

PEDESTRIAN SPACE CAPACITY AND MOVEMENT PATTERN FOR ELEMENTARY STUDENTS IN URBAN AND RURAL AREA

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ABSTRACT: Elementary students as children pedestrians on their journeys to school, demonstrate the way they use space and movement pattern. Their unique space used can be seen on the pedestrian pathway in which safety should be the priority. Study space capacity of children pedestrian pathway and their movement pattern is urgent since there is limited research in related to child pedestrians and there is an inadequate guideline for it in the urban and rural area. The aim of this research is to analyze children space capacity and movement pattern. Data is taken in the form of video recording and photos using camera and smartphone and is counted using drawing program AutoCAD 2016 for measurement. Research location is 14 elementary schools in the urban area of the city of Manado and 9 schools in the rural area of Minahasa, North Minahasa, and Sangihe Island. The sample is based on Krejcie Morgan formula where there is a need for a minimum of 383 children considering the number of the population of elementary students in North Sulawesi province, Indonesia. Data is analyzed using SPSS 24. Results are children pedestrian space capacity with consideration to the number of children in a walking group and straight and zig-zag movement pattern. There is a need to have a special child pedestrian standard for the urban and rural area. Future research could develop the variant of location and time in which children walk to their destination, such as shopping precinct and housing area.

Keywords: Children pedestrian, an elementary student, space capacity, movement pattern, North Sulawesi

1. INTRODUCTION

Walking is a transportation mode for the journey to a destination [1]. As one of the active transportations, walking is a process or activity of moving people or goods from one place to another [2]. Children need safe and adequate space for their activity. Mobility helps children to interact with the environment [3]. However, pedestrian pathways in Manado are not safe, not well maintained and most of the streets do not have pedestrian pathways [4], [5], [6]. In term of the street problem in Manado, there is congestion caused by all types of vehicles and movement of goods and people in Manado [7]. Moreover, transport problem of pollution and traffic jam should consider car emissions [8] and manage an efficient public transport such as campus bus [9]. School as a destination for the students require a good access and its facility along the street. According to neighborhood standards, a school requires pedestrian pathways for a radius of 1000 meter for elementary school. By walking to school, children can have a detailed knowledge regarding the local environment, the texture of landscape by exploring along their journey. The pedestrian pathway should be safe and comfortable for children as part of a planning principle for a pathway system in suburban areas [10]. Special guidelines for child pedestrians has not formed yet.

Therefore, there is a need to study child space movement and capacity along streets in urban and rural areas.

2. LITERATURE REVIEW

2.1 Pedestrian Pathway

Pedestrian pathway for children is an area that children use for their journey to and from school. An area for a pedestrian in this research is an area including pedestrian pathways, side roads and any open space in the premier, secondary and local streets.

2.1 Pedestrian Space Capacity

Pedestrian space capacity is related to space movement on the pathway and different factors influence it. One factor that influence capacity is speed [11], [12], [13]. The characteristic of pedestrian flow for students age 18 to 25 years [14]. For pedestrian behavior [11], this research study the capacity for three groups of age less than 20 years, 20 to 65 years and more than 65 years old. Pedestrian volume studies in research are analyzed for facility need and pedestrian behavior [15].

2.1 Pedestrian Movement Pattern

The movement pattern is a movement of an elementary student on the pathway along their journey to and from school. The trip pattern has been used as an important factor in research for school children [16] in related to counting the calorie usage for walking. Route choice shapes movement pattern according to behavior analysis [15], route choice based on pedestrian choice [3], [16] and as part of behavior model evaluation [16].

3. METHODS

Research sample population is elementary students grade 1 to 6 with age between 6 to 12 years old. Research location is North Sulawesi Province in Indonesia with a total potential number of students 281,853 consists of 183,167 students in the rural area and 98,363 students in an urban area [17]. Using the Krejcie Morgan formula for limited population [18] such as a number of students there is a need for 383 sample for each area. Data were taken from a sample of pedestrian elementary students from 23 schools in the urban and rural area. The sample distribution can be seen in the figure below.

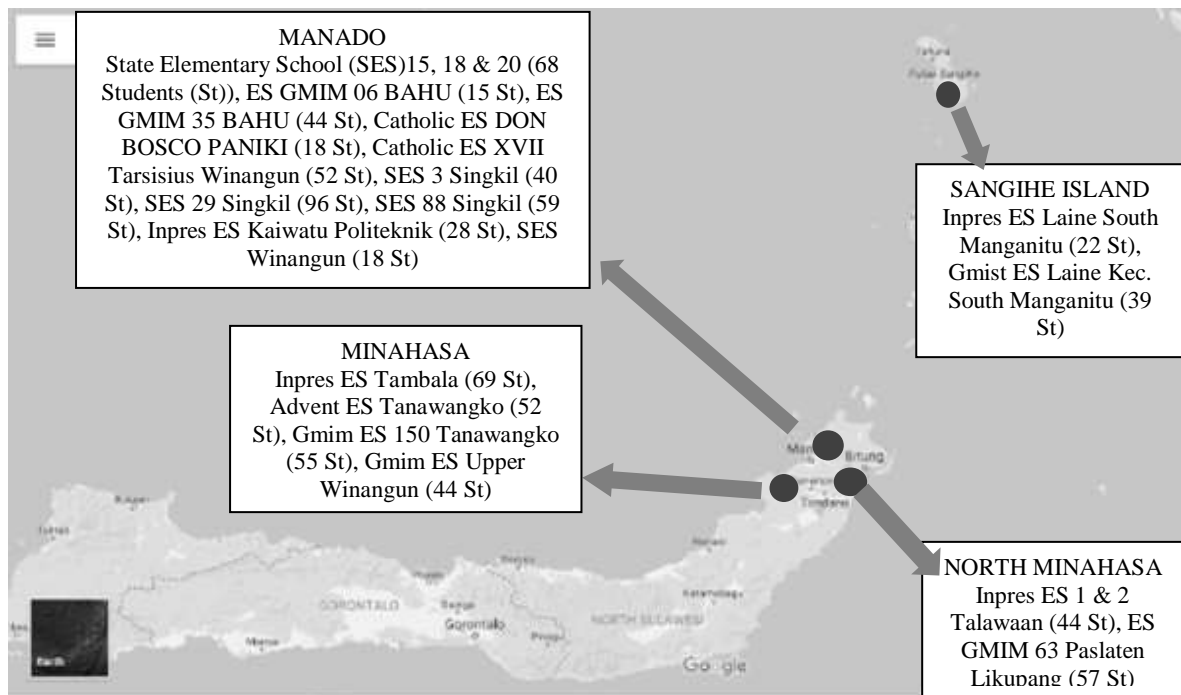


Fig. 1 North Sulawesi elementary students sample distribution map

Data is taken by camera and smartphone when students are walking to and from school and their activities in school hours on the pedestrian pathway. Recording and photos are taken undisclosed, unknown by students to get natural data. Data for dimension and movement pattern is measured and drawn using computer program AutoCAD 2016 and Ms. Office Excel for total calculation. All data is analyzed using computer program SPSS 24 to get a description related to the result of mean, mode, maximum and minimum dimension.

4. RESULT AND DISCUSSION

4.1 Child Pedestrians Dimension and Space Capacity

The result of child pedestrians' width can be seen in the figure below. From the sample available in the urban and rural area, 387 sample in each area is measured and counted using SPSS 24 statistic program.

Table 1 Comparison of child pedestrian width and standard

Type of Value	Urban (m)	Rural (m)	Standard (m)	Source	Adult (A)/ Child (C)
Mean	0.78	0.81	1.2	[19]	A
			1.6	[21]	A
			0.8	[20]	A
			1	[21]	A
			1.5	[21]	A & 1 C

This research found that the average dimension of width pathway in urban areas is smaller than in rural area. The average width of the urban area is 0.78 m and in a rural area is 0.81 m. maximum width in an urban area is 1.65 m and in a rural area is 1.78 m. With a group of walking students in a rural area up to 14 students and in the urban area up to 7 students, average group of walking in the rural area is larger than an urban area, an average walking group in the rural area is 3 students while in an urban area is 2 students.

Child pedestrian's width per person is less than standard available which indicate that space is adequate. However, considering the number children in a group of walking in the rural area is larger than urban area than the size should be different.

The number of a walking group and the frequency per act is dominated by two and three students. By comparison, a student is more likely to walk alone. The comparison can be seen in the next figure.

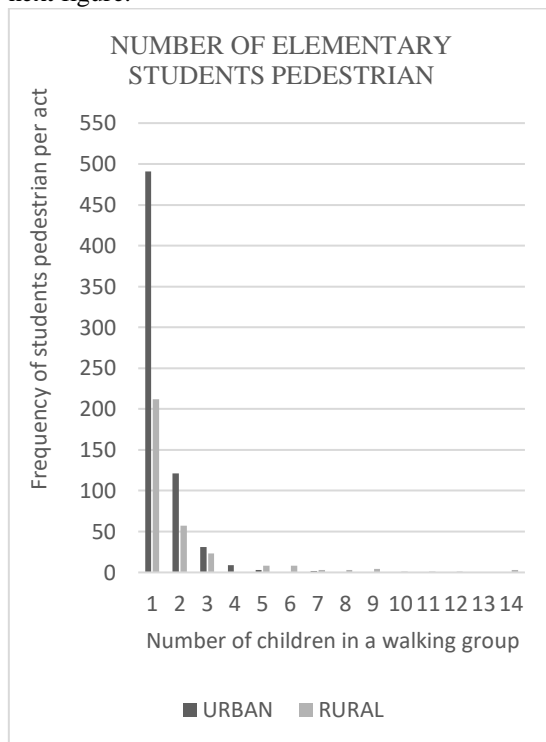
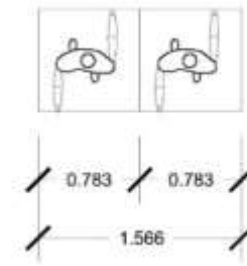
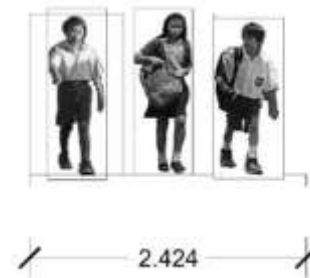
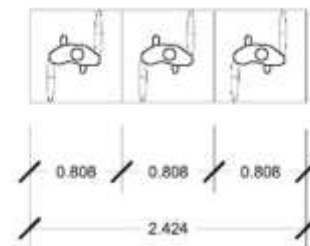


Fig. 2. Comparison of frequency of student pedestrians per act and number of walking group



(a)



(b)

Fig. 3 Children pedestrian width in (a) urban area and (b) rural area

Based on the width of children pedestrian in the rural and urban area, section street consists children pedestrian area can be planned. The example is for the local street with the 6-meter-wide premier street in the urban and rural area as shown in figures 4 and 5.

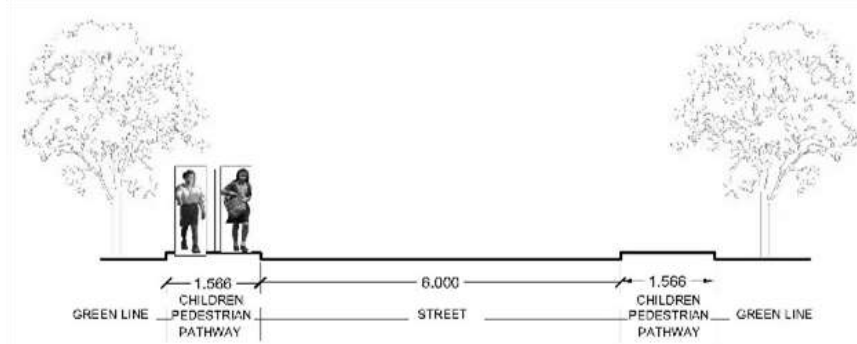


Fig.4 Street section with children pedestrian area for 6-meter-wide premier urban street

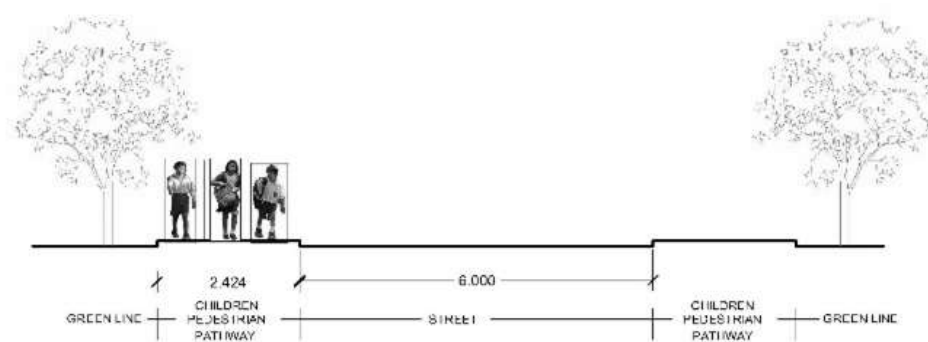


Fig.5 Street section with children pedestrian area for 6-meter-wide premier rural street

Considering the numbers of the walking group, the width of the pedestrian pathway for children is counting and the result of average width child pedestrians is 1.566 m with average 2 students for urban area and 2.343 m for rural area with average 3 students. Based on this result the size is larger than a standard such as by Highway Capacity Manual [20] with 0.8 m standard for adult and by Ministry of Public Works [21] with 1 m standard for an adult carry bag.

Space capacity of elementary student pedestrians, based on movement, can be seen in table 2.

Table 2 Comparison result of space capacity with standard and previous research

Type of Value	Urban (m ²)	Rural (m ²)	Previous Research /Standard (m ²)	Source	A / C
Mean	0.783	0.842	0.4 – 0.9	[11]	A
			1.35 – 1.62	[21]	A

Note. A=Adult, C=Child

Space capacity of elementary students in this research is larger than previous research. Average space capacity is 0.783 m² in urban area and 0.842 m² in rural area. By comparison, average space capacity [11] is between 0.4 to 0.9 m². Considering the number of walking group in the urban and rural area is different as discussed before, space capacity

in an urban area for average 2 students is 1.566m² and in a rural area with 3 students is 2.526 m². Space capacity in a rural area is larger than Ministry of Public works standard with average 1.35 to 1.62 m² for adult walking and carrying goods.

4.2 Children Pedestrian Movement Pattern

Elementary students' pedestrian movement pattern in the urban and rural area found in this research is dominated by straight pattern and followed by a zig-zag pattern [22]. The curve below shows a comparison of the frequency of movement and group of elementary students with the straight pattern.

Although the percentage of zig-zag movement is less than straight movement, the space usage is significantly larger. The percentage of movement pattern can be seen in table 3.

Table 3 Number of movement pattern

Type of Movement	Urban		Rural	
	Amount	%	Amount	%
Straight	722	98.63	468	93.79
Zig-zag	3	0.41	26	5.21
Half zig-zag	0	0	1	0.20
Zig-zag & straight	7	0.96	4	0.80
Total	732		499	

Zig-zag movement using maximum area of the street wherein the local street is 3-meter-wide and for the secondary and premier street is 6-meter-wide which shown in figure 6 and 7.

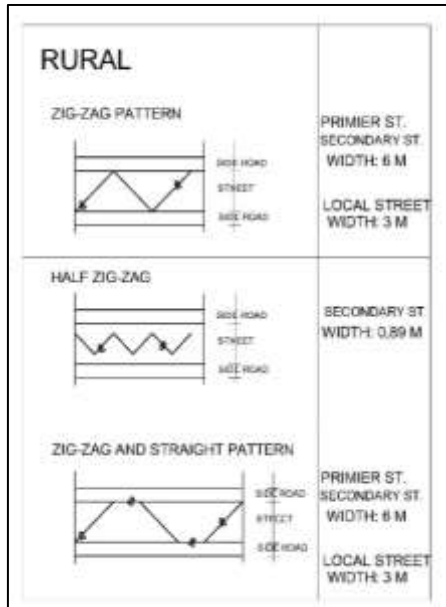


Fig. 6 Space usage based on movement pattern zig-zag and straight movement in the rural area

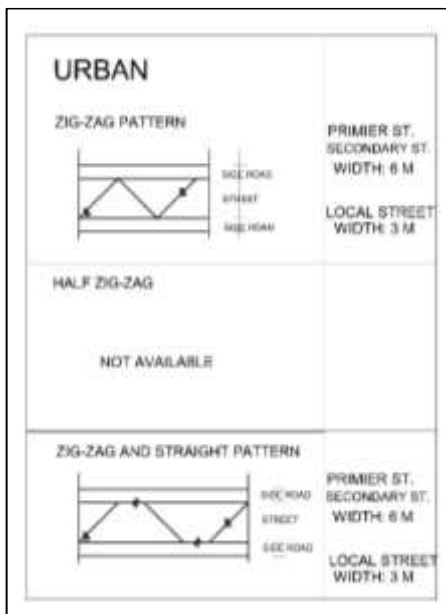


Fig. 7 Space usage based on movement pattern zig-zag and straight movement in an urban area

This research considers aspects as in previous research such as school neighborhood character [23], destination of child journey [24], access to outdoor landscape [3], obstacles in the environment [25] and child pedestrian behavior [26]. Considering all these aspects, movement

pattern is analyzed and the pattern found is straight and zig zag.

From this result of pedestrian space capacity and movement pattern, it is important to give priority to children as pedestrians. In the intersection area where there is no crossing area, children use the area of the street which is dominated by vehicles (Fig.8).

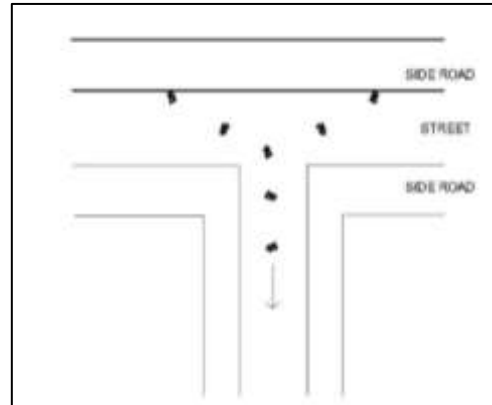


Fig. 8 Zig zag movement pattern on intersection area without crossing area

By giving priority to child pedestrians, area potential for a zig-zag movement pattern such as in street intersection can have priority areas such as a special area for crossing and a zig-zag movement which can be seen on figure 9.

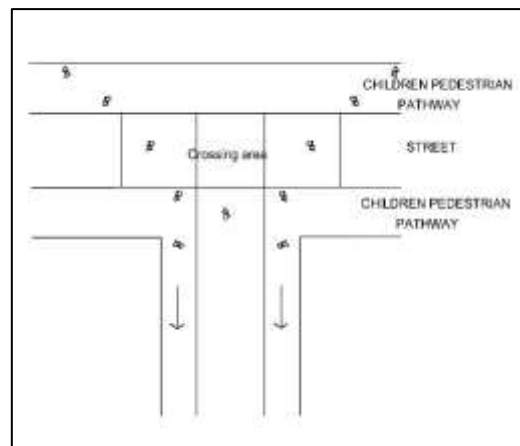


Fig. 9 Crossing area for zig-zag movement on the intersection of the street

5. CONCLUSION

Elementary student pedestrians' space capacity show differences in the urban and rural area in terms of dimension and space area. By comparison with previous research and standards available, the result show adequate dimension and size per person yet need to consider the number of walking group

Result dimension width of children pedestrian for rural area is larger than an urban area. The group walking children in the rural area is larger up to 14 students while in an urban area is up to 7 children. In terms of the pedestrian movement pattern, in the urban and rural area, it has found a straight and zig-zag pattern. Although the proportion of zig-zag pattern is less than the straight patterns, the space usage influence significantly due to maximum use of space available on street. In 3-meter-wide local street as well as 6-meter-wide secondary and primer street in both areas, space usage is as wide as these sizes. Although aspects considered in this research for movement pattern using previous research, movement pattern found such as a zig-zag is a unique one. The number of children in the walking group influence the width of children pedestrian pathway is another new finding. Therefore, it will need to establish a rule for children pedestrian particularly in an area dominated by children. In the future, a variant of location such as a public area, shopping precinct, and neighborhood of housing and settlement could be explored.

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