partially enclosed by the Engineering College and a retaining wall, offering moderate enclosure with benches and trees along the sidewalks.

Activity Mapping

These observations were based on the description of the activities that people indulged in, usage of design features, and where the activity was located. Based on these reasons, the analysis of data collected had to be done in a manner that would outline the similarities, differences, and expectations of the common usage patterns during the observation period. First, an observation session was conducted without field data collection to identify active spaces within the location. Thus, the University Campus include five main zones, which excluded less active areas and open spaces within the college boundaries. These include: a) the central square-White Square, b) the Science and Engineering square, c) the open space in front of medical colleges, d) the open area between the Fine Art and Graduate Study College and e) the open space in front of the Engineering College. Observations were carried out over the first three mentioned areas without any overlap and this paper shall dwell upon the first three areas mentioned above.

The data collection was done on campus and took several observation sessions between the three months, from March, to May 2016. These periods are selected to avoid the impact of weather change, as temperatures are recorded to be warm at this time. Each day, observations were made between 12 and 1 pm as a means to capture a range of activity types at break period on campus. The activities were documented onto a map as a record while physically using a paper map to walk through each area and to take photographs. These maps served as ancillary data that included activity type and location. Activity patterns for daily cycles could be captured from each observation session to highlight frequent locations for students. Activities were then classified according to their types (sit, stand, move, interact) at certain times of the day onto a floor plan. In three different sessions of observation, students were observed doing different activities in the open campus areas. Many students convened with friends for coffee, lunch, or post-class meetings, while others walked, socialized, or enjoyed a leisurely stroll. The types and locations of activities were recorded on paper activity maps.

On the first observation day, Thursday, March 24, warm weather created an inviting atmosphere for diverse activities. Students were observed sitting, standing, and walking, with the main square (White Square) being a focal point. Despite the availability of shaded areas, many students opted to sit under the sun. Figure 3 illustrates the various activities of students in the main square, highlighting a range from active discussions to passive enjoyment of the surroundings. Students engaging in passive activities are primarily standing or sitting on benches, often seeking shade along edges and stairs due to the limited availability of seating (Figure 3).

The second and last observation day, April 21, May 26th, saw a decrease in outdoor space usage due to warmer weather. Despite this, the activities were similar, including sitting, walking, and standing. Notably, fewer students sat directly under sunlight. Analyzing the collected data revealed March 24th with highest population rate and May 26th as the least. The main square was the most utilized space. Regarding the use of design features, benches, edges, and stairs consistently emerged as popular choices for sitting during all observation times.

Figure (3): Activity map of the white square.

The study concluded that many spaces lacked sufficient seating despite observed usage of edges and stairs. Natural elements were present but limited. The results are illustrated in table 2. Notably, none of the squares featured a landmark, emphasizing the need for distinctive elements to enhance the campus environment. The following section presents the space syntax analysis of the campus. It will show the usages similarities, differences and expectations inside the university campus.

Table (2): Design features of spaces.

	White Square	Sciences Square	Medical Colleges route
Edges	Exists but are few	stairs are present and edges on the terrace	Non
Seating places	Few benches	Very few	Yes
Landmarks	Non landmark	Non	Non
Natural features	Non	Some trees and a small fountain	Non

Space Syntax results

Axial Line Analysis: The analysis covered diverse parameters including integration, choice, and connectivity, each evaluated according to numerical results. These values were then categorized into distinct color ranges, as illustrated in the legend of Figure (4). Figure (5) (r-n) in the global integration analysis indicates that the most integrated lines connect the medical colleges with Hikmat Al Masri Amphitheater and the stairs leading to the main square. The subsequent highly integrated line is perpendicular, linking the main square with the amphitheater. This suggests that these areas have the greatest potential for student movements and gatherings.

Local integration analysis in Figure (5) yielded similar results to the global analysis, with a focus on the main square and the science square and the path leading to the fine art square, all demonstrating nearly identical integration values.

Red		High
Orange		High-medium
Yellow		Medium
Green		Medium-low
Blue		Low

Figure (4): Space Syntax analysis legend.

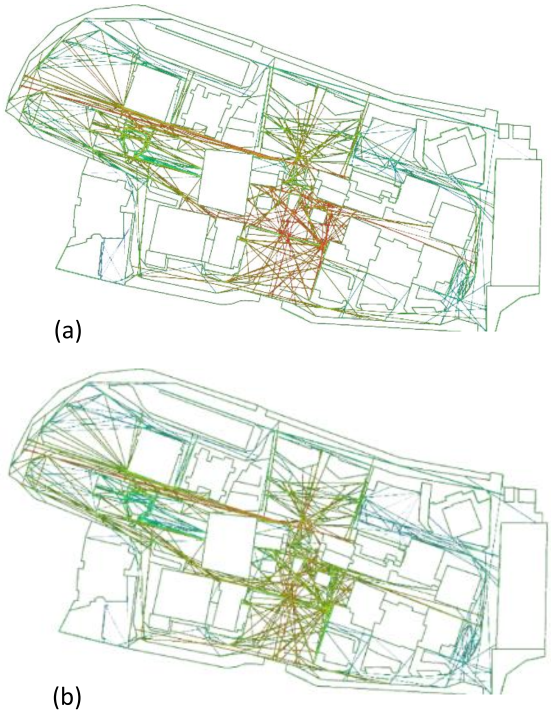


Figure (5): (a) The local integration of the campus. (b) The global integration of the campus.

Connectivity, measuring accessibility, designates the white square as the most accessible space on the campus (Figure 7), likely due to its central location. The path of medical colleges ranks as the second most connected space. Figure (6) demonstrates the two parameters of connectivity and local integration in the scattergram. Previous studies emphasize the significance of intelligibility, and in this case, there's a clear relationship between local integration and connectivity across the entire campus model, with an R2 value of 0.78. This depicts the understanding of the spatial layout.

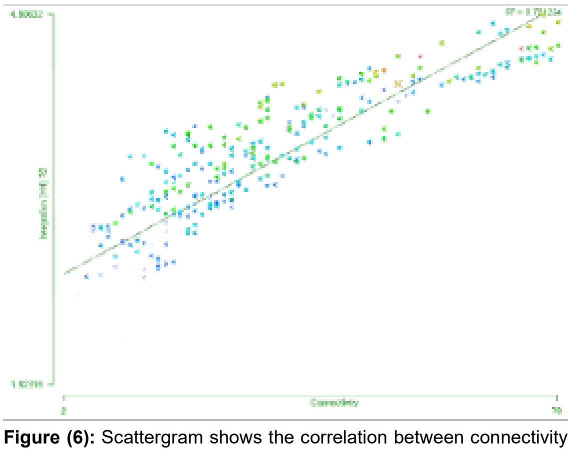


Figure (6): Scattergram shows the correlation between connectivity and local integration.

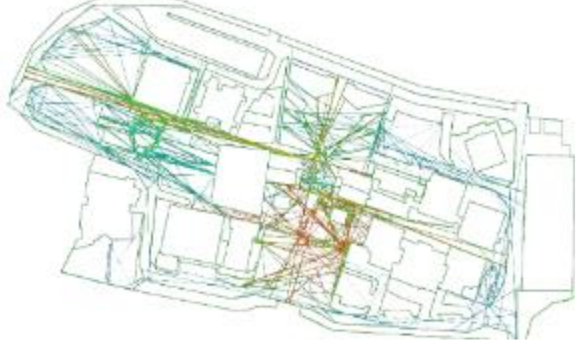


Figure (7): Connectivity analysis of campus.

Spaces of high global choice are positioned on the shortest paths. The local choice analysis mirrors the global results shown in figure 8.

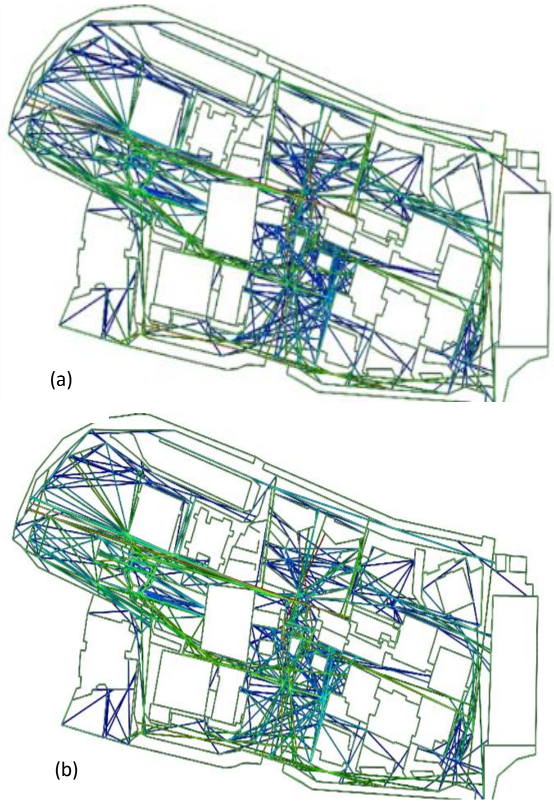


Figure (8): (a) Choice analysis of campus. (b) choice analysis for R3.

The second axial line analysis excluded the Hekmat Al Masri Amphitheater. Figure (9) highlights that the exclusion of the amphitheater did not significantly impact the overall results. The most affected analysis were the local integration values. The lines with the highest local integration values are concentrated, of the area between the engineering and science colleges, and the axis linking the main square with the fine art college with an average value of 3.62. The road facing the medical colleges is the next integrated line as shown in Figure (9).

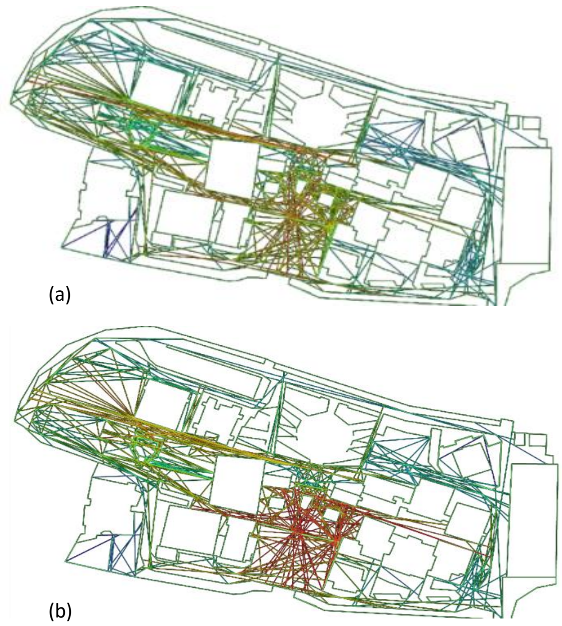


Figure (9): (a) The global integration analysis for the campus excluding the amphitheater. (b) The local integration analysis with (R3) excluding the amphitheater.

Figure (10) shows the connectivity analysis excluding the amphitheater. Figure (11) presents a robust link between campus connectivity and local integration in the scattergram. At the case of the excluded amphitheater model, R2 value is 0.82. This correlation surpasses the intelligibility observed in the previous analysis that included the amphitheater. The results signify the link between local and global structures, indicating a valid understanding and readability of the campus, allowing users to comprehend the whole from the local parts. Tables 3 and 4 below show the values of the axial line analysis of campus with and excluding the amphitheater.

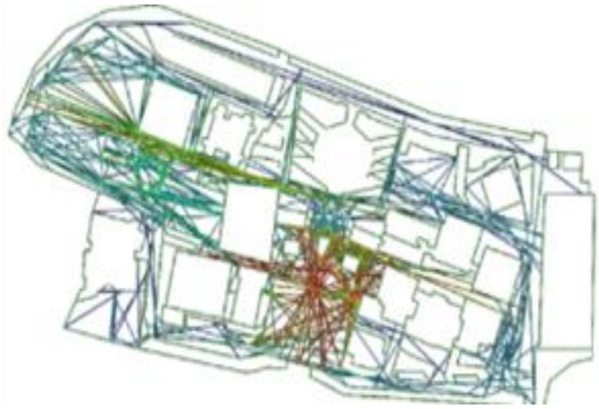


Figure (10): The connectivity analysis excluding the amphitheater.

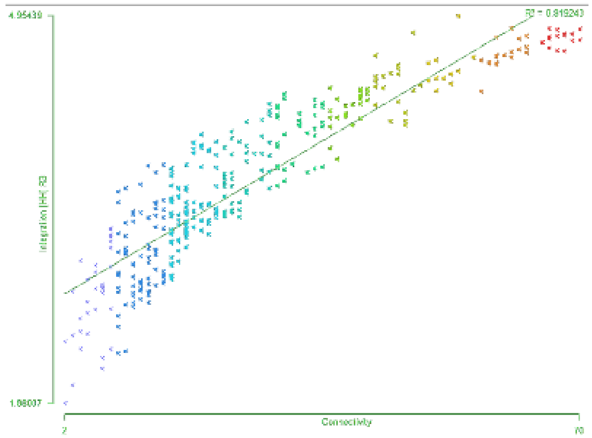


Figure (11): scattergram shows the correlation between connectivity and local integration excluding the amphitheater.

Table 3 and 4 indicate that the presence or absence of the amphitheater doesn't significantly alter the analysis, suggesting it is well-integrated within the campus. This integration might be intentional, as events in the amphitheater open for everyone. Placing the amphitheater at the junction of the highest two integrated axes facilitate guest access. Both analyses affirm the campus's intelligence, where the whole can be comprehended from its parts. The axial line analysis emphasizes the main square's prominence in terms of sightlines and movement, prompting a detailed analysis of this area in the following section.

Table (3): An overview of numerical Space Syntax results obtained for the entire campus.

The whole campus	
2.44	Global integration
3.60	Local integration (R3)
27.16	Connectivity
1070.16	Global Choice
264.85	Local Choice (R3)
0.78	Intelligibility

Table (4): An overview of numerical Space Syntax results obtained for the campus excluding the amphitheater.

The whole campus	
2.38	Global integration
3.62	Local integration (R3)
26.40	Connectivity
995.37	Global Choice
239.56	Local Choice (R3)
0.82	Intelligibility

Strategic value: Strategic value expresses the success and level of activity of space. According to Table 5, the white square has a maximum strategic value, referring to the most used and busiest place on campus. This is followed, in descending order, by the street beside the colleges of medicine, fine art square, sciences square, and engineering square.

Table (5): Strategic values of investigated area.

Strategic value	
10.57	White Square
3.69	Engineering Square
2.51	Sciences Square
8.04	Fine art square
8.41	Medical colleges street

Visibility Graph Analysis: Syntax theory employed the map of visibility generated by DepthmapX software to assess the visibility in the New Campus. The map calculates the measure of visual integration, control and clustering coefficient. Figure (12a) indicates high visibility at the campus boundaries (red spots), particularly along vehicle roads. Open spaces within the campus show moderately high visibility. Notably, the visibility map aligns with axial map findings, highlighting the white square, amphitheater, and the path connecting medical colleges with the amphitheater as areas with the highest visibility. This corresponds with the concentration of activities and the similarity to the most integrated paths.

In terms of the clustering coefficient, higher values suggest more convex spaces with less information loss during movement, see figure (12b). Spaces with low clustering coefficients are decision points. The main square has the lowest clustering coefficient, reflecting its multiple directional choices.

Figure (12c) displays the visual control analysis for the campus, revealing red spots in areas with maximum visibility, particularly along boundaries where visual obstructions are minimal. Notable spots include the entrance of the white square from the south (main university entrance) and the intersection between the medical colleges' axis and the amphitheater entrance.

Since compactness is a factor affecting people's perception about space, the isovist compactness analysis was done. Higher values of compactness come out to be in the west part of the campus, which shows that the areas are somewhat enclosed. Low compactness values were revealed for all the studied areas except for the space facing the engineering college with a compactness value of 0.51.

Figure (12d) presents the isovist area analysis for the campus, which illustrates how much can a user see. This visual analysis aligns with axial line analysis, emphasizing the white square as the most utilized space on the campus, given its high visual integration, control, and isovist area values, along with low compactness values.

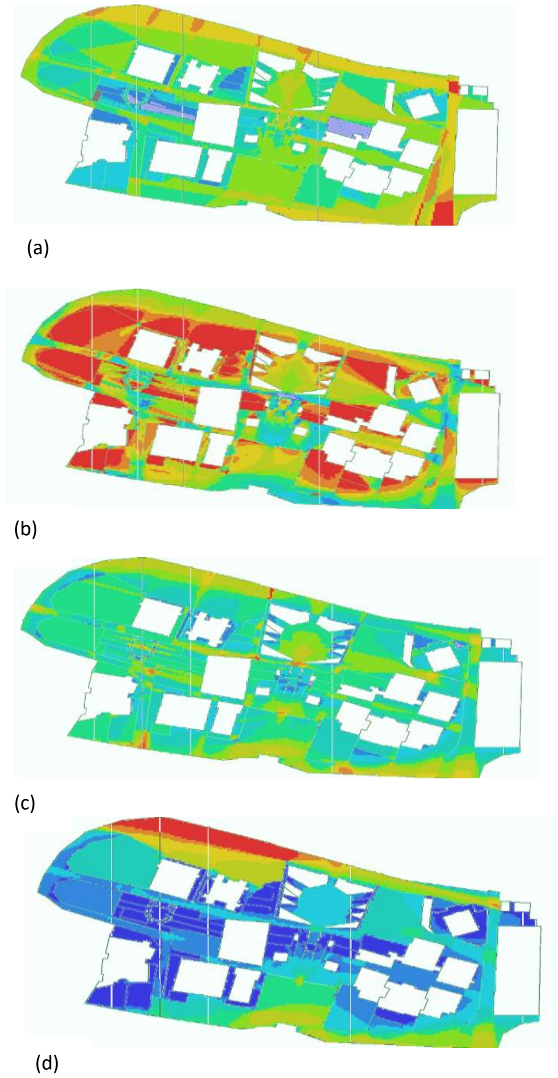


Figure (12): (a) Visual integration of campus. (b) Clustering Coefficient of Campus. (c) Visual control of campus. (d) Isovist area analysis of Campus.

DISCUSSION

Axial map correlations

The campus integration analysis, without the amphitheater, presented an integration value along the area linking the medical colleges, which got the maximum value. This evidences that it receives most of the movement, which does agree with on-site observations. The second most integrated area was the White Square, matching the observations and activity maps; besides that, the western part of the campus presented high integration. However, these high values in the western area may not accurately reflect pedestrian movement patterns, as they may be influenced by vehicular traffic near streets and parking lots, thus potentially skewing the integration index toward vehicle flow rather than pedestrian flow.

Visibility Graph and isovist correlation

This section reveals a comparison of the visibility and isovist analysis results and the results of the activity maps of the five selected spaces, highlighting the correlation between spatial characteristics and student activities.

The white square: To explore the reason some parts are preferred by students, an exploration into the stationary activities and syntactic and isovist properties of space was conducted within the main square (White Square). The observer is perceiving the space as a user of the space. The behavior mapping, carried out in March 2016, revealed that most students engaged in stationary activities, as when students sit or stand in informal spaces. The lack of formal seating forced many students to sit on ledges or stand along the edges.

The square was divided into four subspaces (main space A, terraces B, stairs C, and space in front of the amphitheater D). Analysis revealed that the main space A, with the highest integration, attracted the most students, primarily standing due to limited seating (Figure 13). Terraces B and stairs C had lower occupancy, influenced by low visibility and limited seating. Space D in front of the amphitheater, despite lacking seating, attracted students due to its high integration, aligning with isovist area and visual control analyses (Figure 14), where student numbers correlated with higher isovist areas and control values. The study highlights the impact of spatial characteristics on user behavior in the main square.

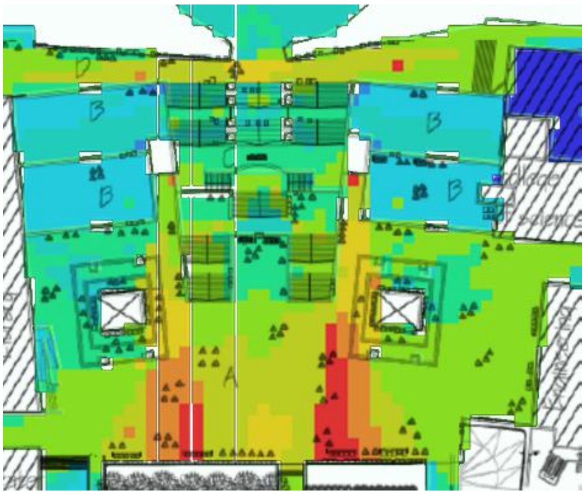
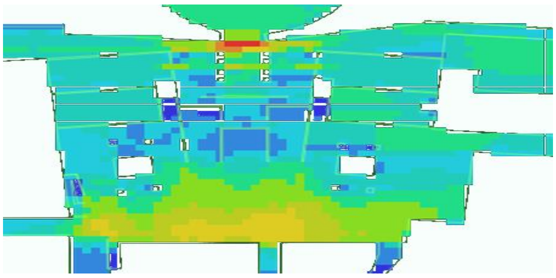
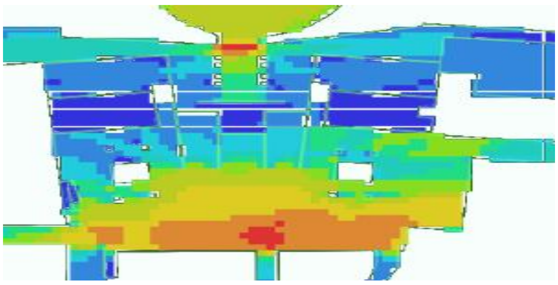


Figure (13): overlapping the visual integration with observation map.



(a)



(b)

Figure 14: (a) visual control for white square. (b) isovist area for white square.

The sciences square: The square contains two areas; south square A and north square B. Behavior mapping revealed limited standing students, with most students utilizing benches, stairs, and ledges due to the scarcity of seating. Occupancy was higher along the edges, and fewer students occupied the middle zone around the pond.

The overlap of behavior mapping and visual graph analysis (Figure 15) highlighted the higher integrated zone of the main space A, while the north square B, with lower visibility integration, attracted more students, possibly due to its proximity to the main cafeteria and continuous movement. Axial analysis further supported this observation.

Students who were stationary and sitting tended to favor lower-integrated areas near the pond, suggesting a preference for more relaxed, quieter spaces. This behavior aligns with the isovist area and visual control analysis (Figure 16), where higher student numbers correlated with areas of greater visual control, indicating that students prefer spaces where they feel a sense of safety and enjoy a broader view of their surroundings.

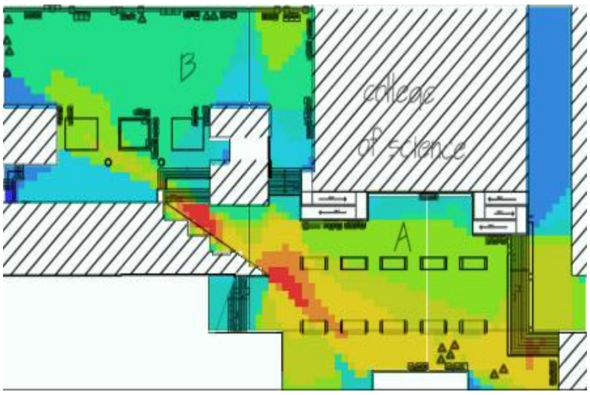
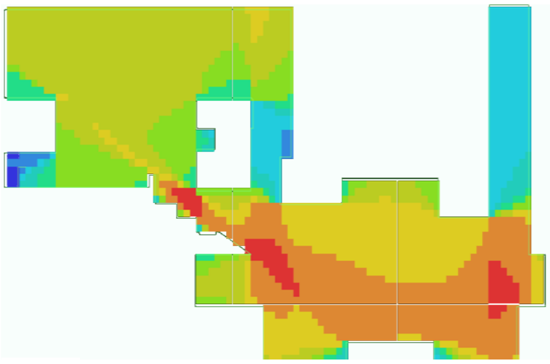
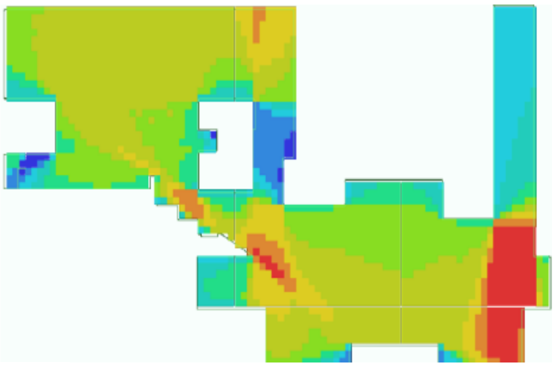


Figure (15): overlapping the visual integration graph with the observation map.



(a)



(b)

Figure 16: (a) isovist area analysis. (b) visual control analysis.

The medical colleges square: The medical square includes a street, a parking area, and terraces accessible from the fine art square. Students occupy most of the benches and chairs along the street, even though a few of them are standing. Only small percentage of students are sitting on benches under tree shade, otherwise the terraces would be unused. Overlaying the student activity map on the visual integration graph (Figure 17) revealed that most seated students were located in areas with high visual visibility, while those on the terraces stood in areas with medium visibility integration. This observation was corroborated by the isovist area and visual control analysis (Figure 18), further demonstrating that students tend to occupy spaces with high visual control and visibility, which provide them with a greater sense of safety and spatial awareness.

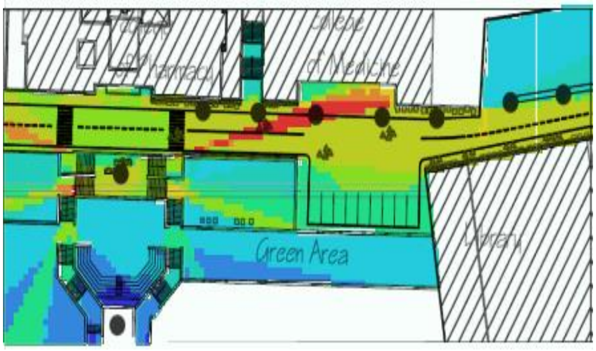
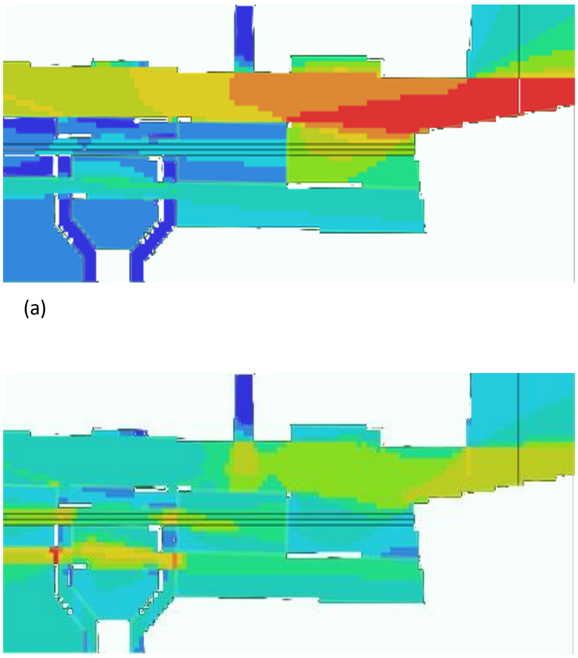


Figure (17): overlapping visual integration with observation map.



(a)

(b)

Figure (18): (a) isovist area analysis. (b) visual control analysis.

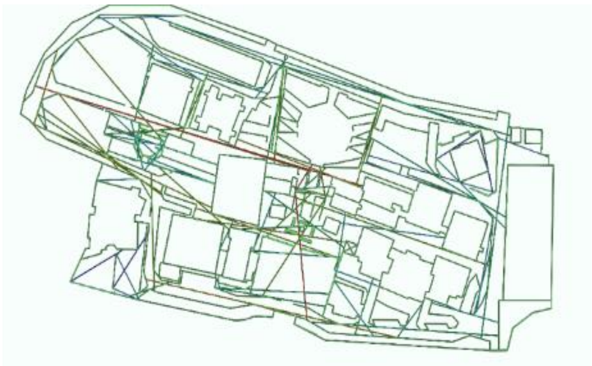
RECOMMENDATIONS

To enhance the usability and attractiveness of the campus's open spaces, several targeted interventions are proposed:

1. **Movable Seating for Flexibility:** Adding movable seats in key areas like the southeast corner of the White Square and the east end of the Sciences Square would allow students and visitors to adjust their seating according to their preferences. Whether someone wants to sit in the sun, seek shade, sit alone, or gather in groups, this flexibility helps create a more personalized and comfortable environment. Movable seating gives users control over their surroundings, encouraging them to stay longer and use the space more creatively.
2. **Small Coffee Shops or Bookstores:** Placing small coffee shops or bookstands in these areas would provide convenient meeting points and encourage social interaction. These amenities would turn open spaces from mere walkways into lively, engaging places where people can pause, meet friends, or take a break between classes. With the addition of these small gathering spots, campus life would feel more connected, fostering community spirit and interaction.
3. **Landmarks for Character and Identity**: Incorporating visually appealing landmarks such as fountains, statues, or large trees in the center of squares like the White Square and the Sciences Square would add depth and interest to these spaces. These landmarks would not only enhance the aesthetic appeal but also create focal points that naturally draw people in. Surrounding these landmarks with seating would invite people to sit, relax, or gather, giving the space a stronger identity and making it more memorable and welcoming.
4. **Creating More Seating Along the Edges:** Enhancing the edges of squares by adding extra steps to the existing ledges could turn them into additional seating areas. Since these ledges are about a meter high, the extra steps would create casual, informal seating that feels integrated into the space's natural flow. This would make the squares more functional for resting, chatting, or simply enjoying the surroundings, without the need for additional furniture.
5. **Evaluating Impact with Space Syntax Analysis:** To ensure these changes make a positive impact, an axial line analysis was performed using space syntax theory. The results for both the White Square and the Sciences Square showed a rise in intersecting lines with higher integration values (see Table 6 and Figure 19), indicating that these spaces would likely see increased movement and activity. This analysis confirms that the proposed changes would improve how people navigate and use the spaces, making them more connected and vibrant parts of campus life.

Table (6): The potential maximum strategic values achievable within the investigated area.

Strategic value	
14.7	White Square
3.69	Engineering Square
2.65	Sciences Square
8.04	Fine art square
9.96	Medical colleges street



(a)

(b)

Figure (19): (a) Axial line integration analysis for the suggestion. (b) Axial line integration analysis for second suggestion.

These suggestions aim to improve user experience, encourage interaction, and enhance the vitality of campus spaces. Further research is recommended across different Palestinian campuses to assess the generalizability of spatial layout impacts on student interaction and space vitality.

Conclusion

In conclusion, this study provides a thorough investigation into the spatial configuration of An-Najah National University's campus and its impact on the use of open spaces and squares. The existing literature reveals a notable gap in research on the relationship between user behavior and the physical layout of university environments, particularly in relation to open spaces. This research addresses this gap by applying direct observation and activity mapping within the framework of space syntax theory to elucidate the correlation between urban open spaces and student activities. By analyzing how these spaces are used in practice and their physical characteristics, the study offers valuable insights into criteria essential for the design and functionality of such spaces.

The findings underscore the importance of spatial layout in shaping the function and usage of urban open spaces, especially squares. A key observation is that the White Square, centrally located and integrated with major campus routes, serves predominantly as a transit area rather than a destination. This aligns with Hillier's theory, emphasizing the strategic value of spatial connectivity in influencing space utilization. Moreover, the lack of adequate seating and the underutilization of natural elements on campus were identified as limiting factors for static activities, with the absence of elements of discovery and "mystery" further constraining space use.

Visibility emerged as a critical issue in shaping human activities, with most occurring in areas offering maximum visibility. This study's combined data approach—integrating existing and collected data—proved effective in assessing the relationship between spatial configurations and student activities. This methodology offers practical insights into space quality and its alignment with student needs, making it a valuable tool for evaluating and designing campus environments.

The research, however, is limited by its focus on a single campus and a specific timeframe. Future studies should broaden their scope to include other university campuses in Palestine and internationally. Additionally, integrating emerging technologies such as AI and mobile sensing could provide more detailed data on campus activities. Advanced tools like Building Information Modeling (BIM) and 3D city models can also play a significant role in assessing urban attributes, thereby supporting decision-making and design processes for urban and architectural projects [45-46].

The implications of this research are significant for stakeholders, including policymakers, urban planners, engineers, and designers. The methodology employed in this study can be adapted to improve mobility, visibility, and overall spatial functionality in similar campus settings. Moreover, expanding the range of stakeholders involved in future research—such as faculty, staff, and visitors—would offer a more comprehensive understanding of campus spatial dynamics. Exploring how first-time visitors interact with the campus configuration also presents an interesting direction for further investigation.

In summary, this study highlights the critical role of visibility and spatial perception in creating vibrant, functional, and livable campus environments. By leveraging the insights gained from this research, stakeholders can enhance campus design and improve the overall student experience.

DISCLOSURE STATEMENT

- **Ethics approval and consent to participate: Not applicable**
- **Consent for publication: Not applicable**
- **Availability of data and materials:** The raw data required to reproduce these findings are available in the body and illustrations of this manuscript.
- **Author's contribution:** The authors confirm contribution to the paper as follows: study conception: NH, IH, IS, HA, KQ; methodology: NH, IH, SQ, HA, KQ; Literature review: NH, DE, SQ; modeling and mapping: NH, IH; data analysis and validation; NH, IH, HA, KQ; draft manuscript preparation: NH, draft manuscript revision: NH, IH, DE, SQ, IS; Template filling: DE

  All authors reviewed the results and approved the final version of the manuscript.
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References

1] Speake J, Edmondson S, Nawaz H. Everyday encounters with nature: Students' perceptions and use of university campus green spaces. Hum Geogr. 2013 May;7(1):21–31.

2] Prakhar P, Jha AG. Making Healthy Campus By treating open space. Int Sci J Eng Manag. 2023;2(4).

3] Yangambi M, Yangambi M. Impact of School Infrastructures on Students Learning and Performance: Case of Three Public Schools in a Developing Country. Creat Educ [Internet]. 2023 Apr 4 [cited 2024 Oct 7];14(4):788–809. Available from: https://www.scirp.org/journal/paperinformation?paperid=124699

4] Hawkins GT, Chung CS, Hertz MF, Antolin N. The School Environment and Physical and Social-Emotional Well-Being: Implications for Students and School Employees. J Sch Health. 2023;93(9):799–812.

5] Whyte W. 1980_Whyte_Small_Spaces_Book. 1980;

6] Gehl, J. (2011). Life between Buildings Using Public Space. Washington DC Island Press. - References - Scientific Research Publishing [Internet]. [cited 2024 Sep 2]. Available from: https://www.scirp.org/reference/ReferencesPapers?ReferenceID=1845563

7] Kyriazis A, Chaveneau C, Dubucs H. Abu Dhabi Public Spaces: Urban Encounters, Social Diversity and (In)formality. Motivate Media Group; 2021. 104 p.

8] Enab D, Zawawi Z, Qanazi S, Shahrour I. Socio-Spatial Analysis of Schools Based on Neighborhood Planning of the 15-min City. Urban Sci 2024, Vol 8, Page 143 [Internet]. 2024 Sep 13 [cited 2024 Sep 15];8(3):143. Available from: https://www.mdpi.com/2413-8851/8/3/143/htm

9] Soares I, Yamu C, Weitkamp G. Space syntax and volunteered geographic information for university campus planning and design: Evidence from the Netherlands, Zernike Campus Groningen. 12th Int Sp Syntax Symp SSS 2019. 2019;(July).

10] Alnusairat S, Ayyad Y, Al-Shatnawi Z. Towards meaningful university space: perceptions of the quality of open spaces for students. Buildings. 2021;11(11).

11] Guo K, Peng G, Pang J, Shen S, Lin X, Wan Q. A dynamic post-evaluation analysis strategy based on Space syntax for optimizing middle school campus layout. E3S Web Conf [Internet]. 2021 Apr 12 [cited 2024 Jan 23];248. Available from: https://www.researchgate.net/publication/350818623_A_dynamic_post-evaluation_analysis_strategy_based_on_Space_syntax_for_optimizing_middle_school_campus_layout

12] Aydin D, Ter U. Outdoor Space Quality:Case Studyof a University Campus Plaza. Archnet-IJAR, Int J Archit Res. 2008;2(3):189–203.

13] Kim Y. Difference of Place Vitality in Two Central Plazas A Comparison of the Diag on the Central Campus and the Lurie Bell Tower Plaza on the North Campus of the University of Michigan. 7th Int Sp Syntax Symp. 2009;(March):056-1: 056-12.

14] Yaylali-Yildiz B, Çil E, Can I, Kiliç-Çalğici P. Analyzing the socio-spatial construction of a university campus: Aegean University as public space of student community. 2013 Int Sp Syntax Symp. 2013;

15] Schwander C, Kohlert Ch, Aras R. Campusanalyst. Towards a spatial benchmarking system for university campuses . Eighth Int Sp Syntax Symp. 2012;1–18.

16] van Nes A, Yamu C. Introduction to Space Syntax in Urban Studies. Introduction to Space Syntax in Urban Studies. 2021.

17] Hillier B, Hanson J. The social logic of space. Cambridge University Press.; 1984. 1–23 p.

18] Hillier B. Cities as movement economies. Vol. 1, Urban Design International. 1996. p. 41–60.

19] Heitor T V., Tomé A, Dimas P, Silva JP. SYNCHRONIZING SPATIAL INFORMATION IN COMPLEX ENVIRONMENTS: a crossover of space syntax and spatial information visualization. 6th Int Sp Syntax Symp İstanbul, 2007. 2007;1–18.

20] Mohamed AA. Space Syntax Approach for Articulating Space and Social Life. In: Handbook of Research on Digital Research Methods and Architectural Tools in Urban Planning and Design [Internet]. IGI Global; 2019 [cited 2024 Jan 23]. p. 223–49. Available from: https://www.igi-global.com/chapter/space-syntax-approach-for-articulating-space-and-social-life/230530

21] Li X, Lv Z, Zheng Z, Zhong C, Hijazi IH, Cheng S. Assessment of lively street network based on geographic information system and space syntax. Multimed Tools Appl. 2017;76(17):17801–19.

22] Abdelalim A, Hussein W, Alaa'ElDien N. Streets Magnitude: Approach for Measuring Accessibility and Transportation Potential Using Space Syntax. 2024 [cited 2024 Aug 24];93–103. Available from: https://link.springer.com/chapter/10.1007/978-3-031-57385-9_8

23] Can Traunmüller I, İnce Keller İ, Şenol F. Application of space syntax in neighbourhood park research: an investigation of multiple socio-spatial attributes of park use. Local Environ [Internet]. 2023 Apr 3 [cited 2024 Aug 24];28(4):529–46. Available from: https://www.tandfonline.com/doi/abs/10.1080/13549839.2022.2160973

24] Qanazi S, Hijazi IH, Shahrour I, Meouche R El. Investigating the Spatial Suitability of the Location of Urban Services Using Space Syntax Theory. Lect Notes Networks Syst [Internet]. 2024 [cited 2024 Jul 26];906 LNNS:86–98. Available from: https://link.springer.com/chapter/10.1007/978-3-031-53824-7_9

25] Refaat AM. Space Syntax Theory and Its Contribution to Urban Design. In: Handbook of Research on Digital Research Methods and Architectural Tools in Urban Planning and Design [Internet]. IGI Global; 2019 [cited 2024 Jan 23]. p. 203–22. Available from: https://www.igi-global.com/chapter/space-syntax-theory-and-its-contribution-to-urban-design/230529

26] Qanazi S, Hijazi IH, Shahrour I, Meouche R El. Exploring Urban Service Location Suitability: Mapping Social Behavior Dynamics with Space Syntax Theory. Land. 2024;13(5):1–15.

27] Dabbour LM. Morphology of quarters in traditional Arab Islamic city: A case of the traditional city of Damascus. Front Archit Res [Internet]. 2021;10(1):50–65. Available from: https://doi.org/10.1016/j.foar.2020.11.004

28] Dettlaff W. Space syntax analysis – methodology of understanding the space. PhD Interdiscip J. 2014;

29] Osman KM, Suliman M. The space syntax methodology: fits and misfits. Archit Comport Behav. 1994;10(2):189–204.

30] Esposito D, Santoro S, Camarda D. Agent-based analysis of urban spaces using space syntax and spatial cognition approaches: A case study in Bari, Italy. Sustain. 2020;12(11).

31] Campos MB, Golka T. Public spaces revisted: a study of the relationship between patterns of stationary activity and visual Fields. In: 5th International Space Syntax Symposium Delft. 2005.

32] Hillier B. Space is the machine: a configurational theory of architecture. Sp Syntax London, UK . 2007;

33] Al Sayed K, Turner A, Hillier B, Lida S, Penn A. Space syntax methodology. A teaching textbook for the MSc Spatial Design: Architecture & Cities. London: Bartlett School of Architecture, UCL.; 2014.

34] Hillier B. Space is the machine. Space syntax, UCL. 2007.

35] Haghlesan M. Optimizing the Spatial Design of Urban Metro Stations Using the Space Syntax Method. 2023;45–62.

36] Figueiredo L, Amorim L. Continuity lines in the axial system. 2005;

37] Jiang B, Claramunt C, Klarqvist B. Integration of space syntax into GIS for modelling urban spaces. Int J Appl Earth Obs Geoinf. 2000 Jan 1;2(3–4):161–71.

38] Pafka E, Dovey K, Aschwanden GDPA. Limits of space syntax for urban design: Axiality, scale and sinuosity. https://doi.org/101177/2399808318786512 [Internet]. 2018 Jul 11 [cited 2024 Aug 24];47(3):508–22. Available from: https://journals.sagepub.com/doi/10.1177/2399808318786512

39] Srirangam S, Gunasagaran S, Mari TS, Ng V, Kusumo CML. Spatial intelligence: integration of land use to connectivity in the context of eastern urbanism. Archnet-IJAR Int J Archit Res. 2023 Mar 17;17(1):184–202.

40] van Nes A. Spatial Configurations and Walkability Potentials. Measuring Urban Compactness with Space Syntax. Sustain 2021, Vol 13, Page 5785 [Internet]. 2021 May 21 [cited 2024 Aug 24];13(11):5785. Available from: https://www.mdpi.com/2071-1050/13/11/5785/htm

41] Hijazi IH, Koenig R, Schneider S, Li X, Bielik M, Schmit GNJ, et al. Geostatistical Analysis for the Study of Relationships between the Emotional Responses of Urban Walkers to Urban Spaces. Int J E-Planning Res. 2016 Jan 1;5(1):1–19.

42] Xing Z, Guo W. A New Urban Space Analysis Method Based on Space Syntax and Geographic Information System Using Multisource Data. ISPRS Int J Geo-Information 2022, Vol 11, Page 297 [Internet]. 2022 May 4 [cited 2024 Aug 24];11(5):297. Available from: https://www.mdpi.com/2220-9964/11/5/297/htm

43] Aadithya V, Dutta S, Amalan Sigmund Kaushik S. Layout and Daylight Optimization of a Residential Module using Syntactic Design Strategies. IOP Conf Ser Earth Environ Sci [Internet]. 2023 Jul 1 [cited 2024 Aug 24];1210(1):012013. Available from: https://iopscience.iop.org/article/10.1088/1755-1315/1210/1/012013

44] Enab D. Overlooking the Visibility of Mosques : From a Norm to a Harm on Developed Urbanism in Nablus City. In: 7th International Conference of Contemporary Affairs in Architecture and Urbanism –

Full paper proceedings of ICCAUA2024,. Municipality of Alanya; 2024.

45] Hijazi IH, Krauth T, Donaubauer A, Kolbe T. 3DCITYDB4BIM: A system architecture for linking bim server and 3d citydb for bim-gis-integration. ISPRS Ann Photogramm Remote Sens Spat Inf Sci. 2020;5(4):195–202.

46] Albrecht F, Moser J, Hijazi I. Assessing façade visibility in 3D city models for city marketing. Int Arch Photogramm Remote Sens Spat Inf Sci - ISPRS Arch. 2013;XL-2/W2(November):1–5.