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AN EVALUATION OF THE ROLE OF PHYSICAL LAYOUT IN CAMPUS MASTERPLAN DESIGN TO PROMOTE SUSTAINABILITY

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Abstract

Many of the current campus design development tends to be more ad-hoc and focus more on free-standing buildings in the landscape settings that do not respond to the environment of the local contexts. Those designs have been criticized for creating a high dependency on automobiles, sprawling and segregating campus outdoor spaces with roads and large parking lots that pose challenges to meet sustainability goals. This paper aims to evaluate the role of physical layout in the design of campus masterplan at Malaysian Public Universities (MPUs) to promote sustainability. Using a qualitative method of a multiple case study, a connection between physical layout and sustainability was evaluated based on document reviews, morphological studies, visual surveys, and semi-structured interview techniques. The finding reveals that the physical layout plays an important role in promoting a sustainable campus environment. It is recommended to emphasize the design of physical layout in the MPUs' campus masterplan to ensure compactness and structured configurations, which enhance design sustainability. These are important attributes in the design approaches that should be taken by MPUs for it to be agents of sustainability.

Keywords: Campus design, campus physical layout, urban form, morphological study, sustainability

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INTRODUCTION

Universities have a great responsibility to integrate sustainable design strategies for campus development. Universities should be the hubs for sustainability (Abdullah et al., 2024; Muhiddin et al., 2023; Sugiarto et al., 2022) and become communities with high potential for pursuing and promoting sustainability (Dawodu et al., 2022). Although most universities worldwide implement various strategies to address sustainability in higher education, Muhiddin et al. (2023) argue they vary substantially and remain fragmented due to several challenges. Among the challenges relate to the design of campus masterplans, which have been criticised for creating a high dependency on automobiles, sprawling and segregating campus outdoor spaces with roads and large parking lots. Sugiarto et al. (2022) emphasize that physical planning and the design of campus masterplans play an important role in achieving sustainability. However, Muhiddin et al. (2023) argue that the horizontal expansion of physical forms on campuses has changed the mode of transportation to motor vehicles, thus contributing to traffic congestion, a decrease in air quality, and an unhealthy environment on campus. Most university campuses have significant carbon footprints, primarily from motor vehicles, which negatively impact campus sustainability (Dawodu et al., 2022). Accordingly, campuses increase demand and supply to develop parking lots, posing a significant land-use problem and leading to a reduction of green spaces on campuses (Dawodu et al., 2022; McKenna & Altringer, 2021).

Furthermore, the design of campus masterplans tends to be more ad-hoc and focus on free-standing buildings in landscape settings. Campuses were built piecemeal, scattered and less integrated with the earlier development that caused a high- dependence on automobiles, traffic congestion and wasted campus land (Carmona, 2021; Samsudin et al. (2018). Additionally, these spatial arrangements reflect a jumble of isolated buildings that create disorientation (Trancik, 1986; Krier, 1979). Accordingly, the sprawl of physical forms often covers large areas of land that become 'lost-space' in low density (Trancik, 1986). In fact, Malaysian Public Universities (MPUs) that foster sustainable campus growth have also encountered these challenges. The previous studies found that most MPUs are sprawling in campus layout, where students' hostels are isolated and faculties are scattered over campus sites (Muhiddin et al., 2023; Nia, 2016; Abd-Razak et al., 2012; Shamsuddin et al., 2007b). Correspondingly, evaluating the physical layout of campus masterplans is crucial for promoting sustainability in MPUs.

LITERATURE REVIEW

Campus sizes have a direct impact on the physical layout of campus masterplans. Gehl (2011) claims that a small-scale campus is typically located in a compact environment. However, on a large-scale, people are dispersed in times and spaces because places are separated in a sprawling physical form with a high-automobile

dependency. On a medium-scale, people and activities disperse when buildings are placed at great distances apart, with entrances and residences oriented in opposite directions. Hajrasouliha (2017) classifies the elements of compactness and configuration in campus layout to establish a well-designed campus where buildings and spaces are interconnected through a hierarchical arrangement of spaces (Figure 1).

Compactness The density of campus and proximity of buildings.			
	Dense-Campus	Nucleus-Campus	Dispersed-Campus
Configuration The strength of campus spatial structure. Buildings are defining open spaces, campus spaces are connected through main corridors, campus main central space.			
	Structured-Campus	Ad-Hoc Campus	Hybrid-Campus

Figure 1: Compactness and configuration of a well-designed campus
Source: Hajrasouliha, 2017

The compactness in a campus layout serves to reduce automobile dependence on the road by minimizing travel distances, encouraging walking and facilitating social interaction (Samsudin et al., 2018; Nia, 2016; Matloob, 2016; Shamsuddin et al., 2007a). Matloob (2016) defines compactness as the degree to which the physical form reduces the distance between campus areas to encourage walking. Dober (1992) suggests that the most effective design for a walkable environment is a 150-acre enclosed campus. In general, pedestrians average walking radius is between 400 to 500 metres (Mehaffy et al., 2020; Gehl, 2011). Hajrasouliha (2017) defines compactness as the density of a campus and the proximity of buildings. He categorizes campus compactness into three types namely dense, nucleus and dispersed. A dense-campus design incorporates closely situated buildings and spaces to enhance a walkable environment for social interaction and safety. People feel safe when they see other people, which encourages walking (Hajrasouliha, 2017). Walking will encourage social interaction because it creates opportunities for contact during which individuals are at ease and able to engage, pause or become involved with others (Gehl, 2011). Compactness facilitates the concentration of activities and people on a large-scale (Gehl, 2011) and increases vitality in areas without relying on automobiles (Jacobs and Appleyard, 1987). Next, a nucleus-campus is

characterized by a concentration of compactness on a portion of the campus area. Shamsuddin et al. (2007a) argue that the development of a large campus should focus on a selected area to ensure easy access and movement, safety and to prevent traffic congestion, rather than utilising the entire site. Similarly, Dober (1992) suggests that both small and large campuses locate most of their buildings within five-minute walking distance from the campus centre. Whereas, a dispersed-campus is characterized by scattered and sprawling development on campus. This dispersed-campus development related to disorganized campus expansion, which caused shared facilities to be isolated and difficult to access by users, limited usage for those without vehicles and created fragmented outdoor spaces.

Hajrasouliha (2017) defines configuration as the strength of a campus's spatial structure, with buildings defining open spaces and campus spaces being connected by main corridors and a central spine. He categorizes campus configuration into three categories namely structured, hybrid and ad-hoc. Structured-campus refers to an organized hierarchy of spaces that are enclosed by buildings and interconnected. This type emphasizes constructing new buildings along the main spatial structure, creating enclosures with many entrances and focal-points, and providing a change in scale to distinguish different hierarchies of outdoor spaces (Hajrasouliha, 2015). Structured-campus provides building arrangements that define and enclose spaces, which is important to bring more people together and encourage social interaction (Gehl, 2011; Jacobs and Appleyard, 1987). Enclosure is an important quality in outdoor spaces for well-defined boundaries and forms that provide a distinct character and function (Alexander et al., 1977; Matloob and Alsoofe, 2018).

In turn, an ad-hoc campus is characterized by unorganized spaces filled with free-standing buildings that are not well-connected to one another (Hajrasouliha, 2015). Ad-hoc configuration tends to create more left-over spaces (Trancik, 1986) and is rarely utilized (Alexander et al., 1977). They are defined as negative spaces, which are shapeless, as compared to structured configurations as positive spaces, which have a distinct and definitive form and are enclosed. Alexander et al. (1977) suggest providing a degree of enclosure for negative spaces by adding small buildings, building projections or walls, transform them entirely into positive spaces. Carmona's (2021) emphasizes that this ad-hoc configuration reflects 'modernist urban spaces' that are contained within the free-standing buildings in landscape settings, large scale with a coarse grid and road network that segregates the urban spaces. Conversely, the structured configuration reflects 'traditional urban spaces' that are the spaces within urban blocks that define and enclose the outdoor spaces, small scale, fine grid meshed street that is well integrated and connected. Finally, a hybrid-campus is characterized by a combination of structured and ad-hoc configurations.

RESEARCH METHODOLOGY

This research employed multiple case studies to evaluate the physical layout of campus masterplans in Malaysian Public Universities (MPUs). As stated in the *Pelan Tindakan Pendidikan Tinggi Malaysia 2022-2025*, public universities are the main higher institutions in Malaysia, with the highest enrolment of students (MoHE, 2022). MPUs have been established since the early 1900s. MPUs play an important role due to their strong historical significance and the remarkable success of their academic achievements and educational quality. This research evaluated three early Malaysian campuses based on their evolving physical layout (Figure 2). The first campus is University Malaya (UM), which is the oldest public university in Malaysia. UM was built as a university in a greenfield development entirely on a vacant site. The second campus is Universiti Teknologi Malaysia Kuala Lumpur (UTMKL) served as the original main campus of UTM until 1989, when the main campus shifted to a new greenfield campus in Johor, which was officially opened in 1985. Finally, Universiti Pendidikan Sultan Idris – Sultan Abdul Jalil Campus (UPSI-KSAJ) is the origin campus of UPSI, which currently has expanded to the new Sultan Azlan Shah Campus, 8 kilometres apart. Both UTMKL and UPSI-KSAJ are small campuses that were established prior to independence and were upgraded from colleges or lower-level institutions into universities on brownfield developments.

The three selected campuses were evaluated based on the triangulation of multiple qualitative techniques of data collection, namely document reviews, morphological studies, visual surveys and semi-structured interviews. The analysis applied figure-ground plans via solid and void to portray the spatial configuration. Figure-ground plans are a significant tool to 'communicate essential information about built form and urban spaces in a graphic that is readily intelligible' (Hebbert, 2016, p.721). It clearly distinguishes 'the patterns of built form (figure) and unbuilt voids (ground), with the voids encompassing a variety of streets, squares, gardens, parks and outdoor spaces' (Carmona, 2021, p.198). Figure-ground plans can represent the past history, the current disintegration of outdoor spaces as a result of abandonment and large carparks, and finally the future of how to fit the current layout (Hebbert, 2016). Additionally, Trancik (1986) argues that it is important to understand the historical evolution of the physical forms in order to understand the current condition of spatial design. Caliskan and Marshall (2011) highlighted that a lack of incorporation of urban morphology in design, particularly in the process of creating physical form compositions and without a good understanding of the existing urban fabric, can lead to the failure of the urban environment. Correspondingly, figure-ground analysis and morphological studies were performed on the campus masterplans to evaluate the change in physical layout of the selected case studies.

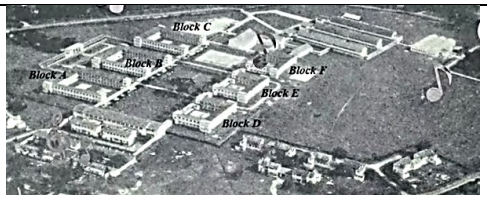
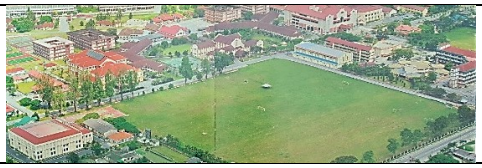
Campus Establishment	Campus Size	Physical Layout	
UM Established in 1961.	750 acres		Greenfield Development - Focus on the lake and *Rimba Ilmu*.
UTMKL Established in 1955 and upgraded to university in 1975.	47 acres		Brownfield Development - Focus on the open spaces.
UPSI-KSAJ Established in 1922 and upgrade to university in 1997.	81 acres		Brownfield Development - Focus on the padang.

Figure 2: Selected case studies with different design approach in campus layout.
Source: U-Malaya Library; UPSI, 2003.

RESULTS AND DISCUSSION

The discussion on the campus physical layout were based on the figure-ground analysis and morphological studies focusing on compactness and configurations as categorized by Hajrasouliha (2017).

Compactness

The findings show that UM is categorised as a dispersed-campus, while UTMKL and UPSI-KSAJ are categorised as dense-campuses (Figure 3). Both UTMKL and UPSI-KSAJ are within a circle 500-meter radius, which contributes to the compactness of the campus layout. The compact size of these two campuses was a result of their initial status as colleges, which were subsequently upgraded into universities.

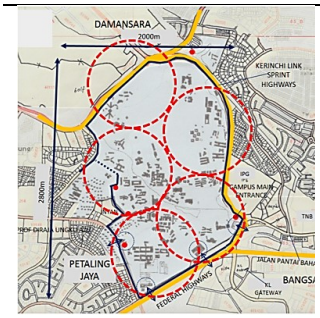
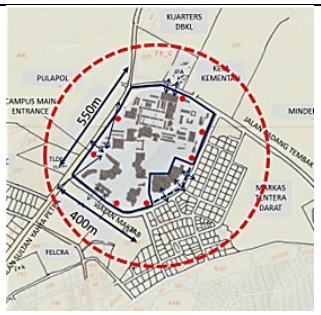
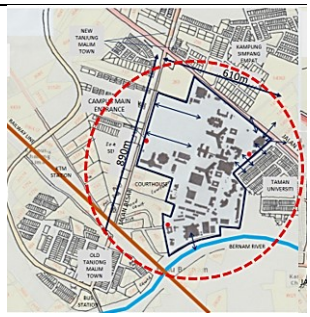
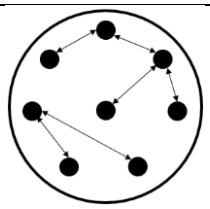
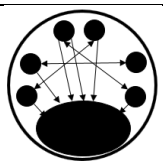
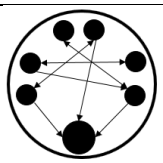
UM	UTMKL	UPSI-KSAJ
		
750 acres	47 acres	81 acres
Dispersed-campus	Dense-campus	Dense-campus
Approximately 5 circulars of 500m radius	Within 1 circular 500m radius	Within 1 circular 500m radius
		
Large Walking Radius	Small Walking Radius	Small Walking Radius

Figure 3: The compactness in the campus layout of three case studies.

The compactness of UTMKL and UPSI-KSAJ allows for a walkable environment within a small walking radius that reduces dependency on automobiles on campus. The result of a visual survey indicates that a greater concentration of users within a walkable space provides a higher chance to meet up for social interaction and natural surveillance. This is in-parallel with Carmona (2021), who highlighted that compactness reduces capacity for private automobiles on the road by reducing travel distances, encouraging walking and fostering social interaction. On a compact campus, people feel safe when they see other people on the campus street, which encourages walking (Hajrasouliha, 2017). However, the results of a visual survey showed that parking space at UTMKL remains high because there is a high demand for private vehicles to go to the campus without effective public transportation.

In turn, UM is a dispersed-campus on 750 acres of land. The visual survey demonstrates that UM requires a larger walking radius, resulting in a high-dependency on private automobiles to travel from one location to another on campus, inadequate parking and pedestrian-vehicle conflict. In-line with the results of interviews, it appears that UM lacks adequate parking on campus. It reflects a study done by Keat et al. (2016) that indicate long distances from

residential-colleges to the faculty and poor shuttle transportation as the reasons for students using private vehicles.

This larger walking radius lowers the chance of meeting up or running into the same circle of people because pedestrians can travel on various routes in different directions. While users who highly depend on private vehicles to travel tend to travel directly from one location to another and rarely meet up on the journey. This is aligned with Gehl (2011), who indicates that on a larger scale, people are dispersed in time and space because places are separated by dispersed physical form and high-automobile dependency. Additionally, Shamsuddin et al. (2007b) argued that the development of a large campus does not require the entire site, but should instead focus on a specific area for ease of access to facilitate movement, safety and the avoidance of traffic congestion. While, Matloob and Alsoofe (2018) emphasized 'infill-development' as an effective strategy to limit the expansion and increase density of the existing built areas, thus creating a more compactness that improves accessibility and enclosure.

Furthermore, the morphological analysis at UM demonstrates that the green spaces on campus decreased over time due to increased demand for built spaces (Figure 4).

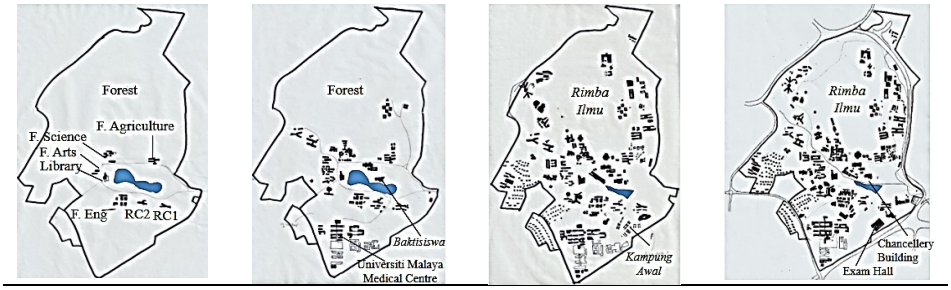
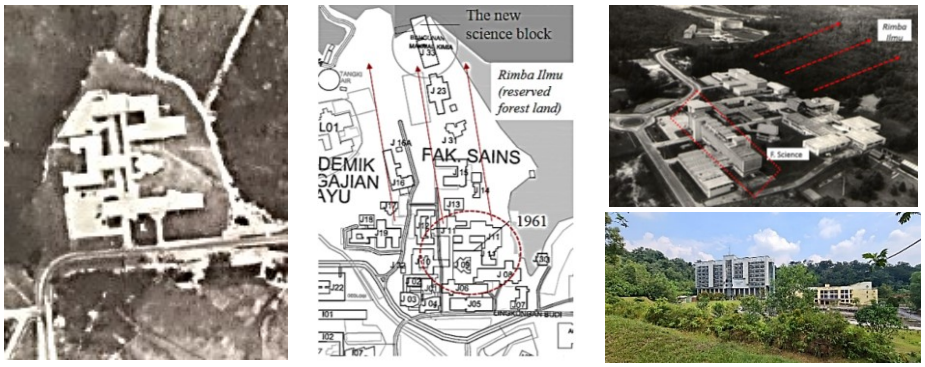


Figure 4: The evolution of physical layout in UM.

The lake served as the sole focal point for UM's development in the 1960s. However, the campus continues to expand around *Rimba-Ilmu* to build additional faculties, residential-colleges and shared facilities. This *Rimba-Ilmu*, was established in 1974 as a tropical rainforest botanical garden with more than 1600 species. It serves as a reserved-forest for conservation, research, education, and public awareness. The morphological analysis revealed that the growth and expansion of the campus are gradually consuming this reserved-forest land. In-line with the visual survey, the Faculty of Science recently built their chemistry-lab on part of the reserved-forest land (Figure 5). This is consistent with Abd-Razak et al. (2012), who highlight that the layout of the UM campus resembles a central core structure but is quite wide, and the campus's topography has a significant influence that results in a dispersed-campus.



1961 2020 The New Science Block

Figure 5: The expansion of the Faculty of Science towards the *Rimba-Ilmu*.
Source: U-Malaya Library.

Correspondingly, there is a need to design the campus layout to prioritize compactness by maximize construction within the existing development to minimize travel distances, promote walking and foster social interaction.

Configuration

The findings demonstrate that the configuration of campus layouts in UM and UPSI-KSAJ is categorised as ad-hoc campuses, while UTMKL is a hybrid-campus (Figure 6). The figure-ground analysis indicates that only UTMKL has a structured configuration on the old campus development, while the new development has an ad-hoc configuration. Hajrasouliha (2017) characterizes this type of layout that combines structured and ad-hoc configurations as a hybrid-campus.

UM	UTMKL	UPSI-KSAJ
		
Ad-hoc campus	Hybrid-campus	Ad-hoc campus

Figure 6: The configuration of campus layout in three case studies.

A visual survey found that the ad-hoc configuration of UM and UPSI-KSAJ are unorganized spaces filled with free-standing buildings that are not well-connected to each other and create lots of left-over outdoor spaces. It is aligned with previous studies indicating that poorly structured campus environments tend to create more left-over spaces between buildings and are rarely utilized (Alexander et al., 1977), which were defined by Trancik (1986) as 'lost-space'. Figure 7 shows UM's free-standing buildings, which significantly result in a great deal of 'lost-space' on their large campus.

Figure 7: Free-standing buildings that creates lots of left-over outdoor spaces in UM.
Source: U-Malaya Library.

Similarly, the campus layout in UPSI-KSAJ demonstrates ad-hoc configurations. The morphological analysis indicates that the campus layout is centred on the *padang* (Figure 8). The campus development began with three main buildings independently facing the *padang* in a symmetrical layout. The main building of Suloh-Budiman was built along the centre axis facing Jalan-Besar, with *Tadahan-Utara* and *Tadahan-Selatan* located side-by-side to the north and south, respectively. When the campus evolved as a result of its expandable function, this axis-line became blurred and eventually changed the earlier configurations. According to the interview results, the current campus environment is more congested and chaotic than it was in the 1950s. In-line with the visual survey, the infill of new free-standing buildings between old buildings creates an unorganized campus layout.

1922-SITC | 1960-MPSI | 1996-IPSI | 2020-UPSI-KSAJ

Figure 8: The change configuration of physical layout in UPSI-KSAJ.

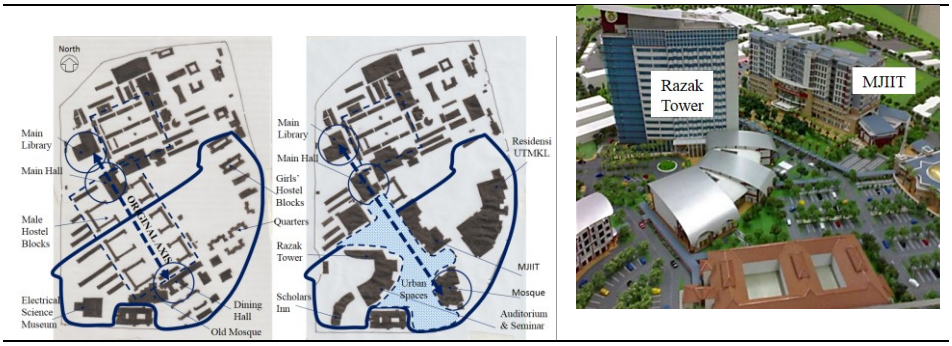
Moreover, the finding found that this ad-hoc configuration affects the local climate to provide users comfort. It creates issues to connect these free-standing buildings with covered walkways to suit the tropical climate. Providing covered walkways in all spaces causes budget constraints, and some spaces are not applicable. The result of the visual survey demonstrates that there are a lack dedicated covered walkways in UM that link the whole campus with faculties, hostels, and shared facilities. On this dispersed-campus, the only significant covered walkways from the hostel to academic blocks are from Residential-College 3, but they are just on sidewalks. This result is in line with Keat et al. (2016), who discovered that students choose to skip classes when it rains due to the lack of covered walkways to connect the residential-colleges and faculties. Moreover, the results of the interview indicate that covered walkways are difficult to implement in UM due to this ad-hoc configuration. Additionally, this free-standing building lacks shaded spaces on the ground floor that limit the activities for vitality (Figure 9). These buildings are limited to the building's primary entrances, which lead only directly to indoor spaces. Thus, it does not provide more space for transitions between internal and external campus buildings for social interaction compared to buildings in early campus development that connect several buildings on the ground floors.

Old buildings-connected ground floors.

New free-standing buildings - solely on individual entrances.

Figure 9: The configuration of the physical layout on the ground floor affects comfort and vitality.

In UTMKL, the morphological analysis discovered that changes in physical layout increase the image of ad-hoc configuration. The campus was originally designed as a structured-configuration centred on open spaces. The evolution and transformation of UTMKL has resulted in the demolition of a portion of the campus, thereby dividing the campus into two separate districts, the old and new developments of the hybrid configuration (Figure 10).



2000 – Old Development 2020 – New Development with less enclosure

Figure 10: The change in configuration of the physical layout in UTMKL.

The earlier layout of UTMKL provides smaller open spaces in each two-storey male hostel that connect to larger open spaces through an axis-line that anchors between the main hall and dining hall, demonstrating the hierarchy of spaces and being enclosed by buildings. This configuration provides a fine-grain, a sense of enclosure and high connectivity. In turn, the new development focuses on free-standing buildings in a coarse-grain landscape setting. When the campus was transformed to accommodate the 17-storey Razak-Tower, 10-storey MJIIT building, 4-storey Scholars-Inn, 2-storey Auditorium and Seminar, and 2-storey mosque, the changes in physical form had an effect on the enclosure, as buildings became objects in open spaces or open spaces that contained buildings. This reflects Carmona's (2021) argument that 'traditional urban spaces' have a small-scale, fine-grid meshed street that is well-integrated and connected, while 'modernist urban spaces' have a large-scale, coarse-grid and emphasize the road network that segregates the outdoor spaces. Besides, the earlier axis has been weakened due to the insufficient enclosure of the new free-standing buildings. UTMKL's early structured configuration enhances campus legibility, facilitating easy movement within easily controlled spaces. These configurations provide human wayfinding and indications to direct users from the starting point to the desired destination.

Moreover, the result of the visual survey found that the covered walkways in UTMKL can be divided into two types, attached to the building and independent (Figure 11). The covered walkways attached to the building are

mostly located in the old development of structured configurations, which provide better connectivity and provide multiple access points. However, the new developments provide covered walkways that are not attached to buildings, and certain parts must have elevated roofs to meet Fire Department requirements when passing through vehicle roads. The results of the interviews demonstrate that the users will get wet enough to move between the new free-standing buildings during rain. Typically, tropical downpours are accompanied by a strong wind that can assault from multiple directions, causing users of single, unattached covered walkways to become wet. Accordingly, structured configuration is a better design approach to reduce strong wind during rain and provide lots of shadow for a walkable environment in a tropical climate.

Structured configuration - old development

Independent covered walkways - new development.

Figure 11: The covered walkways between old and new developments in UTMKL.

Accordingly, there is a need to design the campus layout to reinforce structured configuration to provide a clear hierarchy of physical space in a campus environment. The structured configuration is a better design approach that enhances legibility, vitality and comfort in a walkable environment. A well-connected ground floor layout, typically in a structured configuration, promotes vitality that is accessible to the public for functions and climatic control.

CONCLUSION

The design of physical layout is the most crucial factor because it defines the pattern and structure of the street and buildings on campus. The evaluation of three campuses of Malaysian Public Universities (MPUs) shows that the large campus is expanded horizontally to utilized most of the campus land and finally creates a high dependency on automobiles and reduces green spaces. Sprawling necessitates more provision for campus streets and utility infrastructure. Additionally, the physical layout in MPUs mostly emphasizes the free-standing buildings with weak element that ties everything together. The physical layout must be direct, very clear, very defined and not scattered. Once the buildings are built, they cannot be relocated. The wrong design approach requires MPUs to create more solutions to the problems that have been created in the first place.

Therefore, it is recommended for MPUs to tackle their campus masterplans by designing the physical layout to provide compactness and structured configurations. These considerations contribute to the campus's legibility, vitality and comfort, which enhance a walkable environment. The implications of good design approaches in physical layout will ensure the design of campus masterplans to provide better outdoor spaces in campus development. MPUs need to take various actions to shape and reshape the campus over time as part of the process of shaping better places to promote sustainability.

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