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Exploring the Relationship Between Campus Map Representation and Wayfinding Behavior Through Virtual Environment

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ABSTRACT

This study uses the National Taipei University of Technology campus as the experimental field. It aims to investigate the advantages and disadvantages of the existing map system design through the pathfinding behavior in the virtual environment. The experiment simulated a scenario in which participants could move freely around the campus from a first-person perspective and provided three sets of eight tasks, each to simulate people finding their way around the campus. It was found that the existing campus mapping system had two major design problems: (1) Missing information. Important sites were not marked on the map, so the participants could only find them blindly. (2) Design flaws. The maps on the same road have inconsistent pointing, which causes the participants to spend extra time to confirm the original information and route-finding strategy and increases the error rate. The initial color separation and numbering provided very little help, and participants indicated that they did not always notice, or if they did, did not find it helpful. The You are here information was incomplete, resulting in errors in route-finding decisions. The maps were not set in the same place as the participants' orientation, adding unnecessary thinking time. The results of this study allow us to understand the users' pathfinding behavior on campus, which can be used as a design reference for subsequent design improvements.

Keywords: Map design, Virtual environment, Wayfinding behavior

INTRODUCTION

Finding your way around an unfamiliar environment is a challenge for many people, especially with the complex environment and the variety of information available on campus. Therefore, it is imperative to enhance the user experience of finding their way around the campus. The most direct wayfinder in the campus environment is the campus map. The map allows the wayfinder to locate their location and build their cognitive map and spatial knowledge. Provision of a landmark at a decision point affects the decision maker's cognitive wayfinding strategies and facilitates positioning (Richter, 2007). The spatial knowledge provided by the map can help the wayfinder determine the direction and distance of the target and then plan the route (Golledge, 1999). The visual complexity of map information affects the wayfinder experience (Keil et al., 2020). Compared with ordinary maps, thematic maps emphasize the presentation of thematic concepts and the expression of thematic imagery and have clear objectives (Cheng et al., 2002; Cheng et al., 2003; Lee, 2004). The campus map to be studied in this study is a kind of theme map, so the design must follow the characteristics of the theme map elements (Chang, 1991).

National Taipei University of Technology (NTUT) is located in the heart of Taipei's prosperous transportation district. The campus retains many architectural features from the early 20th century. The Red House Historic Monument, a designated historical site in Taipei City, has cultural tourism value in Taiwan's history. The campus is also surrounded by scenic spots such as the Huashan 1914 Creative Park and the Guang Hua Digital Plaza, which attract many tourists. However, the campus is divided into several school districts by major traffic arteries and has three main entrances and exits. Overcrowded layouts and unclear categorized information hierarchies are apparent problems. However, we must investigate why entrants and tourists cannot reach their destinations efficiently through the campus map.

Virtual environments have become a new and viable experimental approach in recent years. Many researchers have conducted experiments on virtual environments with prototypes and their counterparts in the real world to find the differences between them in terms of pathfinding cognitive processes and spatial knowledge acquisition. It is found that people find their way in the virtual environment and the natural world in a similar way, and there is no significant difference (Conroy, 2001). With this technology, all changes in the experimental environment can be done at a lower financial cost and in less time (Morganti et al., 2007). It can be used to evaluate or develop a wayfinding system before construction, avoiding the need for costly modifications after the physical structure is completed.

METHODS

This study uses the Taipei University of Science and Technology as an experimental virtual environment to investigate the pathfinding behavior under the campus mapping system design from different aspects. A virtual model of the exterior of the existing campus buildings was built using Blender and then imported into Unity 3D to simulate the first-person free-hand movement of the campus (see Figure 1). The movement is displayed on the desktop screen and controlled by the WASD keys and the mouse looking around the corner of the keyboard.

The test was conducted online using google meet due to the COVID-19 outbreak. Participants were given a virtual campus profile, used a google questionnaire with tasks assigned by the researcher, and were asked to share screenshots. Screen recordings and audio recordings were made throughout.

Three participants, aged 20-39, were recruited for the experiment. These participants had no previous experience visiting the campus of Taipei University of Technology. In the first stage, the participants were asked to complete a basic information questionnaire and their experience playing 3D first-person perspective games. The questionnaire used the three-oriented questions of the Pathfinding Impact Factor Scale to understand the participants' essential

Figure 1: The campus map vertical pointer (left) simulates the screen displayed when walking Campus map vertical pointer (right).

pathfinding ability and confidence. In the second stage, 30 participants were randomly divided into three groups, and each group was given a situational school pathfinding task. The three scenarios each had two tasks with six routes, with the three main entrances appearing equally at the beginning and end of the task. In the middle of each task, there are three campus targets, and the participants must reach them accurately before they can continue their journey. The number of turns for each of the six routes was 15 to ensure that the average difficulty was equal (see Figure 2). At the end of all tasks, participants were asked to complete a 5-point Likert scale comprehensive environmental assessment questionnaire in the third stage. Finally, semi-structured interviews were conducted to understand their decision-making and behavior in route finding and why.

RESULT AND DISCUSSION

Behavioral Performance of the Participants During the Task

The experimental results showed that among the six route-finding tasks in the three sets of scenarios, A2, B1, and B2 took more time (see Table 1). All three tasks had one thing in common: the starting and ending locations were concentrated at the side entrance of South Freshman Road and the Green Gate. The destinations that took the most time were the Art Center, the Third Academic Building, and the Red House. The problem with the Arts Center is that the existing campus map lacks information on the location of the building, leaving the participants to search for it blindly on campus; its location is relatively unknown, making the participants spend more time on the task. The third building was located on the opposite side of the main road, which led to suspicion or uncertainty when the participants arrived at the location of the third building because they could not find the name of the building. The existing campus map has the names of the buildings numbered from the top left to the bottom right of the campus according to the overhead view and placed at the bottom of the map. The issue with the Red Building is that

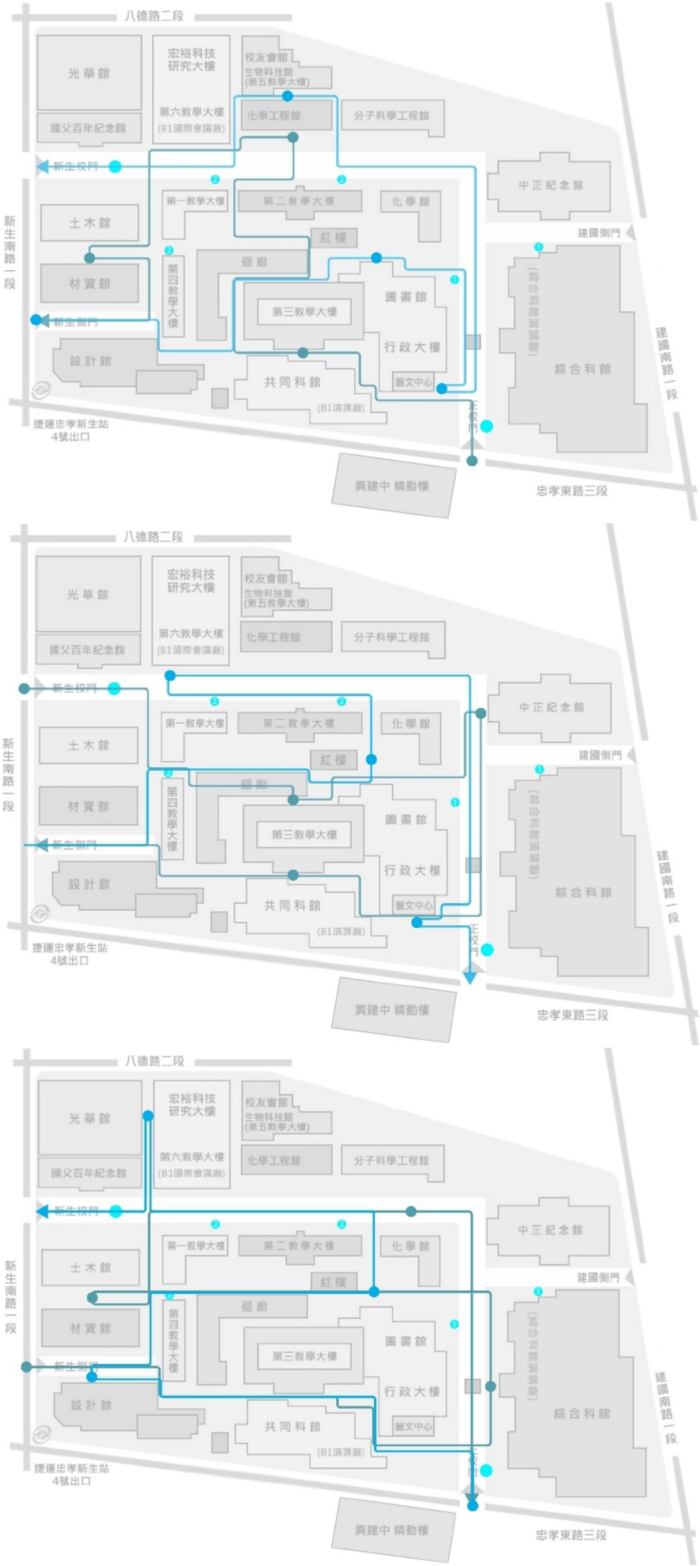

Figure 2: Three official task starting points and target points.

Table 1. Average completion time of each task (seconds).

Question	A1	A2	B1	B2	C1	C2
Average	323.18	604.39	654.27	626.52	404.89	388.72
SD	123.46	179.82	250.63	157.67	99.67	94.53

Table 2. The number of map viewings for each task.

Question	A1	A2	B1	B2	C1	C2
Average	3.8	7	6.4	6.5	5.2	4.7
SD	2.39	1.05	2.41	2.17	2.29	1.63

it is not listed as a building and a viewpoint but directly on the map. The participants responded that such information was presented in an inconsistent logic and was easily missed during visual search. We also found an inconsistency between the information on the map and the wayfinding process from the think-aloud recording. The first reaction of the participants was that they misread or misjudged the map information rather than doubting the reliability of the map, which would increase the time and decision-making difficulty of the wayfinding task.

By counting the number of map views during the task (see Table 2), we can determine whether the existing campus maps in the pathway can provide valid and accurate information. From the statistical results, we found that the number of map views was correlated with the task completion time. From the conversation logs and semi-structured interviews after the task, there were two main reasons for repeated map views:

(1) the information needed could not be found on the map. For instance, the missing Art Center information and the Red Building information are presented differently from other buildings.

(2) inconsistencies between maps. The current campus map is divided into a main map near the main entrance and a sub-map inside the campus, totaling seven maps. The inconsistent presentation of information on the maps along the same road will cause difficulties in viewing and making decisions and will increase the thinking time of the participants. These two problems reduce the functionality of the map itself and affect the experience of route finding.

Ratings Reported by Participants in the Questionnaire

After completing the task, participants were asked two questions to evaluate the map during the wayfinding task ("*The campus map in this task was well understood*") (see Table 3) and their anxiety level ("*This task made me feel anxious*") (see Table 4), both on a five-point Likert scale. The results showed that the A2, B1, and B2 tasks received lower ratings on the campus map among the three situations. That is the same as the results for the time to complete the task.

Table 3. Average campus map rating by task.

Question	A1	A2	B1	B2	C1	C2
M	4	2	2	1.4	3.7	2.5
SD	0.66	0.94	0.94	0.69	0.67	1.26

Table 4. Average anxiousness about each task.

Question	A1	A2	B1	B2	C1	C2
M	2.3	4.1	4.1	4.2	2.1	3
SD	1.15	0.87	1.28	0.91	1.28	0.81

Table 5. The average of the overall environmental assessment scores for each scenario.

Question	A	B	C
M	23.2	19.9	22.7
SD	4.51	5.93	6.61

The results of the overall environmental assessment questionnaire (see Table 5) completed at the end of all tasks showed that the participants did not find the comprehensive campus map very comprehensible (M = 3.13, SD = 1.08). However, they agreed that it was helpful for wayfinding (M = 3.33, SD = 1.18). In addition, participants gave higher scores to the main map (M = 3.46, SD = 0.9) near the main entrance compared to the sub-map inside the campus (M = 2.70, SD = 1.05). It indicates that they thought the main map was more helpful in finding their way around and that the existing sub-map of the campus did not meet the needs of the participants.

The Effect of Relevant Game Experience on Pathfinding Performance

Participants were asked about their experience with 3D first-person perspective games in the pre-experimental questionnaire. 22 of the 30 participants reported that they had played the game, while eight reported that they had never been exposed to it. After the T-testing of game experience and task completion times, Task 1 in Scenario A and Task 2 in Scenario C were found to be significant. It shows that although the participants moved freely at a consistent speed during the simulated pathfinding process, in some cases, those with 3D first-person perspective game experience could still reach the target relatively quickly. We also observed the behavioral performance during the task, where experienced players have a smoother performance in view angle rotation and manipulation movements. The inexperienced players sometimes made operational mistakes, leading to poor pathfinding.

The Effect of Directional Awareness on Pathfinding Performance

This study analyzed the direction-finding ability-oriented questions using the Direction-Finding Ability Influence Factor Scale. We classified those with scores higher than the mean plus one standard deviation as high spatial ability and those with lower than the mean minus one standard deviation as low spatial ability. Seven of them were high spatial abilities, two were low spatial abilities, and the remaining 21 were normal spatial abilities. After the independent sample t-testing of high and low altitude abilities and the completion time of each mission, there was no significant difference. It shows no significant difference in the performance of the high directional perception ability in the pathfinding task. Similarly, no significance was found with task performance or feedback for the other pathfinding anxiety and path memory-oriented questions.

Participants' Feedback in Semi-Structured Interviews

In the semi-structured interviews, ten people thought the You are here information was not easy to find, and 16 people thought it was impossible to determine their direction. Participants indicated that people with poor spatial ability or sense of direction may have increased considering time and difficulty in making decisions about finding their way. Regarding the color distinction and numbering of buildings on the existing maps, 25 and 22 people did not find the information helpful. All participants thought the two pieces of information should be linked to benefit the reading process. In addition, some of the information on the map was disturbing to the participants. Seven people thought the way the red buildings were labeled differed from other facilities, making it difficult to find them. Six people believed that some roads on the map looked passable but were not, forcing the participants to change their route-finding finding strategies. Eight people thought that some buildings could not be identified from the front, making it challenging to find the names of the buildings and reducing the pathfinding experience.

Regarding the location and overall layout of the campus map, 17 people said that the direction of the main map at the side entrance of South Freshman Road was not consistent with the actual direction, which caused interference in reading and judgment and increased the time for thinking and deciding. Eight people mentioned that the green gate should have a map to provide information; otherwise, they would have to search for the internal map blindly. As for the sub-map inside the campus, three people said they did not notice it at all, and four people thought it was not easy to read. The main reasons for this were that the map was too small and the placement angle was unsuitable for reading. Lastly, 16 people responded that there were inconsistent information and wrong directions on the maps. The three maps on the new South Road had three different directions of information presentation (see Figure 3), which interfered with the original information and decision-making of the participants.

CONCLUSION

This study uses a virtual environment as the experimental approach, which has the advantage of better control over the variables and scope of the experimental field and saves a lot of time and physical effort. The first-person

Figure 3: Two types of campus maps are available (three types of information presentation).

perspective of the participants' pathfinding allows the researchers to understand what they observe in the environment. However, this experiment still has some limitations, as less "crowd" and "clutter" may impact perception and pathfinding behavior. In addition to the participant's orientation perception ability, the experience of 3D first-person perspective games may also affect the experiment's performance. In addition, this study was conducted with a desktop computer screen, which has a narrower view angle than the actual walking field, and it is easy to ignore the scenery on both sides. However, the virtual environment is still a feasible tool for evaluating the campus map pathfinding system.

The study's results revealed that if the participants could not determine their location and orientation in the first place, it would significantly increase the time and difficulty of decision-making. The correlation between the primary and secondary maps affects the smoothness of the navigation process, including the orientation of the map settings and the layout of the information content. The existing map elements are color-coded, and the buildings are numbered, so they are of little help. Participants indicated that they did not necessarily notice them; even if they did, they did not find them helpful or counterproductive. Overall, the layout on the campus map did not meet the needs of the participants.

Regarding design, there are two significant problems: missing information and information deficiencies. For the missing part, the primary goal of improvement is to fill in the critical information that does not appear on the existing map. For information deficiencies, the problem of inconsistent presentation of information in the same direction of the map should be improved to avoid spending extra time to verify the original information and strategies. The information about "You are here" is incomplete, causing errors in the participants' decision to find their way, and a more understandable and clear presentation should be proposed. The original color distinction and numbering were adjusted to give practical help based on the feedback from the participants. The overall layout of the map settings will be optimized based on the experimental results to provide the most efficient layout for the best user experience.

REFERENCES

Conroy, R. A. (2001). Spatial navigation in immersive virtual environments. PhD diss., University of London.

Golledge, R. G. (1999). Human wayfinding and cognitive maps. Wayfinding behavior: Cognitive mapping and other spatial processes, 5–45.

Jyun-Wun Chen, Wan-Lai You (2002). Visual Communication Design in Cartography. Design Research, 2, 117-127○

Jyun-Wun Chen, Wan-Lai You, Shang-Jia Ciou (2003). Methodology and application of pathfinding research. Design Research, 3, 222–223.

Ke-Q uan Chang, Ren-Tao Huang (1991). Thematic map preparation, Beijing: Survey and Painting Publishing.

Keil, J.; Edler, D.; Kuchinke, L.; Dickmann, F. (2020). Effects of visual map complexity on the attentional processing of landmarks. PLoS ONE, 15, e0229575.

Morganti, F., Carassa, A., & Geminiani, G. (2007). Planning optimal paths: A simple assessment of survey spatial knowledge in virtual environments. Computers in Human Behavior, 23(4), 1982–1996.

Pei-Jin Lee (2004). A study on usability of wayfinding map styles. Master's Thesis, Department of Industrial Design, National Yunlin University of Science and Technology, Unpublished, Yunlin.

Richter, K.-F. (2007). A Uniform Handling of Different Landmark Types in Route Directions. Lect. Notes Comput. Sci. 4736, 373–389.