



ENVIRONMENTAL QUALITY OF TRANSITIONAL SPACES AND STUDENT BEHAVIOUR ON A UNIVERSITY CAMPUS

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Abstract

Transitional spaces (outdoor and semi-open areas) are increasingly used by university students for informal learning and social interaction; however, these spaces are often overlooked in campus planning, resulting in environmental conditions that may not support learning-related behaviours and user satisfaction. This study aims to evaluate the environmental qualities of campus transitional spaces and examine how these qualities relate to students' behaviours and satisfaction in a tropical university setting. A case study was conducted at the Universiti Sains Malaysia (USM) main campus using on-site observation and a questionnaire survey (n = 300). Environmental quality was assessed across six dimensions (colour, size, temperature, ventilation, acoustics, and lighting), while students' behaviours were measured through learning outcomes and interactions, together with satisfaction regarding environmental quality. Descriptive and inferential analyses show that temperature and lighting are the most problematic aspects across the study areas and are associated with students' behaviours and satisfaction. Higher temperatures, unstable thermal conditions, and insufficient lighting are linked to reduced learning outcomes and lower satisfaction in transitional spaces. These findings suggest that improving transitional spaces requires a system-level approach rather than isolated upgrades, and they support planning actions to integrate transitional spaces into campus public realm optimisation strategies for tropical university campuses.

Keywords: Campus master planning, Transitional spaces, Informal learning, Microclimate, Malaysia

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INTRODUCTION

Universities are increasingly expected to function as campus-scale learning ecosystems where students study, collaborate, and socialise between scheduled classes. Alongside student-centred and active learning approaches, learning activities have expanded beyond formal classrooms into a distributed “learning landscape” that includes libraries, breakout areas, outdoor settings, and circulation zones (DeFraín & Hong, 2020). Consequently, spaces historically treated as circulation or “in-between” areas are now frequently used for short-duration study, waiting, peer discussion, and spontaneous collaboration.

This shift raises an international planning issue: campuses must support learning-related behaviours and student experience across a network of formal, informal, and transitional settings, yet research and planning practice often remain centred on discrete indoor spaces. Transitional (in-between/interstitial) spaces—such as covered walkways, verandas, breezeways, corridors, entrance forecourts, semi-open terraces, and courtyard edges—operate at the boundary between movement and stay and form part of the campus public realm network that structures everyday mobility and encounter patterns (Wang et al., 2025). In the Malaysian higher-education context, Abdul Munir et al. (2018) reported that learning-space attributes are associated with students’ satisfaction and perceived performance, while Yaman et al. (2018) highlighted the relevance of outdoor learning settings for contemporary learning approaches in universities. These perspectives indicate that transitional spaces should be assessed and improved as a connected system supporting learning and student experience, rather than treated as residual leftover areas.

The challenge is especially salient in tropical, hot–humid campuses where environmental conditions strongly influence whether semi-open and outdoor spaces can be occupied beyond brief periods. Transitional-space comfort requires context-specific responses in shade, ventilation pathways, and radiation exposure (Hou et al., 2024), and studies of campus pedestrian environments in tropical regions further suggest that microclimatic performance must be integrated with physical design attributes in circulation and public realm planning (Suwanmanee et al., 2024). Beyond microclimate, transitional spaces must also support adequate lighting, visibility, and acoustic conditions that enable both quiet individual use and small-group interaction.

Despite increasing recognition of informal learning spaces, transitional spaces remain less systematically studied as a campus planning issue in two ways: (i) many studies focus on discrete indoor settings rather than examining how formal, informal, and transitional spaces operate together as a coherent campus system; and (ii) empirical findings are not always translated into planning-oriented outputs that can inform campus master planning, spatial hierarchy, and prioritised investment decisions. Guided by Social Cognitive Theory (SCT),

which conceptualises reciprocal relationships between environmental influences and behavioural outcomes (Bandura, 1989), this study evaluates transitional spaces within the USM main campus and examines how environmental quality relates to student behaviour and satisfaction. Using a zone-based case study design across three selected campus zones (School of Housing, Building and Planning; School of Arts; and the Main Hall and Library area), the research assesses six environmental dimensions (colour, size, temperature, ventilation, acoustics, and lighting) through on-site observation and a questionnaire survey ($n = 300$). The study identifies critical environmental deficiencies and translates the findings into actionable planning strategies to support system-level optimisation of transitional-space networks in tropical university contexts.

LITERATURE REVIEW

Theoretical Background: Social Cognitive Theory

This study is grounded in SCT, which explains behaviour through reciprocal interactions among environmental influences, individual factors, and behavioural outcomes (Bandura, 1989). SCT provides a lens for linking perceived environmental qualities of transitional spaces to students' behavioural use and satisfaction.

Informal Learning and Campus Learning-Space Ecosystems

Informal learning is commonly described as learning initiated and self-regulated by the learner, differing from structured learning in traditional classroom settings (Akkurt & Akbulut, 2025). In contemporary higher education, informal learning is increasingly linked to flexibility, short-duration study, peer exchange, and spontaneous collaboration occurring across semi-formal and informal settings. This has led scholars to frame the campus as a distributed learning-space ecosystem in which learning support depends on the availability, accessibility, and quality of multiple alternative spaces rather than any single facility (DeFrain & Hong, 2020; Peng et al., 2022). Within this perspective, learning environments should facilitate interaction, communication, and cooperation to complement formal teaching spaces (Salih et al., 2024).

Methodologically, informal learning research has used diverse approaches to capture both behaviours and perceptions. Studies have applied surveys, behavioural measures, and choice-based methods (Peng et al., 2022; Zhang et al., 2022), qualitative techniques such as behavioural logs, focus groups, and interviews (Mantooth, 2020; Wang, 2020), and mixed methods combining questionnaires with interviews to strengthen interpretation and context sensitivity (Peng et al., 2021; Wu et al., 2021). Across these approaches, a consistent planning implication is that learning-support spaces should be evaluated not only

by provision but also by how students perceive, choose, and use spaces during everyday academic routines.

Transitional Spaces as Learning-Support Settings Within the Campus

Transitional spaces are commonly discussed as in-between or interstitial settings that mediate movement and environmental change between indoor and outdoor conditions. Literature offers several ways to define and classify transitional spaces. Some define them as bridges connecting interior and exterior environments (e.g., balconies, pavilions, lobbies, corridors), emphasising boundary conditions and hybrid environmental characteristics (Akkurt & Akbulut, 2025). Others emphasise transitional spaces as accessory spaces attached to main buildings and highlight distinctions between enclosed and semi-open transitional environments (Han et al., 2024). Transitional spaces have also been classified based on their relationship to buildings (not connected, connected, or inside the building), reflecting differences in environmental exposure and functional use (Diz-Mellado et al., 2020). A shared characteristic across these accounts is that transitional spaces tend to show greater variability and instability due to stronger influence from the external environment, which affects comfort and usability (Han et al., 2024).

Within university campuses, transitional spaces connect functional zones and shape everyday mobility patterns. As learning increasingly extends beyond classrooms, these spaces may evolve from pass-through corridors into low-threshold learning-support environments where students wait, study briefly, meet peers, or conduct short discussions between classes. In Malaysia, Ibrahim et al. (2018) discuss learning activities outside classrooms on campus grounds and the contribution of outdoor and semi-open environments to learning-related use. Abdul Munir et al. (2018) further reported that learning-space attributes are associated with students' satisfaction and perceived performance, reinforcing the planning importance of learning-support spatial quality, while Yaman et al. (2018) discussed outdoor learning settings in Malaysian universities in relation to pedagogical approaches such as problem-based learning. At a broader level, tertiary education is increasingly framed as requiring social learning-built environments that support interaction and flexibility, implying that learning-support spaces should be planned as a connected system rather than isolated rooms (Ramu et al., 2021). Collectively, these studies support positioning transitional spaces as part of the campus public realm network, where connectivity, comfort, and opportunities for interaction jointly influence learning-support potential.

Environmental Quality Dimensions and Their Relationships with Behaviour and Satisfaction

Because transitional spaces sit at the indoor–outdoor boundary, environmental quality strongly influences whether students are willing to stay for learning-related activities. Thermal comfort is repeatedly identified as a central constraint in transitional environments, especially in tropical hot–humid contexts where heat, humidity, and radiation can limit usability (Han et al., 2024; Hou et al., 2024). Beyond microclimate, multi-dimensional factors—including colour, lighting, acoustics, spatial size, and ventilation—shape perceived suitability for short study and small-group interaction (Al-Ramahi et al., 2023; Mogas-Recalde et al., 2021; Yewande Bakare & Alibaba, 2020). Accordingly, perceived environmental quality can be operationalised using six dimensions: colour, lighting, temperature, acoustics, size, and ventilation.

To translate environmental quality into planning-relevant evidence, transitional space studies should link space attributes to behavioural outcomes and user satisfaction. In campus learning research, “student behaviour” is commonly operationalised through learning-related outcomes (e.g., perceived productivity, focus, task completion) and social/interaction outcomes (e.g., communication, collaboration, peer exchange) (Areche, 2022; Iberahim & Sulaiman, 2023). Learning outcomes refer to knowledge, competencies, or skills developed through learning activities and can be assessed through perceived effectiveness in specific settings (Sturrock & Zandvliet, 2023). Interaction can be examined through perceived communication efficiency, collaboration, depth of discussion, and thereby whether a space supports productive peer engagement (Baanqud et al., 2020; Rothhouse, 2020). Student satisfaction is widely used as an indicator of environmental performance in higher education contexts and is relevant for evaluating whether campus spaces meet user expectations and support educational experience (Ou et al., 2026).

Overall, existing literature indicates that transitional spaces should be treated as planning objects within campus master planning due to their network role in connecting destinations and their emerging function as informal learning-support settings. Multi-dimensional environmental quality—particularly microclimate and lighting in tropical contexts—can influence whether students use transitional spaces for learning and interaction, and these relationships can be assessed through behaviour and satisfaction measures to inform prioritised, system-level campus public realm optimisation.

Conceptual Framework and Underlying Theory

Guided by SCT, this study conceptualises student behaviour and satisfaction in transitional spaces as outcomes associated with environmental influences. SCT explains behaviour through reciprocal relationships among environmental

conditions, behavioural engagement, and experienced outcomes (Bandura, 1989). In this study, the “environment” component is operationalised as perceived environmental quality of transitional spaces (colour, lighting, temperature, acoustics, size, and ventilation). Based on the reviewed literature, these perceived environmental qualities are expected to be associated with students’ behaviours in transitional spaces—captured through learning outcomes and interactions—and students’ behaviours are expected to be associated with overall satisfaction. To strengthen planning relevance, zone-based comparisons (Zone 1–Zone 3) are used to support prioritised intervention decisions across the campus public realm network (Figure 1).

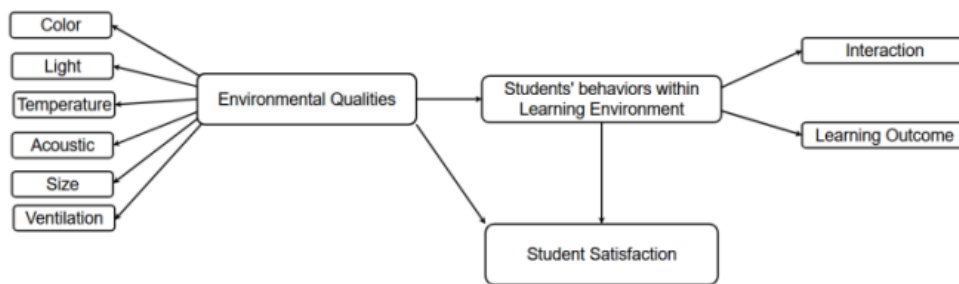


Figure 1: Conceptual Framework
Source: By Author

RESEARCH METHODOLOGY

Study Area and Research Design

This study was conducted at the USM main campus in Penang, Malaysia. The campus is located on Penang Island in the north-west of Peninsular Malaysia and represents a tropical hot-humid university environment. As a campus-scale learning ecosystem, students frequently move between academic buildings and shared facilities through covered walkways and semi-open circulation networks, where short-duration activities (e.g., waiting, brief study, and peer discussion) commonly occur between scheduled classes. A quantitative case study design was adopted, combining on-site observation with a questionnaire survey to evaluate transitional spaces and examine relationships between perceived environmental quality, student behaviour, and satisfaction.

To capture spatial variability for planning interpretation, a zone-based approach was applied. Three campus zones were selected based on (i) differences in campus function and activity patterns (faculty-based academic cluster, creative/arts cluster, and a campus-core public facility cluster), (ii) variations in transitional-space typologies and degrees of enclosure (e.g., corridors, covered walkways, semi-open terraces, courtyard edges), and (iii) high pedestrian

movement and frequent short stays observed during preliminary site visits. The selected zones were: (i) the School of Housing, Building and Planning (HBP) area, (ii) the School of Arts area, and (iii) the Main Hall and Library area. Figure 2 shows the USM main campus study area and the zoning of the three selected areas.

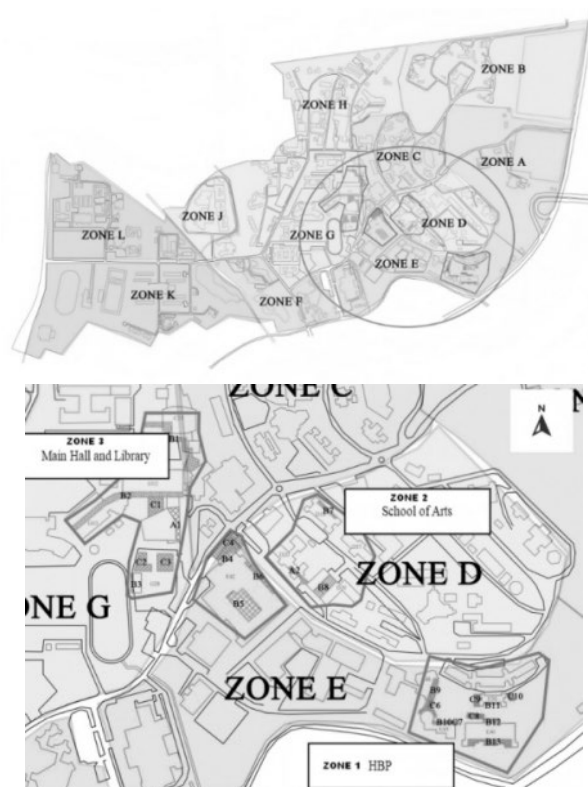


Figure 2: Study Area (USM Main Campus) and Zoning of the Three Selected Campus Areas: Zone 1 (HBP), Zone 2 (School of Arts), and Zone 3 (Main Hall & Library)

Source: By Author

Transitional Space Identification and On-Site Observation

Field observation was conducted prior to the survey to identify and document transitional spaces within the three zones. A walk-through inventory was undertaken to locate outdoor and semi-open in-between spaces that mediate movement between buildings and support short stays. For each identified space, basic attributes were recorded (e.g., location, degree of enclosure, shading condition, lighting availability, ventilation exposure, surrounding noise sources, and observed user activities such as waiting, studying, or social interaction). A

total of 25 transitional spaces were inventoried and categorised into three space types (Type A–C) based on spatial characteristics and contextual relationships (e.g., degree of enclosure and functional role). These space types describe transitional-space typologies, whereas Zone 1–Zone 3 refer to the three spatial study zones illustrated in Figure 2. The identified spaces served as the settings for survey administration and supported interpretation of zone-level differences. It should be noted that environmental quality in this study refers to students' perceived environmental quality, measured through questionnaire responses. On-site observation was used to identify, classify, and document transitional spaces and to contextualise the survey findings; it did not involve objective instrumental measurements such as air temperature, humidity, illuminance, or sound level monitoring. The observation results were organised into a transitional-space typology to clarify the physical characteristics and planning relevance of the identified spaces (Table 1).

Table 1: Typology of observed transitional spaces

Space type	Defining characteristics	Typical examples
Type A: Linear circulation spaces	Semi-open or covered movement corridors connecting buildings	Covered walkways, corridors
Type B: Building interface spaces	Transitional areas attached to building entrances or edges	Entrance forecourts, verandas, lobby edges
Type C: Open/semi-open stay spaces	Wider transitional spaces with potential for short stay or social use	Courtyard edges, semi-open terraces, sheltered nodes

Source: By Author

Sampling and Participants

The target population comprised students at the USM main campus. A zone-based stratified approach was used, with respondents recruited in the identified transitional spaces within each zone. A total of 300 valid and complete questionnaires were included in the final analysis (Zone 1/HBP = 101; Zone 2/School of Arts = 105; Zone 3/Main Hall & Library = 94). Given an estimated student population of approximately 30,000 at the USM main campus, the minimum required sample size was determined using G-power. Based on this calculation, approximately 190 completed questionnaires were required to obtain a sufficiently representative sample. The present study analysed 300 valid and complete responses, which exceeds this minimum requirement.

Measures and Instrument Development

The questionnaire consisted of five sections: (1) respondent background and usage profile; (2) perceived environmental quality; (3) student behaviour; (4) satisfaction. All main constructs were measured using a five-point Likert scale.

Survey items were developed through a review of prior studies on informal/transitional learning settings, environmental comfort/quality, and

learning-support outcomes. Items for perceived environmental quality were adapted and contextualised for semi-open campus transitional settings, covering six dimensions frequently discussed in the literature: colour, size, temperature, ventilation, acoustics, and lighting (Al-Ramahi et al., 2023; Han et al., 2024; Hou et al., 2024; Mogas-Recalde et al., 2021). Student behaviour was operationalised as self-reported behavioural functioning in transitional spaces, measured through two dimensions: learning outcomes (six items) and interaction (five items). Learning outcomes captured students' perceived ability to study, focus, and complete learning-related tasks in transitional spaces, while interaction captured perceived opportunities for peer communication, discussion, and collaboration. A composite student behaviour score was computed by averaging the learning outcome and interaction dimension scores (Areche, 2022; Iberahim & Sulaiman, 2023; Sturrock & Zandvliet, 2023). Satisfaction was measured for the six environmental dimensions and overall satisfaction, aligning with learning-space satisfaction approaches used in Malaysian higher-education studies (Abdul Munir et al., 2018) and recent campus satisfaction literature (Ou et al., 2026).

Statistical Analysis

Data were analysed using descriptive and inferential statistics in IBM SPSS Statistics 24. Reliability testing was conducted for multi-item subscales using Cronbach's alpha. Descriptive statistics (means, standard deviations, and frequencies) were used to profile perceived environmental quality, behaviour, and satisfaction. In addition, partial least squares structural equation modelling (PLS-SEM) was conducted using SmartPLS 4. Before assessing the structural model, the PLS-SEM measurement model was evaluated using outer loadings, internal consistency reliability, convergent validity, and discriminant validity. The assessment criteria followed established PLS-SEM guidelines, including outer loadings above 0.70, composite reliability above 0.70, AVE above 0.50, and HTMT for discriminant validity (Hair et al., 2022). Bootstrapping with 5,000 resamples was applied to test the significance of path coefficients and indirect (mediation) effects, with statistical significance set at $p < 0.05$. One-way ANOVA was used to test differences across the three zones; homogeneity of variance was assessed using Levene's test, and Tukey HSD post-hoc comparisons were applied where the omnibus test was significant.

ANALYSIS AND DISCUSSION

Sample Profile and Descriptive Statistics

A total of 300 valid questionnaires were analysed (Zone 1/HBP = 101; Zone 2/School of Arts = 105; Zone 3/Main Hall & Library = 94). Table 2 summarises the descriptive statistics of the study constructs.

Table 2: Descriptive Statistics of Study Constructs

Construct / Dimension	No. of items	Mean	SD
Colour	3	2.38	0.93
Size	3	2.43	0.78
Temperature	2	1.93	0.90
Acoustics	3	2.64	0.98
Ventilation	2	3.06	0.91
Lighting	3	1.85	0.86
Environmental qualities (composite)	-	2.38	0.73
Learning outcome	6	2.47	0.96
Interaction	5	2.32	1.05
Students' behaviour (composite)	-	2.40	0.96
Overall satisfaction	-	2.10	0.72

Source: By Author

Overall perceived environmental quality of transitional spaces was moderate-to-low ($M = 2.38$, $SD = 0.73$). Among the six dimensions, ventilation ($M = 3.06$) and acoustics ($M = 2.64$) were rated relatively higher, while temperature ($M = 1.93$) and lighting ($M = 1.85$) received the lowest ratings, indicating the most critical constraints on usability.

Students' behaviour in transitional spaces was rated moderate-to-low (overall $M = 2.40$; learning outcome $M = 2.47$; interaction $M = 2.32$). Overall satisfaction was low ($M = 2.10$, $SD = 0.72$), suggesting that current transitional spaces do not adequately support students' learning-related use and experience.

PLS-SEM Measurement Model Assessment

The measurement model was assessed at the first-order construct level before evaluating the structural model. As shown in Table X, all retained questionnaire items achieved acceptable outer loadings, ranging from 0.736 to 0.928. The first-order constructs also met the recommended reliability and convergent validity thresholds, with Cronbach's alpha values ranging from 0.745 to 0.909, CR values ranging from 0.854 to 0.932, and AVE values ranging from 0.594 to 0.861.

Table 3: PLS-SEM Measurement Model Assessment

First-order construct	Item	Outer loading	Cronbach's α	rho_A	CR	AVE
EQ Colour	B.A1	0.858	0.747	0.753	0.855	0.664
	B.A2	0.784				
	B.A3	0.801				
EQ Size	B.B1	0.819	0.745	0.750	0.854	0.661
	B.B2	0.834				
	B.B3	0.787				
EQ Temperature	B.C1	0.903	0.804	0.812	0.910	0.836
	B.C2	0.925				
EQ Acoustics	B.D1	0.869	0.805	0.816	0.884	0.718
	B.D2	0.837				
	B.D3	0.836				

First-order construct	Item	Outer loading	Cronbach's α	rho A	CR	AVE
EQ Ventilation	B.E1	0.928	0.838	0.838	0.925	0.861
	B.E2	0.928				
EQ Lighting	B.F1	0.858	0.853	0.855	0.911	0.773
	B.F2	0.888				
	B.F3	0.892				
BEH LearningOutcome	C.G1	0.779	0.863	0.864	0.898	0.594
	C.G2	0.736				
	C.G3	0.758				
	C.G4	0.787				
	C.G5	0.783				
	C.G6	0.778				
BEH Interaction	C.G7	0.862	0.909	0.909	0.932	0.733
	C.G8	0.823				
	C.G9	0.865				
	C.G10	0.854				
	C.G11	0.876				

Source: By Author

Discriminant validity was further supported by HTMT values below the recommended threshold. The HTMT value was 0.768 between Environmental Quality and Students' Behaviour, 0.563 between Students' Behaviour and Overall Satisfaction, and 0.406 between Environmental Quality and Overall Satisfaction. These results indicate acceptable discriminant validity among the constructs.

Structural Model Results (PLS-SEM)

PLS-SEM results indicate that Environmental Quality significantly predicts Students' Behaviour ($\beta = 0.703$, $t = 17.456$, $p < 0.001$), explaining 49.4% of the variance in behaviour ($R^2 = 0.494$). When predicting Satisfaction, Students' Behaviour remains a significant predictor ($\beta = 0.523$, $t = 6.940$, $p < 0.001$), whereas the direct effect of Environmental Quality on Satisfaction is non-significant ($\beta = 0.022$, $t = 0.255$, $p = 0.799$), with $R^2 = 0.290$ for Satisfaction. Bootstrapping further confirmed a significant indirect effect of Environmental Quality on Satisfaction via Students' Behaviour ($\beta = 0.367$, $t = 5.833$, $p < 0.001$), indicating an indirect-only (full mediation) pattern in which environmental improvements enhance satisfaction primarily by improving what students can do in transitional spaces (learning outcomes and interactions).

Table 4: PLS-SEM Structural Model Results (Bootstrapping, 5,000 Resamples)

Path	β (Original sample)	t	p
Direct Effect			
Environmental Quality → Students' Behaviour	0.703	17.456	< 0.001
Students' Behaviour → Satisfaction	0.523	6.940	<0.001
Environmental Quality → Satisfaction	0.022	0.255	0.799
Indirect Effect			
Environmental Quality → Students' Behaviour → Satisfaction	0.367	5.833	< 0.001

R^2 (Students' Behaviour) = 0.494; R^2 (Satisfaction) = 0.290.

Source: By Author

Zone Comparison Results (ANOVA)

One-way ANOVA showed significant differences across the three zones for environmental quality, students' behaviour, and satisfaction (Table 5). Effect sizes ranged from small to moderate, with the largest effect observed for student satisfaction ($\eta^2 = 0.124$). Tukey HSD post-hoc comparisons indicated that Zone 1 performed significantly higher than Zones 2 and 3 across all three outcomes, supporting spatially targeted prioritisation rather than uniform campus-wide upgrades.

Table 5: One-Way ANOVA Results Comparing Environmental Quality, Students' Behaviour, and Satisfaction Across the Three Campus Zones

Variable	Zone 1 Mean (SD)	Zone 2 Mean (SD)	Zone 3 Mean (SD)	F(df)	p	η^2	Post-hoc (Tukey)
Environmental Qualities	2.55 (0.72)	2.31 (0.68)	2.27 (0.76)	F(2,297)= 4.379	0.013	0.029	Z1 > Z2; Z1 > Z3
Students' Behaviour	2.70 (1.04)	2.26 (0.89)	2.23 (0.89)	F(2,297)= 7.779	0.001	0.050	Z1 > Z2; Z1 > Z3
Student Satisfaction	2.45 (0.85)	1.96 (0.58)	1.88 (0.56)	F(2,297)= 21.007	<0.001	0.124	Z1 > Z2; Z1 > Z3

η^2 = eta squared effect size. Tukey HSD post-hoc tests were used for pairwise comparisons.

Source: By Author

DISCUSSION AND PLANNING IMPLICATIONS

To translate the empirical findings into a planning-oriented output, Figure 3 synthesises the evidence into key planning levers and priority implementation focuses for campus-scale optimisation of transitional spaces.

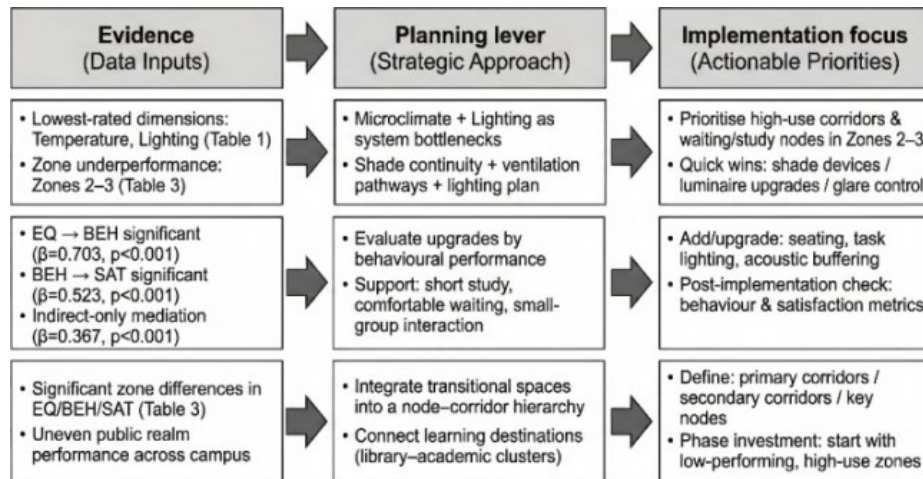


Figure 3: Evidence-To-Action Framework for Transitional-Space Optimisation

Source: By Author

Table 6 synthesises the empirical findings into evidence-based campus design actions by linking priority issues with targeted interventions, implementation locations, and expected performance outcomes. The recommendations emphasise microclimatic comfort, visual legibility, seating provision, and short-stay usability, positioning transitional spaces as integral components of the campus public realm system that support learning, interaction, and everyday movement.

Table 6: Campus design actions for transitional-space optimisation

Priority issue	Evidence	Campus design action	Priority location	Expected outcome
Thermal discomfort	Temperature was the lowest-rated environmental dimension	Provide continuous shade structures, and heat-reducing surface materials; improve natural ventilation paths	Zones 2–3; high-use corridors and waiting nodes	Improved thermal comfort, longer stay duration, higher behaviour scores
Poor lighting	Lighting received the lowest mean score after temperature	Upgrade walkway lighting, add task lighting at seating/study nodes, and improve night-time visibility	Key pedestrian links and transitional nodes in Zones 2–3	Improved perceived safety, usability, and satisfaction
Limited short-stay support	Behaviour mediates the relationship between environmental quality and satisfaction	Provide shaded seating, informal discussion spots, small tables, and flexible short-stay areas	Building edges, courtyard edges, lobby/entrance interfaces	Improved learning outcomes and interaction

Priority issue	Evidence	Campus design action	Priority location	Expected outcome
Uneven zone performance	Significant differences across zones from ANOVA	Implement phased corridor–node upgrading based on performance gaps	Start with Zones 2–3, then expand campus-wide	Reduced spatial inequality and improved public realm performance

Source: By Author

The matrix operationalises the PLS-SEM pathway by using behavioural functioning as the key performance indicator, supporting phased investment that targets lower-performing yet high-use areas rather than uniform upgrades. This is consistent with the non-significant direct path from Environmental Quality to Satisfaction, indicating that “cosmetic” improvements may not raise satisfaction unless they generate observable behavioural gains. From a campus master planning perspective, three planning implications follow:

- 1) Prioritise microclimate and lighting as system bottlenecks through shade continuity, ventilation-supportive corridor design, and a campus-wide lighting strategy for comfort and night-time legibility.
- 2) Adopt behaviour-based performance criteria to guide and evaluate upgrades, focusing on measurable improvements in short study, comfortable waiting, and small-group interaction.
- 3) Integrate transitional spaces into a corridor–node hierarchy and phase investments by targeting lower-performing yet high-use zones (Zones 2–3) and key links between major learning destinations.

CONCLUSION

This study repositions campus transitional spaces as a critical component of the campus public realm network and evaluates how perceived environmental quality relates to students’ learning-related behaviour, interaction, and satisfaction in a tropical university setting. Using a case-based assessment across three zones of USM main campus and a questionnaire survey (n = 300), the findings show that overall environmental quality, student behaviour, and satisfaction in transitional spaces are moderate-to-low. Among the six assessed dimensions, temperature and lighting emerged as the most problematic constraints, indicating that microclimate and illumination performance are key bottlenecks limiting the usability of transitional spaces for informal learning and everyday student life.

The analysis further indicates that environmental quality is strongly associated with students’ behaviour in transitional spaces, and that students’ behaviour is the direct predictor of satisfaction when considered together with environmental quality. In practical terms, this suggests that campus public realm improvements are most likely to increase student satisfaction when interventions

measurably enhance what students can actually do in transitional spaces—such as brief study, waiting in comfort, and small-group discussion—rather than merely improving appearance. In addition, significant differences across the three zones highlight uneven performance within the campus spatial system. The HBP zone performed comparatively better, while the School of Arts zone and the Main Hall and Library zone showed lower outcomes, supporting a planning approach that prioritises investments by location and performance.

Building on the evidence-to-action framework and the intervention priority matrix (Figure 3; Table 6), campus master planning should prioritise microclimate and lighting bottlenecks, adopt behaviour-based performance criteria for evaluating upgrades, and implement a phased corridor-node programme starting from lower-performing yet high-use zones (Zones 2–3). These recommendations support targeted, system-level optimisation of transitional spaces as part of the campus public realm network in tropical university contexts.

This study has limitations. The assessment focused on three zones and relied on self-reported perceptions and behaviours; thus, findings may not represent all campus areas or capture objective microclimatic conditions. Future research can extend the approach by combining subjective measures with objective environmental monitoring (e.g., thermal indices and illuminance measures), expanding zoning coverage across the full campus, and testing intervention scenarios to strengthen causal interpretation. Nevertheless, the study provides evidence-based guidance for integrating transitional spaces into campus public realm optimisation and supports more targeted, system-level decisions in campus master planning within tropical university contexts.

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DISCLOSURE STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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