Influence of material application to wayfinding issue in underground station design

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Abstract. Getting lost and disoriented due to the lack of legibility of the space are common problems found in underground stations. Wayfinding inside underground stations is often thought as being solely supported by the presence of signage and directory maps as the tools that help users to understand their orientation and route better. However, the influence of materials on wayfinding in underground stations is often overlooked. Hence this paper presents a comprehensive examination of literature studies and an analysis on Dhoby Ghaut Station in Singapore as case studies. This station serves three interchange MRT lines and complex routes, which renders wayfinding issues even more urgent. The goal of this paper is to examine the potential of contrasting the material application for effective wayfinding inside the underground station. To identify aspects regarding the impact of selection and placement of materials applied (on floors, walls, and ceilings of underground stations), literature and case study are carried out. The results indicate that the materials used in underground station influences wayfinding in varying degrees.

1. Introduction
Underground station is a type of underground space that is built to support the public transportation system where people move throughout the space to access another building that is integrated to the station [3]. Underground station provides flexibility and security in mobilization inside the space in which people are able to navigate themselves independently. However, there is some underground station design that still has issues in wayfinding; difficulty in finding the access in and out of the station and to locate specific destination inside the station. The issues are caused by the knowledge gap that people experience which leads to disorientation. To overcome the problems, people perceive the visual information that is provided by the underground station design based on the characteristics of material surfaces. By perceiving the visual information, people are able identify their surrounding and access the space in ease. Accordingly, material application has potential to increase legibility of space and solve the wayfinding issue inside underground station.

2. Background
Wayfinding is a term to describe the spatial experience which people undergoes when they navigate themselves inside a space. According to Passini (1996, 1997), wayfinding is a cognitive ability to assimilate spatial information, make maps to find one’s way, make decisions, and execute the three decisions: cognitive mapping, decision-making, and decision execution based on visual perception.

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Through the process, people determine their orientation by choosing a point of reference along the route they are about to pick. Therefore, the necessity of sufficient visual information for wayfinding demands interesting settings that allow for gratifying spatial experiences that are accessible and efficient, despite any complexity that different type of space carries (Arthur and Passini, 1992, p.37, 43).

Looking up to the main function of underground station design as a transitional space in which accommodates people’s mobility, wayfinding is a process that involves one’s visual knowledge about the station in order to identify and access the space easily as an important aspect of wayfinding system in an underground station. Passengers obtain the visual knowledge by perceiving the surface of materials of spatial features of the station design. The visual perception formed gives birth to material experience, which gives an aesthetic, meaning, and emotional value to the human being who interacts with the material.

When interacting with materials, humans use their visual perception of materials to understand material characteristics such as colors and shapes. Therefore, materials are applied significantly on the surface of spatial features by contrasting the materials colours with a consideration of the material’s reflectivity and provided artificial illumination [10]. As a windowless environment, the presence of artificial illumination is important to induce surface reflectance of materials inside an underground station. Furthermore, surface reflectance is affected by the amount of intensity and direction of the illumination itself—whether the illumination would cause glare or shadow on an object and thus affects legibility of a space in general. According to Nancy Kwallek on her research with NASA [17], colors of material are the characteristics that exert the most influence on the human perception of color. Not only certain colors, therefore, or certain juxtaposition of color, but also certain degrees of color of materials may have a positive or negative influence on our productivity, including sense of direction, mental lucidity, and psychological level. However, contrasting in material to highlights the spatial features does not take account solely on colors and shapes, but also on the additional aspects such as size, distance, and scale. These aspects create foreground-background relationship between materials with significance. Therefore, material selection should encounter the importance of creating a legible space that is easy to identify.

3. Methodology
This paper aims to identify the potential of material application to solve wayfinding issue in the underground station design. The study of this paper begins with literature study to identify the aspects of wayfinding in underground station and surface properties of materials in which takes part in enhancing legibility and accessibility of space. A study case has been conducted to test the relevancy of wayfinding, materials, and the performance of the wayfinding design of underground station in Dhoby Ghaut Station, Singapore. A direct observation was then carried out to test the relevancy of theories in Dhoby Ghaut Station, Singapore, addressing the superimposed layout and interchange lines problems that may rise as part of wayfinding issue inside the station.

4. Findings
4.1. Background of Case Study
Dhoby Ghaut Station is the largest Mass Rapid Transfer (MRT) in Singapore with three interchange lines. The building is located underground, span from Orchard Road to Penang Road to connect the station to many integrated public places around. The large massing has caused numerous options of route with different complexity for passengers to take inside the station, such as crossing of paths from one room to another and crossing of access from one floor level to another. Hence, it has caused issues on wayfinding in which affects human movement and activities inside the station.
4.2. Findings

4.2.1. Materials and Wayfinding Correlation in Underground Station
Wayfinding is human cognitive ability to process different kinds of spatial information (Passini, 1996, 1997). The information is perceived visually and becomes a reference for user to make decision independently, and thus human is able to determine their orientation while moving inside a building (Montello, 2001). One of many types of visual information is the material use on the spatial elements of underground station. Materials facilitate human movement that is associated with wayfinding in a space because the presence of materials is able to increase the readability of a space, thus it is easy to identify (Symonds, P., n.d). This is beneficial for user as it helps them to mark the territory of their activities inside the underground station as per their needs (Abrams, B., 2010).

4.2.2. The Importance of Material Surface Characteristics
Significance of material application on spatial features depends on the characteristics that appear on the surface of materials, such as colors and pattern. Characteristics arise after the substance of material reacts with the subsequent medium of material. In underground station, the medium of material is light from artificial illumination as compensation to the absence of natural light [17]. It reacts with the material substance through reflection and transmission to give material effects, such as reflectivity [10]. Therefore, the level of reflectivity depends on the type of materials applied, as different types of material have different surface reflectance (Anter, K.F., 2000). It affects the way humans capture and perceive the materials as visual information to guide them to determine their orientation inside the station [17]. Different level of reflectivity affects color contrast and pattern helps to form foreground and background besides the scale of the material itself. Accordingly, it forms focal point and key area of a space and thus emphasizes the presence of both spatial and legibility features as guidance and to create continuous navigation experience.

![Figure 1. Foreground-background relationship](image)

4.2.3. Material Application on Spatial Features of Underground Station
Materials are applied in interesting arrangement with consideration on pattern and color coordination to highlight spatial features and define their function, such as nodes and landmarks (Wright, 2012). Both of the features become point of references for humans to consider when they choose the most favorable routes because they have the greatest appeal (Alexander, C., 1977, p. 577). Accordingly, material application creates clear articulation of space and thus helps user to navigate themselves inside the station.
5. Results

Dhoby Ghaut Station as a train station with the most complex route in Singapore is located 28 meters below the surface of the ground makes the entire room isolated from access to natural light. Therefore, the type of material used is taken into consideration so that the reflection of light from artificial illumination existing in the station space on the surface of the material does not cause glare or shadow which can disturb human sight navigation within the underground station (Wright, 2012). The application of materials is contrast with one and another to form the foreground and background (Lawson, 2005) that is perceived as point of interest and reference when someone is determining his orientation inside the station. Therefore, it can be concluded that contrasting material applications have an effect on solving the wayfinding issue in underground stations.
6. Conclusion
In analyzing the effect of material application on wayfinding in an underground station, an aspect that is studied is the material surface characteristics of materials as visual information perceived by humans as underground station space users. Surface characteristics arising from the reaction between the material substance and the surrounding medium. It is perceived visually by humans regarding wayfinding issue is color. This characteristic arises from the reaction between light as medium and the related material substance. It is then being identified through the process of observation, interpretation, and synthesizing of material of an object that a person sees. The process becomes easy to conduct when the material's presence is significant, whether the contrasting material between one and another in terms of color, scale, or pattern that are applied on spatial elements and legibility features. The significance makes them appear as point of interests of the underground station. Consequently, it becomes a tool to use as guidance during navigation within the underground station.

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