Designing a Graphic Configuration of University Cartography to Enhance Wayfinding Performance on Campus

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***Abstract*—**In public spaces, an appropriate wayfinding design and implementation can enable people to reach their destination correctly and safely. This article aims to design a wayfinding map of Mahasarakham University (Khamriang campus). In the first stage, a qualitative method was applied to inquire a key finding before being summarized as a concept of design agreement. This agreement was employed to guide the development of a prototype map. Meanwhile, a quantitative method was applied to test the prototype in order to evaluate the wayfinding behavior and map-reading skills of the sampling groups. They include two majors: an internal and external group (total 60 participants). The key findings from the evaluative process showed that the walking speeds from the starting point to the destination (distance: 300 m) between the internal and external groups averaged at 2.96 minutes and 6.84 minutes. Another key finding indicated that the average score under map-reading skills from all the participants remained at ($\bar{X}$) 4.41 points from 5 points. In the meantime, the result for the design satisfaction from the survey averaged at ($\bar{X}$) 4.40 points from 5 points.

***Index terms*—**Wayfinding behavior, readability, graphic design, cartography, communication design.

I. Backround of the Study

Mahasarakham University (MSU) is the setting for this case study. MSU is one of the public universities in Thailand. It also has two campuses referred to as; "City Campus" and "Khamriang Campus." Presently Khamriang campus is the center of MSU headquarters, which contains 18 faculties, two colleges, five institutions, two banks, and 15 head-offices of the Thai government. The area of the campus is 516 acres with 1,210 lecturers, 2,198 staff, and 45,681 students. However, MSU has one of the highest student populations in in Thailand. To serve this large population of students, faculty, and staff, MSU carries out an abundance of educational activities and services within the campus.

In the main part of campus, MSU has more than 40 buildings and a main traffic system, which separates the campus into four sections. With the complex structure in the campus it is understandable that many people can become confused when navigating from point A to B. Conversely, from our observations, we found the campus is lacking enough signage and wayfinding to guide people. Wayfinding boards were installed in the campus in only 4 points. Moreover, the two of them were hidden behind a tree.

This situation shows that the number of wayfinding boards is not sufficent enough to guide people who are unfamiliar with the campus. In addition, the design of the wayfinding boards lack the empowerment to make the reader build-up a mental map of the campus layout. This is because the materials on the boards have a poor quality lettering, which is hard for people to read. Passini described the lack of wayfinding system within a new environment can make people lose their skills in part of 1) cognitive map, 2) decision making, and 3) decision execution [1]. On the other hand, without a wayfinding system, a visitor may not feel welcome on the campus. The above reasons lead to the aim of this research to develop a graphical wayfinding system to assist internal/external people who visit the campus. We hope that this project will make it more convenient for people to find their way around the University. The key objectives are the following: 1) study the key human factor that affects the design contribution of the MSU wayfinding map, 2) analysis of the wayfinding behavior, and map-reading skills from representatives after using the prototype map, and 3) evaluation of the usability of prototype map in terms of graphical legibility, design suitability, and design satisfaction

II. Significance of Wayfinding

A study of wayfinding in public areas is a significant issue for people. This is because the areas that provide multiple services could make the user become lost and confused with complex layouts such as shopping malls, hospitals, airports, and universities. Carpman and Myron described a complex layout where the users deal with a lot of buildings, intersections, and routes and may incur problems during their journey [2]. This problem is confirmed by the research of Bitgood [3]. He found most complex areas and buildings will make a confusing situation for users to identify their destination. It can also make a serious problem in more ways. For example, when people are not able to easily navigate in an area, they will have disoriented feelings at times and an

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uncomfortable and unsettling experience of being unfamiliar with their surroundings [4]. When people lose their way, they are likely to miss their appointment or waste their time. In an extreme case, people may perish if they cannot find their way to a hospital in an emergency situation [5].

There are some proven ways to alleviate this situation. Cartography and signage are the graphical materials in a wayfinding system, which has the role as the medium instrument to bridge the gap between people and place. The definition of wayfinding is defined from several perpectives. Peponis et.al. described wayfinding as the decision making process of human behavior when they want to move themselves from one place to another [6]. Meanwhile, Passini defined the elements of decision making in a wayfinding processes as cognitive mapping, decision making and decision execution [7]. Therefore, it can be justified that the wayfinding process includes internal behavior (cognition, mental picture and decision making) and external behavior (manner and performance). Nevertheless, the evaluation on internal behavior is difficult because it is an intangible observation. Conversely, the consideration of external behavior is uncomplicated. Therefore, the success of wayfinding in this paper is when the finder can locate themselves and realize how to get to their destination along with a recognitive way to return back to their initial point.

Darken and Peterson explained that the navigation system is a primary task, which is essential to guide people to meet their objectives in any complex environment with very large spaces [4]. With respect to usability, the wayfinding concept focuses on the cognitive element of navigation. Its sole focus is the strategic and tactical sections that guide movement [4]. The "cognitive map" is an essential part of wayfinding that focuses on use and develops a guideline conceptual framework, also referred to as a mental map [8]. Moreover, it includes the development of knowledge on the cognition and comprehension of users based on their visual literacy of the interpretative information that is presented in a pattern of symbolic and graphical representations [9]-[11].

As part of his wayfinding measurements, O'Neill demonstrated a new model for investigating the target wayfinding behavior with an emphasis on the external behavior, which consists of (1) finding the walking speed, (2) discontinuity, (3) walking with turning errors, and (4) walking with returning [12]. However, the walking speed was tested from the same walking distance per person and divided with all the walking speeds, in order to find the average time of the wayfinding per person. While, the diccontinuity was evaluated from the number of stops during walking when a representative hesitates on their journey and looks at the wayfinding board. The walking with turning error and returning are measured from the number of walking mistakes by the representative. O'Neill employed 5 levels of the likert scale to define the number of mistakes followed by the number 1 representing one mistake and the number 5 representing five mistakes. However, this measurable method was applied to evaluate a wayfinding behavior of the sampling. The next section will justify the representative groups, key principles and variables used to create a successful wayfinding system.

III. Participants

The research participants in this project were divided into two main groups: The first group consists of internal people, which was collected using an accidental sampling technique.

First year student in the campus (30 respondents)

Meanwhile, the second group are external people (visitor) who come to visit the campus. Accidental sampling was employed to conduct this stage.

Visitors (30 respondents, i.e., parents, relatives and guests)

IV. Methodology

A mixed method was applied to design the methods used for the data collection and data analysis strategies. Both qualitative (inductive) and quantitative (deductive) concepts were employed to investigate the key factors from the documentaries and participants (stakeholders). The strategies of data collection and analysis were defined as two major stages;

A. Stage 1: Pre-production

Data collection–In this stage, we applied a qualitative approach to review a documentary and theoretical studies were collected. It also included observation on the field at Khamriang campus. The theme of this observation was to look at the natural wayfinding behavior, the road system on campus and the campus buildings and environment.

Data analysis–We used content analysis to classify the type of key information, themes, terminologies, principles, and literature we read. A typological analysis was applied to identify a group of keywords, ideas, information, and themes from the interview processes. The key interview data were arranged and set as a group of finding domains. Finally, a triangulation of sources was applied to triangulate the findings from the content and typological analysis in order to create credibility and internal validity before summarizing into the key findings. These findings were defined as a key concept of the design agreement such geographic design, building style, color, landmark, and symbol on a prototype map.

B. Stage 2: Post-production

Data collection–This stage was performed after finishing the design protocol of the MSU wayfinding prototype. An evaluative survey was applied as the instrument to rate the design satisfaction, assessment of wayfinding behavior and map-reading skills from a visitor who are the respondents on campus (a total of 60 people). The likert scales were used as the answer items by starting from 1 (= strongly disagree) to 5 (= strongly agree) [13].

Data analysis–A frequency and descriptive analysis was applied to indicate the empirical results, which include the mean score ($\bar{X}$), percentage (%), the value of number (N), and the standard of deviation (*SD*). However, key feedback from the survey was summarized in order to adjust the design protocol into the complete version.

V. Fingdings and Design Outcomes

The key findings from the field work were divided into two stages. The first stage describes the key findings from the observation site and documentary studies. Meanwhile, the second stage presents the evaluative results from the respondents. The design outputs will also display and augment in both stages.

A. *Key findings–Stage 1*

Finding A–From the observations it was found that the wayfinding behavior on campus had to be separated into two major groups. The first group contains internal people. In the field, the first year students were not familiar with the campus buildings and environment. Meanwhile, lecturers, and staff have more familiarity with the campus because some of them live on campus or have been working on campus for a long time. In this case, the first year students are the main target who came to assess the prototype map. The second group contains external people who come to visit the campus infrequently. For example, a parent, a relative or guest.

Finding B–From our observations we found a lack of wayfinding is an obstacle for new students and visitors to find their desired destination. In fact, the wayfinding boards are not efficient to provide clear information and direction. This is because, the detail on the boards only show a text and arrow to give directions without any map images.

Finding C–The traffic system found on campus has three one-way roads and 12 intersections, while the wayfinding boards were installed at only 4 points on campus.

B. *Design outputs–Stage 1*

A design prototype was developed using three major processes. The first stage conducted a pre-production by studying the geographic information system (see Fig. 4). The detailed map layers were categorized into 10 data sets, which consists of 1) The geographic information system (GIS) view, 2) mapping-areas, 3) sub-areas, 4) water resource, 5) roads system, 6) car parks, 7) buildings, 8) service information, 9) map legends, and 10) building and place services. Next, all buildings and environments were drafted in the design software. All the categories of the data sets were combined into the prototype map (See Fig. 1).

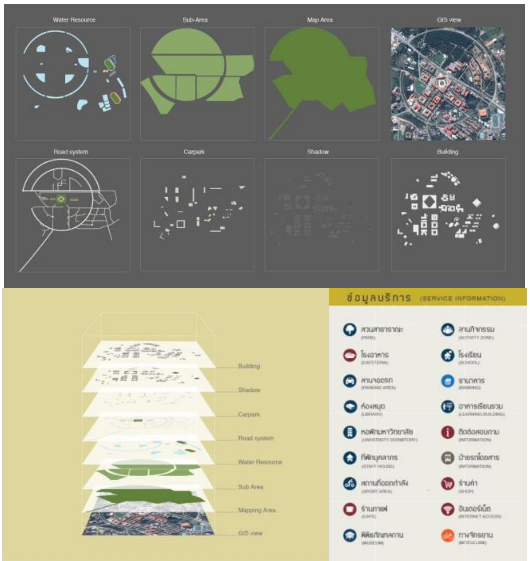

Fig. 1. Designing the GIS data sets and graphical layers.

C. *Key findings–Stage 2*

Finding D–The demographic of the respondents who came to assess the design prototype showed that the internal group consists of first year students (30 people; 15 male and 15 female). Meanwhile, the external group consists of 20 parents and 10 relatives and friends. The total number was 60 respondents. The age of the respondents illustrates that the large group was 15–19 years old (50%) and the second largest group was 41–50 years old (25%).

TABLE I. The Statistic Results for the Walking Speed.

Topic of wayfinding behavior	**N**	**Walking speed (Minutes/seconds)**
Internal group		
1. Male students (aged 15–19)	15	2.80
2. Female students (aged 15–19)	15	3.12
Total	*30*	*2.96*
External group (aged 20–25)		
1. Male	3	3.93
2. Female	4	4.47
Total	*7*	*4.20*
External group (aged 26–30)		
1. Male	2	4.65
2. Female	1	4.90
Total	*3*	*4.77*
External group (aged 41–50)		
1. Male	10	6.69
2. Female	5	8.04
Total	*15*	*7.36*
External group (aged up to 61)		
1. Male	3	10.43
2. Female	2	11.65
Total	*5*	*11.04*
Total	**60**	**6.06**

Finding E–The wayfinding behavior of the respondents was divided into four sections as follows: 1) Walking speed, 2) discontinuity, 3) turning error, and 4) walking with returning. In terms of the walking speed the results showed the internal group averaged at 2.96 min, while the external group averaged at 6.84 min (see Table I). The results of walking with discontinuity indicated that the internal group stopped during walking; 1 time/7 persons, 2 times/12 persons, and non-stopping 8 persons. In terms of the external group stopping during walking: 1 time/8 persons, 2 times/14 persons, 3 times/3 persons, 4 times/3 persons, and 5 times/1 person (see Table II). The results of turning error from the internal group were: 1 time/13 persons, 2 times/2persons, and non-turning error 15 persons. While, the turning errors from the external groups were: 1 time/8 persons, 2 times/8 persons, 3 times/3 persons, and 4 times/2 persons (see Table III). The results for the returning behavior from the internal group were: 1 time/10 persons and non-returning 20 persons. In results of the external groups with returning behavior were: 1 time/ 13 persons, 2 times/7 persons, and 3 times/1 person (See Table IV).

TABLE II. THE STATISTIC RESULTS FOR WALKING WITH DISCONTINUITY.

	Number of discontinuity						
	1T*	2T*	3T*	4T*	5T*	Non**	N
Internal group Student age (Aged 15–19)	7	12	3	0	0	8	30
External groups							
Aged 20–25	2	4	1	0	0	0	7
Aged 26–30	3	0	0	0	0	0	3
Aged 41–50	3	9	2	0	0	1	15
Aged up to 61	0	1	0	3	1	0	5
Total	**15**	**26**	**6**	**3**	**1**	**9**	**60**

T* = times, Non** = non-stopping.

TABLE III. THE STATISTIC RESULTS FOR WALKING WITH TURNING ERROR.

	Number of discontinuity						
	1T*	2T*	3T*	4T*	5T*	Non**	N
Internal group Student age (Aged 15–19)	13	2	0	0	0	15	30
External groups							
Aged 20–25	2	2	0	0	0	3	7
Aged 26–30	1	0	0	0	0	2	3
Aged 41–50	5	6	0	0	0	4	15
Aged up to 61	0	0	3	2	0	0	5
Total	**21**	**10**	**3**	**2**	**0**	**24**	**60**

T* = times, Non** = non-turning.

TABLE IV. STATISTICS RESULTS FOR WALKING WITH RETURNING.

	Number of discontinuity						
	1T*	2T*	3T*	4T*	5T*	Non**	N
Internal group– Student age (Aged 15–19)	10	0	0	0	0	20	30
External groups							
Aged 20–25	3	0	0	0	0	4	7
Aged 26–30	0	0	0	0	0	3	3
Aged 41–50	10	3	0	0	0	2	15
Aged up to 61	0	4	1	0	0	0	5
Total	**23**	**7**	**1**	**0**	**0**	**29**	**60**

T* = times, Non** = non-returning

Finding F–The results for the map-reading skills show that the lowest score in this section is the legibility of the graphic building images, which averaged at 4.13 points. Meanwhile, the highest score was the legibility on the graphic route images, which averaged at 4.52 points. However, the overall score in map-reading skills averaged at 4.35 points and .600 SD points (See Table V)

TABLE V. THE STATISTIC RESULTS FOR LEGIBILITY.

Topic	N	Min	Max	$(\bar{X})$	SD
1.Legibility on the service information set	60	300.	500.	4.35	.633
2.Legibility on the Map legends set	60	300.	500.	4.37	.610
3.Legibility on the environmental graphic image	60	300.	500.	4.35	.659
4.Legibility on the graphic route images	60	400.	500.	4.52	.504
5.Legibility on the graphic building images	60	300.	500.	4.13	.724
6.Legibility on the typographic proportion (TH language)	60	400.	500.	4.60	.494
7.Legibility on the typeface (TH language)	60	400.	500.	4.48	.504
8.Legibility on the typographic proportion (EN language)	60	300.	500.	4.25	.654
9.Legibility on the typeface (EN language)	60	300.	500.	4.43	.621
Total	**60**	**3.33**	**500.**	**4.35**	**.600**

Finding G–The results for the design suitability and satisfaction found that the overall of design suitability averaged at 4.49 points. Meanwhile, the overall of design satisfaction averaged at 4.4 points. However, the design satisfaction of the graphical map images was the lowest and averaged at 4.20. Finally, the average point in this section was 4.44 points and .545 SD points (See Table VI).

TABLE VI. THE RESULTS FOR THE DESIGN SUITABILITY AND SATISFACTION.

Topic	N	Min	Max	$(\bar{X})$	SD
1.Suitability of the symbol colors	60	300.	500.	4.45	.565
2.Suitability of the graphical map colors	60	300.	500.	4.42	.561
3.Suitability of the typographic colors	60	400.	500.	4.62	.490
4.Satisfaction with the design of the graphical symbols	60	400.	500.	4.48	.504
5.Satisfaction with the design of the graphical map images	60	300.	500.	4.20	.546
6.Satisfaction with the design of the typographic sets	60	300.	500.	4.47	.650
7.Satisfaction with the use of color systems on the map	60	400.	500.	4.45	.502
Total	**60**	**3.42**	**500.**	**4.44**	**0.545**

D. Design Outputs–Stage 2

From the low scores observed for the legibility, the graphic building images were adapted. This is because the feedback from the internal and external groups described that the 2D images of the buildings made it difficult to connect with real physical appearance of the buildings. So, the images of buildings were adapted into 3D forms, in order to create a physiology link between the 3D images and the real buildings (See Fig. 2).

Fig. 2. The final design after the adapting processes.

Meanwhile, another low score was the graphic map image. This problem occurred from the external groups who are aging and have poor eyesight. This group could not clearly see the small images in the graphic materials. This problem was solved by creating an extending scale to highlight the zoning areas, in which the wayfinding boards are installed [14]. (See Fig. 3)

Fig. 3. The final design after the adapting processes.

From the evaluative tables it can be noticed that the key points of this case study were concerned with the problem of visual literacy in map design. The key issue is the map recognition between a teenager and their elders have a contrary gap even in the same page of map design. Most of the participants who are aged between 41 and 61 years old commented that the use of 2D visualization of the buildings lead to difficulties in creating a mental map, in which to locate themselves. Their preference was a 3D visualization of building, which can assist them to comfortably connect with their sense of location. With this problematic issue, we suggest that a virtual realty (VR) map could be a fitting method to improve the wayfinding recognition.

VI. Conclusions

This article presents the experience of developing a wayfinding system in Mahasarakham University, Thailand. However, this study still has a limitation to install a complete system. This is because we have started to develop the primary need for such a wayfinding map and wayfinding board. To complete the whole system of wayfinding, we have to develop a mobile system to link with the wayfinding board around campus. We must also create a connected system of wayfinding inside a building in order to create a hierarchy of service information availible to user. Finally, we will develop wayfinding on campus connected to mobile devices in order to create convenience for students, staff, and visitors who come to Mahasarakham University.

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