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Comparative Analysis of Evolving Wayfinding Behaviours in the Digital Era: A Case Study of Dhaka

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Abstract

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Wayfinding behaviour is fundamental to how individuals perceive and navigate urban spaces. Kevin Lynch identified five key elements that shape mental maps and enhance urban legibility. Every year, many students migrate to Dhaka for higher education. In the dense urban environment of Dhaka, wayfinding becomes challenging as their spatial perception differs from the local students. This study examines cognitive spatial perception and dependency on digital tools in wayfinding behaviour between local and internally migrant students of the Bangladesh University of Engineering and Technology, focusing on their journey from the campus to the Dhaka University MRT Station. Using PedCatch, the study identifies two routes that are within a 15-minute walkable distance. To assess their cognitive wayfinding behaviour, sketch map analysis and a structured questionnaire were conducted among the students. Findings indicate that Lynch's spatial elements significantly contribute to shaping cognitive ability for navigating within the urban fabric. Results also show that local students demonstrate detailed mental representations and less reliance on digital navigation tools, suggesting that familiarity with the urban environment enhances spatial cognition. The study offers insights for urban designers to integrate cognitive perceptions into urban planning strategies, improving urban legibility in the digital era.

Keywords: Wayfinding; Legibility; Spatial Cognition; Urban environment; Digital Navigation Tools.

1. Introduction

Dhaka is one of the fastest-growing megacities in the world, and draws thousands of internal migrants each year for employment and education (Khaleda et al., 2017). This influx has made the execution of urban strategies volatile, as the city continuously adapts to accommodate these migrant populations (Swapan et al., 2017). As the national capital and central educational hub of Bangladesh, thousands of students migrate to the city each year, including a substantial number of students pursuing higher education (Alam & Mamun, 2022). According to Amin (2010), 15.8% of internal migrants move to Dhaka for educational purposes. There are almost 41.59% and 53.56% residential students in Dhaka University and Bangladesh University of Engineering and Technology (BUET), respectively. These internally migrated students must become self-reliant to continue their education (Ali et al., 2021). The newcomer students often find it difficult to navigate within the city due to unfamiliarity with the urban environment. It is complicated for migrants, particularly newcomer students, to identify the intricate pattern and layering of the urban setting and thus prompting them to actively seek points of reference to understand the city's arrangements and distances, which are key aspects of spatial cognition. As cities grow more complex, both locals and newcomers face challenges in wayfinding, making legibility an important aspect of inclusive urban design (Yavuz et al., 2020, Amen, Afara, and Nia 2023; Aziz Amen 2022; Amen and Nia 2020). How a city can be arranged in a coherent pattern for the ease of the perceiving, the physical perspective is referred as legibility. While roaming around a city, people use various cues and some wayfinding tools like maps, street numbers, billboards, etc., which help them find strategic links to create their mental image of the environment. They actively seek points of reference to perceive the city and create a mental image based on their experience and memory. To comprehend the dialect between the city and its residents and migrants, it is essential to identify how people acquire, mentally store, organize, and recall locations. These are the key aspects of a city's imageability, as stated by Kevin Lynch in his book, "The Image of the City" (1984). However, with widespread access to smartphones, digital tools like Google Maps have become the default wayfinding aids, especially for newcomers. While these apps improve efficiency, emerging research shows they may reduce the development of internal spatial awareness (Ishikawa, 2019).

The rapid pace of urbanization in South Asian cities, particularly in Dhaka, has intensified the need for inclusive and cognitively accessible urban design. Previous research has addressed urban legibility (Lynch, 1960), individual spatial

cognition (Murray & Spencer, 1979). Recent research underscores how spatial cognition, urban legibility, and the use of digital navigation tools are increasingly shaping the way individuals experience cities (Ishikawa, 2019; Park & Evans, 2021). Moreover, limited research has been done on how migrant people perceive and navigate in complex urban settings. However, these strands have rarely been brought together. This study contributes to bridging this gap by offering a cognitive-behavioural perspective on urban wayfinding and the impact of dependency on digital navigation tools among two key urban user groups— local and internally migrant students. Therefore, this paper aims to analyze the differences in cognitive wayfinding behaviour based on Lynch’s five elements contributing to their mental perception and the impact of dependency on digital tools between local and migrant students for navigation in urban environments. The objectives of the paper are as follows:

1. To understand the differences in how local and migrant students perceive and mentally map urban routes based on their familiarity with the built environment.
2. To assess the role of Kevin Lynch’s five elements—paths, edges, districts, nodes, and landmarks—in shaping students’ mental perception and urban legibility.
3. To examine the impact of digital navigation tools on cognitive mapping and wayfinding behaviour.

This study will provide insightful data to urban designers and practitioners in developing strategies that improve city legibility, thereby promoting greater walkability and inclusiveness, especially for migrant communities. Pedestrian-friendly urban strategies have been shown to significantly improve walkability, safety, and the overall vitality of urban spaces when pedestrianization is applied thoughtfully (Hussein, 2018). This research thus supports the ongoing shift in urban studies toward more behaviourally informed, inclusive, and adaptive city-making, where design meets cognitive accessibility in a digitally influenced world.

This study is organized into four parts. The first chapter reviews the available literature on city legibility, cognitive mapping, and the impact of digital navigation tools on cognitive decline. The second section discusses the methodology. The third section analyzes the results based on the data and discusses the main contributions of this paper.

2. Literature Review

2.1. Urban Legibility and Kevin Lynch’s Theory

Wayfinding refers to the ability to navigate spatial environments using cues from the surrounding urban elements. In cities, this process depends largely on the legibility of the urban form. Kevin Lynch (1960) proposed that cities are made legible through five key elements: paths (routes of travel), edges (boundaries), districts (zones with distinct character), nodes (intersections or focal points), and landmarks (visual reference points). Mental mapping and wayfinding behaviour are shaped not just by the physical structure of a city but also by how individuals cognitively process this information. According to Yavuz et al. (2020), legibility and direction-finding become more critical as urban forms expand and converge in visual complexity, requiring clearer spatial cues and universal design elements. These urban elements help individuals to build a mental map of their surroundings. Apart from these urban elements, urban identity is also shaped by the collective memories, historical layering, and unique cultural imprints embedded in a city’s everyday spaces (Erçevik Sönmez, 2020). A city with a clear organization of these elements is considered highly legible, meaning it can be easily perceived and navigated by its users. Apart from these urban elements, urban identity is also shaped by the collective memories, historical layering, and unique cultural imprints embedded in a city’s everyday spaces (Erçevik Sönmez, 2020).

Lynch (1960) argued that cities with a strong “imageability” or legibility offer clear cues to help users perceive and provide direction. Subsequent researchers expanded on this framework to highlight the role of legibility in fostering walkability and urban comfort (Yavuz et al., 2020). Urban environments with strong reference points support faster spatial learning and more confident navigation. In contrast, poorly organized spaces can lead to disorientation and reliance on external aids (Zmudzińska-Nowak, 2003). Urban legibility thus becomes a crucial factor in inclusive city-making, especially for the transient population or unfamiliar users.

2.2 Cognitive Mapping

While urban legibility is a spatial property, cognitive mapping is its human counterpart. The way individuals perceive, interpret, and navigate urban environments is deeply rooted in how they interact with and recall spatial information. This cognitive process is shaped by several factors. While exploring spatial cognition, numerous variables— including age, gender, spatial ability, the degree of familiarity with the environment and the other personal characteristics that influence the spatial cognition of a city dweller— have been studied thoroughly (Levine et al., 2016; Proulx et al., 2016; Verghote et al., 2019). Beyond these individual attributes, the possibilities and functions that the city offers are also essential in shaping how urban identity is perceived and constructed (Erçevik Sönmez, 2020). A key dimension of variation in spatial cognition arises from the differing experiences of local residents and internal migrants. Migrant students, in particular, often enter urban settings with limited or no prior exposure to the complexities of city life, placing them at a relative disadvantage in developing accurate mental representations. Murray and Spencer (1979) observed in their classic study on geographical mobility that individuals who had lived in multiple cities produced more nuanced mental maps than those with static life experiences. However, Proulx et al. (2016) emphasize that cognitive mapping ability is also influenced by life stage and early upbringing, both of which significantly shape spatial cognition over time. Therefore, cognitive mapping is essential for understanding urban legibility because it reveals how individuals mentally interpret and navigate spatial environments.

2.3 Digital Navigation Tools and Cognitive Decline

The widespread adoption of digital navigation tools has fundamentally transformed the way individuals engage with urban space. This has shifted reliance from memory-based strategies to app-dependent behaviours. While these technologies offer unparalleled convenience, they may simultaneously inhibit long-term spatial learning and cognitive mapping ability. Users of mobile navigation have been found to make more errors and remember fewer surrounding details than those using traditional maps or personal exploration (Ishikawa, 2019). The convenience of digital guides might come at the cost of reduced geospatial awareness (Kalin & Frith, 2016, as cited in Ishikawa, 2019). This phenomenon is described as “cognitive deskilling”. This raises concerns about the over-reliance on smartphones for wayfinding. Given that internal migrant students are likely to depend on these tools in an unfamiliar city, it becomes crucial to understand how digital navigation interacts with their spatial perception. However, Park and Evans (2018) argue that the digital era reshapes how users engage with Lynch’s urban elements. Landmarks and nodes tend to lose prominence when users follow digital prompts without looking around. GPS-based navigation may guide users through less legible, efficiency-optimized paths rather than paths that provide cognitive clarity. In this way, digital tools can undermine the formation of mental maps and reduce city legibility, especially for newcomers. In response to this concern, enhancing walkability through pedestrianization can serve as a counterbalance by creating more engaging and intuitive spatial experiences, thereby promoting physical navigation over digital reliance (Hussein, 2018).

3. Materials and methods

It is important to understand individuals’ spatial knowledge to investigate wayfinding strategies and the influence of digital navigation tools. Although various methods exist for examining spatial cognition, relying solely on a single technique has often been critiqued for its limited reliability and validity (Gifford, 2007). Therefore, this research incorporated multiple methods of assessing spatial cognition. For this study, a mixed-method approach, combining qualitative and quantitative techniques, was used for data collection. The methodological framework comprises structured questionnaire surveys, and the representation of mental map through sketch maps. These methods collectively facilitate an in-depth assessment of participants' spatial cognition and the wayfinding strategies (Nandi & Kundu, 2024).

3.1 Study Design and Participants

Since the study focuses on analyzing the cognitive differences among the local and migrant students, the 1st year and 2nd year students of BUET were chosen as the participant group. Total 81 students took part in the questionnaire survey. Among them, 60% were from local students (from Dhaka), and 40% as migrant students (from outside Dhaka). The respondent pool consisted of an almost even gender distribution, with 51.2% male and 48.8% female participants. Most respondents were aged between 18 to 22, with 64% falling within the 19–20-year age range, which reflects the typical age of 1st and 2nd year students. Since the participants fall within a similar age range, potential variations in cognitive function and spatial ability attributable to age-related differences are effectively minimized.

Table 1: Participant data.

Local Student (48)		Migrated Student (33)	
Male	Female	Male	Female
19	29	22	11

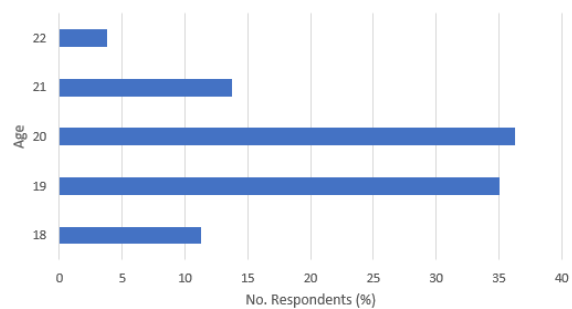


Figure 2. Age distribution of the participant group.

The Dhaka University MRT Station is the closest metro station to BUET and is frequently used by students for commuting within Dhaka and for long-distance travel. Several walking routes connect BUET to this station. Since the station is located within a reasonable distance and walking helps reduce travel expenses, most students prefer to walk. Using the PedCatch walkability analysis, the two shortest routes were identified, both allowing students to reach the MRT station within approximately 15 minutes on foot (Figure 3). The routes are -

1. **Route A** follows the path through Fuller Road and Nilkhet Road, leading directly to the Dhaka University MRT Station.
2. **Route B** proceeds via Shaheed Minar Road and Shamsunnahar Hall Road to the Dhaka University MRT Station

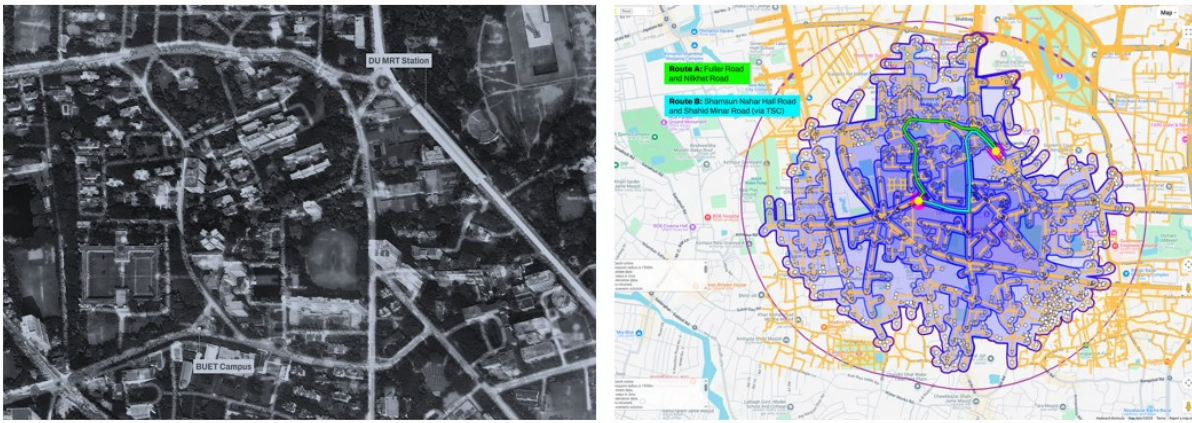


Figure 3. Selected Study Routes from BUET to Dhaka University MRT Station Identified through PedCatch 15-Minute Walkability Analysis.

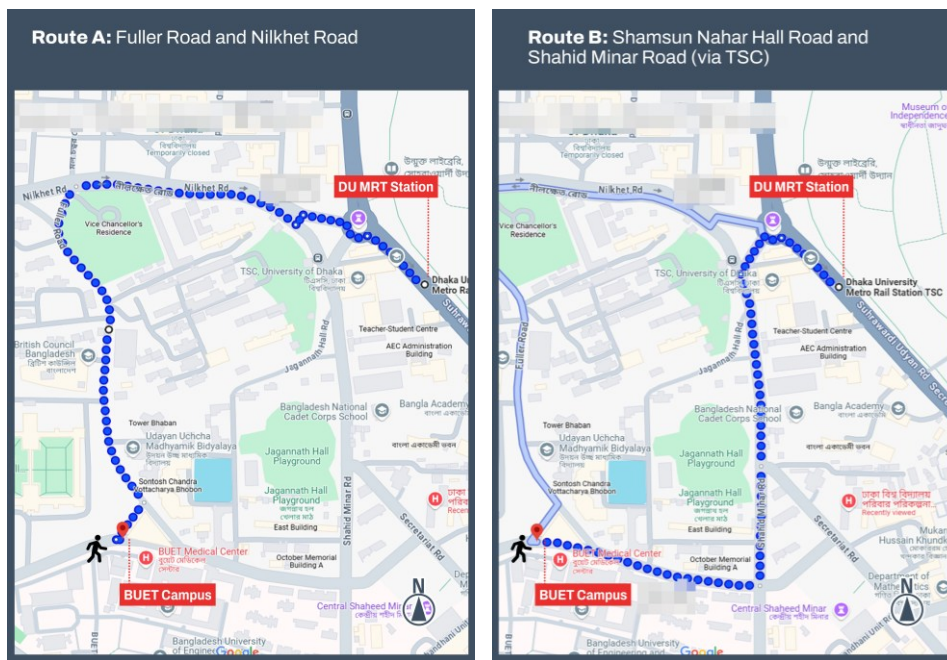


Figure 4. Route A and Route B Within the Selected Urban Study Area (Source: Google map).

3.2 Data collection

The participants responded to a structured questionnaire of 16 questions to examine patterns in route selection, spatial cognition, and navigational dependency. They were asked to choose their preferred route and why they think that was more legible to them. The selected study group was informed about the research, and the aim of the study was also shared with them to eliminate any confusion. The survey was conducted in their habitual campus setting. The questionnaire consisted of three sections: basic demographic data (gender, current address, age, etc.), familiarity with the routes, and transforming mental maps in both sketches and descriptive format. Participants' cognitive mapping ability was assessed by asking them to identify Lynch's elements—paths, edges, districts, nodes, and landmarks as visual cues for navigating through the routes based on their memory and by visual representation of their mental map into a sketch map. In the last section of the questionnaire, participants were asked about their frequency of using digital navigation tools and their ability to navigate with or without the help of these tools.

3.3 Data Analysis

Based on the data collected from 81 participants, quantitative data were recorded in Microsoft Excel, and correlations between various variables were established. Open-ended responses were categorized to sort the qualitative data. The responses were reviewed to identify recurring themes related to Lynchian elements—paths, edges, districts, nodes, and landmarks. Identified themes were grouped accordingly, facilitating the quantification of qualitative data for further analysis. This thematic analysis approach allowed for the identification of common spaces and elements perceived by students, categorized into the five Lynchian elements. The analysis provided insights into how these elements contribute to the students' imageability of the city. In analyzing sketch maps, distortions were disregarded, focusing solely on identified spatial elements for comparative purposes. The integration of quantitative and qualitative analyses provided a comprehensive understanding of how participants perceive and navigate urban spaces. The

findings highlighted the influence of familiarity and environmental cues on route selection and the internalization of urban elements, contributing to the broader discourse on city imageability and spatial cognition.

4. Results

The analysis revealed notable distinctions in spatial cognition and wayfinding abilities between local and migrant student groups. These differences highlight interaction with urban environments and the impact of digital navigation tools. These findings provide a deeper understanding of how diverse groups perceive and interact with the city layout. This analysis is crucial for developing targeted urban interventions. By acknowledging and integrating the unique spatial perceptions of different groups, urban planners can develop strategies that enhance accessibility, usability, and overall city imageability especially for the migrant population. Among the participants, 65% of students preferred Route A, while 35% opted for Route B. Notably, among migrant students, approximately 75% favoured Route A, potentially due to its abundance of visual cues and higher legibility. Conversely, a greater proportion of local students selected Route B, likely appreciating its simplicity and direct alignment.

4.1 Perception of inter-place distance

The functional distance of the two selected routes was almost the same, approximately 1.2 km, as recorded from Google Maps (Figure 4). Around 44% of total participants perceived the distance accurately (Fig. 5). From the collected data displayed in Figure 5, it is evident that almost 45% of the Local students and more than 36% of the Migrant students have estimated the cognitive distance to be between 1 and 1.5km. The accuracy of exact inter-place distance judgement is higher among the Local students. Only 5% of students overestimated the distance.

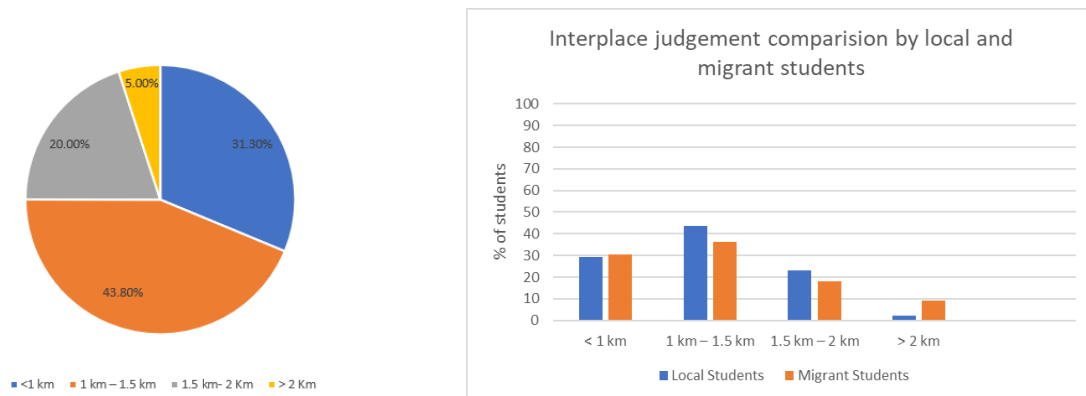


Figure 5. Perception of Inter-Place Distance by Local and Migrant Students Based on Cognitive Estimation.

17 participants from the local category estimated the exact distance 1.2 km. These findings suggest that, though perceived ranges were almost similar, local students demonstrated greater accuracy of exact inter-place distance judgement.

4.2 Sketch map analysis

Student participants were asked to transform their mental perception into sketches. They were asked to draw their chosen route, either Route A or Route B, highlighting the spatial elements they recalled during navigation. These sketches reveal notable variations in spatial perception across gender and migrant status. Local male students produced more detailed sketches, including side streets, intersections, and district-level elements. Their drawings reflected a broader familiarity with the urban context.

Table 2. Comparative Analysis between Local and Migrant Students for Route A.

Route	Typology	Physical Elements	Local Students				Migrant Students			
			From Questionnaire		From Sketch Map		From Questionnaire		From Sketch Map	
			No.	%	No.	%	No.	%	No.	%
A. BUET to Dhaka University MRT station via Fuller Road and Nilkhet Road	Landmark	TSC	19	40	26	54	11	34	19	59
		Raju Bhaskorjo	5	10	4	8	5	16	7	22
		British Council Building	10	21	5	10	5	16	3	9
		Udayan School	3	6	7	15	5	16	2	6
	Node	Palashi Intersections	29	60	38	79	17	53	21	66
		TSC node	32	67	31	65	19	59	22	69
		Fuller Road Intersection	20	42	12	25	7	22	3	9
		VC Chattar	14	29	2	4	3	9	0	0
	District	Jagannath Hall area	23	48	3	6	7	22	4	13
		DU Teacher's Quarter	19	40	7	15	7	22	5	16
		DU Student's hall	28	58	20	42	10	31	15	47
		BUET Campus	31	65	35	73	19	59	10	31
	Edge	Fuller Road Sidewalk (Graffiti Walls)	19	40	10	21	12	38	15	47
		Nilkhet Road between DU Faculty buildings and DU Residential Halls	32	67	24	50	10	31	20	63

b) Route B (Shahid Minar Road via Shamsunnahar Hall Road)

Spatial recall for Route B leaned more heavily toward landmarks and major junctions, particularly among migrant students. Key landmarks identified include TSC, Raju Bhaskarjo, Shahid Minar, and Sheikh Rasel Tower. Among these, Raju Bhaskarjo and Shahid Minar were recalled more frequently by migrant male students (8 to 9), with local students also providing consistent recall in sketch mapping. Node identification followed a similar trend. Both the TSC Node and Shahid Minar Node were recognized across all subgroups, with values ranging from 6 to 8. These junctions served as prominent cognitive anchors, with migrant males again showing higher familiarity with these elements. District-level features were less frequently recalled along this route compared to Route A. The Jagannath Hall area, DU Teacher’s Quarter, BUET Campus, and Sohrawardy Uddyan were modestly identified, with local females marking these districts slightly more often. Migrant females registered minimal recognition of district-level features overall.

Edge recognition was comparatively lower along Route B. Features such as Shahid Minar Graffiti Walls, TSC Graffiti Walls, and Sohrawardy Uddyan Fence received only 2 to 5 mentions across all participant groups, with the lowest edge recall observed among migrant female students. Overall, the cognitive recall pattern for Route B reveals a dominance of landmarks and nodes, particularly among migrant students, whereas edge and district-level awareness remained relatively limited. This may reflect the visually prominent but less spatially complex nature of Route B.

Table 3. Comparative Analysis between Local and Migrant Students for Route B.

Route	Typology	Physical Element	Local Students				Migrant Students			
			From Questionnaire		From Sketch Map		From Questionnaire		From Sketch Map	
			No.	%	No.	%	No.	%	No.	%
B. BUET to Dhaka University MRT station via Shahid Minar road	Landmark	TSC	14	29	15	31	11	34	16	50
		Raju Bhaskorjo	16	33	10	21	10	31	14	44
		Shahid Minar	13	27	12	25	13	41	12	38
		Sheikh Rasel Tower	3	6	6	13	-	0	1	3
		Tareque- Mishuk Munir Memorial	1	2	0	0	-	0	2	6
	Node	Shahid Minar Node	14	29	16	33	13	41	11	34
		TSC node	17	35	21	44	13	41	16	50
	District	Jagannath Hall area	8	17	6	13	4	13	3	9
		DU Teacher's Quarter	5	10	3	6	4	13	6	19
		DU Student's hall	6	13	1	2	8	25	10	31
		BUET Campus	14	29	11	23	13	41	16	50
		Sohrawardy Uddyan	8	17	6	13	4	13	8	25
	Edge	Shahid Minar (Graffiti Walls)	8	17	7	15	10	31	5	16
		TSC Graffiti Walls	11	23	13	27	9	28	6	19
		Sohrawardy Uddyan fence	3	6	1	2	2	6	1	3

The spatial elements distributed along Route A and Route B function as significant visual anchors, contributing to wayfinding through their high visibility, symbolic significance, and spatial clarity. Shaheed Minar, a national monument commemorating the martyrs of the 1952 Language Movement, holds profound cultural meaning. Its vertical form and elevated base make it prominently visible from surrounding areas, helping both local and migrant students orient themselves within the urban fabric. The Raju Sculpture, situated near the Teacher-Student Centre (TSC), marks a critical node of convergence. Known for its political symbolism and historical association with student activism, the sculpture is positioned at a key intersection and remains visible from various points, including the adjacent metro line, enhancing its role as a spatial focal point.

Table 3. Comparative Analysis between Local and Migrant Students for Route B.

Typology	Physical Element	Route	From Questionnaire		From Sketch Map		From Questionnaire		From Sketch Map	
			Local Male %	Local Female %	Local Male %	Local Female %	Migrant Male %	Migrant Female %	Migrant Male %	Migrant Female %
Landmark	TSC	A & B	74	66	89	76	77	50	64	40
	Raju Bhaskorjo	A & B	58	34	68	48	68	0	91	10
	Udayan School	A	11	3	11	3	18	10	18	20
	British Council Building	A	21	21	21	14	18	10	9	10
	Shahid Minar	B	32	24	16	21	45	30	50	30
	Sheikh Rasel Tower	B	11	3	5	3	0	0	5	10
	Tareque- Mishuk Munir Memorial	B	5	0	5	3	0	0	5	20
Node	Palashi Intersections	A	74	52	63	66	45	70	64	40
	TSC node	A	100	97	95	86	100	100	91	70
	Fuller Road Intersection	A	37	45	26	38	27	10	23	20
	VC Chattar	A	42	21	53	24	14	0	5	0

	Shahid Minar Node	B	26	31	32	38	45	30	55	30
District	Jagannath Hall area	A & B	58	62	68	48	36	30	18	50
	DU Teacher's Quarter	A & B	58	45	74	55	36	30	32	20
	DU Student's Hall	A & B	79	66	58	48	59	50	50	50
	BUET Campus	A & B	95	93	68	72	100	100	91	80
	Sohrawardy Uddyan	B	16	17	21	7	14	10	5	10
Edge	Fuller Road Sidewalk	A	47	34	42	17	36	40	36	50
	Nilkhet Road between DU Faculty buildings and DU Halls	A	95	48	89	24	32	30	32	30
	Shahid Minar (Graffiti Walls)	B	26	10	21	7	36	20	18	10
	TSC Graffiti Walls	B	26	21	16	14	27	30	23	10
	Sohrawardy Uddyan fence	B	11	3	5	0	9	0	9	0

Route A features key institutional landmarks such as Udayan School, British Council, and Rokeya Hall, contributing to an identifiable educational corridor. In contrast, Route B, demonstrates spatial identity strengthens with landmarks like Shahid Minar, and district zones such as Jagannath Hall and the DU Teacher’s Quarters, which are mid- to high-rise residential buildings visible from afar. The TSC area, common in both routes, is characterized by open gathering spaces and hub of student activity. This vibrant setting offers clarity in spatial cognition.

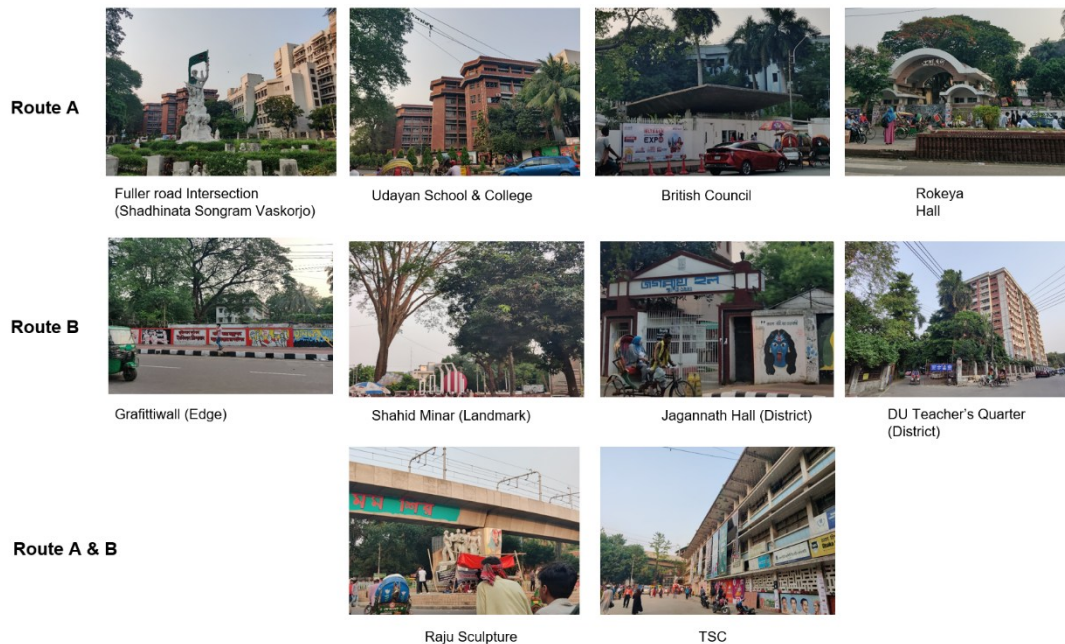


Figure 7. Photographic Documentation of Key Spatial Elements Identified Along Route A and Route B.

These key urban elements were categorized into node, landmarks, edge, and district (Fig. 7) along the selected routes by the participants, which played a crucial role in enhancing the imageability of the environment, as described in Kevin Lynch’s theory. The visible cues recognized by the students contributed to forming a more coherent and memorable mental image of the chosen routes. This clarity in spatial cognition helped improve their wayfinding ability, making navigation through the environment more intuitive and efficient.

4.4 Influence of Digital Navigation Tools in Wayfinding

From the questionnaire survey, it was found that 36.3% of students “always” use digital navigation tools while moving through the city, while 46.3% use them occasionally. This indicates a higher rate of dependency on digital tools for wayfinding, facilitated by the accessibility of smartphones and mobile internet. Only 12.5% rarely use such tools, and 5% stated they never use digital navigation tools for wayfinding. The study also reveals that migrant students, particularly migrant female students, have higher dependency on digital navigation aids while local male students rarely use such tools for navigation.

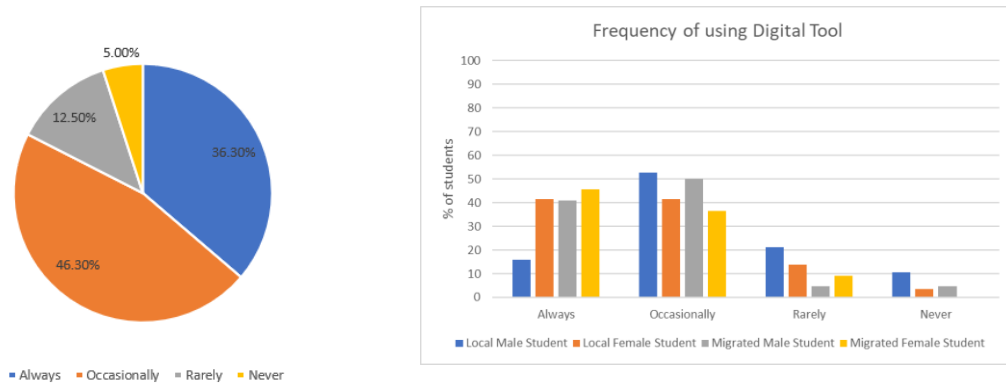


Figure 8. Frequency and User Group Comparison of Digital Navigation Tool Dependency in Urban Wayfinding.

However, in terms of navigating these particular study routes without any digital assistance (fig 9a), 67.5% of participants rated themselves as “very or moderately confident,” while 13% stated less or no confidence. Local male students showed the highest confidence (fig 9b), while migrant female students were more often neutral or less confident, highlighting a cognitive gap in urban wayfinding. This finding highlights the high legibility of the surrounding urban environment of the study routes.

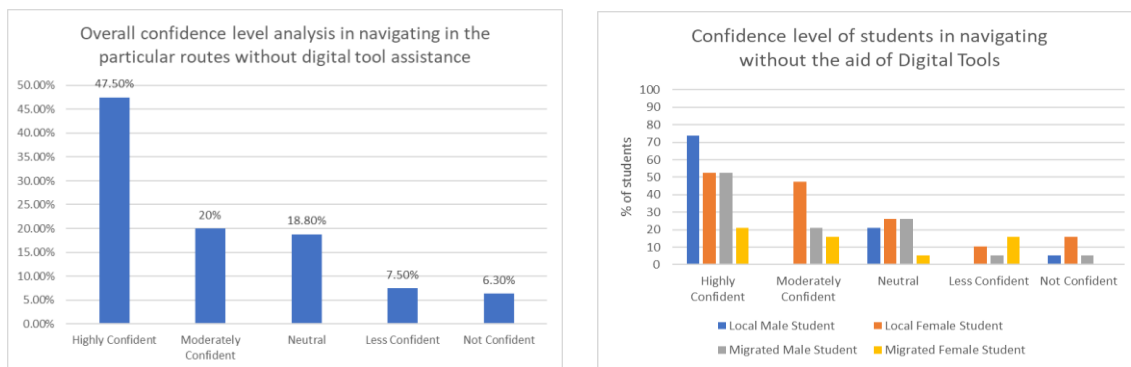


Figure 9. a) Overall Confidence Levels of Participants in Navigating Without Digital Assistance. b) Comparison of Navigation Confidence Without Digital Tools by Gender and Migration Status.

And finally, when asked what they rely on most for navigation (Fig 10), nearly 49% of respondents indicated using a mix of memory, visual landmarks, and digital tools, while 27.5% relied on memory alone and 26.3% on visual landmarks. Only 16.3% reported relying primarily on digital navigation tools, indicating that multimodal cognitive strategies are prevalent among users.

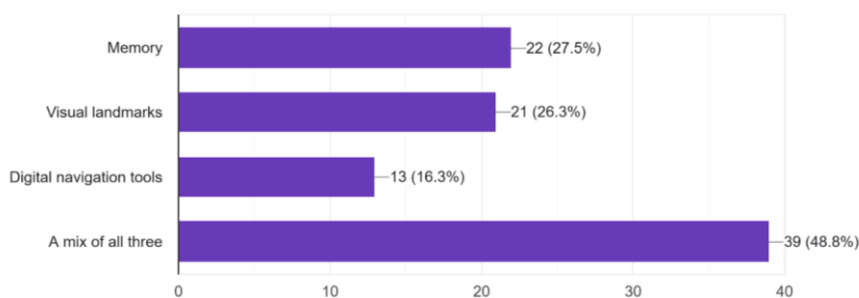


Figure 10. Primary Navigation Strategies Reported by Participants During Urban Wayfinding.

5. Discussion

The study highlights distinct patterns in spatial behavior and cognitive mapping ability among the two student groups. In both routes, TSC, Raju Bhaskorjo, and Shahid Minar were identified by the majority of students as they are deeply rooted in the history of the country and hold significant cultural value. These landmarks are familiar to migrant students even before arriving in Dhaka, as they have read or seen the landmarks in their textbooks or on television. Previous familiarity with the landmarks provided a form of pre-constructed mental mapping that supports their wayfinding decisions, specially for migrant female students. TSC has long served as a central space for cultural gatherings, student protests, and informal urban activities. Both Raju Sculpture and Shahid Minar are nationally recognized landmarks associated with student protests throughout the history of the country. For migrant students unfamiliar with Dhaka’s urban layout, such culturally embedded landmarks act as stable cognitive anchors in

wayfinding, making the route feel easy to navigate. The study affirms Lynch's notion that legible cities depend on the visibility and recognizability of urban elements, especially for transient users.

Again, local students displayed a more expansive and detailed spatial understanding. Their sketch maps and recall patterns included side streets, district-level boundaries, and lesser-known urban elements, indicating a deeper engagement with the built environment. This was further reflected in their reduced reliance on digital navigation and greater confidence when navigating unaided. On the other hand, migrant students, especially the female participants, often depended on digital aids, indicating more surface-level spatial engagement. This reflects limited urban exposure among the female students from outside Dhaka, who are often restricted from independent mobility due to prevailing socio-cultural practice requiring accompaniment by their guardian (Nandi & Kundu, 2024). While digital navigation tools helped them complete routes more efficiently, they appeared to limit their spatial learning and internal mapping. However, almost 50% of students used a blend of memory, landmark recognition, and digital guidance. This suggests an evolving pattern of hybrid navigation, where traditional wayfinding strategies are complemented, rather than replaced, by technological aids. The layered navigation approaches observed in this study highlight an ongoing shift in how urban youth engage with the city, balancing traditional spatial learning with technological reliance. They also underline the importance of designing urban environments that are not only walkable but also cognitively supportive, where landmarks are visible, transitions are clear, and spatial learning is encouraged through both physical cues and digital integration.

6. Conclusions

This study highlights the importance of Lynch's element of imageability, emphasizing the impact of digital navigation tools on wayfinding behavior among local and migrant students in Dhaka. The analysis reveals that migrant students' reliance on digital navigation tools significantly influences their wayfinding behavior by providing immediate navigational assistance. This reliance results in cognitive deskilling in the newcomers, often at the expense of deeper spatial learning and environmental engagement. While such tools offer practical utility, particularly for migrants unfamiliar with the urban context, they may contribute to diminished development of long-term spatial memory and orientation skills. Moreover, the research identifies socio-cultural factors, notably gender, as influential in shaping cognitive abilities and wayfinding strategies. Gendered experience, irrespective of familiarity with the urban environments, is shaped by perceptions of safety, mobility constraints, and cultural norms, resulting in differentiated spatial behaviors and mental representations of the urban environment. These findings underscore the importance of considering diverse cognitive experiences in urban design and planning frameworks. These findings will help urban designers in creating legible urban environments by enhancing landmark visibility, legible paths, improving pedestrian safety, and designing gender-inclusive routes. In addition to that, integrating digital technologies in a manner that supports rather than substitutes spatial learning can contribute to more inclusive and navigable urban environments. Such interventions are especially pertinent in rapidly urbanizing and densely populated contexts like Dhaka, where walkability is essential for sustainable urban mobility. A significant strength of this study lies in its combined methodological approach, allowing comprehensive insights into participants' mental representations and navigational strategies. Therefore, this study offers an in-depth understanding of spatial cognition by integrating both quantitative and qualitative data. Future research could expand this scope by incorporating broader institutional samples, diverse demographic groups, and varied urban settings to enhance applicability.

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Conflict of Interests

The Author(s) declares(s) that there is no conflict of interest.

References

- Ali, S., Sarker, M. F., Islam, M. K., & Mahmud, R. A. (2021, April 12). Pursuing higher education: Adaptation challenges and coping strategies of rural students at urban universities in Bangladesh. *Tertiary Education and Management*, 27, 91. <https://doi.org/10.1007/s11233-021-09067-3>
- Amin, A. T. (2010). *Internal migration and urbanisation in Bangladesh: Trends, patterns and policy issues*. Bangladesh Institute of Development Studies.
- Amen, M. A., Afara, A., & Nia, H. A. (2023). Exploring the link between street layout centrality and walkability for sustainable tourism in historical urban areas. *Urban Science*, 7(2), 67. <https://doi.org/10.3390/urbansci7020067>
- Amen, M. A. (2021). The assessment of cities' physical complexity through urban energy consumption. *Civil Engineering and Architecture*, 9(7), 2517–2527. <https://doi.org/10.13189/cea.2021.090735>
- Amen, M. A., & Nia, H. A. (2020). The effect of centrality values in urban gentrification development: A case study of Erbil City. *Civil Engineering and Architecture*, 8(5), 916–928. <https://doi.org/10.13189/cea.2020.080519>
- Aziz Amen, M. (2022). The effects of buildings' physical characteristics on urban network centrality. *Ain Shams Engineering Journal*, 13(6), 101765. <https://doi.org/10.1016/j.asej.2022.101765>
- Bangladesh Bureau of Statistics. (1994). *Statistical yearbook of Bangladesh 1994*. Ministry of Planning, Government of the People's Republic of Bangladesh.

- Çağlar, A., & Schiller, N. G. (2018). *Migrants and city-making: Dispossession, displacement, and urban regeneration*. Duke University Press. <https://doi.org/10.1215/9780822372011>
- Erçevik Sönmez, B. (2020). A research on urban identity: Sample of Kadıköy district. *Journal of Contemporary Urban Affairs*, 4(1), 21–32. <https://doi.org/10.25034/ijcua.2020.v4n1-3>
- Gifford, R. (2007). *Environmental psychology: Principles and practice* (4th ed.). Optimal Books.
- Hussein, M. N. (2018). The pedestrianisation and its relation with enhancing walkability in urban spaces. *Journal of Contemporary Urban Affairs*, 2(1), 102–112. <https://doi.org/10.25034/ijcua.2018.3666>
- Kalin, J., & Frith, J. (2016). Wearing the city: Memory p(a)laces, smartphones, and the rhetorical invention of embodied space. *Rhetoric Society Quarterly*, 46(3), 222–235. <https://doi.org/10.1080/02773945.2016.1171692>
- Kärholm, M., Jensen, T. G., Foroughanfar, L., & Söderberg, R. (2023). Migration, place-making and the rescaling of urban space. *European Planning Studies*, 31(2), 270–286. <https://doi.org/10.1080/09654313.2022.2038544>
- Levine, S. C., Foley, A., Lourenco, S., Ehrlich, S., & Ratliff, K. (2016). Sex differences in spatial cognition: Advancing the conversation. *Wiley Interdisciplinary Reviews: Cognitive Science*, 127–155. <https://doi.org/10.1002/wcs.1380>
- Lynch, K. (1984). Reconsidering the image of the city. In L. Rodwin & R. Hollister (Eds.), *Cities of the mind* (pp. 151–173). Springer. https://doi.org/10.1007/978-1-4757-9697-1_9
- Murray, A. T., & Spencer, J. E. (1979). Geographical mobility and the formation of cognitive maps. *Annals of the Association of American Geographers*, 69(1), 135–143.
- Nandi, D., & Kundu, G. (2024). A comparative analysis of the cognitive differences in wayfinding among local and internally migrant students in urban environments: A trip from BUET campus to Dhaka New Market. In *Proceedings of the 17th International Research Conference of Faculty of Architecture Research Unit (FARU 2024)* (pp. 85–96). University of Moratuwa, Sri Lanka. <http://dx.doi.org/10.31705/FARU.2024.8>
- Park, G., & Evans, G. W. (2021). Lynch's elements of the city in the digital era. *Journal of Urban Design*, 26(5), 563–582. <https://doi.org/10.1080/01944363.2018.1524308>
- Proulx, M. J., Brown, D. J., & Pasqualotto, A. (2014). Multisensory perceptual learning and sensory substitution. *Neuroscience & Biobehavioral Reviews*, 41, 16–25. <https://doi.org/10.1016/j.neubiorev.2012.11.017>
- Swapna, M. S. H., Zaman, A. U., Ahsan, T., & Ahmed, F. (2017). Transforming urban dichotomies and challenges of South Asian megacities: Rethinking sustainable growth of Dhaka, Bangladesh. *Urban Science*, 1(4), 31. <https://doi.org/10.3390/urbansci1040031>
- Verghote, A., Al-Haddad, S., Goodrum, P., & Van, E. (2019). The effects of information format and spatial cognition on individual wayfinding performance. *Buildings*, 9(2), 29. <https://doi.org/10.3390/buildings9020029>
- White, M., Kimm, G., & Lengenheim, N. (n.d.). *Pedestriancatch*. Retrieved from <https://pedestriancatch.com/>
- Yavuz, A., Ataoğlu, N. C., & Acar, H. (2020). The identification of the city on the legibility and wayfinding concepts: A case of Trabzon. *Journal of Contemporary Urban Affairs*, 4(2), 1–12. <https://doi.org/10.25034/ijcua.2020.v4n2-1>
- Zmudzinska-Nowak, M. (2003). Searching for legible city form: Kevin Lynch's theory in contemporary perspective. *Journal of Urban Technology*, 10(3), 19–39. <https://doi.org/10.1080/1063073032000175390>