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Towards Meaningful University Space: Perceptions of the Quality of Open Spaces for Students

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Abstract: This study investigated students' attitudes towards the use of outdoor open space in universities, identifying the most comfortable conditions and favourable factors, including urban layout, physical features, and outdoor thermal conditions, as well as the students' needs and behaviour. A quasi-experiment was used to assess the quality of the outdoor spaces. Three outdoor open spaces on the university's campus were used for the case study. A spatial analysis employing space syntax was used to determine the integration, agent, and connection factors. For the microclimate conditions, simulations were conducted. The students' actions were recorded, and a questionnaire concerning their preferences was disseminated. According to the respondents, the key advantages of campus open spaces are that they provide places in which to socialise and rest and to pass by. The data revealed a correlation between microclimate conditions and the use of outdoor spaces. However, the students use outdoor venues even in unfavourable microclimates. The visual factor and spatial configuration of the site have a significant impact on the use of open spaces; hence, visibility is an important feature in campus layouts. This study established a baseline of data to integrate social and contextual factors for the creation of meaningful spaces in universities.

Keywords: university campus; outdoor open spaces; students' perceptions; behaviour pattern; spatial layout; thermal perception; CFD modelling

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1. Introduction

A well-designed campus is an essential component of students' educational experiences, equal in importance to the students' academic courses and linked to the mission of higher education [1]. A substantial amount of literature has been published on the design of the physical requirements of university campuses, with universities seen as small cities that have a huge impact on their environment and resources [2]. However, most research focuses on the overall environmental assessment of the campus. In addition, physical requirements are considered the primary motivator for design, as they directly influences behaviour [3]. The physical landscape directly affects human behaviour by presenting the students with an active, experiential learning experience in place of a passive or theoretical one [1]. University is a place for the cultivation of critical thinking, the development of new ideas, and the forging of connections between academics and students to generate new knowledge. Stress and poor academic performance are two possible consequences of failing to ensure quality of life on campus. Interaction with one's colleagues in the outdoor environment is a key component of the formal learning process, as well as promoting collegial encounters. When classes are spread out throughout different departments, it is easier for students to cross paths with one another, thus increasing the possibility of collegiality and interdisciplinary dialogue [4]. However, much uncertainty remains about the impact of the design features and urban layout of university campuses on the users. In addition, the failure to consider the active roles of users' choices and expectations has frequently been a major flaw and limitation in the planning and design of university campuses. Therefore, research is needed to explore the effect of the campus environment on users' behaviour (and vice versa), as this affects perceptions of the quality of students' experiences and their evaluation of the campus environment.

Outdoor open spaces are essential features of universities, as community-oriented places in which students can meet, interact, and relax, which result in academic and personal growth. Moreover, these spaces are critical for enhancing university quality of life. Therefore, it is vital to understand the relationship between open spaces and students' personal needs, particularly in relation to factors that make outdoor spaces attractive and meaningful to university students. In an urban environment, however, external conditions are complex and variable, raising multiple concerns. One important aspect is the users' experience. An outdoor open space is defined as a space with an unroofed structure, formed largely by the relationship between a human and his perception of the space and its relationship with nature [3,5]. Therefore, positive perceptions of the outdoor space are important, with emphasis on the impact of the design and the organisation of the space [6].

It is important to consider whether an outdoor space can be designed to facilitate both learning and socialising, thereby aiding the success of students, as outdoor design can affect certain behaviours that contribute to academic and social success. For a public space to be successful, the following characteristics are critical: it must be easily accessible, be available for use, be intended for use, be aesthetically pleasing, encourage different activities, ensure user privacy and safety, encourage different user groups, be socially comfortable, and provide choices [4]. Although little research has been done to ensure that university campuses have sufficient outdoor educational and social programmes, it is understood that these fundamental characteristics should be incorporated when designing these spaces. Studies must consider the wants and needs of the students who will be using these places to aid their education [7].

When investigating open spaces in universities, one must take into consideration that the age group in question mostly comprises young people. Consequently, there is a need to explore the perceptions and functions of open spaces in relation to young people—along with other factors affecting their experiences—to form meanings for the open spaces and make them socially acceptable and educational. Access to outdoor spaces has a great impact on how young people socialise. These structures are crucial on university campuses, serving a multitude of utilitarian purposes, including as places for rest, work, and dwelling. They allow younger individuals to meet with their peers and participate in diverse activities, thus sharpening their abilities and helping them to become better problem-solvers [8]. It has been shown that the environmental preferences and requirements of youth are distinct from those of the general population [8]. For example, landscapes with leisure settings are favoured, since they not only offer students an alternative to traditional campus life, but they are also better for the environment [9]. Studies of the psychological and social aspects have found that young people who are content with their surroundings communicate better with their peers and make better life decisions. Therefore, it is critical to explore the psychosocial requirements and provide young people with open green space for activities [8], as this may lessen the burden of stress, burnout, and depression that many students suffer from today [10,11]. A cross-sectional study in England linked the quality of, and access to, green space with reduced psychological distress [12]. Another study demonstrated that greater surrounding greenness at home and school was associated with improved cognitive development in students [13]. The usage of urban spaces was explored using functional and psychological metrics [14,15], with plaza quality determined by two key components: first, the quality characteristics of the physical environment (e.g., climate, location, connection with the surrounding structures, accessibility for pedestrian/vehicle connections, fixed areas/machinery, landscaping), and second, by the users' characteristics, which are affected by the quality of their behaviour and experiences, as well as the visual quality. The social wellbeing of users is tied to their personal characteristics and habits [16], and the characteristics of the students are affected by social, cultural, and ideological aspects and needs [3]. Students' behaviour is greatly influenced by the previous two components in educational settings, where physical characteristics determine how their connections form, how they get into groups, their personal space, their territory, how they communicate, and how they find personal safety.

In summary, students' experiences in university open spaces are influenced by a variety of elements, and these have been investigated in a number of studies. Table 1 outlines the characteristics that influence students' satisfaction with open places, highlighting three key issues: the urban layout and physical features (accessibility, spatial organisations, surrounding buildings, seating, landscape); the outdoor 'thermal comfort' conditions; and the students' needs and behaviour. Several other factors also influence open-space experiences. These include safety and security, activities, engagement, administration issues, time, and distinctiveness. Other factors identified as barriers include slope, location or distance from faculties, limited space for interaction, cold or hot climate, and noise. Whilst there is a substantial amount of literature on open-area environments, there is a need to comprehensively examine the quality of these spaces in universities integrating the three key aspects. In addition, the primary contributors to students' perception should be considered, with reference to the impact of each factor and the relationships between them. Moreover, the factors should then be prioritised according to their importance to the students. This study highlights the primary influences on the quality and meaning of open spaces in universities and investigates them from the perspective of the students themselves. This study considers the factors that influence students' attitudes towards the use of outdoor open space in universities, including urban layout, physical features, and outdoor thermal conditions, as well as the students' needs and behaviour. Then, the main factors are integrated and the most comfortable conditions and favourable factors according to students' perceptions are identified.

This will provide a framework for university planners to predict the impact of the design standards and considerations (physical and psychosocial, quantitative and qualitative) on students' perceptions and reactions. It is anticipated that this process will highlight principles and implications for urban design and planning practices, whilst greater understanding of the relationships between open space layout, thermal sensation, and students' behaviour and preferences will reveal the design solutions that best meet users' expectations and needs. The significance of this research lies in investigating the new need for the design of outdoor spaces in universities, which deals with creating a meaning for these spaces based on the perception of the quality of open spaces for students. In addition, the significance of undertaking a systematic methodology, which deals with a triangulated experiment of quantitative and qualitative methods, is illustrated in the next section.

Table 1. Literature exploring the key elements that influence students' experiences of outdoor open spaces.

Elements	Features Affecting Students' Experience of Outdoor Open Spaces in Universities	Studies
The urban layout and physical features	Natural landscape.	[1]
	Physical features: the functions, activities, uses, and location relevant to the whole site.	[3]
	Setting and design of open spaces.	[6]
	Physical environment that encourages learning and development (use of various design attributes).	[7]
	Use of bicycle, walkability.	[17]
	Spatial organization.	[18]
	Effect of slope: a 1% increase in slope makes a walk roughly 10% less attractive / slopes have a strong detrimental impact on the attraction of walking.	[19]
	Flexibility of use, visual attraction.	[4]

The students' needs, perception, and behaviour	Users' age: young people.	[8]
	Preferences and usage during students' leisure time. Preferences of character and spatial landscape.	[9]
	User characteristics.	[15]
	Personality of users.	[16]
	Users' needs: physiological, security, belonging, esteem, self-actualization, intellectual.	[18]
	Users' needs: social, cultural, and ideological dimensions.	[20]
	Friendship.	[21]
	Perception of pedestrians of the presences and the steepness of space.	[22]
The thermal conditions	The effects of microclimate.	[14]
	The thermal comfort.	[23]
	The meteorological conditions.	[24]
	Thermal perception of outdoor urban spaces.	[25]
	Thermal comfort of outdoor urban spaces.	[26]
	The impact of a sun sail-shading strategy on the thermal comfort.	[27]
	The impact of outdoor shading strategies on student thermal comfort.	[28]
	Thermal conditions in outdoor public spaces.	[29]

2. Materials and Methods

As stated in the introduction, the purpose of this study is to investigate the factors that influence students' perceptions of the quality of the open spaces on university campuses. A quasi-experiment was conducted in the three primary outdoor open spaces at Al-Ahliyya Amman University (AAU) in Jordan, which was employed as a model university campus. Spatial analysis was conducted using space syntax to define the parameters of integration, agent, and connectivity. Computer simulations was developed during peak hours for outdoor-space occupancy during the four seasons to define the microclimate conditions. The students' activities were observed, and a questionnaire survey was disseminated to capture the students' behavioural preferences. Figure 1 illustrates the study methods and research flow.

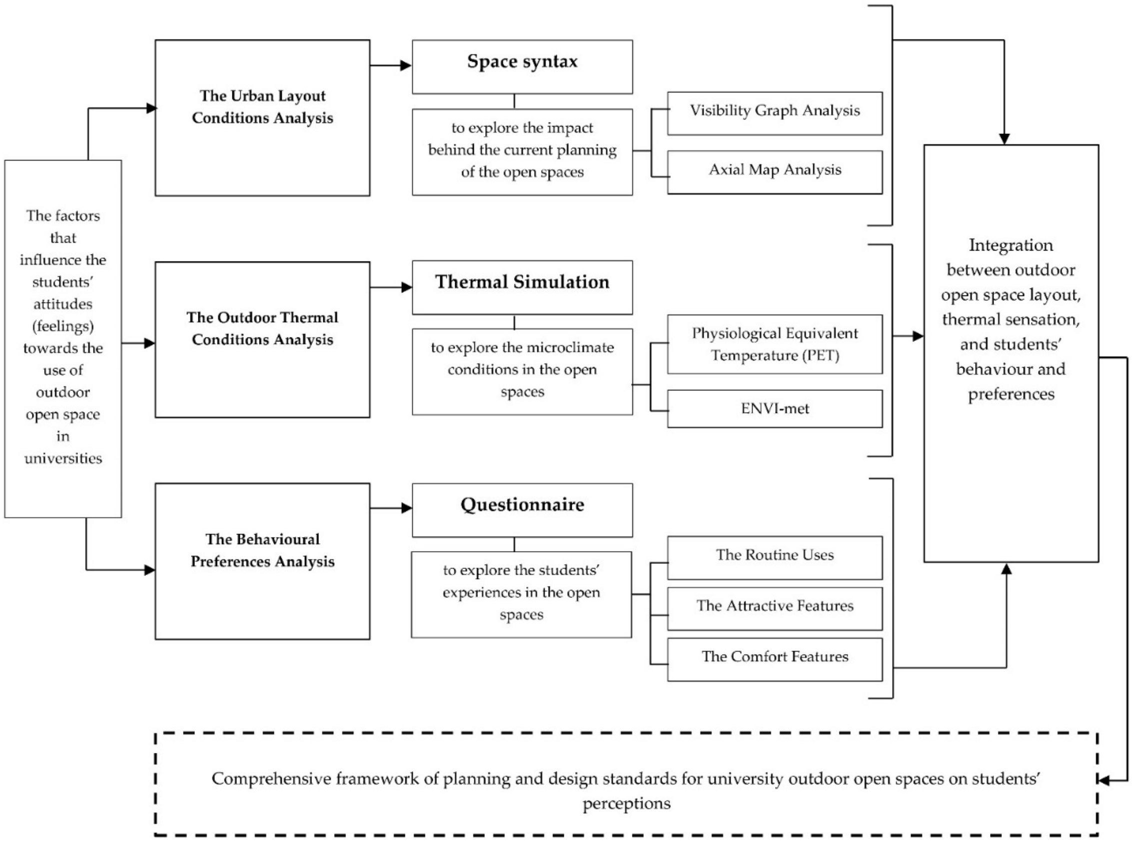

Figure 1. Research design: methods and phases.

2.1. Study Area (Case Study)

Al-Ahliyya Amman University (AAU) has one campus, covering a total land area of 185,109 m². It is situated in a suburban area between Amman and the city of Al-Salt. The campus comprises 21 permanent structures (academic faculties, sports facilities, female student dormitories, and services) and nine temporary structures (including caravans, kiosks, and shelters). The footprint of the main campus building is 22,476 m². Each semester, an average of 7000 students enrol at the university [30].

2.1.1. Study Area Meteorological Data

According to the Köppen-Geiger climate classification, the area under study has a cold, semi-arid climate (BSk) [31]. Winters are cold, with some precipitation, whilst summers are hot and dry. The meteorological data extracted from Meteonorm indicate that the mean annual air temperature is 17.9 °C, the annual minimum average temperature is 12.9 °C, and the maximum is 23.2 °C. The hottest months are July (average daily temperature, 26.9 °C; average daily high temperature, 32.3 °C; highest temperature recorded, 38.4 °C) and August (average daily temperature, 26.3 °C; average daily high temperature, 31.9 °C; highest temperature recorded, 36.5 °C). The coldest months are January (average daily temperature, 8 °C; average daily low temperature, 4.2 °C; lowest temperature recorded, −1.7 °C) and February (average daily temperature, 9.2 °C; average daily low temperature, 5.2 °C; lowest temperature recorded, 1.5 °C). The prevailing wind direction is south-west in the summer and south/south-east in winter, and the average wind speed in winter is 2.5 m/s and 3.8 m/s in summer. The relative humidity has an annual mean value of 51.1%, an average annual high value of 70.7%, and an average annual low value of 33.2%, whilst the average annual precipitation value is 200 mm. The annual mean global horizontal radiation is 454.2 W/m², with an average annual low of 78.2 W/m² and an average annual high of 773.4 W/m². The annual mean direct normal radiation is 522.2 W/m², with an average annual low of 173.6 W/m² and an average annual high of 730.2 W/m².

2.1.2. Study Area Urban Configuration

The campus is a gated, urban setting, with an 'autonomous urban fabric'. A ring road linking the facilities together is provided for vehicles, with sidewalks for pedestrians. The modernistic masterplan consists of cubist buildings that were designed and built at different times and placed freely on privately owned land. In addition to the ring road, there are open spaces for car parking, sports use, landscaping, and student gatherings, which link the campus buildings. The steep slope of the campus site puts the buildings and open spaces on multiple levels. There are gaps between some of the buildings, and the distances between the buildings' levels vary. This makes walking undesirable in most areas, especially due to the lack of shade.

There are multiple outdoor student-gathering areas on the campus. Three spaces were chosen for this study. The criteria for choosing these sites were the location and frequency of use. These spaces are heavily occupied by the students most of the time and are located between major faculties on campus. Table 2 summarises the characteristics of the selected open spaces and is followed by the masterplan for the academic section of the campus (Figure 2).

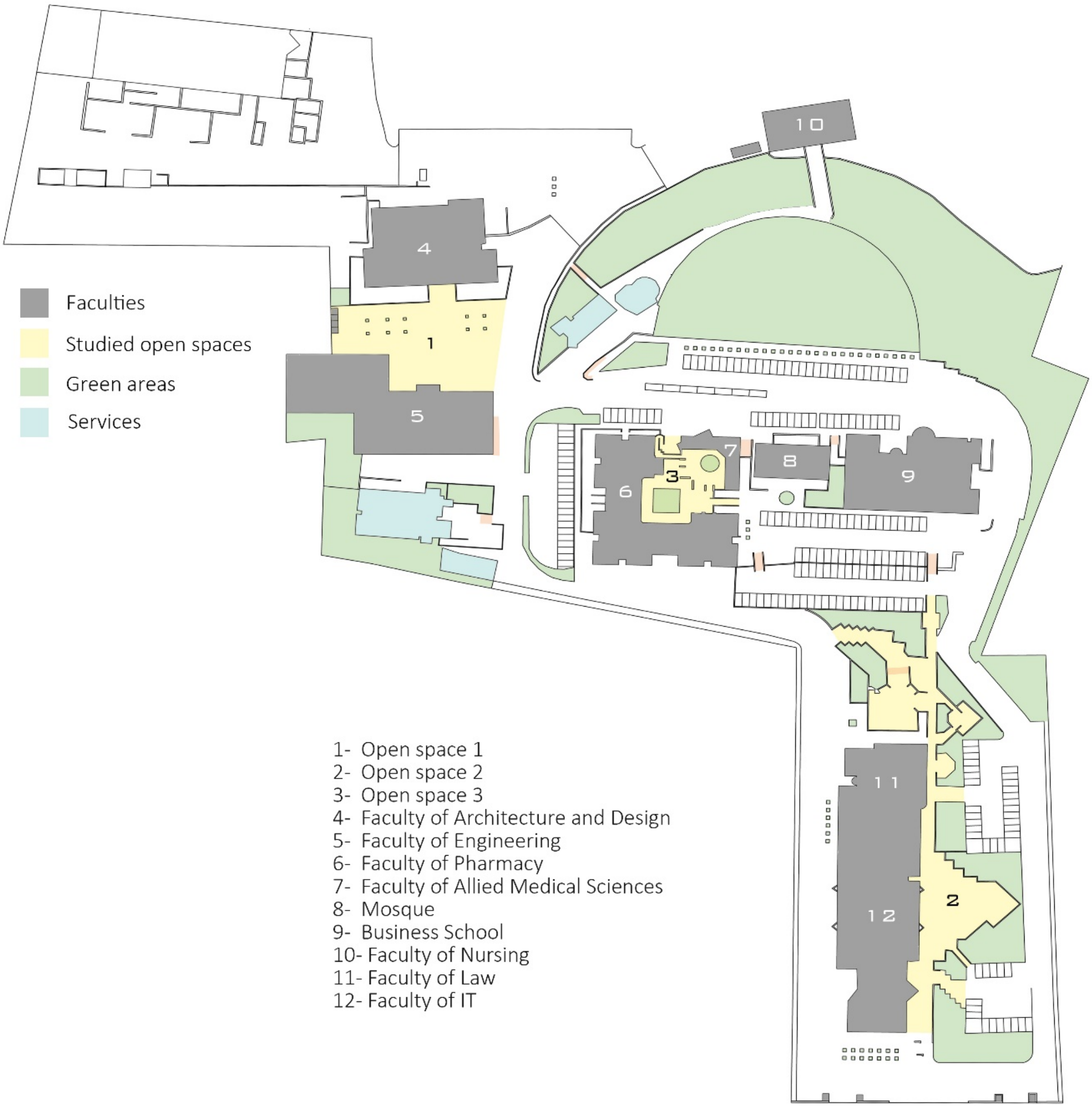

Figure 2. Campus layout and open spaces in Al-Ahliyya Amman University (AAU).

Table 2. Summary of the three open spaces.

Site	Open Space 1	Open Space 2	Open Space 3
Area (m²)	1680	4375	645
Spatial configuration	Open area with low level of enclosure	Clustered gathering spaces along an axial path	Enclosed courtyard
Shaded area (m²)	140	355	-
Access	Architecture and design faculty Engineering faculty Student parking	Main university entrance IT faculty Law faculty Staff parking	Pharmacy faculty Allied medical sciences faculty Staff parking
Surrounding buildings and services	Architecture and design faculty Engineering faculty Student parking	IT faculty Law faculty	Pharmacy faculty
Vegetation cover	10	1725	115

area (m^2)			
Seating length (m)	50	65	15

2.1.3. Study Area Physical Context

The building cladding in the studied areas is white limestone, with a measured albedo of 60%. In open space 1, the buildings at both ends of the court are 16 metres high and the ground is paved with grey tiles, with a measured albedo of 45%. The area is planted with six 8-metre palm trees. In open space 2, the building adjacent to the south of the court is 12 metres high and the ground is paved with grey tiles, with a measured albedo of 40%. The area is planted with mostly local species, including deciduous trees (such as *Populus nigra*) and coniferous trees (such as *Phoenix dactylifera*, *Pinus halepensis*, *Mediterranean cypress* (Cupressaceae), and *Cupressus macrocarpa*). In open space 3, 16-metre-high buildings surround the court on all sides and the ground is paved with light-coloured, sand-beige tiles, with no vegetation planted on-site [32].

2.2. Spatial Analysis: Space Syntax

Space syntax methods were employed to investigate the spatial structure of the university campus. Space syntax identifies the social meaning of the space [33]. There are three basic spatial segmentation methods for space syntax, using the principle of spatial cognition: convex space, axial line, and visibility graph analysis (VGA) [34]. VGA and the axial line method are used in this paper.

2.2.1. Visibility Graph Analysis

VGA is primarily used in architectural and urban space to determine how visibility defines spatial element relationships, influences movement, and contributes to a better understanding of the surrounding space. Turner et al. [35] created the VGA study based on space syntax theory [36] and previous research on visibility fields [37,38]. Turner et al. [35] proposed the computational foundations of visibility graphs as a method for recording spatial configurations and relationships. VGA was conducted using the open source and multi-platform spatial network analysis software ‘depthmapX’ [39,40]. DepthmapX divides any given plan into a grid whose size is adjustable by the user and allows the user to generate and examine a visibility graph that represents visible connections between different point-locations at the centre of each grid. In this study, the depthmapX software for VGA enabled an investigation of the depth of the visual fields in the open spaces and an examination of the locations that provided users with more visual information.

The term ‘VGA’ refers to a variety of tests, including the following:

- Connectivity analysis, which identifies the number of points that are visually connected to other adjacent spaces;
- Visual integration, which provides a representation of potential core areas in the layout or where the majority of the layout can be seen;
- Through-vision analysis, which shows how visual fields change in a given environment;
- Agent analysis, which identifies movement patterns and the frequent use of spaces released from a single point.

In all graphs, a red colour indicates the highest value, and blue represents the lowest. For this study, VGA was conducted for the whole academic, urban section of the campus and separately in each of the three open spaces.

2.2.2. Axial Map

People generally orient themselves based on what they see and where they can go [35]. On a plan, this can be represented by a straight line with no visual or access interruptions, indicating how far a person can see or go in a single direction. This vector is known as an 'axial line' in space syntax [41]. An axial line is the longest sightline indicating a movement path within a specific space in the built environment. Each axial line represents a space that connects to other spaces in urban studies, and an axial map of a built environment illustrates the longest and fewest axial lines [36]. DepthmapX was used in this study to perform the axial map analysis for the whole academic section of the campus.

The 'axial map' includes different tests:

- Connectivity, which is a static local measure of the number of connections that each space has to its immediate neighbours. One of the fundamental concepts of graph theory in mathematics is connectivity. A space with a high connectivity value has many connections to its surroundings, whereas a space with few connections has a low connectivity value [36,41].
- Axial integration, which estimates a space's access to all other spaces in the urban system by taking into account the total number of direction changes (syntactic steps) of an urban entity [36]. Axial integration and connectivity are inextricably linked. The longer an axial line in an urban area, the more connected it is to other lines and the greater its integration value (and vice versa). The fewer the direction changes of a specific space to all other spaces in the system, the greater its integration and thus its inter-accessibility.

In the axial view, the axial line from red to blue represents the strongest to weakest connection or integration.

2.3. Thermal Simulation

2.3.1. Thermal Comfort

The thermal comfort index known as the physiological equivalent temperature (PET) was employed in this study. PET uses the Munich energy-balance model for individuals (MEMI) for its base calculation [42] and considers all basic thermoregulatory processes when solving the heat balance equations. This allows for accurate estimations of the body's thermal quantities, such as skin temperature and sweat rate [43]. The main climatic and personal parameters that concern PET are air temperature, wind speed, mean radiant temperature, relative humidity, clothing insulation, and metabolism rate. The personal parameters in PET are fixed at work metabolism of 80 W and heat resistance of clothing 0.9 clo [44]. From the abundance of thermal comfort indices, PET was found to be the most frequently used in recent studies to assess thermal sensation in outdoor conditions [45].

To calculate PET, ENVI-met was used, which is a computational fluid dynamics (CFD) modelling software that analyses the interaction between metrological parameters and the built environment. This includes the interaction between the microclimate and vegetation, bodies of water, and buildings [46]. Due to the high variable calculations of ENVI-met, several studies have been conducted to confirm the integrity and accuracy of the predicted data, and they have been found to be sufficiently accurate [25,32,47].

2.3.2. Thermal Comfort Range

Individual perceptions of climate are a function of past experience and exposure [26,48,49]. To examine this phenomenon, several studies have been conducted in different climatic zones to determine human thermal sensitivity to the surrounding meteorological factors. In their study of the humid subtropical city of Mendoza, Argentina, Ruiz and Correa [50] showed that relying on universal thermal comfort indices—without correlating them to the studied area climate—is not sufficient. Their results revealed a 75% discrepancy in predictions of thermal sensation, compared to the actual sensation vote, across the six thermal comfort indices included in the study.

PET was designed based on the MEMI [42]. The temperate climate of the initial study area in Höppe's work [42] influenced the range of comfort sensation correlated with the PET levels produced; therefore, several studies were conducted across different climatic zones to modify the PET comfort range. Kruger et al. [51] modified the PET range for the

Oceanic climate of Glasgow, Scotland, and found that the acceptable comfort range in the summer period was between 9 °C and 18 °C, which falls into the cool range of the universal PET. Lin and Matzarakis [52] studied the tropical climate of Taiwan and found that the modified PET range for comfort was between 26 °C and 30 °C, which falls under the warm universal PET range.

For this study, an acceptable comfort range of between 21.6 °C and 32 °C was chosen, based on a study conducted in Konya, Turkey, as both the studied area and Konya fall under the same Köppen climate classification of a cold, semi-arid climate (BSk) [31]. This study included extensive questionnaires and on-site monitoring, and via multiple regression methods, it was found that the comfort range shifted between 3.6 °C on the lower end of the comfort range and 9 °C on the higher end [53]. Table 3 presents the universal PET range developed by Höppe [42] and the modified PET based on the correlation equation using PET and the mean thermal sensation votes (MTSVs) [53]:

$$y = 0.0968\ (PET) - 2.5924\ (R2 = 0.8327) \quad (1)$$

Table 3. The universal physiological equivalent temperature (PET) [42] and the modified PET range for Konya, Turkey. Based on Equation (1). Edited from ref. [53].

Universal PET	Modified PET	Thermal Perception	Grade of Physiological Stress
<4	<6	Very cold	Extreme cold stress
4 to 8	6 to 11.2	Cold	Strong cold stress
8 to 13	11.2 to 16.5	Cool	Moderate cold stress
13 to 18	16.5 to 21.6	Slightly cool	Slight cold stress
18 to 23	21.6 to 32	Comfortable	No thermal stress
23 to 29	32 to 37	Slightly warm	Slight heat stress
29 to 35	37 to 42	Warm	Moderate heat stress
32 to 41	42 to 47	Hot	Strong heat stress
>41	>41	Very hot	Extreme heat stress

2.3.3. Thermal Modelling

The site was modelled using ENVI-met at four times: at summer solstice on 21 June, at winter solstice on 21 December, at spring equinox on 20 March, and at autumn equinox on 22 September. This covered the thermal stress throughout the year in the studied area. The analysis was extracted at a human height of 1.6 m. The focus was on the critical areas in which users gathered and the areas with climatic significance in terms of solar access and wind speed. Figure 3 displays the location of the receptors across the study area, where the thermal analysis focused on the unshaded area in open space 2 as it presented a critically high thermal load on users.

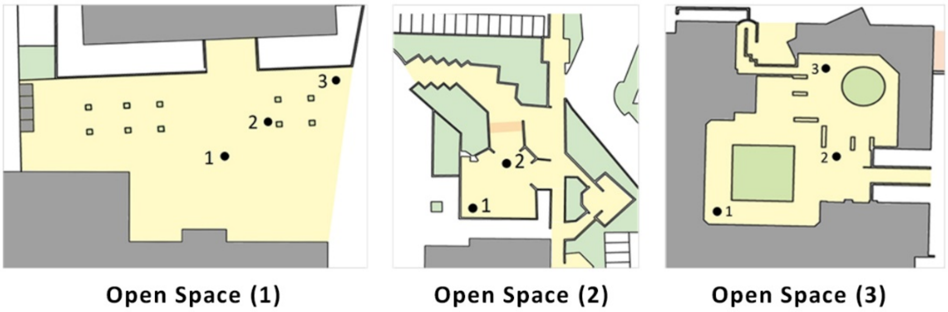

Figure 3. Receptors' locations in the study areas: open space 1 (**left**), open space 2 (**centre**), open space 3 (**right**).

The wind speed and direction were extracted from Meteonorm and set at south-east with wind speed of 2 m/s on 21 June, north-east with wind speed of 1.5 m/s on 21 December, south-west with wind speed of 4 m/s on 20 March, and north-east with wind speed of 2.5 m/s on 22 September. Table A1 (Appendix B) shows the initial meteorological data (air temperature, relative humidity), which were imported into ENVI-met for each season.

2.4. Questionnaire

To ensure the creation of rich and vibrant spaces, urban designers should work with users to foster social presence, celebrate multiculturalism, and enable livelihoods [54]. Designs based on students' preferences may increase their satisfaction and strengthen the positive values whilst they are using the spaces [9]. This can create sustainable characteristics of open spaces. Therefore, this study considered the viewpoints of the most common users of the open spaces in universities, namely, the students. A better understanding of student behaviour could allow us to identify and evaluate the benefits and drawbacks of students' experiences, which could serve as the foundation for university outdoor-space planning. The occupants' activities were recorded using a questionnaire to capture their behavioural preferences. The questionnaire was developed after a review of the literature on open-space design. After identifying the necessary elements, the study concentrated on issues that have a direct impact on the design of universities' open spaces. A preliminary set of 17 questions was derived from the literature and grouped into four dimensions: (1) student profile, (2) routine use, (3) attractive features, and (4) comfort features (Table 4). The students' responses were measured as descriptive statistics using SPSS to determine the uses and purposes of the spaces and users' satisfaction with them.

To determine the relationship between the students' attitudes and their outdoor-space preferences, a correlation analysis was performed. The responses were examined in relation to the three outdoor open spaces: 'open space 1', 'open space 2', and 'open space 3'.

Table 4. The questionnaire structure (dimensions, categories, and questions).

Dimension	Category	Questions
The student profile	Socio-demographic	Faculty
		Gender
		Level of study
The routine uses of the open spaces	Experiences in open spaces	How much time do you spend in university on a daily basis?
		How important is the use of courtyards for you?
		Which open space do you prefer in the university campus?
	Frequency	How often do you visit or spend time in the open spaces on campus?
		If you spend time in the university's open spaces, answer the following questions. When do you spend time in the open spaces on campus?
		How long do you usually stay in this place?
The attractive features of the open spaces	Student needs	Why do you spend time in this place?
		When you are in this place, how crowded do you find it to be?
	Physical features	What physical features in this place do you consider attractive?
The comfort features of the open spaces	Thermal satisfaction	How satisfied are you with the temperatures in the open space in which you spend the most time?
		When do you feel most unsatisfied in the open space?
		In warm/hot weather, how would you describe the temperatures in the open space?
		In cool/cold weather, how would you describe the temperatures in the open space?
		What would you describe as the source of this discomfort?

3. Results and Discussion

This study explored the primary influences on the quality of open spaces in universities from the perspective of students. The study objectives were achieved by means of (1) an urban layout conditions analysis of the space syntax to explore the logic behind the current planning; (2) a thermal conditions analysis to determine the microclimate conditions in the studied open spaces; and (3) a descriptive analysis of the research data derived from the online questionnaire to explore the students' experiences in the open spaces and capture their behavioural preferences. The data gleaned from this study are presented in three sections.

3.1. The Urban Layout Conditions Analysis

3.1.1. Visibility Graphs Analysis

According to the VGA of the academic section of the campus (Figure 4), there is a link between visual connectivity and integration value distribution. The most-integrated and best-connected area (red) is located on the ring road, between the open space in front of the architecture and engineering faculties (open space 1) and the staff parking for the pharmacy faculty, allied medical sciences, and business. This space is accessible and well-connected to other spaces on the campus. Open space 1 is also well-connected and well-integrated with the rest of the campus (yellow). This might be due to its accessibility from the ring road and its openness.

Spaces on the ring road are at least moderately integrated and connected (red, yellow, and green). This means the circulatory path in the campus has a high or moderate level of visual integration and connection with the rest of the campus, which is normal, as this path is supposed to link the buildings and facilities. The clustered open spaces in front of the law and IT facilities (open space 2) are also moderately integrated with and connected to (green) the rest of the campus, with the axial path being more integrated. The middle section of the academic area of the campus is the least integrated and least connected with the rest of the campus (blue, green). This includes the courtyard of the pharmacy and allied medical sciences faculties (open space 3). This segregation can be explained by the closed urban configuration of this space.

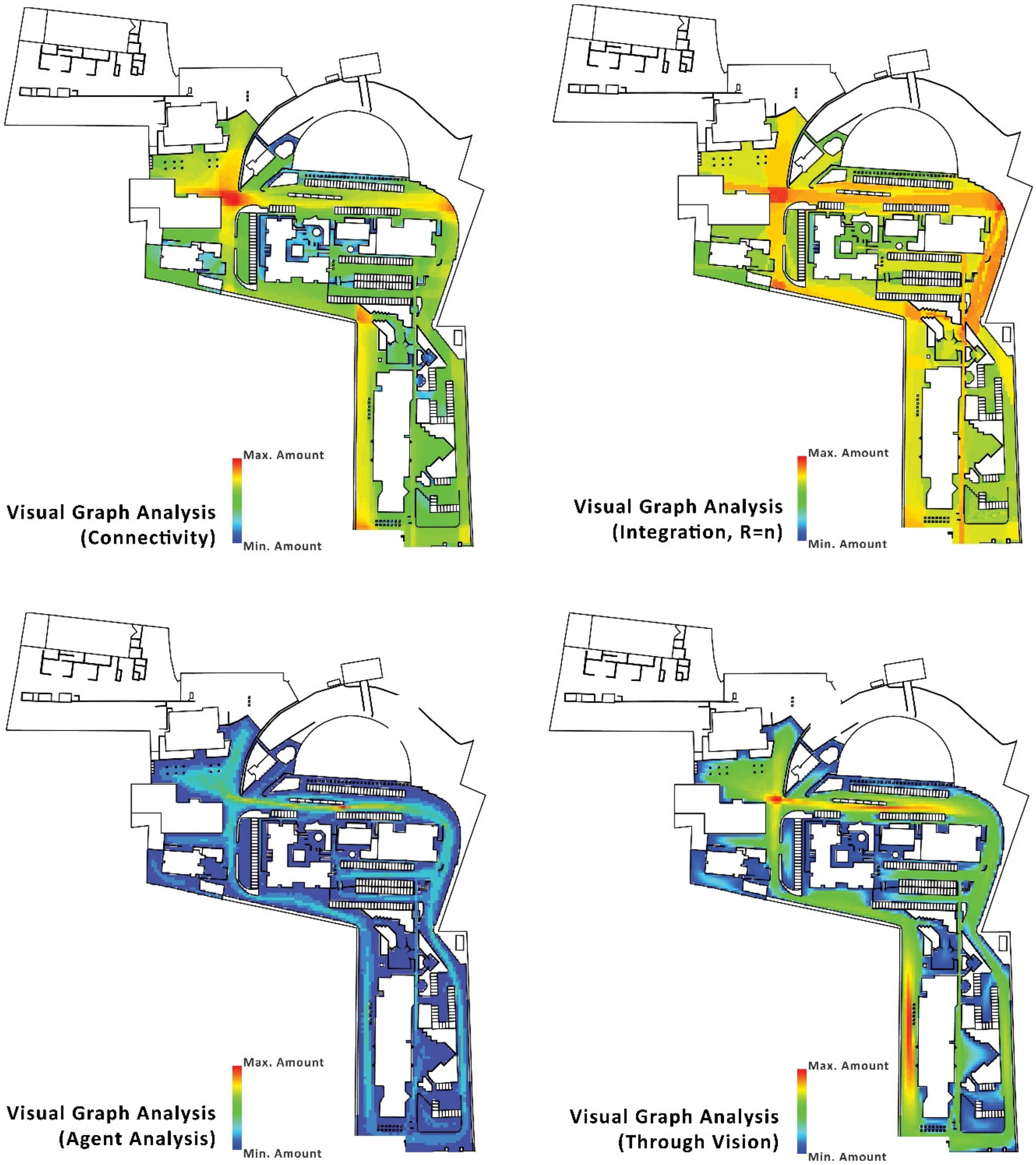

Figure 4. Visibility graph analysis (VGA) for the academic section of the campus.

The agent analysis of the academic section of the campus revealed the highest levels of movement in the axis linking the business school, the faculty of pharmacy, the faculty of applied science, and open space 1. This is because pedestrians prefer to walk towards larger spaces (open space 1) and towards long lines of sight. Findings of the through-vision analysis of the campus support the previous result, as the most defined visual fields are located on the axis with the most pedestrian movement and the axis linking the main gate and the faculties of IT and law. However, due to the lack of large open spaces along this axis, pedestrian movement is low.

The VGA for space 1 (Figure 5) indicates strong connectivity in the whole space and strong integration in the centre (red, yellow). The openness and lack of obstacles in the space allow for this strong visual connection and integration. The agent analysis of space 1 revealed a hierarchy in the level of movement. In the heart of the space, there is a large amount of movement by people (red, yellow). The number of people decreases towards the edges, where there is the smallest amount of movement (blue). This hierarchy is also noted in the through-vision analysis, where the longest lines of sight are located in the centre of the space; this explains the heavy movement in this particular section.

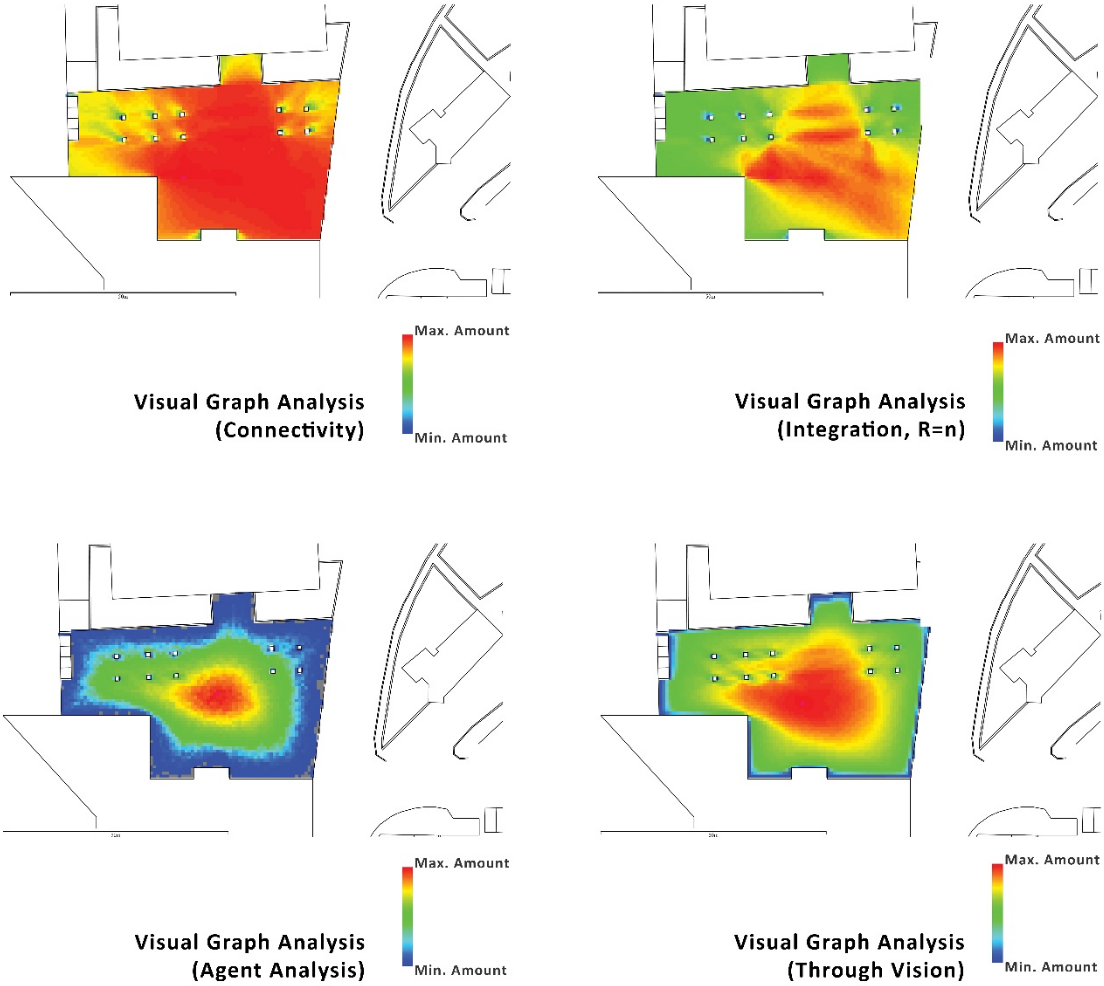

Figure 5. Visibility graph analysis (VGA) for open space 1.

The VGA for space 2 (Figure 6) revealed that the most visual connectivity and integration occur in the spine connecting the clustered gathering spaces (red, yellow), especially in the zone that opens up to the largest gathering area (red). The largest gathering area is the best-connected and most-integrated with the rest of space 2. The second largest gathering area has a moderate level of connectivity and integration with other parts of space 2 (green). This can be explained by the barriers (walls) that separate most of this space from the main axial path. The smaller clustered areas are less spatially connected to their immediate context (green, blue), as these spaces are more enclosed. The difference in the visual connectivity and integration of the different parts of space 2 could create some imbalance in the occupancy rates for the clustered areas. Moreover, this lack of continuity between the spaces creates weak spatial structure.

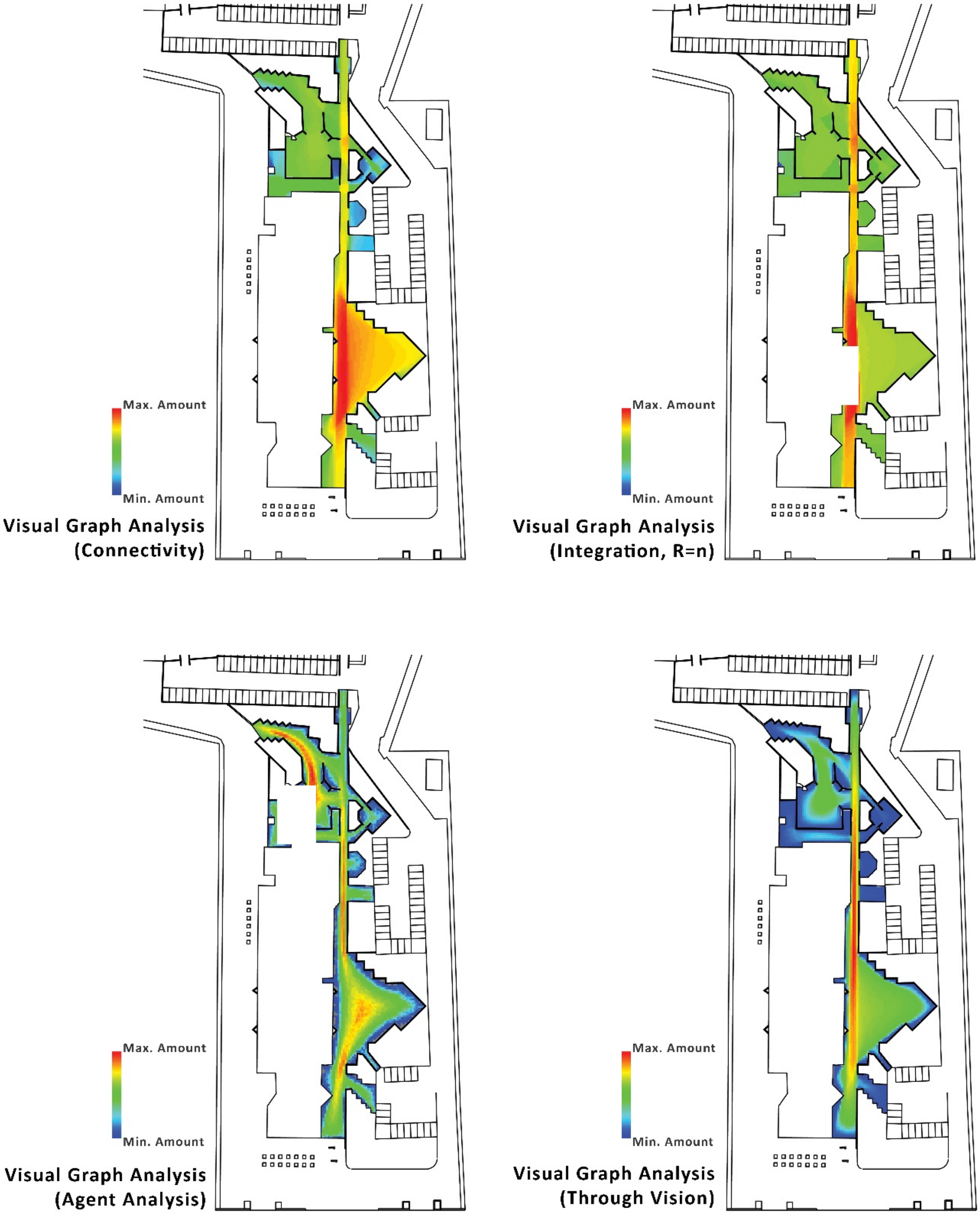

Figure 6. Visibility graph analysis (VGA) for open space 2.

According to the agent analysis, students tend to use the main axial path, rather than being circulatory, due to the better visual fields shown in the through-vision graph. The two largest gathering areas also show a high volume of movement, particularly in the centre, where lines of sight are longest. The smaller clustered areas have low visibility, which could explain the minimal movement between them (blue).

Open space 3 has an enclosed courtyard spatial configuration, and the VGA (Figure 7) shows that most of this space has a strong level of visual connectivity and integration, largely occurring in the centre (red, yellow). The entrance to the courtyard, however, is visually segregated from the space (blue), making it more difficult for users to locate. It is also noted that most movement in open space 3 occurs in the centre, where there are longer lines of vision (red, yellow). The through-vision analysis shows that vegetated areas in the space create a visual barrier, leading to moderate visibility in the areas surrounding the vegetation (green). At the entrance of open space 3, visibility is low (blue) due to the built barriers (walls) that leave limited lines of sight.

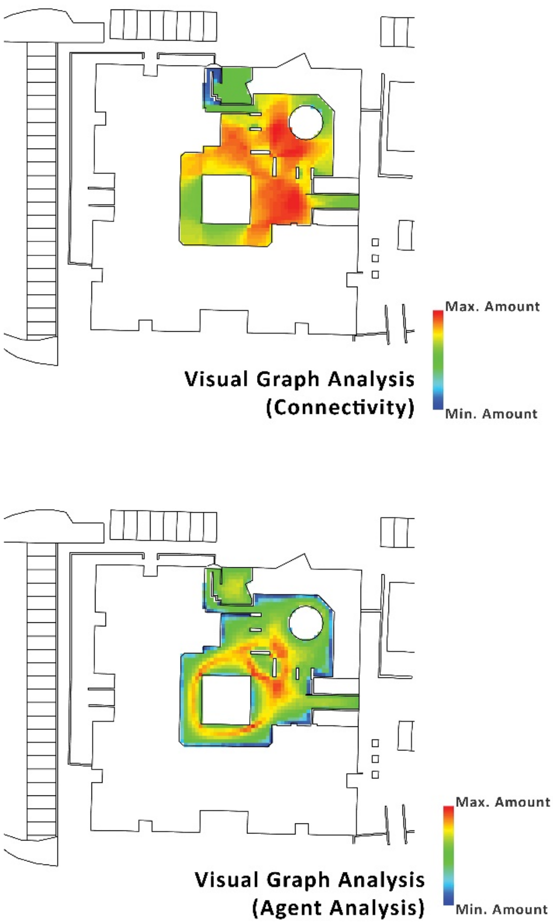

Figure 7. Visibility graph analysis (VGA) for open space 3.

3.1.2. Axial Map

Travel towards the axis is the best way to move and it is the way people move instinctively, so that the axis has the double significance of a line of sight and a state of motion. The higher the connectivity value of the space, the better the space permeability in the practical space systems. According to the axial map (Figure 8), there are two major groups of connectivity lines for the academic section of the campus (red): first, the axial path that starts from the main gate, continues through open space 2, and terminates at the staff parking in front of the business school, and second, the path between the parking space, in front of the pharmacy faculty and open space 1. These lines are characterised by their length. Open space 3 shows low axial connectivity (blue).

The integration in the axial map illustrates the accessibility of any space from all other spaces in the system. The higher the value of integration of an axial line, the greater the accessibility from all other segments. The axial map highlights a major line that is the most-integrated and best-connected, which is the axial path that starts from the main gate, continues through open space 2, and ends in the section of the ring road next to the business school (red). Due to the dominant position of this path (in terms of accessibility), it has far stronger social functions than the other parts (clusters) of open space 2 (green, blue). The zone between the business school and pharmacy faculty staff parking and open space 1 also shows strong axial integration values (yellow). Open space 3, however, shows moderate integration values (green).

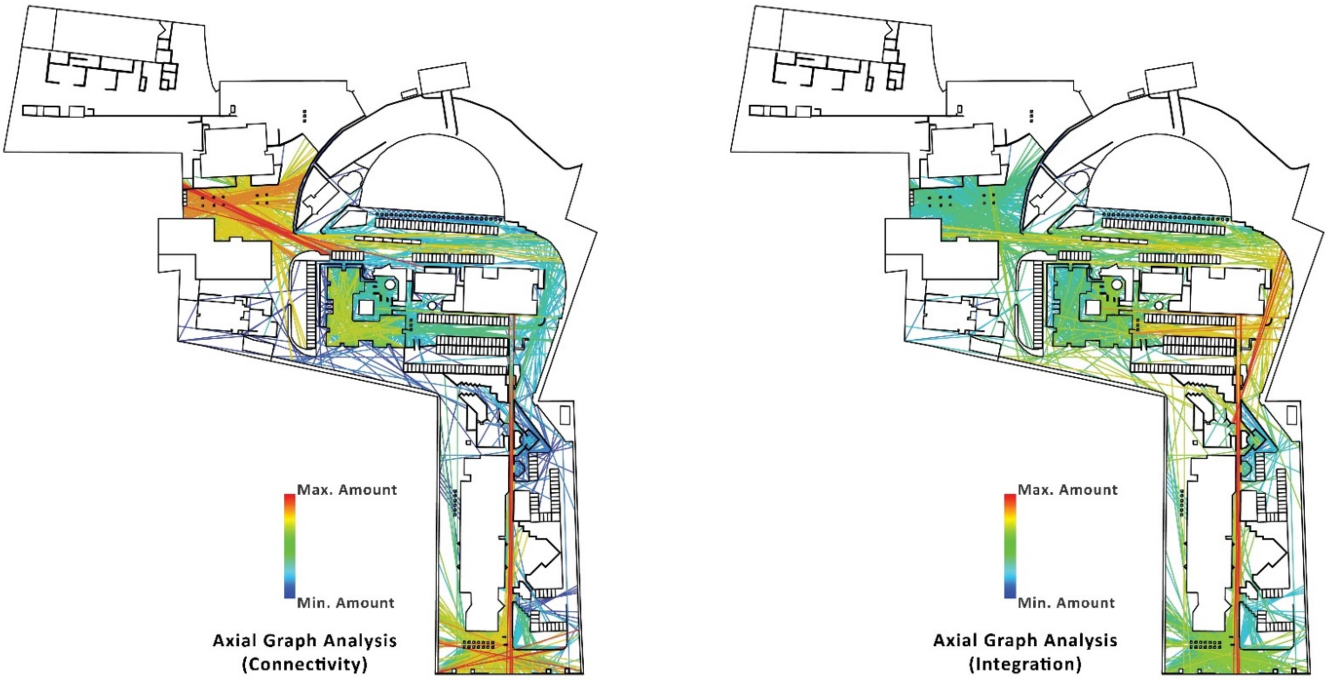

Figure 8. Axial map for the academic section of the campus.

3.2. The Outdoor Thermal Conditions Analysis

3.2.1. Open Space 1

The PET values differ in the studied scenarios due to the intensity and access of the solar radiation throughout the day in the examined receptors (Figure 9). In summer, there were a total of just 6 h of 'comfort perception' amongst the users, and the period of 08:00 to 17:00—when users occupied the courts—fell completely outside of the comfort zone. This is due to the lack of shading elements and adequate vegetation in the centre of the court. The PET values are noticeably lower in receptor 3, due to the lack of direct solar radiation and shading elements above the benches. However, the thermal sensation did not reach the comfort range due to the high reflected solar radiation emitted from the adjacent building's glazed facade (Appendix A, Figure A1). In winter, the PET values all fall below the comfort range due to the low intensity and access of solar radiation during the season. The highest direct solar radiation reached in winter was 742 W/m^2, compared to 1057 W/m^2 in summer, and consequently the reflected solar radiation was reduced. It should be noted that the total solar access through direct radiation was reduced to 3 h a day in winter, which also contributed to lowering the PET values (Appendix A, Figures A2–A4).

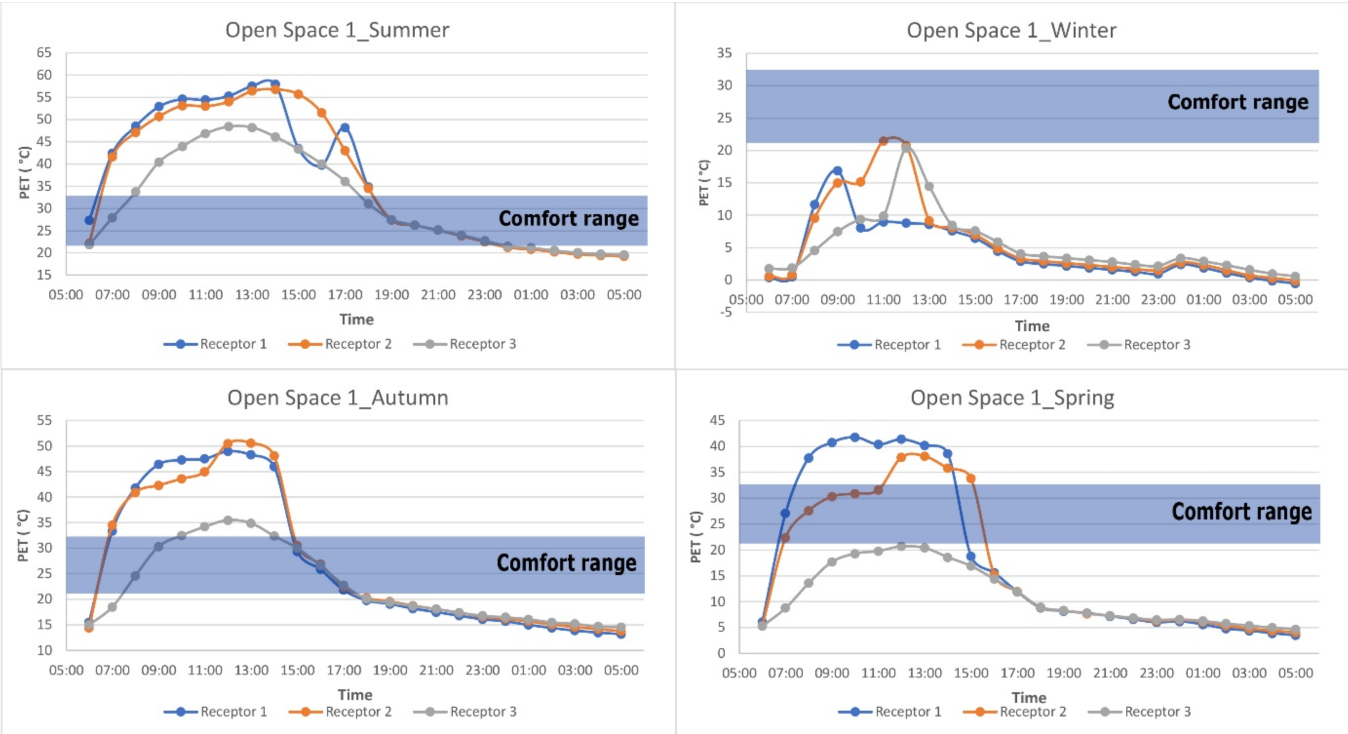

Figure 9. Open space 1 physiological equivalent temperature (PET) values throughout the year.

In autumn, the PET values that fell outside of the comfort zone were limited to just 3 h in receptors 1 and 2, with 5 h in receptor 3. Unlike in winter, the autumn simulation results showed favourable PET values during the period in which students occupied the studied area. However, between 10:00 and 14:00, the comfort conditions were not met, due to high solar access of 8 h and seasonal temperature lag. The autumn simulation produced the best thermal comfort conditions in the studied area throughout the year. In spring, users of open space 1 felt slightly cold under complete shade and warm under direct solar radiation. This is due to the seasonal temperature lag that means the ground is warming up from the cold winter. There was a noticeable drop in PET values between the hours of 09:00 and 11:00 in receptor 2, compared to receptor 1, despite the close proximity of the receptors, due to the palm trees planted right above receptor 2 that cast a small, shaded area during those hours.

3.2.2. Open Space 2

In open space 2, a considerable amount of vegetation surrounds the setting area, and consequently, the resulted PET shows a significant drop in values when compared to open space 1 (Figure 10). In summer, there were a total of 7 h of comfort perception reported by the users in receptor 1, with 9 h in receptor 2, with only 2 h falling within the students' occupying time due to high solar radiation of 1055 W/m^2 during the hours of 08:00 to 12:00 at receptor 1 (Appendix A, Figure A5) and of 1043 W/m^2 during the hours of 12:00 to 15:00 in receptor 2 (Appendix A, Figure A6). In winter, receptor 1 was completely covered by shade generated from the surrounding vegetation, whilst receptor 2 had 3 h of direct solar radiation that raised the PET values to the comfort range.

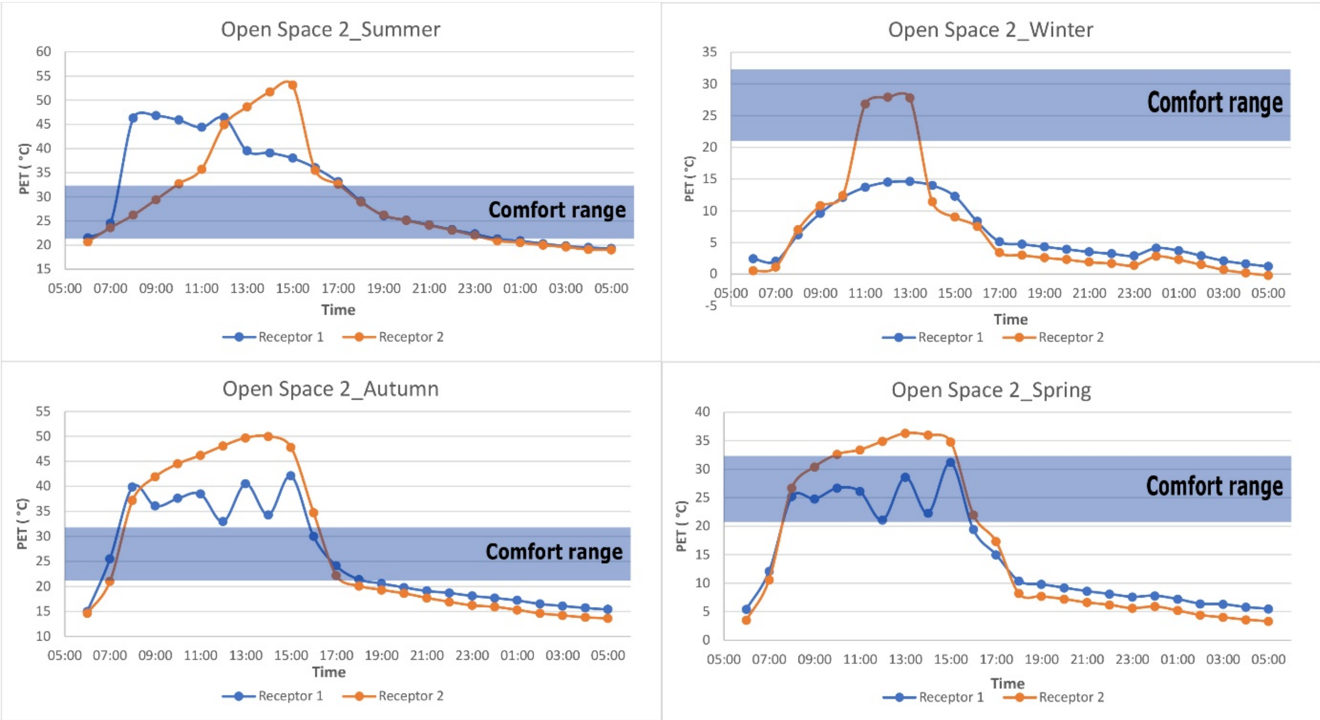

Figure 10. Open space 2 physiological equivalent temperature (PET) values throughout the year.

In autumn, the PET values show high-level thermal sensation due not only to seasonal lag but also to high solar access. Figure 10 shows a fluctuation in the PET values at receptor 1, due to the close proximity of the receptor to the trees, where shading differs according to the sun angle. There was a total comfort duration of 3 h at receptor 1 and 1 h at receptor 2. In spring, the PET values fall within the comfort range during the hours of 08:00 to 15:00 around receptor 1, due to lower solar intensity caused by the shade from the trees, where receptor 2's location is exposed to higher solar radiation intensity and access, causing higher PET values.

3.2.3. Open Space 3

The PET values in open space 3 are noticeably lower than those around open space 1, due to the larger height-to-width (H/W) ratio in open space 3, where the area is mostly shaded throughout the day. The H/W ratio for open space 1 is 0.4 and for open space 3 ranges between 0.64 and 0.94. In summer, the PET values are above the comfort range during the hours of 10:00 to 17:00, with receptor 2 showing the highest PET values due to a higher sky view factor (SVF) of 0.42, which left the area more exposed to diffused and direct solar radiation (Figure 11). However, the comfort perception was between 'warm' and 'slightly warm' under shade, especially for receptor 3, where the SVF is 0.05. The comfort range duration was limited to 7 h at receptor 1, 9 h at receptor 2, and 11 h at receptor 3.

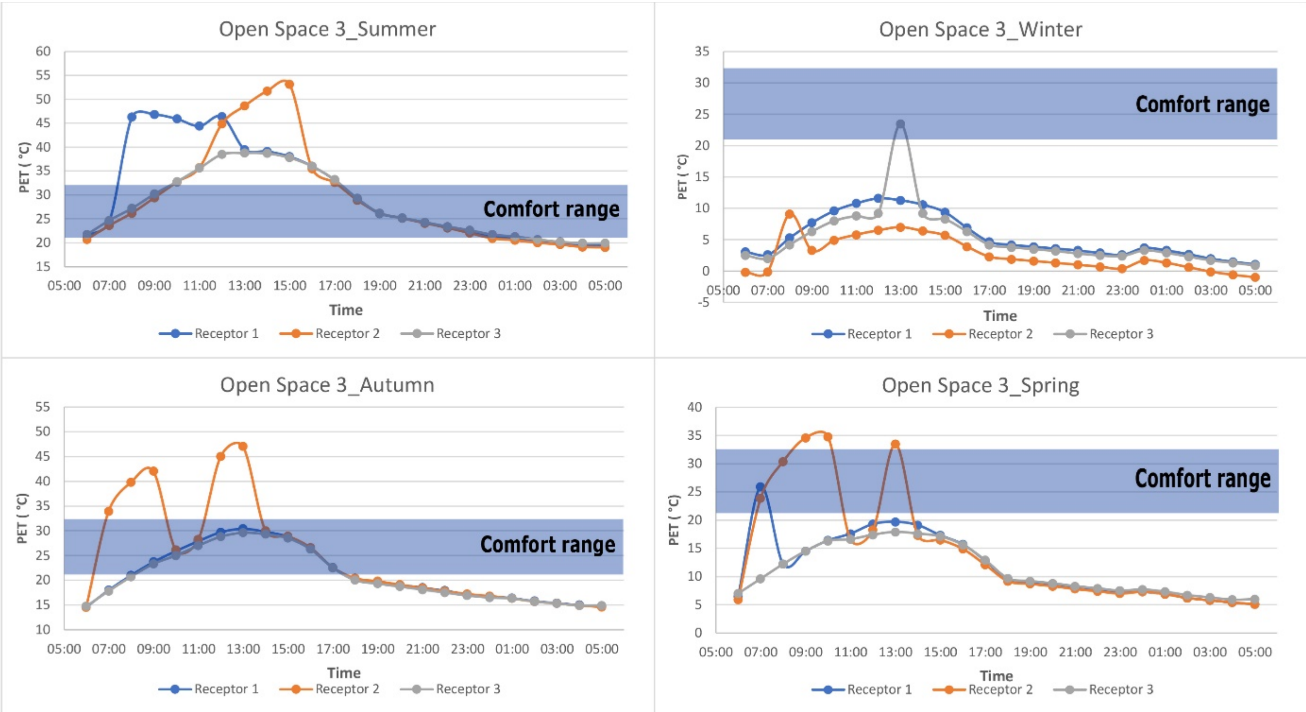

Figure 11. Open space 3 physiological equivalent temperature (PET) values throughout the year.

In winter, the solar access was limited to 1 h at receptor 2 at 08:00 and 1 h at receptor 3 at 13:00; thus, the PET values were below the comfort range. In autumn, the PET values largely fell in the comfort range during the occupied hours, except for a few hours in receptor 2's location, when solar radiation was present. The total comfort duration was 9 h at receptors 1 and 3 and 6 h at receptor 2. In spring, the majority of PET values fell below the comfort range due to the seasonal temperature lag and the lack of direct solar access to the receptors. In the few instances where PET values were within or above the comfort range, direct solar radiation was present, which deterred users from using the shaded area. The total comfort duration was 2 h at receptor 2 and 1 h at receptor 1.

3.3. The Students' Observation and Behaviour Analysis

The online questionnaire was disseminated during the spring semester (March to May 2021) to students from the nine AAU faculties. The analysis results are presented in the form of percentages, and a correlation analysis was conducted to evaluate the significance and strength of the relationships between the items in the questionnaire. Of the 336 students who responded, 52.7% were male and 47.3% female, with 37 from each faculty. Each student provided information about their academic year, indicating that 122 were in their third year, 155 in their fourth, and 63 in their fifth. The findings of the questionnaire reveal positive significant correlations ($p < 0.05$) between the following variables: time spent in university, time spent in open space, frequency of time spent in open space, when in open space, preferred open space, and location of open space. Negative significant correlations were observed between preferred open space, thermal satisfaction, and crowdedness (Appendix C, Table A2).

Regarding the location of the open space, it was noted that 92% to 100% of the students of architecture, engineering, art, and sciences used open space 1. These faculties surround this open space. Approximately 65% of the law and information technology students used 'open space 2', which is closer to the location of their faculties. In addition, more than half (55%) of the pharmacy and applied medical sciences students frequently used 'open space 3', which is closer to the location of their faculties. Thus, it appears that the location of the open space is closely correlated with student preferences: specifically, the closer the faculty is to the open space, the more preferable the open space is deemed to be. However, 'open space 1' was the most preferable, with more than 65% of all students primarily using this space. The other two were preferred by the rest of the students (Figure 12). The average values pertaining to the students' views of their 'open-space experiences' are shown in Table A3 (Appendix C).

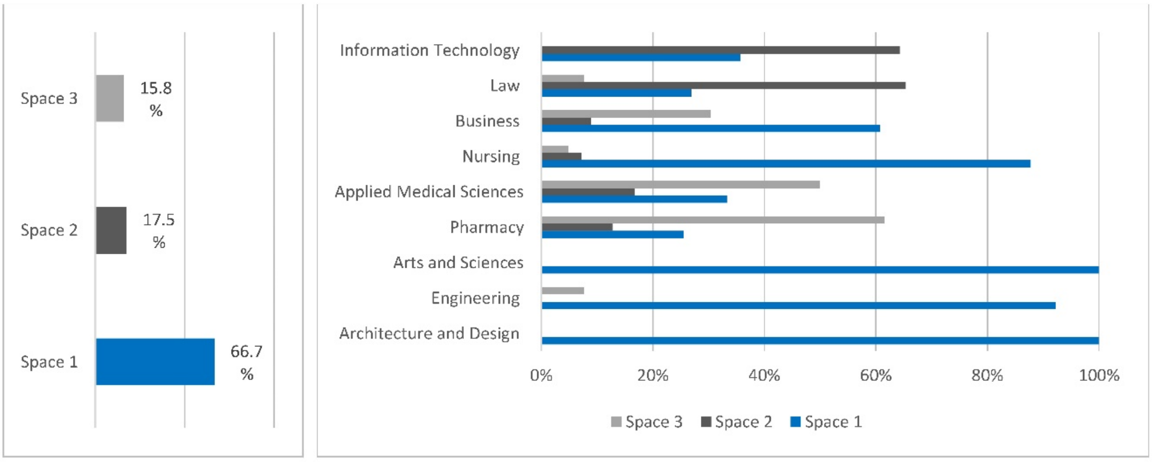

Figure 12. Preferred open space in the university campus.

3.3.1. The Routine Uses of the Open Spaces

Most of the students (84%) said they spent more than 4 h per day in the university, with 43.5% spending 6–7 h due to their busy schedules. In addition, 83% of the students said that open spaces were important or very important in their daily lives. Most (69%) said they used the open spaces on a daily basis, and 67.7% preferred 'open space 1' (Figure 13). In addition, 68% of the students used open spaces between 11:00 and 14:00, with 69% using 'open space 1'. Nearly half of the participants (47%) said they spend 30–60 min in the open space, enjoying their 1 h daily break. This usage-frequency pattern reveals the value of the open spaces for students during their break times.

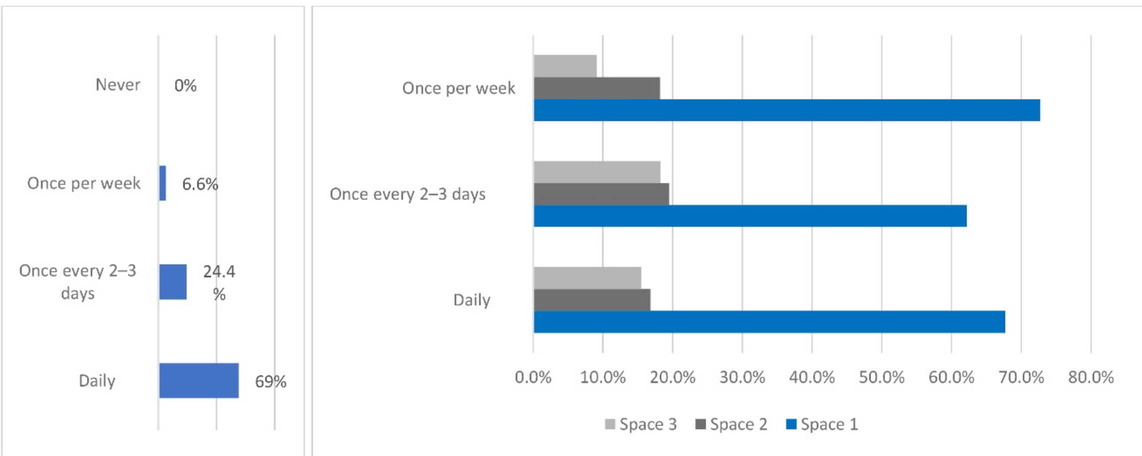

Figure 13. Respondents' opinions about the routine use of open spaces.

3.3.2. The Attractive Features of the Open Spaces

Previous studies have considered the attractive features of university open spaces in terms of student needs, with a focus on the physical features of the open spaces [3,6,7,9]. From the point of view of the students, social and interaction activities during break times are the primary functions of the open spaces. The students spend time in the open spaces for three primary reasons: socialising (84.2% of the students), eating and drinking (77.4%), and relaxing (64.3%). Some 38% of the students said they visit the open spaces to attend activities, and less than 30% said they use them for studying. Open space 1, the most-favoured of the three, was described by 58.3% of the respondents as partially crowded most of the time. This aligns with the finding that students primarily use the open spaces for social and interaction activities.

The results show that, for students, the most attractive features are the seating (51.2%) and the shade and rain shelters (41.4%). The surrounding buildings and facilities—such as the departments and kiosks—were preferred by approximately 40%. Accessibility was considered an attractive feature by 38.4% of the students. Although the seating is limited in open space 1, this was not cited by the students as a problem. This is consistent with the findings of another study, which found that the amount of seating had a minor impact on the number of people present and may even be considered irrelevant in terms of open space use. In contrast, the quality and location of the seating—which are controlled by climatic elements such as temperature and sunlight—were discovered to have a significant influence on whether the seating was used [14]. In addition, the results indicate that greenery is not found in many of these spaces. In addition, there is no space for group discussion nor any central space for performance. The design elements (colour, texture, etc.) in these spaces are not considered attractive. Moreover, the requirements of handicapped people are not respected in the design and layout of these spaces.

Further analysis of the results reveals that open space 1 has the most highly favoured physical features, with a central space for performance, greenery, places for group discussion, and seating (Figure 14). Open space 3 was ranked the lowest for its surrounding buildings, with only 11.2% of the students regarding them favourably. This is because this open space functions as a court and is surrounded by buildings on all four sides. High-density surroundings may limit the size of an open space and impede circulation and accessibility in a compact court, whilst a small open space may provide its users with more intimate contact and natural restorative elements, as well as a more controllable microclimate for physical comfort [55].

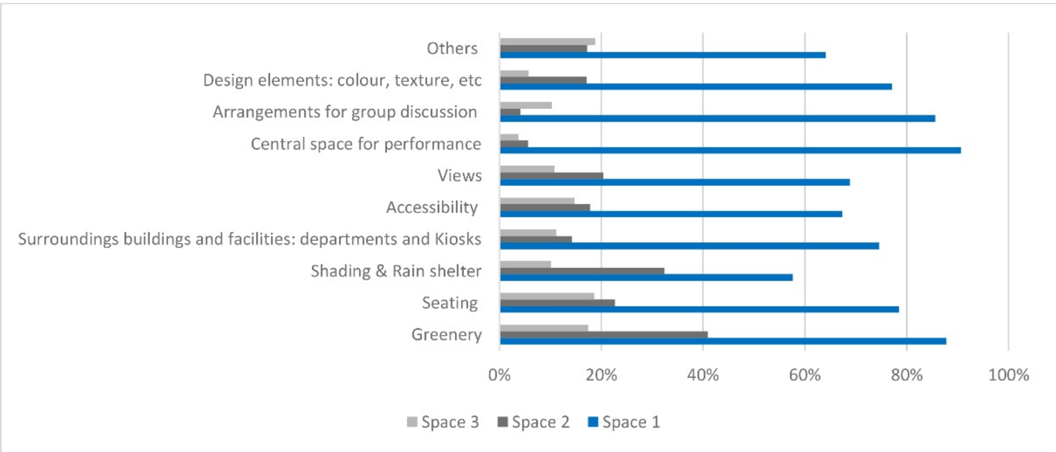

Figure 14. Respondents' opinions about the physical features of the open spaces.

3.3.3. The Thermal Environment of the Open Spaces

The impact of thermal comfort on outdoor activities is complex and concerns both climate and behaviour, but there is currently no general assessment framework in the literature [21]. When considering outdoor thermal sensations of human beings, it is necessary to include the following variables: air temperature, solar radiation, humidity, air velocity, and heat conduction [23]. Studies have revealed that strong sun radiation gives the sense of heat, that a strong wind gives the impression of coolness, and high humidity gives the feeling of being unpleasantly warm [23]. Temperature, solar radiation, and wind speed are thus shown to be the most significant factors. Of the respondents in this study, only 19% were satisfied with the temperatures in the open space in which they spent the most time (Figure 15). However, it seems that although the thermal conditions are not comfortable in the open spaces, the students are nonetheless happy to use them. These open spaces are most thermally unsatisfactory in the middle of the day (11:00–14:00), when most of the students (68%) reported being there.

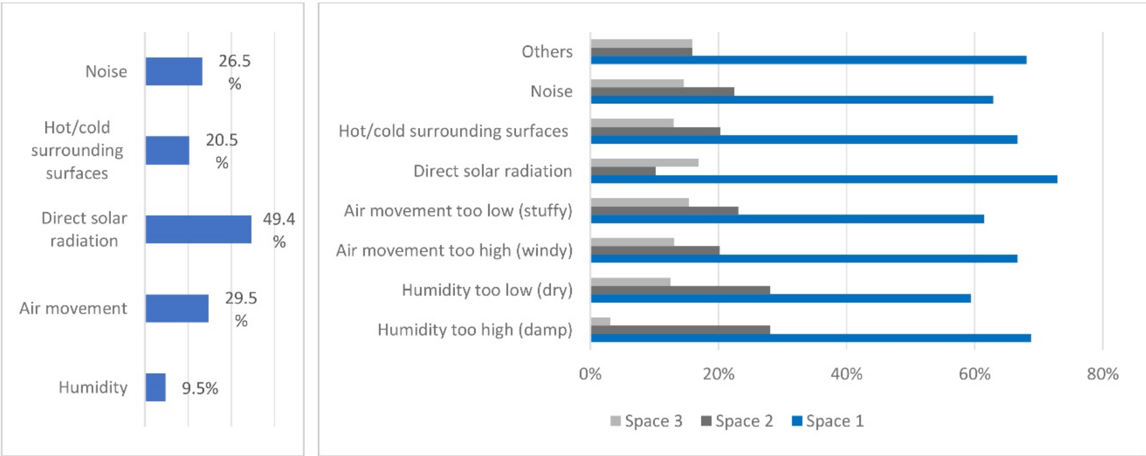

Figure 15. Respondents' opinions about the discomfort features of the open spaces.

More than half of the students (53.2%) described the open spaces as always or often too hot during summer, and only 15.8% said that the temperature was neutral. Similar percentages were recorded for winter: the open spaces were described as always or often too cold by 53.6% of the respondents, with just 15.2% reporting a neutral temperature. Almost half of the students (49.4%) felt that direct solar radiation was the key source of the discomfort. Significantly, 73% of the users of open space 1 recorded that this was the major source of discomfort. However, in open space 2, just 10.2% reported direct solar radiation, due to the presence of shading elements. Other sources of discomfort were related to air movement (20%), the surrounding surfaces (20.5%), noise (26.5%), and humidity (9.5%). Open space 3 recorded the least air movement (14%), as this open space functions as a court and is surrounded by buildings on all four sides.

Open space 1 was deemed the noisiest court (highlighted by 62.9% of the students) and is crowded most of the time. Although this was described as the space of most sources of discomfort, it was also the most-commonly used of the spaces. Unsurprisingly, as the most-commonly used space, open space 1 was also described as the noisiest and most crowded of the three

3.4. Overall Findings: Most Comfortable and Favourable Conditions of Outdoor Open Spaces

This section illustrates the significant findings from the study, showing the primary contributors to the quality of outdoor open spaces and the meaning of such spaces from the perspective of their users. The results of the space syntax analysis show that, of the three open spaces, the space with the lowest level of enclosure (open space 1) has the best visual connectivity and strongest integration with the rest of the academic section of the campus. The enclosed courtyard (open space 3) has the least visual connectivity and integration (visual segregation). For open space 2, the axial path was the most visually connected and best integrated. The clustered spaces around this path have low visual connectivity and are poorly integrated with the rest of the academic section of the campus (Table 5). The axial map results confirm the VGA results, indicating that the zones with the highest levels of axial integration and connection were open space 1 and the axial path of open space 2. These spaces were the most accessible and permeable.

The research results highlight an inverse link between visibility and the use of open areas in the campus setting, as open space 1 was the most-used space and open space 3 was the least-used. This is supported by literature, as space configuration plays a crucial part in visibility, which as a result affects space use [36,38]. Moreover, the visual integration and connection of the open spaces with the rest of the campus has a greater impact than weather conditions on their use. In conclusion, this study found that the visual factors and spatial configuration greatly influence the use of public open areas. Visibility is therefore an important factor to consider in the design of a campus. The age group of campus users plays a crucial part in these findings as previous research found a statistically significant correlation between user group and user preferences [8,9].

Table 5. Summary of the major space syntax findings for the three open spaces.

Area	Visibility Graph Analysis		Axial Map Analysis	
	Connectivity	**Integration**	**Connectivity**	**Integration**
Open space 1	High/moderate	High	High	Moderate
Open space 2	Moderate/low	High/moderate	High in axial path Low in clustered spaces	High in axial path Low in clustered spaces
Open space 3	Low	Moderate	Low	Moderate

Recent literature shows that the users' 'thermal perceptions' in the various open spaces are affected by different factors, including the time of the year [56,57], shading elements [27,28], vegetation placement [58,59], and building-facade materials [29,60]. In open space 1, the lack of shading elements and high levels of solar radiation—both directed by and reflected off the buildings—raised the PET values, whilst autumn saw favourable thermal conditions during usage hours. Receptor 3 is located under shade, which lowered the PET values during summer and autumn, but it also lowered the PET values for winter and spring, which influenced thermal perceptions and brought them under the comfort level. In open space 2, the vegetation that surrounds the setting lowered the PET values during the hot seasons. Spring saw the most favourable thermal perceptions, due to the fluctuations in shade produced by the nearby trees. In open space 3, the PET values were lower than those of open space 1, despite the site's lack of vegetation. However, the buildings' geometry helped by shading most of studied area during the day, which significantly reduced the thermal stress generated by solar radiation, where the H/W ratio ranged between 0.64 and 0.94. Autumn had the best PET values overall, with 6–9 h of comfortable thermal stress. Table 6 presents a summary of the findings on thermal comfort duration for all three open spaces.

Table 6. Summary of thermal comfort duration for usage hours (08:00–17:00) and out-of-usage hours for all open spaces.

Area	Seasons	Summer			Winter			Autumn			Spring		
	Receptors Number	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Open space 1	Usage hours	0	0	0	0	1	0	3	3	5	0	4	0
	Out of usage hours	6	6	8	0	0	0	0	0	0	1	1	0
Open space 2	Usage hours	0	2	-	0	3	-	2	1	-	7	3	-
	Out of usage hours	7	6	-	0	0	-	1	0	-	0	0	-
Open space 3	Usage hours	0	2	2	0	0	1	9	6	9	0	1	0
	Out of usage hours	7	7	9	0	0	0	0	0	0	1	1	0

Understanding how students use, view, and interact with the university's outdoor spaces is critical for assisting campus design. This study identified the areas on campus in which students tend to spend their time, investigated their perceptions and satisfaction levels, and drew conclusions on the characteristics of these areas. As illustrated in Table 7, an examination of the routine use of the open spaces (including consideration of the students' preferred locations, the frequency of their visits to the locations, and the time spent in them) found that open space 1 was the most satisfactory area for the students.

The findings on the perceived attractiveness of the open spaces—taking into consideration the students' needs and the spaces' physical features—indicate that open space 1 is the most-favoured. In addition, the students reported open space 1 to be the most favourable in terms of thermal conditions.

Table 7. Summary of students' satisfaction based on their experience of the three open spaces.

Area	The Routine Uses of the Open Spaces	The Attractive Features of the Open Spaces	The Thermal Comfort of the Open Spaces
Open space 1	70.8%	65.8%	66.4%
Open space 2	16.7%	21.7%	17.5%
Open space 3	12.5%	12.6%	16.1%

The study concludes by stating that, to boost student satisfaction and promote alternative social activities outside of class hours, it is vital to consider the needs and preferences of the students. Several studies have come to the same conclusion [4,9,18,20,21]. This shapes the meaning and significance of open spaces from the students' perception. Therefore, to improve the current situation and provide data to support future designs, the requirements for high-quality open spaces on campus must be defined, considering the students' expectations of the outdoor open spaces; in other words, the meaning and function of such areas, as seen from the perspective of the students themselves. Context-related aspects (e.g., design and climate conditions) can then be included when designing and planning outdoor places. In addition, the physical features that enhance thermal conditions must also be a priority.

4. Conclusions

The outdoor open areas on the university campus give information on the environment of university students' lives. Open space attracts and retains students by providing them with the opportunity to connect and interact with one another. This study explored the major determinants of quality and significance of open spaces in universities, as seen from the perspective of the students themselves, and prioritised them in order of importance.

The first step was to map student preferences for outdoor campus spaces, highlighting those places selected by the students for regular activities. The study then classified the outdoor spaces in terms of their meaning to the students, taking into account the users' needs and behaviour and associating these with the urban layout, the physical features, and the outdoor thermal conditions. There was an examination of the students' preferences for the urban layout (accessibility, spatial organisations, views); physical features (seating, shading and rain shelter, surrounding buildings and facilities, landscape, greenery, areas for groups, design elements (colour, texture, etc.)); the outdoor thermal perceptions (air temperature, solar radiation, relative humidity air speed); as well as the students' needs and behaviour (socialising, eating and drinking, relaxing, attending activities, exercising/walking, studying).

This study's findings could help to establish performance criteria for developing new open spaces and upgrading the existing provision. The outcome of the study was a framework for university planners, enabling predictions of the impact of outdoor open-space design on students' perspectives, as illustrated in Figure 16.

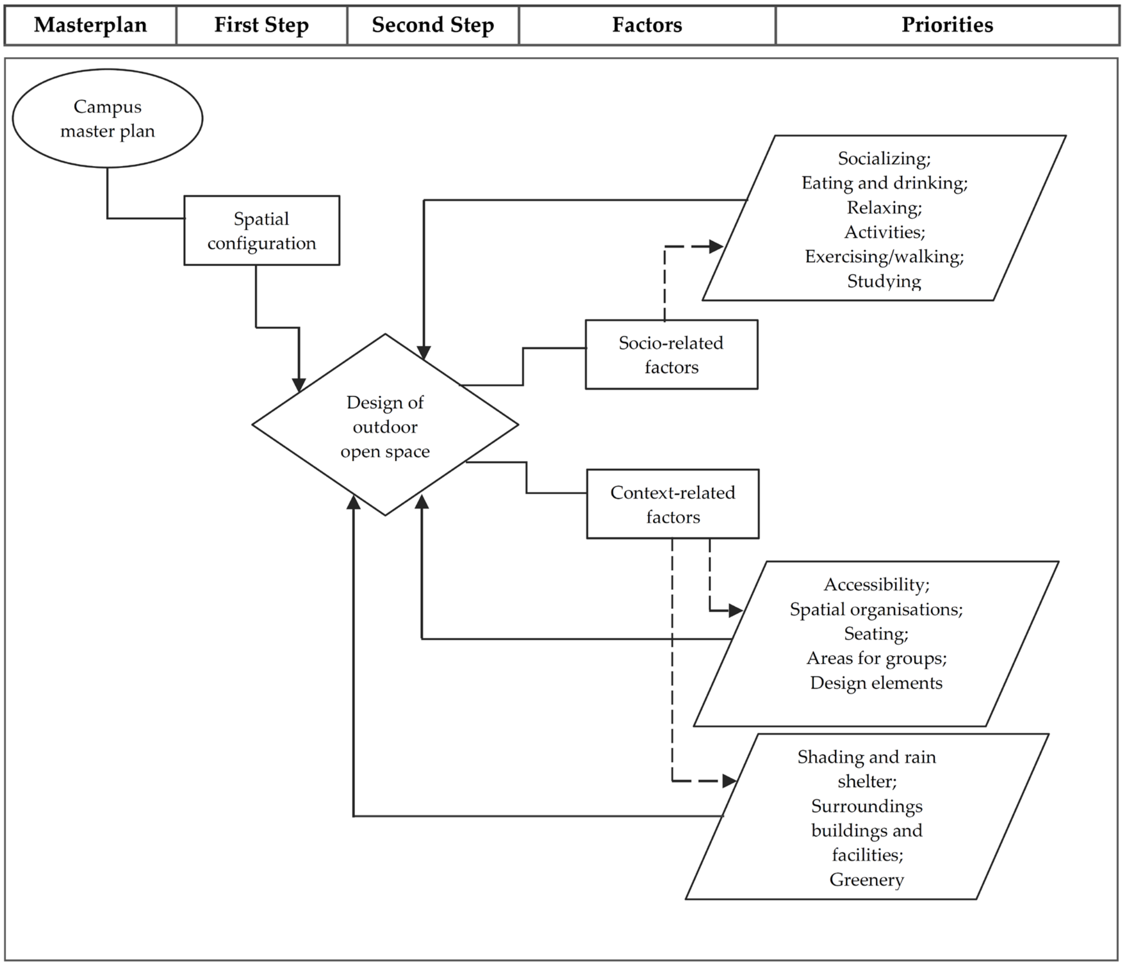

Figure 16. General framework for outdoor open spaces on campus from students' perspectives.

Author Contributions: Conceptualization, S.A.; methodology, S.A.; software, S.A. and Z.A.-S. (Space Syntax), Y.A. (ENVI-met); validation, S.A., Z.A.-S. and Y.A.; formal analysis, S.A.; investigation, S.A., Z.A.-S. and Y.A.; resources, S.A., Z.A.-S. and Y.A.; data curation, S.A., Z.A.-S. and Y.A.; writing—original draft preparation, S.A.; writing—review and editing, S.A., Z.A.-S. and Y.A.; visualization, S.A., Z.A.-S. and Y.A.; supervision, S.A.; project administration, S.A.; funding acquisition, S.A. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available in Appendices A–C.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Appendix A.1. Solar Radiation in Open Space 1

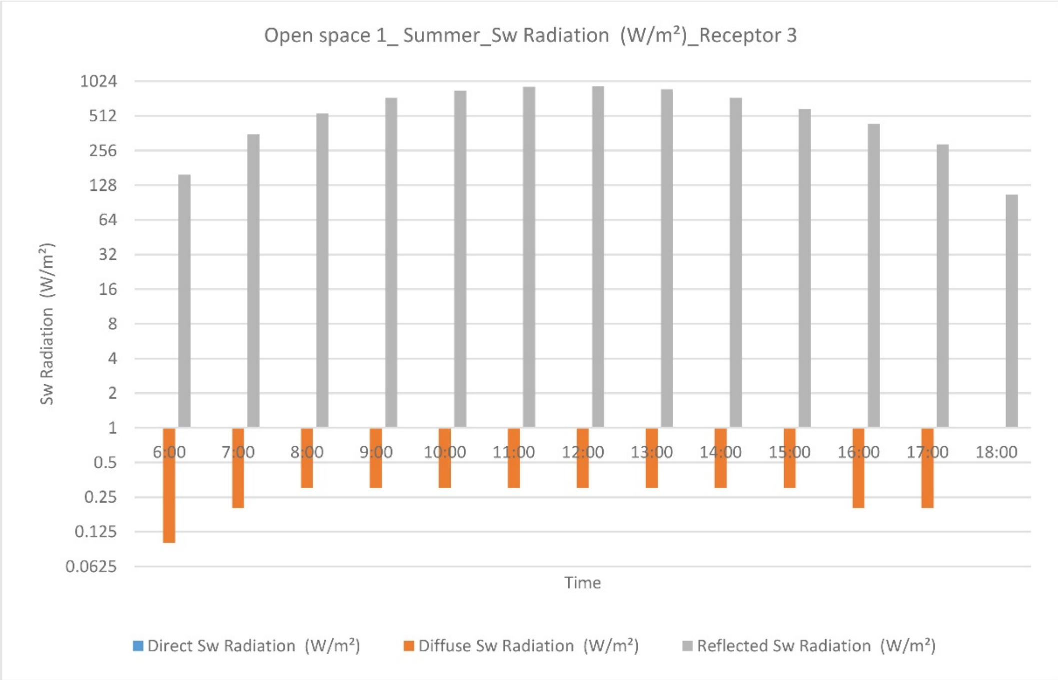

Figure A1. Open space 1 solar radiation in summer at receptor 3.

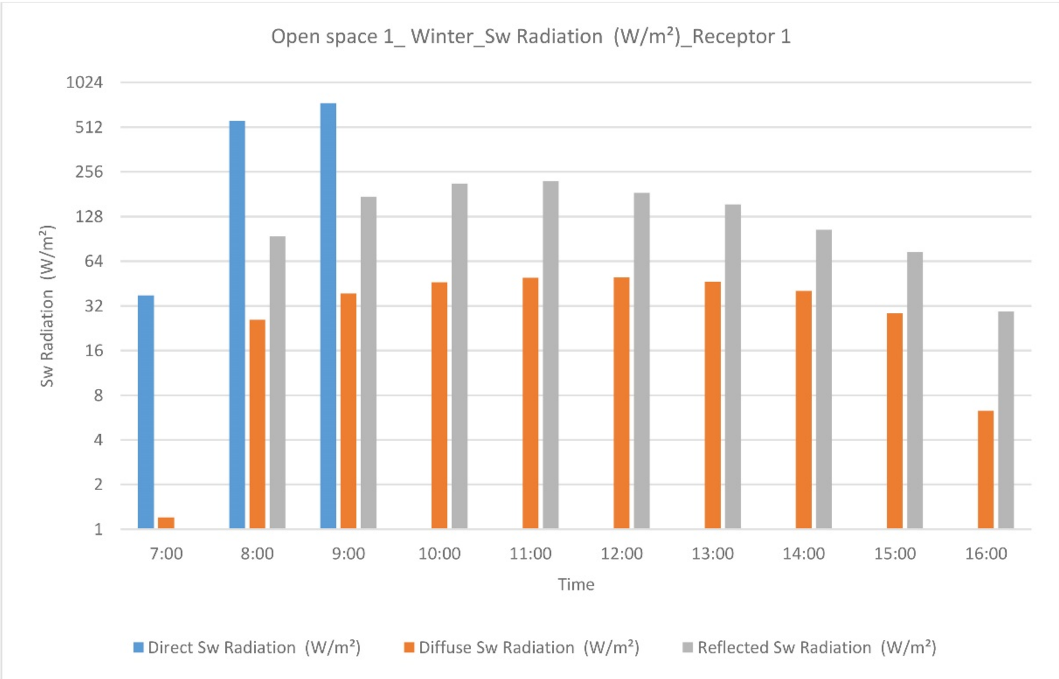

Figure A2. Open space 1 solar radiation in winter at receptor 1.

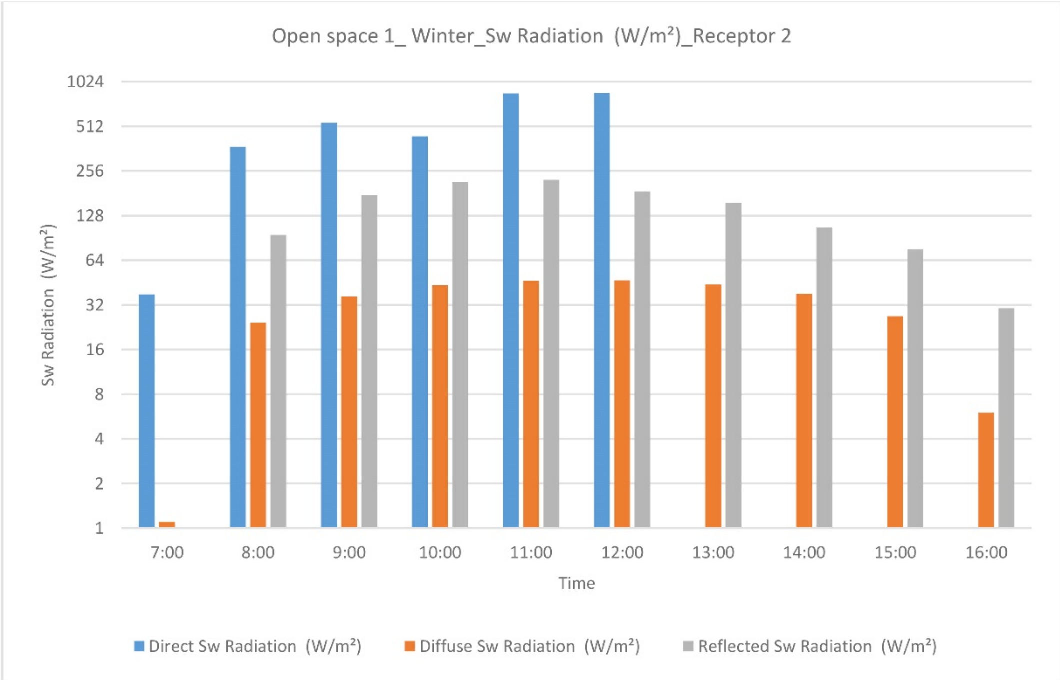

Figure A3. Open space 1 solar radiation in winter at receptor 2.

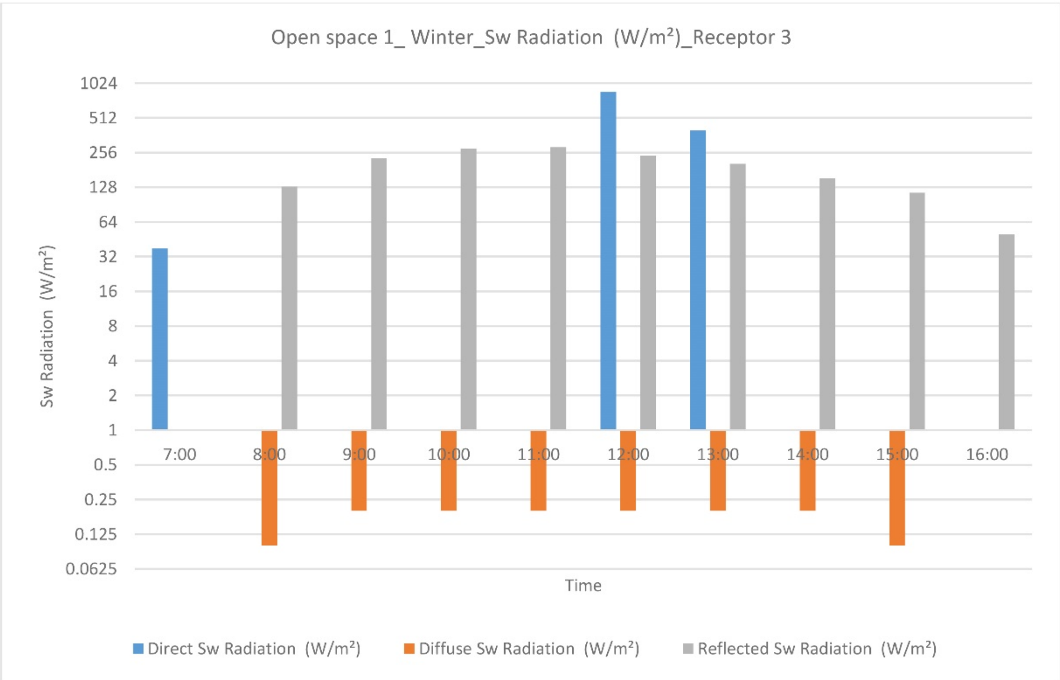

Figure A4. Open space 1 solar radiation in winter at receptor 3.

Appendix A.2. Solar Radiation in Open Space 2

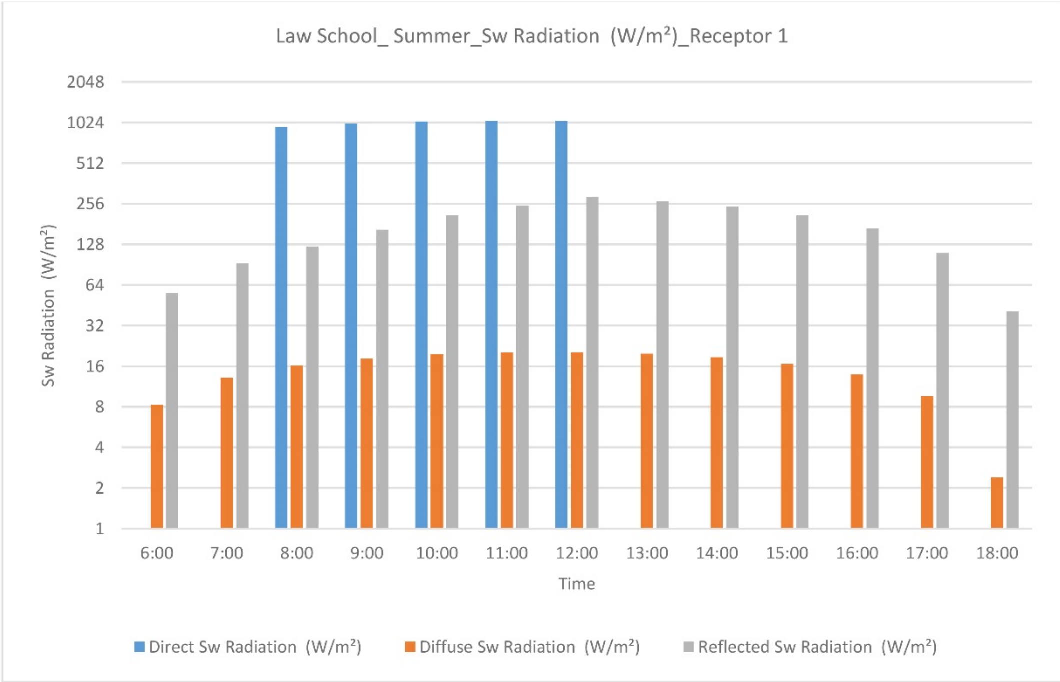

Figure A5. Open space 2 solar radiation in summer at receptor 1.

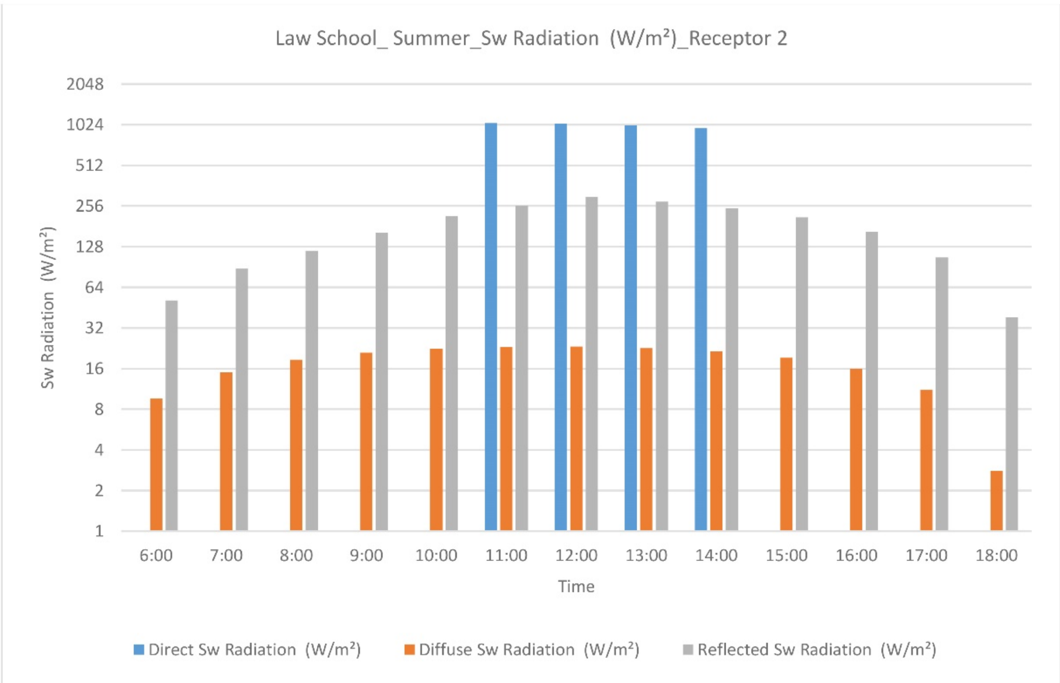

Figure A6. Open space 2 solar radiation in summer at receptor 2.

Appendix B

Table A1. Air temperature and relative humidity values for each seasonal simulation.

Time	Summer (21 June)		Winter (21 Dec)		Autumn (22 Sep)		Spring (20 Mar)	
	Ta	Rh	Ta	Rh	Ta	Rh	Ta	Rh
00:00:00	25.2	38	9.5	69	22.7	64	11.9	59
01:00:00	24.5	41	8.6	71	21.9	67	11	59
02:00:00	23.7	41	7.5	75	21	70	10	61
03:00:00	23.3	41	6.5	82	20.5	67	9.5	63
04:00:00	23	42	5.9	88	20	69	9	64
05:00:00	23	42	5.4	93	19.7	72	8.6	69
06:00:00	24	39	5	87	20	69	8.5	72
07:00:00	25.5	37	4.9	88	21.7	61	9.3	68
08:00:00	27.1	34	6	85	23.5	54	11.1	63
09:00:00	28.6	31	7.3	78	25.2	48	11.9	59
10:00:00	30.1	27	8.7	66	26.8	37	12.7	52
11:00:00	31.4	26	9.8	61	28.1	35	13.2	51
12:00:00	32.5	25	10.6	57	29.1	32	14.4	47
13:00:00	33.3	24	11.2	57	29.8	31	15	45
14:00:00	33.8	25	11.3	55	30.1	30	15.5	46
15:00:00	33.9	26	11	56	30.2	30	15.9	43
16:00:00	33.7	26	10.3	59	29.7	30	15.9	44
17:00:00	33.1	27	9.2	66	28.8	32	15.2	46
18:00:00	32.1	28	8.9	68	27.6	33	14.2	51
19:00:00	30.9	30	8.6	68	26.3	35	13.6	59
20:00:00	29.6	35	8.3	69	25.4	40	13	62
21:00:00	28.3	36	7.9	72	24.5	42	12.4	66
22:00:00	27	38	7.6	72	23.6	47	11.8	69
23:00:00	25.7	41	7.3	74	22.6	49	11.2	71

Appendix C

Table A2. Chi-square correlation matrix between main variables of the questionnaire.

Variable	Questions	p
The routine uses of the open spaces		
How much time do you spend in university on a daily basis?	How important is the use of courtyards for you?	0.126 (>0.05)
	Which open space do you prefer in the university campus?	0.000 (<0.05)
	How often do you visit or spend time in the open spaces on campus?	0.000 (<0.05)
	How long do you usually stay at this place?	0.020 (<0.05)
	When do you spend time in the open spaces on campus?	0.004 (<0.05)
Which open space do you prefer in the university campus?	Faculty/location of the open space	0.000 (<0.05)
	How satisfied are you with the temperatures in the open space that you spend the most time in?	0.356 (>0.05)
The attractive features of the open spaces		
When you are in this place, how crowded do you find it to be?	How satisfied are you with the temperatures in the open space in which you spend the most time?	0.640 (>0.05)
	In warm/hot weather, how you describe the temperatures in the open space?	0.023 (<0.05)

	In cool/cold weather, how you describe the temperatures in the open space?	0.057 (>0.05)
The routine uses of the open spaces		
Which open space do you prefer in the university campus?	The attractive features of the open spaces	
	Student needs	
	Attending activities occurring in the open space	0.102 (>0.05)
	Physical features	
	Greenery	0.00 (<0.05)
	Seating	0.002 (<0.05)
	Shading and rain shelter	0.056 (>0.05)
	Surrounding buildings and facilities (departments, kiosks)	0.556 (>0.05)
	Accessibility	0.012 (<0.05)
	Views	0.610 (>0.05)
	Central space for performance	0.443 (>0.05)
	Arrangements for group discussion	0.815 (>0.05)
	Design elements (colour, texture, etc.)	0.766 (>0.05)
	Others	0.458 (>0.05)
	What would you describe as the source of this discomfort?	
	Humidity too high (damp)	0.014 (<0.05)
	Humidity too low (dry)	0.194 (>0.05)
	Air movement too high (windy)	0.708 (>0.05)
	Air movement too low (stuffy)	0.493 (>0.05)
	Direct solar radiation	0.696 (>0.05)
	Hot/cold surrounding surfaces	0.605 (>0.05)
	Noise	0.605 (>0.05)
The comfort features of the open spaces		
How satisfied are you with the temperatures in the open space in which you spend the most time?	Physical features	
	Greenery	0.00 (<0.05)
	Seating	0.002 (<0.05)
	Shading and rain shelter	0.065 (>0.05)
	Surrounding buildings and facilities (departments, kiosks)	0.00 (<0.05)
	Accessibility	0.030 (<0.05)
	Views	0.019 (<0.05)
	Central space for performance	0.014 (<0.05)
	Arrangements for group discussion	0.025 (<0.05)
	Design elements (colour, texture, etc.)	0.005 (<0.05)
	Others	0.224 (>0.05)

Table A3. Descriptive statistics on the three dimensions of open space experience in student responses of the questionnaire.

Dimension	Category	Questions	Answers	Response (%)
The routine uses of the open spaces	Experiences in open spaces	How much time do you spend in university on a daily basis?	<2 h	6
			2–3 h	8.8
			4–5 h	41.7
			6–7 h	43.5
		How important is the use of courtyards for you?	Not very important	0.9
			Not important	3
			Neutral	13.1
			Important	24.1
			Very important	58.9

		Which open space do you prefer in the university campus?	Open space (1)	66.7
			Open space (2)	17.5
			Open space (3)	15.8
	Frequency	How often do you visit or spend time in the open spaces on campus?	Daily	69
			Once every 2–3 days	24.4
			Once per week	6.6
			Never	0
		If you spend time in the university's open spaces, answer the following questions. When do you spend time in the open spaces on campus?	Morning (before 11:00)	17.3
			Midday (11:00–14:00)	67.9
			Afternoon (14:00–17:00)	14.8
		How long do you usually stay in this place?	Less than 30 min.	18.2
			30 min–1 h	47
			1–2 h	25.3
			More than 2 h	9.5
The attractive features of the open spaces	Student needs	Why do you spend time in this place? *	Socialising	84.2
			Eating and drinking	77.4
			Relaxing	64.3
			Studying	29.5
			Exercising/walking	29.8
			Attending activities occurring in the open space	37.8
			Other	17.9
		When you are in this place, how crowded do you find it to be?	The space is empty most of the time	8.1
			The space is partially crowded most of the time	58.3
			The space is crowded most of the time	33.6
	Physical features	What physical features in this place do you consider attractive? *	Greenery	34.2
			Seating	51.2
			Shading and rain shelter	41.4
			Surrounding buildings and facilities (departments, kiosks)	39.9
			Accessibility	38.4
			Views	27.7
			Central space for performance	16.1
			Arrangements for group discussion	28.9
			Design elements (colour, texture, etc.)	10.4
			Others	19
The comfortable features of the open spaces	Thermal satisfaction	How satisfied are you with the temperatures in the open space in which you spend the most time?	1 (Very dissatisfied)	5.7
			2	6.8
			3	15.2
			4	29.2
			5	24.1
			6	11.9
			7 (Very satisfied)	7.1

	When do you feel most unsatisfied in the open space? *	Morning (before 11:00)	12.2
		Midday (11:00–14:00)	61.6
		Afternoon (14:00–17:00)	32.7
		Not found	14.6
	In warm/hot weather, how you describe the temperatures in the open space?	Always too hot	21.4
		Often too hot	31.8
		Occasionally too hot	29.5
		Neutral	15.8
		Occasionally too cold	0.3
		Often too cold	1.2
		Always too cold	0
	In cool/cold weather, how you describe the temperatures in the open space?	Always too hot	2.7
		Often too hot	1.5
		Occasionally too hot	2.9
		Neutral	15.2
		Occasionally too cold	24.1
		Often too cold	34.8
		Always too cold	18.8
	What would you describe as the source of this discomfort? *	Humidity too high (damp)	9.5
		Humidity too low (dry)	9.5
		Air movement too high (windy)	29.5
		Air movement too low (stuffy)	11.6
		Direct solar radiation	49.4
		Hot/cold surrounding surfaces	20.5
		Noise	26.5
		Others	20.5

* Respondents are allowed to select more than one answer.

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