Evaluating Neighbourhood Accessibility: A Spatial Analysis of Walking Preferences

Nurul Shakila Khalid*, Na'asah Nasrudin and Naimah Osman

Abstract--- *This study aims to examine how spatial layout affects parent decision-making of mode choice to school. The spatial layout of the neighbourhood has analyzed the configuration within the scope of integration, connectivity and street network by using Space Syntax's Axial analysis model. To analyse the spatial quantitative, two parameters in Space Syntax were used; global (Rn) and local integration (R3) to measure the network configuration of streets design in the neighbourhood within 800 meter radius from schools in two different neighbourhoods. The purpose to compare two (2) different neighbourhood density and layout pattern; grid and curvilinear is to hypothesise which built environment characteristics have a strong association with mode choice. The result indicates that the very grid with mainly linear, shortest paths and block lengths that are accessible within children walking range, are significantly correlated with of choice to/from school. It is proposed in this paper that streets with a high degree of integration and school that is adjacent to main streets with the co-presence of attractors such as shophouses, offices, restaurants, open spaces and other service providers, encourage school children to walk to/from school. This research improves our understanding of the spatial layout of residential exerts a powerfully influenced children active mobility and syntax-based study helps to design better-connected street networks in the neighbourhood.*

Keywords--- *Spatial Layout, Choice of Mode, Space Syntax, Integration, Landuse.*

I. INTRODUCTION

Children are not born obsessed with speed and productivity – we make them that way.

Jannette Sadik-Khan

The statement above does reflect the questions of how can urban planners integrate the environmental experiences that children have into the process of designing a city and does the loss of children's freedom matter to planning as overall? The freedom of children to independently explore their neighbourhood is of far more value than we may first realize. With obesity rates and road accidents increasing, and social opportunity decreasing among children, children's freedom of movement, in combination with diverse environmental affordances to learn, facilitate play and living, is fundamentally important in a child-friendly environment (Hannah et al., 2017). According to Urry (2016), there are the licenses given to the children by their parents – license to travel to school alone, catch buses alone, cross the main road alone, and play in the playground with friends. The age at which children are given these license becomes an indicator of the level of freedom that children have or their level of independent mobility. This claim can also be supported by a similar study done by Waygood and Susilo (2015), children in Japan and German were likely to be given this license of freedom for children aged 9 to 12.

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Very low numbers of Japan and German children were driven to school compared with children in Singapore. The impacts of these ongoing demographic shifts have initiated a critical debate on urban planning discourses for their inclusiveness of family life in cities. In placing more emphasis, Rojas et al., (2015) claimed that the given the background of families may affect with children active and independent travel. Families of lower-income face challenges related to housing prices, quality of housing, services and living in less than desirable neighbourhood. What this implies for urban planning is redefining the nature of planning for families in urban areas. He and Giuliano (1990) and Hannah et al., (2017) have found the lack of understanding by urban planners of the importance of the local scale in the everyday lives of children and their parents and plea for more family-inclusive policies at all scale of development plan. To understand these problems, several scholars explored the relationships between children mobility behaviour to school and the built environment conditions (Broberg and Sarjala, 2015; Curtis et al., 2015, and Sharmin and Kamruzzaman, 2017) including the residential and school surrounding environments (Hashim et al., 2019). In recent studies, Hashim et al. (2019) reported that children living in denser neighborhood and mixed land use were more likely and willing to walk and cycle to school as frequently. This can be supported by Larsen et al, (2012) and Larsen, Buliung and Faulkner (2015) found that built environment factors such as distance to destination, block length, density, street quality, signalised intersections, mixed land use and schools in low-income neighborhood were positively associated with active and independent mobility. For an example, in Hong Kong, high shade-tree density and the well-covered pathway was provided as to overcome the issue of climatic and successfully encouraged children to walk to school independently without parents to worry the children safety (Rojas et al., 2017). Large block sizes and increased numbers of intersections in neighbourhood discouraged children from walking to school independently as mentioned by Hashim et al., (2019). To be aware that children mode of choice to school may influence from parents' perceptions on neighbourhoodand decision-making process - how they give a trust to their children to travel independently to school (Rothman et al., 2015 and Nasrudin and Nor, 2013). This includes many factors such as the linking the school trip with the trip to the workplace, convenience, concerns about road safety, the growing number of working mothers, social and cultural norms (Nasrudin and Nor, 2013, Rothman et al., 2015 and He and Giuliano, 2017) as the result of traveling by car to school has increased from 20% to 40%since 2009 (Sharmin and Kamruzzaman, 2017). Therefore, it is important to understand also the influence of parents' perception on the neighbourhood and their activity-trip constraints to their children travel mode choice and analyses this issues under an integrated decision structure.

Curties et al., (2015) and Broberg and Sarjala (2015) debate that there is essential lack of understanding of to what extent the observed behaviours are the result of the prior self-selection of residents into built-environment characteristics that are consistent with their tendencies towards the choice of mode and land use configurations. The neighbourhood was defined as the immediate environment around the house within a distance of 1 kilometre (10 to 15 minutes of walking distance). Despite the seeming simplicity of the sustainable mode share, very little is known about how street layout affects people's willingness or capacity to access the desired destination on foot. This study investigates the effect of street layout on the different neighbourhood spatial pattern. So, too, to answer the two main research questions related to the topic of children mobility behaviour; (i) To what extent residential street layout could influence parent decision-making on choice of mode of their children, and (ii) what is the right degree of

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permeability that could ensure the safety to walk or cycle in a layout? Baran et al., (2008) described the spatial layout as the morphology of the street network thus the configuration of streets and public spaces. According to the Space Syntax theory, the spatial layout is a system of lines and convex spaces and how they interrelate to each other. This paper presents preliminary findings of an ongoing study on the relationship between choice of mode to school and spatial layouts analysis.

1.1 Spatial configuration and walking preferences

The spatial configuration of a city can be seen as a projection of the social relations of its inhabitants. In this case, the spatial configuration affects to pedestrian to make a decision about what route they take for their trips. In additional, spatial configuration may encourage or discourage the pedestrian in selection of a route. Configurational descriptions and observational studies of cities have revealed that the layout design includes the length, connectedness and position occupied by each route of movement within the urban grid will influence the density of human movement that occurs along it (Hillier, 2007). Out of this theory has emerged the understanding that integration is a powerful predictor of how “busy” or how “quiet” a path or street is likely to be. Integration is measured by examining the differences in trip lengths required to move from each individual route to all other routes within the urban grid. The more centrally located the route, the shorter the trip lengths to other destinations within the grid, and the higher level of its integration – how integration is related to the concept of pedestrian movement in aspects of spatial configuration (Ozbil, Yeşiltepe and Argin, 2015).

Measures commonly applied in urban planning literature such as the density of street intersections per area (Irvin, 2008), block size area (Larsen, Buliung and Faulkner, 2015) and the average distance between intersections (Larsen et al., 2012) are concerned with the average or aggregate properties of areas. It is suggested that shorter distances between intersections and smaller block sizes encourage walking. Particularly, children are more likely and willing to walk or cycle to/from school when street connectivity are denser (Ozbil, Peponis and Stone, 2011, and Ozbil, Yeşiltepe and Argin, 2015). It is concerned with the internal structure of areas and with the way in which street network layout impacts walking behavior. This can be useful in supporting guidelines and policies, but cannot inform design decisions about alternative street alignments or alternative keys of designing an effective street network.

The significance of spatial structures in affecting the walking behavior or pedestrian movement has been addressed through the framework of configurational analysis of Space Syntax. The methodology of Space Syntax involves measuring the accessibility of all parts of a network under consideration from each individual element. The aim is to provide a narrative of spatial structure and connectivity hierarchy in the whole system. In Space Syntax, specific attention is given to the number of direction changes that are needed to move from one location to another (Hillier, Yang, and Turner, 2012). Previous studies have shown that road segments that are accessible from their surroundings with fewer direction changes tend to attract higher flows (Irvin, 2008 and Giles-Corti, 2011). Since walking occurs according to the fine grain of the environment as well as according to its larger-scale structure, appropriately discriminating measures of street connectivity are critical for designing for walkability.

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This study indeed contributes to the literature by offering insightful knowledgeof the roles of layout design, street network configuration, and land use patterns with the effects on walking preferences.

II. METHODOLOGY

Focusing on school mode of choice, this study used Space Syntax to analyze the street network Configurational in the two different neighbourhood. Space Syntax is a set of tool for analyzing street networks of whole (global integration R*n*) and part of whole system(local integration R3) to identify the underlying patterns which influence patterns of children walking preferences and how integrated the various neighbourhood are in the city using the axial map as was produced in Figure 1.

According to Hillier and Iida (2005), an axial map is a network of intersecting lines that comprises the longest sets of lines of sight that pass through all the spaces in a study area. The resulting axial map can be analyzed using a number of statistical measures of walking characteristics of selected school children that describe the configurational properties of the network.

Configurational analysis refers to any way of spatial analysis which characterizes the relation of each elementary spatial unit, here the road segment, to all others. Hence, street network configuration is the interface between designs and planning attributes (Baran et al., 2008). It is related to land-use and population density (Chen et al., 2008), movement patterns (Aditjandra et al., 2013), activity (Hannah et al., 2017 and Ozbil et al., 2011), accessibility (Rojas and Wong, 2017) and the built environment significant factors such as block size and length, and intersection distances (Larsen et al., 2012).

To measure the spatial configuration analysis of the street network, the framework of the configurational analysis techniques of Space Syntax has been developed by using spatial configuration software – DepthMap to measure the pedestrian connectivity.

Depthmap is a multi-platform program to perform a set of spatial network analyses to examine social processes in the built environment. To measure the connectivity of each line in axial map which represents a street, the relationship of each axial line is examined by integration. Integration is an indicator of howeasily one can reach a specific line of the axial map (Hillier, 2007).Integration measures the mean depth of every axial line in the grid relative to all other lines.

For the context of this study, the researcher employed the parameters in Space Syntax that uses to measure the local integration (at neighbourhood scale) and global integration (for the entire street system). For the global integration of analysis, Space Syntax takes into account every possible relationship in the system – from anywhere to anywhere, whereas for the local integration analysis, only examine a certain local catchment as three steps from the main line. For this study, analysis of two neighbourhoods was done within a 3 km radius which both represent the local area. The more spatially integrated the street (represented by warmer colors or dark grey), the more people and car on the streets. In contrast, the more spatially segregated (cooler colors or light grey) the streets are, the fewer people and car on the streets.

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(a) (b)

Figure 1: Dark to light grey lines represent higher to lower for 596 street segments of (a) Bukit Jelutong and 1,440 street segments of (b) Seksyen 18 were audited in Depthmap within the overall of the neighbourhood.

The underlying reason for studying the Bukit Jelutong and Seksyen 18 Shah Alam is because both represent the different housing density and spatial layout pattern dominating each area. Mostly the neighbourhood in Malaysia reflects a residential character with mixed land-uses prevailing the central parts. Although the selected areas represent a small cross-section of the entire city of Shah Alam, the sum of their population equals to one-eighth of Shah Alam’s total population.

Bukit Jelutong is an elite residential area with its gross density is 6 units per acre along with the walkable built environments as per designed, well-designed of pedestrian infrastructures (sidewalks and crosswalks) and flat topography but private cars are increasing common. While Seksyen 18 was chosen to compare how spatial layout affect the choice of mode. Seksyen 18 Shah Alamgross residential density is16 units per acre. In Seksyen 18, the total number of houses are 2,430 units which consist of the low and medium terrace houses with the estimated population is 5,700 resident.

The schools (in red) are drawn from the neighbourhood that varies substantially in street connectivity patterns. The selected school environments have notable differences in aspect of their street layouts and land-use composition as shown in Figure 2. In terms of land-use compositions, Bukit Jelutong have mostly high mixed-use density with small parcel sizes, short blocks and cul-de-sac while Seksyen 18 zoned to accommodate residential and institutions buildings, includes a non-uniform distribution of land uses and long linear blocks (16 units per row) linked by a complex pathways.

According to Aditjandra et al., (2013),there is the strong associations between children mode of choice to school and the built environment setting; design, density and distance (3Ds). However, this study only considers the street layout design and housing density to test walking preferences among school children. In addition, this study took

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into account the effects of land use distribution on children walking movement as a sub-variable of connectivity and accessibility to/from school. Broberg and Sarjala (2015) reported that children living in denser neighbourhoods and mixed land use were more likely to walk for school. Larsen, Buliung and Faulkner (2015) in their previous study found that factors such as distance to destination, block density, walking density, signalised intersections, mixed land use and schools in low-income neighbourhoods were positively associated with active and independent mobility among children at age of 10. There has been an observation by Hashim et al., (2019) that the denser the urban structure, particularly when locating a mix of uses (e.g houses and commercial) close to each other, the less dependence there is on private vehicles and thus become important in developing a walking environment.This claim also is supported by Chen, Gong and Paaswell (2008) that stated walking trips became more frequent at higher densities, growing from 0.5 daily walking trips to 1.5 trips by the average resident within an increase from 5,000 to 50,000 residents per square feet. Other analysis of the influences of density and land use mix on the choice of walking found that walking share of school trips increased at higher population densities. While walking and cycling is considerably associated with the number of destinations available within walking range for children ability, walkability could be increased by providing the regular need of children.

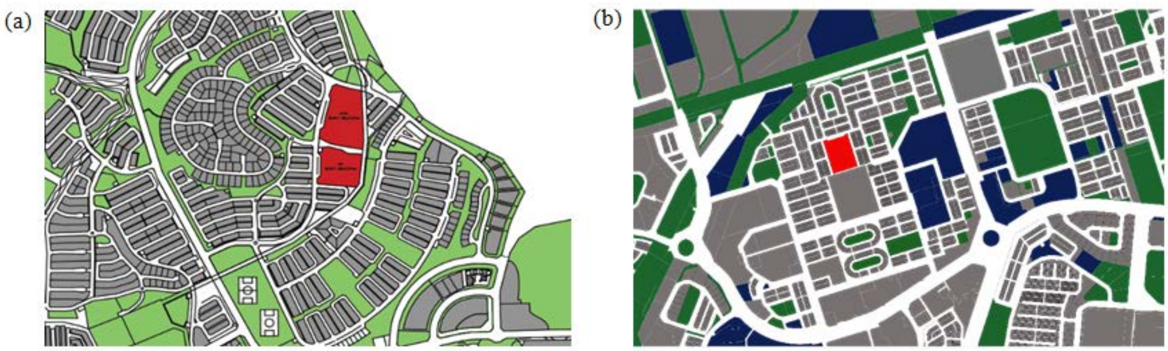

Figure 2: (a) The warped street network pattern can be found in Bukit Jelutong consists of a lower density of streets and street connections, and (b) traditional street grids with linear blocks are common for school environments for the old neighbourhood in most cities in Malaysia with high-density street networks.

III. RESULTS AND FINDINGS

3.1 Descriptive statistics of socio-demographic and household economic background

The survey collects several social backgrounds and household-level characteristics that producing the school trips including the information on children gender, their mode to/from school and its composition by gender, and with whom they walk are presented in descriptive analyses (see Table 1). The data socio-demographics were also compared between Bukit Jelutong and Seksyen 18 to identify to what extent the socio-demographic characteristics in the different neighbourhood may affect the parents' decision on mode choice to/from school for their children. The sample consisted of a total of 297 parents of 10-12 year old children from two (2) selected primary schools; SK Bukit Jelutong and SK Seksyen 18, Shah Alam. The study chose this age group of school children because existing literature on children's school travel patterns reported that 10 to 12 years old have a freedom and higher tendency to

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walk more or cycling for school trips with or without the adult supervision (Sarmiento et al., 2015 and Larsen, Buliung and Faulkner, 2015).

Table 1: Characteristics of school children from SK Bukit Jelutong and SK Seksyen 18 according to gender and mode to/from school

Characteristics of school children	Bukit Jelutong N= 135(%)	Seksyen 18 N= 162 (%)
Children Gender		
Boy	61.5	68.0
Girl	38.5	32.0
Mode to/from school		
Walking	9.6	14.1
Cycling	2.2	14.6
Van/school bus	28.3	18.5
Car pooling	14.1	4.3
Motorcycle	2.2	25.5
Private car	41.4	22.4
Public transportation	2.2	0.6
Gender composition of students walking to/from school		
Boy	75.0	57.5
Girl	25.0	42.5
Walking to/from school characteristics		
Walking alone	46.3	38.5
Walking with friends	45.0	52.5
Walking with adult	8.7	9.0

n = 297

The result in Table 1 shows that 14.1% of school children in Seksyen 18 reported walking to/from school while only 9.6% of school children in Bukit Jelutong are walking to/from school. The findings also stated that the most mode of transport to/from school for both neighbourhood is completely different. For Bukit Jelutong, the highest score of the mode to/from school is private car which mean most of the school children are driven by their parents and the second highest score is by van or school bus. School buses serving when parents cannot provide rides themselves because of excessive distances between home and school. While in Seksyen 18, the highest score of the mode to/from school is motorcycle and private car is the second highest score of mode to/from school. In the case of Bukit Jelutong, parents found the reason for taking children to school by car or the children take a van/school bus is more convenience, safety, time-saving and "on their way".Increased use of the car as the most natural travel mode for children results in less independence for them. These reasons associate well with the socio-demographic background of parents in Bukit Jelutong whereas they have the strong capability for budget and resources (time and cars). The score of school children in Seksyen 18 to walk and cycle to/from school may take as a potential to convince parents to allow their children to independently travel in their neighbourhood compared to the score of walking and cycling freedom in Bukit Jelutong. The parents only allow their children access to walk or cycle as it convenience for recreational purpose or to their friend's house in the same block.To note from the result, it has been commonly reported that boys who lives in Bukit Jelutongare more likely to actively walk to school and they enjoy do it with their friends.

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The lower level of mobility freedom among girls can be explained by more protective and restrictive parents and the higher perceptions of risk/fear in the neighbourhood among girls than boys. However, the score contrary to the gender composition in Seksyen 18 whereas boys and girls have an equal access to/from school. The girls have more walking trips at the walkable school location. This can be explained that an earlier maturation in girls combined with the fear of stranger danger (Rothman et al., 2015).

3.2 Street network configurational analyses

Street network configuration of Bukit Jelutong and Sekyen 18 was evaluated using connectivity and integration implemented in DepthmapX. By according to the configurational measurements to the several streets segment, relationships between street pattern and school location can be measured. At this point, the study has drawn an attention of how integrated and connected the street layout within 3km radius are in two neighbourhood; Bukit Jelutong and Seksyen 18 as a broad scale using axial map as shown in figures below.

The first spatial analysis to be conducted is connectivity - to evaluate how accessibility can be improved by providing shorter or more direct routes for any origin and destination. The connectivity is measured by using block length and size, pedestrian directness and street layout pattern.The positive influence of connectivity (refer to the pedestrian paths) is the street and pathways connecting home and school on active mobility (walking or cycling) as shaping the mode choice.

According to Figure 3, the highest values of connectivity is Persiaran Gerbang Utama (32) because it is a 100' road that connected from GCE to Shah Alam. Besides, other streets including the pathway are integrated with the Persiaran Gerbang Utama. However, the results indicate that through cul-de-sac (dead ends),it shows clearly that the carriageways are safer as the pedestrian access routes – safest spaces in the system because of the fewer entries to the neighbourhood. Mostly, because high-connected layout attracts car thereby increasing traffic-safety concerns among parents to allow their children to walk or cycle in the neighbourhood. This can be the main reason why children freedom in walking preferences is restricted because of their parent's decision and perceived the neighbourhood environment (unsafe environment, pedestrian infrastructure, far from home, traffic danger). While the two streets in front of the SK Bukit Jelutong; Jalan Serambi U8/21 (11) and Jalan Jendela U8/20 (15) shows the less traffic through and may reduce traffic-safety concerns among parents. Only during the peak hour of the school session, between 6.45 am to 7.20 am, 12.30 pm to 1.15 pm and 6.15 pm to 7.00 pm, the parent's car crowded in front of the school. On the side note, there are two schools alongside in Jalan Serambi U8/21; primary and secondary school thus contributed to the traffic congestion in front of the schools and discouraged school children to walk or cycle. The idea of locating the primary and secondary schools next to is to give convenient for parents to pick their children from both schools.

However, from the statistical data of the number of children who walk or cycle to/from school, total percentage of mode to/from school by walking is 9.6% which breakdown to 46.3% of the school children are walking alone followed by 45.0% who walk with friends and 8.7% walk with adult regardless of local street connectivity. This results suggest that school children who residing within 400 meter distance from a school encouraged to walk to/from school without regard to the street connectivity levels of the school area.

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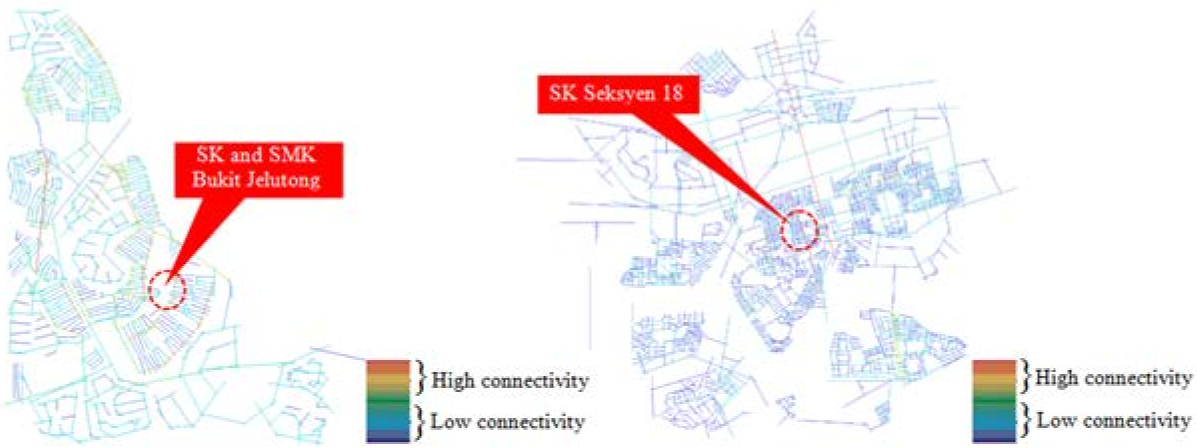
For Seksyen 18, the most connected streets in the whole systemarePersiaranJubli Perak (22) and Persiaran Sultan (17). Both main streets are the carriageway that moves vehicles and have higher street density. It also adds to the poor pedestrian pathway connectivity (segregate pathway) and streetscape – not accessible to walk nor cycle due to the heavy traffic volume. This findings thus can indicate that the main road of 100'is purposely designed to move vehicles instead of walking or cycling. While two (2) other streets near to SK Seksyen 18; JalanBertamTahan 18/7 (6) and JalanCucur 18/13 (3) shows the least connected because the street width is 50' which move small vehicles with sufficient traffic volume (the allowed speed in the neighbourhood is 30km/h) that give children convenient to walk to/from school although the provision of improper pedestrian infrastructures regardless of the lower street connectivity and street pattern. This finding also support by the percentage of school children who walking and cycling to/from school in SK Seksyen 18 which reported that 14.1% school children are walking and 14.6% are cycling. Most of the streets in the school area is short and provide many entries (many routes alternative to walk nor to cycle) to the destination either to home or to the facilities and commercial.



(a) (b)

Figure 3: Axial connectivity analysis for (a) Bukit Jelutong and (b) Seksyen 18 to measure how many streets connect to the other streets in the system.

Table 2: Connectivity values of the Bukit Jelutong and Seksyen 18

	Connectivity
Bukit Jelutong	
PersiaranGerbangUtama	32
PersiaranSinggahsana	10
JalanSerambi U8/21	11
JalanJendela U8/20	15
JalanLelangit U8/45	6
Seksyen 18	
PersiaranJubli Perak	22
Persiaran Sultan	17
JalanBertamTahan 18/7	6
JalanKelapa 18/42	10
JalanCucur 18/13	3

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Other than analysis of connectivity, integration is been analysed to measure the accessibility of the layout pattern, from the very grid with mainly linear through streets to the fewer grids with cul-de-sac carriageway. The local integration value in Space Syntax represents local integration value in radius 3 as represents in Figure 4. The results of local integration displayed a range of colors from the red lines as the more integrated spaces through to the lighter lines as less integrated spaces. The most integrated locally for Bukit Jelutong is JalanBirai U8/66 (3.22) with more movements of vehicles and pedestrians, followed by Jalan Serambi U8/21 (2.88) and Jalan Jendela U8/21 (2.15). JalanBirai U8/66 connected with Jalan Pelapik U8/46 because the co-presence of the neighbourhood commercial area, fast food restaurants and petrol station, as an attractor in the neighbourhood parcel.

While for Seksyen 18, the most integrated streets are Persiaran Jubli Perak (3.43) and Jalan Kelapa 18/42 (2.66) which are accessible by effective public transport (Selangorku Bus and RapidKL through the Seksyen 18) although only 0.6% school children commute by public transportation to/from school. This is due to the many of the school children residing within the walking range of 400 meter and prefer to walk or cycle to/from school. To emphasise, SK Seksyen 18 is a neighbourhood school that the catchment only the population in Seksyen 18. In addition, JalanKelapa 18/42 (in front of the SK Seksyen 18) is a 950 meter street length and stretched to PersiaranJubli Perak, a spine for the whole system.

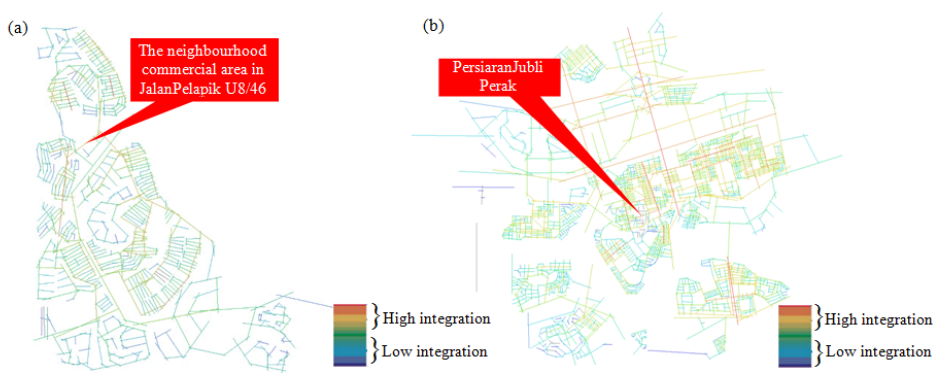

Figure 4: Axial Map processed of the street network at radius 3 (local integration) in (a) Bukit Jelutong and (b) Shah Alam

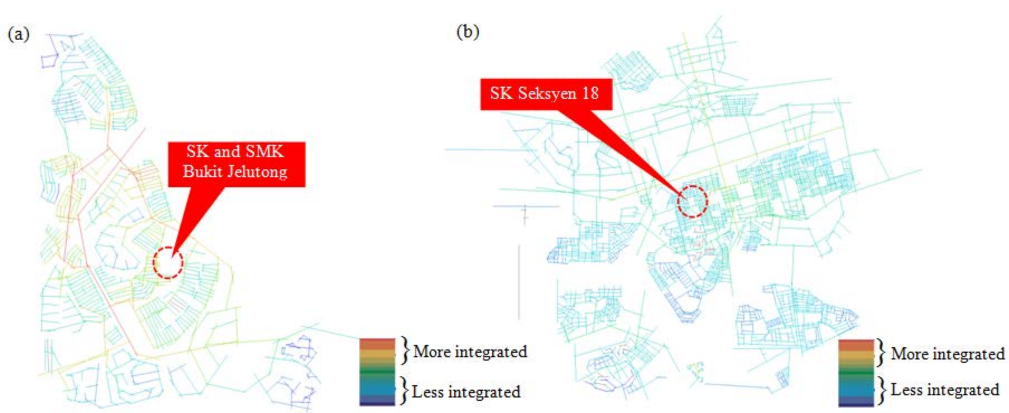

Figure 5: (a) SK Bukit Jelutong is surrounded by lines with values of global integration while (b) SK Seksyen 18 is located with low integration values that result the segregation in the whole neighbourhood

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Figure 5 represents the spatial distribution of axial lines for global integration. The global integration describes the average depth of space to all other spaces in the network system. Global integration values range from 0 as the lowest to approximately 1 as the highest (see Table 2). The higher value of global integration indicates that the axial lines can accessed easily from all other axial lines. Based on Figure 5, the most integrated streets are on the area's central parts both for Bukit Jelutong and Seksyen 18 (the yellow lines represent Persiaran Sultan and KTM railway line to Padang Jawa).

As it turns out from the spatial analyses, Seksyen 18 seems to have clear spatial logic when the central core is segregated on all scale levels where the commercial core areas, service providers and facilities are centralised. There is the Ole-ole Mall, petrol station, Mydin Mart, Giant supermarket, fast food restaurants, banks, and INTEC Collegeare located in Persiaran Jubli Perak become the attractor to the neighbourhood of Seksyen 18 that give the greatest number of movement by foot and vehicles. The two local supermarkets serve a large range of local areas. The adjacent residence from Seksyen 17 and Seksyen 24 for example also come to this area to get their daily needs. Most locals can walk or by the motorcycle to reach to the commercial areas because the location of the commercial core is within the walking range (400 meter) and the grid pattern encourages the many entries and alternatives routes.

However, it is noticeable that in Bukit Jelutong, the most integrated street is Persiaran Gerbang Utama(1.02) at the central parts of Bukit Jelutong. The long lines, coloured red is well integrated and inclines to attract more movement of vehicles. At the edges of the area, JalanPelapikU8/46 (0.65) and Jalan Birai U8/66 (0.97) is connected to Jalan Lelangit U8/45 (0.62). These streets recorded the highest integration value because most through traffic to the neighbourhood centre and to the area itself are on the street on the edges. Besides, various facilities and services can be found in this road – petrol station, fast food restaurant, grocery shops, workshops and supermarket concentrated in the area's northern part. The result of significant correlations between the integration values of an axial line and the amount of pedestrian and vehicular that flows along it suggests that the spatial configuration of the neighbourhoods network exerts a strong effect on people movement. This relationship hence contributes to the potential to walk and the understanding that the idea of movement density by pedestrian and vehicular is determined predominantly by patterns of land use.

Table 3: The comparison of syntactical values between Bukit Jelutong and Seksyen 18 for the global and local integration system

	R*n*	**R3**
Bukit Jelutong (total number of axial lines: 596)		
PersiaranGerbangUtama	1.02	2.70
JalanBirai U8/66	0.97	3.22
JalanSerambi U8/21	0.75	2.88
JalanJendela U8/20	0.91	2.15
Seksyen 18(total number of axial lines: 1440)		
PersiaranJubli Perak	1.05	3.43
Persiaran Raja Muda	0.93	3.18
JalanBertamTahan 18/7	0.83	1.50
JalanKelapa 18/42	0.96	2.66
JalanCucur 18/13	0.77	2.01

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There are 596 and 1440lines respectively in the whole street networks for Bukit Jelutong and Shah Alam. When compared with global integration, the results showed that the value for Bukit Jelutong is slightly higher (0.88) than Shah Alam (0.75). A similar result was also indicated when compared to the local integration where the value is 1.83 and 1.64 respectively. To be discussed the street connectivity, the value of connectivity for Shah Alam is greater (3.57) than Bukit Jelutong (2.80). The higher connectivity value much related to land use pattern and a population density which is Shah Alam is denser and the land use pattern from the home to school is more effective – commercial buildings, institutions, office, services and street stalls. Not to mention, importantly, the layout design in Shah Alam is more permeable with the size of blocks is 200 to 800 square metres thus improve the ability to see the routes through an environment, more freedom to move and encourage walking. Compared to Bukit Jelutong, the co-presence of the attractor such as the commercial area is located decentralised at the edge of the whole system purposely to encourage more people to walk and create safe neighbourhood environment. Further discussion on the neighbourhood environment will be explained in the next following section.

3.3 Neighbourhood environment characteristics

Table 4 shows that parents have varying perceptions of barriers influencing their children mobility to/from school. From the list of parent's perceptions towards neighbourhood environment, it can be divided into three categories; safety, social, and physical barriers. The result provides insight of how positive parent perception of their neighbourhood that obviously affects the choice of mode to/from school. Their perception might differ from the actual operating neighbourhood condition. The more positive perception can increase the number of active mobility to school.

Table 4: The perceived of neighbourhood environment characteristics among parents may affect the freedom of children mobility

Parent's perception towards neighbourhood environment	**Bukit Jelutong Parent agree (%)**	**Seksyen 18 Parent agree (%)**
Pedestrian strain walkway is narrow and disconnected	74.6	81.5
Traffic congestion in front of the school is because of the parent's vehicle	77.1	64.2
Effective crosswalk and traffic lights help students to cross busy roads	62.8	43.2
There is a physical barrier to walk in my neighbourhood	60.2	76.1
Traffic volume in my neighbourhood is heavy	31.5	45.4
The cars are driven fast	33.5	86.0
The distance between intersections is short	71.5	51.5
I can walk to go to the shop lots and facilities	55.3	47.3
The pedestrian pathway and roads are unattractive and safe enough for a child to	58.4	64.6
walk/cycle	91.6	90.7
I am worried about my child interacting with strangers	66.0	62.4
People are out and about, talking and doing things with one another	56.5	40.5
I live in a safe neighbourhood	40.1	58.3
I give trust to my children to walk/cycle in the neighbourhood		

*the total does not sum to 100% because multiple responses were allowed

An accessible neighbourhood has a positive relation with walking and cycling among children especially in high-income economies, most of the parents prefer high walkability levels in promoting active mobility among their children. This finding can be seen in the score of walking and cycling in Bukit Jelutong which is less compared to children in Seksyen 18 due to the socio-demographic background that more higher among parents in Bukit Jelutong.

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Parents in Bukit Jelutong agree to allow their children to walk or cycle in the neighbourhood for leisure activity compare to the children in Seksyen18 who are more freedom to walk and cycle to/from school.

It also be noticed that parents' perception towards neighbourhood environmental setting, accessibility and connectivity is influenced by safety especially traffic safety. Perceptions of safety have the greatest impact on the choice of mode and walking preferences both for children and parents. The perception of the pedestrian pathway is the most agreed by both parents in Bukit Jelutong and Seksyen 18. The provision of poor pedestrian pathway infrastructures, the condition and disconnected linkages gave the negative perceptions among parent to allow their children to walk. In discussing the cycling mode to/from school, most of the parents not allow their children to cycle because of the neighbourhood does not provide the segregated bike lane. In addition, parents noticed that the cars are driven as fast as the high-speed traffic in the neighbourhood was associated with significantly less active mobility. In conclusion, parents see the mentioned barrier make them feel more difficult to walk than drive.

Figure 6: The insufficient width of pedestrian pathways, the shared space between bike and car, and proportion of collectors and services discourage children to walk or cycle to school

Figure 7: The poor sidewalk coverage and on-street car parking reflect the not-bicycle/walking-friendliness of the area

In conclusion, an important application of Space Syntax concerns the analysis pf pedestrian movement among school children within an urban system. This analysis aims to evaluate the level of children freedom in mobility and how layout design affect parent's decision-making in choice of mode. A key finding in Space Syntax research is that there is a strong association between spatial configuration (indicated by the integration value) of each street segment in the whole neighbourhood and mode of choice among parents as a decision-maker.

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This study thus recommends that future research could incorporate the active mobility diary among school children to ensure high sensitivity of the outcome variable and further develop the school walkability index approach to guide future interventions in the aspect of policy, design and promotion. At school with high walkability, education and promotion strategies would be the most practical and holistic way especially transferring the knowledge to parent. Here, the interventions what would create more supportive environments, such as speed limits in the neighbourhood and school area with strict enforcement, segregated pedestrian pathways and bike lane, safe crossings should be examined further.Walking should be encouraged because it is the most efficient and the only fully sustainable mode of travel. From a transport viewpoint, increased walking can mean less use of cars and congested public transport services.

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REFERENCES

[1] Aditjandra, P. T., Mulley, C., and Nelson, J. D. (2013). The influence of neighbourhood design on travel behaviour: Empirical evidence from North East England. *Transport Policy,* 26, 54-65.

[2] Baran, P. K., Rodríguez, D. A., and Khattak, A. J. (2008). Space syntax and walking in a new urbanist and suburban neighbourhoods. *Journal of Urban Design,* 13(1), 5-28.

[3] Broberg, A., and Sarjala, S. (2015). School travel mode choice and the characteristics of the urban built environment: the case of Helsinki, Finland. *Transport Policy,* 37, 1-10.

[4] Chen, C., Gong, H., and Paaswell, R. (2008). Role of the built environment on mode choice decisions: additional evidence on the impact of density. *Transportation,* 35(3), 285-299.

[5] Curtis, C., Babb, C., and Olaru, D. (2015). Built environment and children's travel to school. *Transport Policy,* 42, 21-33.

[6] Ghekiere, A., Carver, A., Veitch, J., Salmon, J., Deforche, B., and Timperio, A. (2016). Does parental accompaniment when walking or cycling moderate the association between physical neighbourhood environment and active transport among 10–12 year olds? *Journal of Science and Medicine in Sport,* 19(2), 149-153.

[7] Giles-Corti, B., Wood, G., Pikora, T., Learnihan, V., Bulsara, M., Van Niel, K., and Villanueva, K. (2011). School site and the potential to walk to school: The impact of street connectivity and traffic exposure in school neighborhoods. *Health and Place,* 17(2), 545-550.

[8] Hannah W., Samuel W., Josef, H., and Felicitas Z. D. (2017). Cities alive. *Designing for urban childhoods. ARUP.*

[9] Hashim, H., Hashim, S. F., Abdullah, Y. A., and Nasrudin, N.(2019). Assessing the residential and schools' surrounding environments for child-friendliness in Precinct 11 Putrajaya, *Journal of Advanced Research in Social Sciences and Humanities,* 2 (4), 136-149.

[10] He, S. Y., and Giuliano, G. (2017). Factors affecting children's journeys to school: a joint escort-mode choice model. *Transportation*, 44(1), 199-224.

[11] Hillier, B., and Iida, S. (2005). Network effects and psychological effects: a theory of urban movement. *In Proceedings of the 5th International Symposium on Space Syntax,* 1, 553-564, Delft: TU Delft.

[12] Hillier, B. (2007). Space is the machine: a configurational theory of architecture. *Space Syntax.*

[13] Hillier, W. R. G., Yang, T., and Turner, A. (2012). Normalising least angle choice in Depthmap-and how it opens up new perspectives on the global and local analysis of city space. *Journal of Space syntax,* 3(2), 155-193.

[14] Irvin, K. (2008). How far, by which route and why? A spatial analysis of pedestrian preference. *Journal of urban design*, 13(1), 81-98.

[15] Larsen, K., Gilliland, J., and Hess, P. M. (2012). Route-based analysis to capture the environmental influences on a child's mode of travel between home and school. *Annals of the Association of American Geographers*, 102(6), 1348-1365.

[16] Larsen, K., Buliung, R. N., and Faulkner, G. E. (2015). School travel route measurement and built environment effects in models of children's school travel behavior. *Journal of Transport and Land Use*, 9(2).

[17] Mitra, R., and Buliung, R. N. (2015). Exploring differences in school travel mode choice behaviour between children and youth. *Transport Policy*, 42, 4-11.

[18] Nasrudin, N., andNor, A. R. M. (2013). Travelling to school: transportation selection by parents and awareness towards sustainable transportation. *Procedia Environmental Sciences*, 17, 392-400.

[19] Özbil, A., Yeşiltepe, D., andArgin, G. (2015). Modeling walkability: The effects of street design, street-network configuration and land-use on pedestrian movement. *A| Z ITU Journal of the Faculty of Architecture*, 12(3), 189-207.

[20] Ozbil, A., Peponis, J., and Stone, B. (2011). Understanding the link between street connectivity, land use and pedestrian flows. *Urban Design International*, 16(2), 125-141.

[21] Rothman, L., Buliung, R., To, T., Macarthur, C., Macpherson, A., and Howard, A. (2015). Associations between parents′ perception of traffic danger, the built environment and walking to school. *Journal of Transport & Health*, 2(3), 327-335.

[22] Rojas Lopez, M. C., and Wong, Y. D. (2017). Children's active trips to school: a review and analysis. *International Journal of Urban Sustainable Development*, 9(1), 79-95.

[23] Sarmiento, O. L., Lemoine, P., Gonzalez, S. A., Broyles, S. T., Denstel, K. D., Larouche, R., and Hu, G. (2015). Relationships between active school transport and adiposity indicators in school-age children from low-, middle-and high-income countries. *International Journal of Obesity Supplements*, 5(S2), 107.

[24] Sharmin, S., andKamruzzaman, M. (2017). Association between the built environment and children's independent mobility: A meta-analytic review. *Journal of Transport Geography*, 61, 104-117.

[25] Urry, J. (2016). Mobilities: new perspectives on transport and society. *Routledge.*

[26] Waygood, E. O. D., andSusilo, Y. O. (2015). Walking to school in Scotland: do perceptions of neighbourhood quality matter? *IATSS Research*, 38(2), 125-129.