



PLANNING MALAYSIA:

Journal of the Malaysian Institute of Planners

VOLUME 23 ISSUE 4 (2025), Page 441 – 455

MULTI-SENSORY ATTRIBUTES IN PERCEIVING CAMPUS OPEN SPACES IN AN URBAN UNIVERSITY IN THE HOT- HUMID CLIMATE

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Abstract

Insufficient outdoor activity leads to physical inactivity, endangering the physical and mental wellbeing of urban residents. This is particularly evident in urban universities within hot-humid climates, where a prevalence of sedentary indoor lifestyles has been linked to increased depression and stress among campus users. Stimulating pleasant sensory experiences can enhance interactive participation in campus green spaces, thereby fostering wellbeing. While the structure of sensory perception plays a crucial role in shaping these outdoor experiences, limited research has explored its multi-sensory dimensions in campus open spaces. This study aims to identify the multi-sensory dimensions of environmental perception in these areas. Using on-site observations and interviews, the research elaborates on the phenomenology of environmental perception. The findings identify key landscape properties and sensory attributes specific to campus open spaces in hot-humid urban universities and establish that these multi-sensory dimensions are positively associated with improved outdoor experiences. However, the tangible manifestation of user engagement stimulated by multi-sensory perception remains uncertain. Further research should, therefore, explore user participation within these environmental settings to facilitate optimal utilisation.

Keywords: Campus open space; multi-sensory perception; outdoor experience; urban university; wellbeing

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INTRODUCTION

Urban citizens who exercise or relax in green spaces regularly are estimated to have fewer health risks than those who engage in physical activities in non-natural venues (Spence, 2020; Ward Thompson et al., 2019; Ellis, 2011). However, due to insufficient green spaces, inadequate interactions with nature have shaped urban residents' living habits into sedentary lifestyles and physical inactivity (De Bell et al., 2020; Ling et al., 2020). Comparatively, university campus users are more likely to be physically inactive, as they are often confined to indoor work and spend less time on outdoor activities (Hazren, 2022; Schultz, 2018). Moreover, the lack of outdoor experience is more prevalent in hot-humid regions due to climatic and habitual reasons (Alattar & Indraganti, 2023). This issue highlights the need for environmental-behavioural interventions to cope with sedentary behaviour, high levels of stress and depression in urban universities (He et al., 2022; Schultz, 2018).

Positive behavioural changes are elaborated through the phenomenology of environmental perception (Gilloran, 2018; Seamon, 2013). This theoretical framework demonstrates the process from perception to reaction, which fosters a sense of place in frequently used open spaces. Landscapes are holistic units that provide stimuli for all senses (Deng et al., 2020). Consequently, multi-sensory perception is key to understanding the ecological phenomenology of the people-place relationship within campus open spaces (Fan et al., 2020). Open spaces adjacent to buildings are particularly important activity areas in hot-humid regions due to their proximity to indoors and high accessibility (Elaouzy & El Fadar, 2022; Harun et al., 2020). These adjacent spaces afford a sense of familiarity and belonging by integrating landscape elements and thoughtful spatial organisation (Spence, 2020). However, the sensory perception of environmental features remains inadequately defined in the context of campus open spaces (Fan et al., 2020). There is a lack of pragmatic evidence exploring how sensory experiences stimulate engagement from the users' perspective. This gap raises a central question: What are the defining attributes of multi-sensory experiences in existing campus open spaces? Accordingly, this investigation aims to reveal the attributes of the multi-sensory perceptual structure in campus open spaces at an urban university in a hot-humid climate. The objectives include 1) to define the environmental settings in selected campus open spaces and 2) to establish users' perceptions of the multi-sensory features afforded by the environmental settings. Figure 1 shows the process from identifying the problem to developing research objectives.

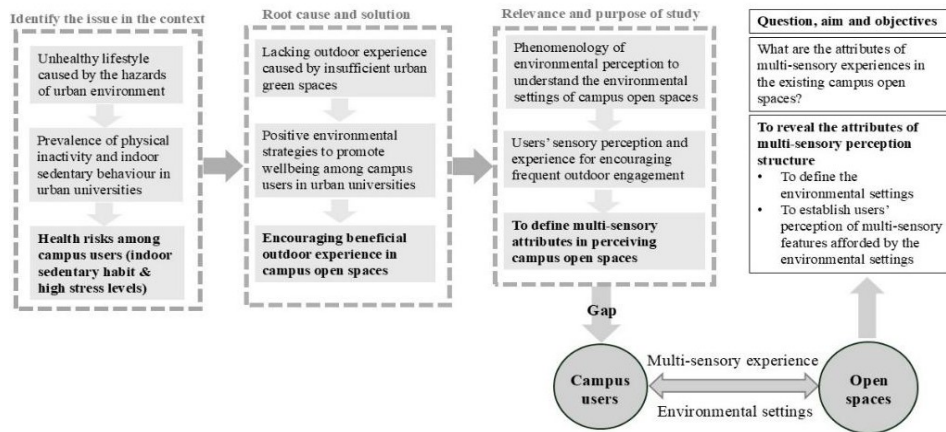


Figure 1: Problem statement, gap, and objectives

Source: Authors

RESEARCH BACKGROUND

The stimulation of multi-sensory perception shapes users' repetitive engagement with campus open spaces. This occurs because sensory stimuli lead to a pervasive, enduring, and dynamic coherence in environmental perception (Abusaada, 2020). Human senses are fundamental to the perceptual comprehensibility of environmental settings (Spence, 2020). Sources of human perception include the five biological senses, in addition to higher-order sensory abilities related to space and atmosphere (Omar & Hussein, 2017; Spence, 2020). Correspondingly, the sensory dimensions of perceptual attributes encompass visual, auditory, olfactory, and tactile perceptions (Gilloran, 2018). For example, the colour and shape of plants' foliage serve as visual attractions in urban parks (Ward Thompson et al., 2019). The texture of finely cut leaves affords a delicate, airy feel, attracting both visual and tactile attention (Lyu et al., 2022; Ellis, 2011). Natural soundscapes, such as those featuring water elements, birdsong, and insect buzzing, elicit pleasant auditory experiences (Li & Lau, 2020). Olfactory perceptions capture the scent of nature, such as fragrances emitted from plant materials (Taylor, 2021). From the perspective of ecological phenomenology, these dimensions of sensory perception construct place memory through continual participation (Gilloran, 2018), resulting in what is known as placeness or a sense of place. Therefore, the sensory attractions in campus open spaces provide pleasant experiences that encourage beneficial outdoor participation as part of users' daily routines.

Optimal sensory perception cultivates wellbeing-beneficial interactions within campus open spaces (Spence, 2020; Ward Thompson et al., 2019). These environmental settings, which incorporate landscape components and spatial

qualities, determine a specific green space's aesthetic values and functional use (Taylor, 2021; Ellis, 2011). A harmonious balance of hardscape and softscape enables landscape elements to become appealing sensory features (Omar & Hussein, 2017). For example, the sensory attractiveness of vegetation and water features is a cornerstone of sensory gardens (Ellis, 2011; He et al., 2022), as are integrated design elements such as wildlife attractors and supportive facilities (Darkhani et al., 2019). In particular, spatial strategies such as shielding conditions and enclosure are emphasised in sensory design to encourage participation during extreme weather (Spence, 2020). Interacting with these environmental settings stimulates multi-sensory experiences, which in turn form a sense of place that reorients users' recognition of the settings themselves (Li et al., 2023; Seamon, 2013). Therefore, clearly defining both the environmental settings and the dimensions of perceived sensory features can help to elaborate the perception-reaction cycle within campus open spaces at urban universities in hot-humid climates. The theoretical framework for sensory perception in campus open spaces is presented in Figure 2. As illustrated, the study is supported by the integration of sensory perception theory and the phenomenology of environmental perception. This framework is constructed by the perception of physical properties and the subsequent responses to sensory attributes, which together shape multi-sensory experiences in campus open spaces.

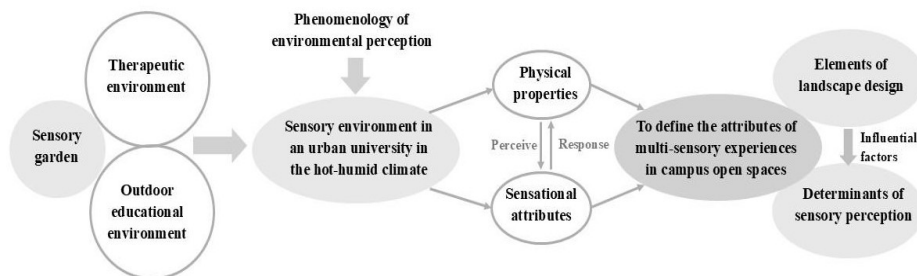


Figure 2: Underpinnings of the multi-sensory attribute in campus open spaces

Source: Authors

METHODOLOGY

Case Study Selection

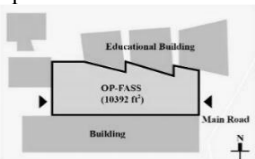
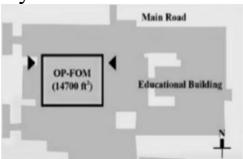
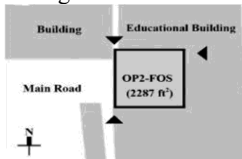
In Malaysia, passive design strategies for the built environment are strongly supported by local policies (Alattar & Indraganti, 2023). The optimal arrangement of open spaces between buildings is crucial for the success of passive building design (Elaouzy & El Fadar, 2022; Harun et al., 2020). Such spaces within building layouts facilitate climatic adaptation and optimize building performance in hot-humid climates (Chen et al., 2021; López-Pérez et

al., 2019). Due to these climatic influences, their design features are more likely to evoke pleasant sensory experiences and form positive user associations. However, this relationship has not been sufficiently investigated in the context of urban universities in hot-humid climates. Given the lack of literature, the primary aim was to establish clear case study selection criteria. Consequently, a preliminary site study was conducted in Kuala Lumpur. As the capital city, it represents typical urban design strategies and experiences a hot-humid climate (Harun et al., 2020). This study compared the physical environments of several urban universities in Kuala Lumpur to explore the environmental and perceptual attributes of their campus open spaces. The criteria for selecting an urban university campus were based on 1) Location and urban environment (Alattar & Indraganti, 2023); 2) Amount and layout of green space (Elaouzy & El Fadar, 2022; Dzhambov, 2018); 3) Development of vegetation (Harun et al., 2020); and 4) Settings of the educational environment (Dzhambov, 2018; Jamaludin et al., 2018). Eventually, the campus of Universiti Malaya (UM) was selected as the case study due to its external environment, history, layout, and academic focus on the physical campus.

The UM campus is a well-known green space within the high-density urban environment of Kuala Lumpur city centre (Bakhshi et al., 2015). Despite its integration with the city's transportation system, which has decreased the time students spend on outdoor exercise on campus (Hazren, 2022), it remains a significant urban oasis. As the oldest university in Malaysia with a history spanning more than five decades, the campus has preserved extensive green spaces within the city centre. Its physical environment is a recognized representation of the green campus concept (Bakhshi et al., 2015). Adjacent open spaces, such as gardens and courtyards, are integral to the campus design, improving daylighting and natural ventilation in residential colleges (Jamaludin et al., 2018). Consequently, the campus has been frequently used as a case study in various investigations aiming to establish an academic focus on sustainable campus environments. These characteristics facilitate more effective data collection regarding the sensory qualities of campus open spaces. Notably, the educational zone—where the core of daily campus life occurs—represents the most significant aspect of the physical campus design (López-Pérez et al., 2019). The open spaces surrounding these educational buildings are the most frequently used and are therefore most likely to represent the daily engaged outdoor environment (Fakourian & Asefi, 2019). This evidence supports the application of a case study focused on these specific sites to investigate the sensory qualities of outdoor environments in urban universities within hot-humid climates. Furthermore, three courtyards adjacent to faculty buildings were selected as case-study sites. The selection was based on several criteria, including size, available amenities, accessibility, location, thermal comfort, safety, proximity to and occupancy levels of educational buildings, and façade design (Elaouzy & El

Fadar, 2022; Chen et al., 2021; Jamaludin et al., 2018). The layouts of the three selected case-study open spaces are presented in Table 1.

Table 1: Selected open spaces on the UM campus

Case Study 1	Case Study 2	Case Study 3
Located in the Faculty of Arts and Social Science, it is a courtyard surrounded by open corridors.	Located in the Faculty of Medicine, this is a courtyard in the middle of the building layout.	Located in the Faculty of Science, this is a courtyard in the Institute of Biological Sciences.
		

Source: Authors

Research Methods and Data Collection

The mixed-methods research strategy began with a preliminary site study to establish case-study selection criteria and develop research instruments. The initial step involved conducting on-site observation, a primary method for evaluating 'sensory function' (Omar & Hussein, 2017; Spence, 2020). This process included field visits and systematic record-keeping (Deng et al., 2020; Hussein, 2012) at the three selected sites to assess and understand the features of their environmental settings. The observation sessions were scheduled during daytime hours on weekdays. Data collected during the observations included narrative notes, videos, photographs, a structured recording checklist, and observation guidelines (Darkhani et al., 2019; Chen et al., 2021). These guidelines covered the physical properties of the selected open spaces—including location, size, layout, types of settings, and user interactions—generating both qualitative and quantitative data. Descriptive analysis was then used to identify the independent factors contributing to the sensory experience. Simultaneously, on-site interviews were conducted with a purposive sample of users who frequently used the selected courtyards. This method effectively captured emotions and behaviours while maintaining the interviewees' focus, sourcing users' self-reported evaluations of sensory quality (Fakourian & Asefi, 2019; Ward Thompson et al., 2019). The interview questions pertained to descriptions of sensory qualities, perceptions of the settings, and preferences for utilisation. A semantic analysis of the resulting qualitative data was conducted to interpret users' sensory perceptions of landscape and spatial qualities. The overall research strategy and methods used to identify the multi-sensory dimensions of the perceptual structure are illustrated in Figure 3.

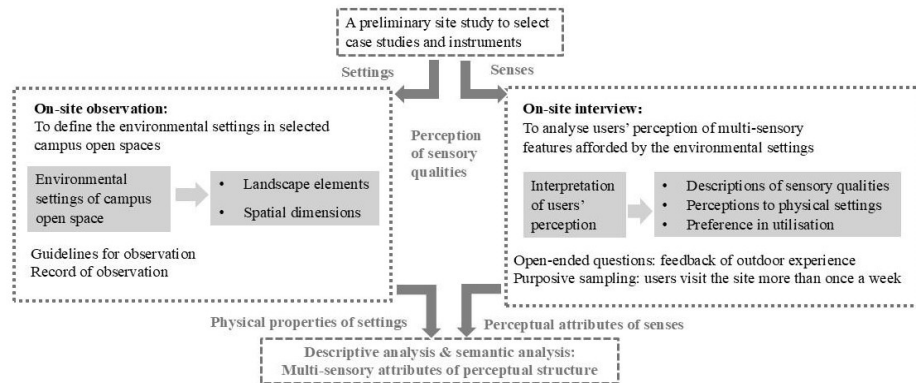


Figure 3: Methods to identify the attributes of multi-sensory experiences
Source: Authors

RESULTS AND ANALYSIS

The selected open spaces are courtyards integrated within faculty buildings, serving multiple educational purposes that include studios and offices. Observations revealed that all three courtyards contained ornamental plants and decorative furniture, which functioned as key attractions supporting outdoor engagement. A detailed inventory of the hardscape and softscape elements present in these spaces is provided in Table 2. The features of these environmental settings and their associated sensory qualities are illustrated in Figures 4 to 6. These figures highlight the specific sensory attributes of landscape elements and spatial qualities that collectively created an appealing atmosphere. As evidenced by the data in Table 2 and Figures 4 to 6, vegetation (functioning as softscapes)—such as shady trees, herbs, and groundcovers—offered pleasant multi-sensory experiences characterized by greenery, naturalness, and freshness. Similarly, the surface textures of furniture and pavements provided tactile satisfaction and invited opportunities for physical interaction and participation. Furthermore, the spatial qualities of the courtyards, particularly the sense of enclosure created by adjacent buildings and walls, enhanced users' sense of belonging and safety by providing defined environmental protection.

Table 2: Environmental settings in the selected open spaces

Code of site	Types of hardscapes	Types of softscapes
Case Study 1	Footpaths with stairs, wooden benches, four pavilions and couches	Two lawn patches with slopes, matrix-grouped trees, shade trees and shrubs
Case Study 2	Pathways, brick perimeter walls, a stone pergola, a sunken platform with stairs, a central plaza, a decorative flowerpot, two pavilions, four sets of tables and chairs	Shady trees, hedges, shrubs with fragrant flowers and sloping grassland
Case Study 3	Pathways, covered corridors, steps, iron stairs, faculty logo, two sets of tables and chairs	Trees, hedges, shrubs, herbs, and potted flowers

Source: Authors

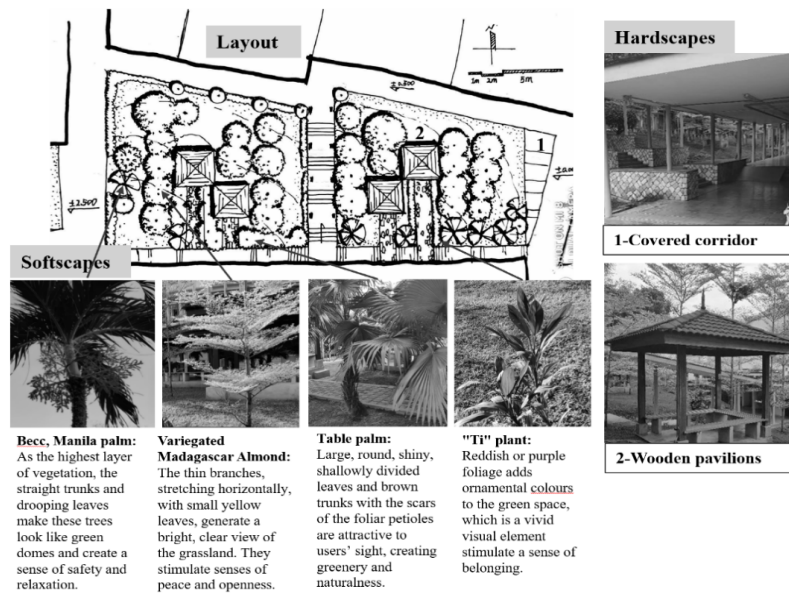


Figure 4: Qualities of environmental settings in Case Study 1

Source: Author

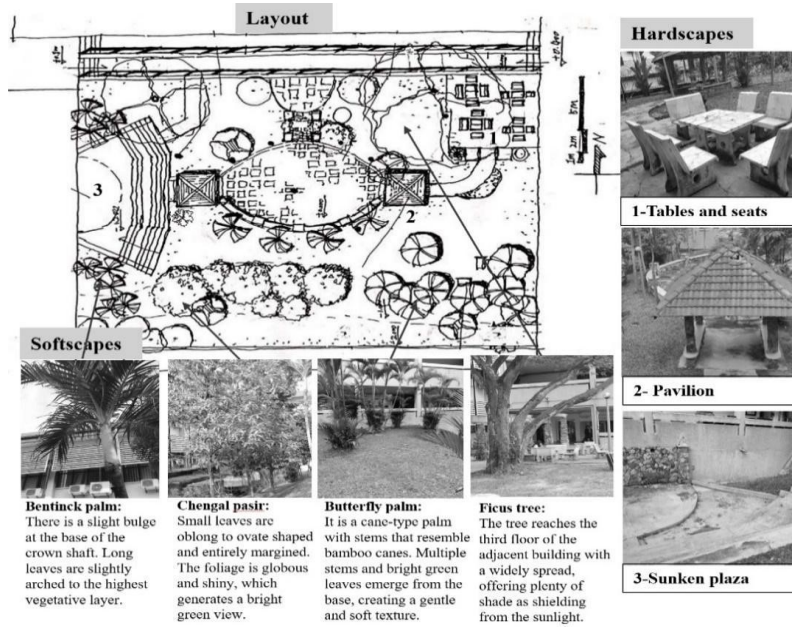


Figure 5: Qualities of environmental settings in Case Study 2
Source: Author

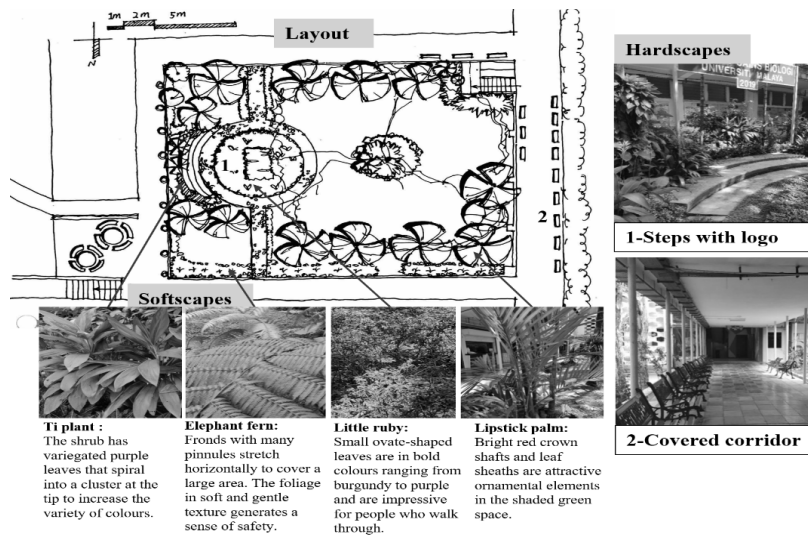


Figure 6: Qualities of environmental settings in Case Study 3
Source: Author

The interview results regarding the perception of sensory features in the case-study open spaces are presented in Table 3. As the data indicate, the identified dimensions of sensory features stimulate a sense of place, fostering feelings of familiarity and belonging. These positive associations between user perception and the physical settings represent new sensibilities cultivated through repetitive engagement. The prevalence of these positive emotions in the responses denotes the significant wellbeing potential of outdoor engagement in these open spaces.

Table 3: Sensory perceptions of environmental settings

Settings	Perception	Vision	Micro-climate	Texture /Touch	Smell	Sound	Aroused emotions
Spatial qualities	External context	*			*	*	Placeness:
	Spatial layout	*	*				Familiarity
	Building façade	*	*			*	Sense of belonging
Hardscapes	Corridors		*	*			Feelings: Relaxation Less stress Calmness Restoration Recovery Enjoyment
	Wooden pavilions	*	*	*			
	Seats & tables	*		*			
	Pavements	*		*			
	Steps & paths	*		*			
Softscapes	(Shady) trees	*	*		*	*	Restoration Recovery Enjoyment
	Shrubs & hedges	*	*	*	*	*	
	Flowers & herbs	*			*	*	
	Groundcover	*		*	*		

Source: Authors

DISCUSSION

The environmental features and physical properties shape the multi-sensory perceptual structure, as illustrated in Figure 7. Visual perceptions of landscape components, such as the form and colour of plants, served as primary attractions (Deng et al., 2020), motivating users' outdoor engagement. This finding confirms the view of Lyu et al. (2022) that vegetative landscapes are among the most attractive elements. However, the role of other senses differed from previous studies. Unlike Ellis's (2011) assertion that the texture of shrubs and herbs functions primarily as a vivid visual attraction in sensory gardens, in these campus open spaces, elements like texture and microclimate were perceived largely through tactile means. The adjacent walls and shady trees provided crucial shielding conditions to ameliorate the microclimate (Lyu et al., 2022), a necessary adaptation as climatic demands shift the focus of comfort needs. Furthermore, interview results indicated that the textures of furniture and pavements offered tangible participation opportunities, enhancing the accessibility of these spaces. The interviews also revealed complexities in auditory perception, contrasting with Li and Lau (2020). The sounds captured in the campus open spaces were not always pleasurable. While rustling leaves stimulated a sense of freshness and naturalness, noise pollution from external surroundings—such as automobiles

and machinery—degraded the overall quality of the auditory environment. Olfactory perceptions also played a key role. Vegetation provided distinctive olfactory information, such as the fragrance of flowers and the scent of fresh-cut grass, which contributed to a pleasant atmosphere (Taylor, 2021). Collectively, both sound and smell were found to play significant roles in constructing sensory comfort and cultivating place memory (Gilloran, 2018; Abu-Ghazze, 1999). These findings indicate that campus users are highly aware of multi-sensory experiences and that a pleasant microclimate, achieved through strategic shading and enclosure, is a fundamental prerequisite for enabling them.

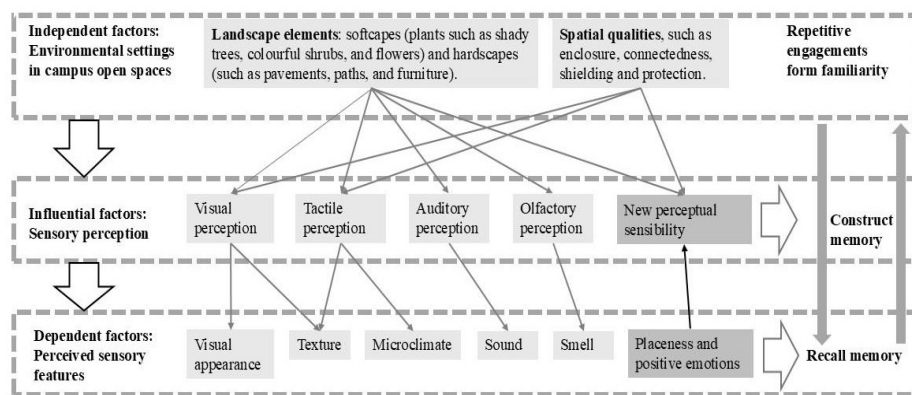


Figure 7: Multi-sensory attributes in campus open spaces
Source: Authors

As shown in Table 3 and Figure 7, familiarity evoked a sense of belonging, which in turn enhanced positive emotions, aligning with the findings of Gilloran (2018). Through this process, placeness and emotional arousal developed as new sensibilities forged through the experience of campus open spaces (Fan et al., 2020; Omar & Hussein, 2017; Seamon, 2013). The stimulation of these pleasurable sensory experiences serves to motivate optimal participation (Abusaada, 2020; Ward Thompson et al., 2019). This intervention ultimately helps to offset the negative wellbeing outcomes caused by physical inactivity and indoor sedentary behaviour, such as depression and stress (Alattar & Indraganti, 2023). Within this framework, environmental settings functioned as independent variables shaping the perception of sensory features. Elements such as the shape and colour of landscape components were identified as features with significant aesthetic value (Spence, 2020; Ward Thompson et al., 2019; Gilloran, 2018). However, interview data revealed that these visually attractive features did not, by themselves, reliably lead to the desired behavioural interactions with the settings. This result suggests that aesthetic value alone is insufficient to support sustained outdoor activities among campus users (Deng et al., 2020).

In contrast, shaded areas with fewer overt visual attractions provided better shielding conditions, which is a critical factor in a hot-humid climate (Chen et al., 2021; Jamaludin et al., 2018). These environmental protections created more comfortable microclimates, which were a primary factor in attracting users (Fakourian & Asefi, 2019). This pleasurable sensory experience—centered on thermal comfort—supports the functional use of enclosed open spaces. Consequently, this finding suggests that in hot-humid climates, campus users prioritize sensory comforts, particularly microclimatic comfort, over purely aesthetic qualities in the environmental settings of these open spaces.

Consequently, vegetation emerged as the most critical element in creating a desired atmosphere (He et al., 2022; Ellis, 2011), primarily because plants stimulated sensations of freshness and naturalness in the campus open spaces. However, interviewees reported that water features were among the least desired landscape components, often due to associated thermal discomforts, such as increased humidity. This finding contrasts with Li et al. (2023), who identified water features as highly appealing natural elements. This discrepancy can be attributed to variations in climatic conditions, underscoring the critical importance of climate-adaptive design (Chen et al., 2021; Jamaludin et al., 2018) for optimising users' sensory satisfaction. The spatial dimensions of courtyards surrounding educational buildings provide optimal shielding and protection from weather hazards. The enclosure created by adjacent buildings enhances outdoor engagement in hot-humid climates by offering refuge from sun and rain (Fakourian & Asefi, 2019; López-Pérez et al., 2019). Consequently, these courtyards function as both behaviour-interactive and climate-adaptive spaces. Contrary to Tafti et al. (2018), who emphasized that enclosure promotes safety and privacy, this study found that in a hot-humid context, the primary driver for engagement is the protection from weather hazards that enclosure provides. This finding denotes that the same behavioural setting—enclosure—can evoke different sensory perceptions and functional values depending on its spatial and climatic milieu.

CONCLUSION

The multi-sensory perceptual structure comprises three core components: environmental settings, sensory perception, and perceived sensory features. Environmental settings—including spatial qualities, softscapes, and hardscapes—function as independent variables that shape the perception of sensory features. These features are categorized into six perceptual dimensions: visual appearance, texture, microclimate, sound, smell, and a higher-order dimension of new sensibility, which encompasses placeness and positive emotions. The process of perception is mediated by individual sensory channels, primarily visual, tactile, auditory, and olfactory. This integrated process constitutes the multi-sensory perceptual structure for campus open spaces. This

structure elucidates the cause-effect cycle of multi-sensory stimulation, grounded in the phenomenology of environmental perception. Ultimately, this dynamic model provides landscape architects with an evidence-based framework for designing interactive and engaging campus open spaces that actively promote user wellbeing.

The perception of desirable environmental qualities contributes to pleasurable sensory experiences, which foster positive associations that, in turn, encourage repeated outdoor participation. This occurs because a satisfying outdoor experience enhances campus users' psychological wellbeing by providing sensory-comfort qualities in frequently used open spaces. Over time, this pleasurable sensory perception is optimized through repetitive engagement, forming a sense of familiarity that stimulates placeness and positive emotions. However, despite these insights, there remains a limited understanding of the specific patterns of user participation. Therefore, further research is needed to explore and quantify users' behavioural interactions within existing open spaces at urban universities. Based on these findings, it is recommended that campus planners and administrators of higher education institutions prioritize both the climatic adaptiveness of campus landscapes and users' subjective sensory perceptions to effectively promote beneficial outdoor engagement.

ACKNOWLEDGEMENT

Authors agree to provide data granted for research as well as for publication.

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Received: 2nd May 2025. Accepted: 10th September 2025