COLOR CONTRIBUTION TO CHILDREN'S WAYFINDING

IN SCHOOL ENVIRONMENTS

A THESIS

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By

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May, 2007

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts.

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ABSTRACT

COLOR CONTRIBUTION TO CHILDREN'S WAYFINDING IN SCHOOL ENVIRONMENTS

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The purpose of this study is to explore the contribution of color to children's wayfinding ability in school environments and to examine the differences between different colors in terms of their remembrance and usability in route learning process. The experiment was conducted with three different sample groups for the three different experiment sets that were differentiated by their color arrangement. The participants were a total of 100 primary school children aged 7-8 years-old. The study was conducted in five phases. Firstly, participants were tested for color vision deficiencies and familiarity with the experiment site. Secondly, they were escorted on the experiment route by the tester one by one, from starting point to the end point and were asked to lead the tester to the end point by the same route. Thirdly, they were asked to verbally describe the route. Fourthly, they were asked to recognize the specific colors at their specific locations. Finally, they were asked to direct the location of the end point with their finger. It was found that color has a significant effect on children's wayfinding and pointing task performances in school environments. However, there were not any differences between different colors in terms of their remembrances in route finding task. In addition, the correct identifications of specific colors and landmarks were depending on their specific locations. Contrary to the literature, gender differences were not found in the accuracy of route learning and pointing task performances.

Keywords: Wayfinding, Route Knowledge, Pointing Task, Color, School Environment.

ÖZET

ÇOCUKLARIN OKUL ORTAMLARINDA YOL BULMA YETİSİNE RENGİN KATKISI

Elif Helvacıoğlu

İç Mimarlık ve Çevre Tasarımı Bölümü, Yüksek Lisans

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Bu çalışmanın amacı, okul ortamında çocukların yol bulma yetileri üzerinde rengin katkısını araştırmak ve farklı renklerin, rota öğrenme sürecindeki etkilerini, hatırlanma ve kullanılma çerçevesinde incelemektir. Deney, renk düzenlemeleri ile birbirinden farklılaşan üç farklı deney seti için, üç farklı katılımcı grubu ile uygulanmıştır. Katılımcıların hepsi, 7 ve 8 yaş grubu olmak üzere, toplamda 100 ilkokul öğrencisini kapsamaktadır. Çalışma, toplam beş aşamadan oluşmaktadır. İlk olarak katılımcılar, renk görme yeterliliklerini ve deney alanına olan aşinalıklarını ölçmek üzere test edilmişlerdir. İkinci olarak, araştırmacı tarafından teker teker başlama noktasından bitiş noktasına kadar olan deney rotasında eşlik edilmiş ve daha sonra kendilerinden aynı rota düzeninde araştırmacıya, rotanın son noktasına kadar kılavuzluk etmeleri istenmiştir. Üçüncü olarak, rotayı sözel olarak tarif etmeleri istenmiştir. Dördüncü olarak, belli renkleri belli konumlarında ayırt etmeleri istenmiştir. Son olarak, işaret parmaklarını kullanarak, rotanın son noktasının konumunu işaret etmeleri istenmiştir. Rengin, çocukların okul ortamında yön bulma ve yön gösterme yetileri üzerinde önemli bir etkisi olduğu bulunmuştur. Ancak, farklı renklerin rota öğrenme durumunda, hatırlanma ve kullanılma çerçevesinde birbirlerinden farklılıkları gözlenmemiştir. Buna ek olarak, belli renk ve yön bulma işaretlerinin doğru saptanmasının, kendi belli konumlarına bağlı olduğu bulunmuştur. Literatüre ters olarak, rota öğrenme ve işaret etme performanslarında, cinsiyete dayalı farklılıklar gözlenmemiştir.

Anahtar Sözcükler: Yol Bulma, Rota Anlama, Yön Gösterme, Renk, Okul Ortamı.

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1. INTRODUCTION

The difficulty of navigating in unfamiliar environments suggests the need to support navigation with the use of environmental design elements such as layout, landmarks, and signage, in real and virtual spaces. One tool for navigation is provided with color. Color is a very important tool in the design of environments for coding, navigation and wayfinding. It can help to develop a mental map of the architectural environment (Dalke, Little, Niemann, Camgöz, Steadman, Hill, Stott, 2005). However, there are only a limited number of studies available on the impact of color on human wayfinding ability.

Adults develop their sense of spatial learning in years. They know how to behave in a case of an inaccurate orientation in an environment and they can control their psychology towards feeling lost. However, it is different for children; by the age of 7, a child starts to understand his environment and then his/her understanding develops in time. By the age of 8, s/he remembers the events at the beginning and at the end (Cornell, Heth, Kneubuhler, & Sehgal, 1996). So they need more support for navigating themselves in an environment and color might be such a support. The studies available generally focus on children's pointing task abilities (e.g. Lehnung, Haaland, Pohl, & Leplow, 2001; Lehnung, Leplow, Haaland, Mehdorn, & Ferstl, 2003) and spatial memories (e.g. Heth, Cornell, & Alberts, 1997; Osmann & Wiedenbauer, 2004; Bell, 2002). By the time of pre-schooling and primary schooling, school starts to be a dominant force in the life of children (Orr, 1992). They have their first experiences in their school and these experiences can positively or negatively affect children’s psychology. Providing legible spaces for children may also contribute to their psychological health.

1.1. Aim of the Study

The main purpose of this study is to understand the contribution of color to children’s wayfinding ability in school environments. It is important to understand how color affects children’s usage of their environment and their accuracy in wayfinding for providing them psychologically healthy environments. In addition, different colors were tested in this study, in terms of their remembrance and usability in route learning.

This study points out the effects of color on children’s route learning performances in their natural environments, and the differences between colors in terms of their remembrance and usability in route learning process. The findings of the experiment may provide some clues not only for interior architects but also for sign makers and educators who may influence the design of safe environments with appropriate wayfinding cues to young children.

1.2. Structure of the Thesis

The thesis consists of five chapters. The first chapter is introduction, in which the importance of wayfinding is stated and the contribution of color to wayfinding is briefly investigated. In addition, children's development of spatial acquisition is discussed in general.

The second chapter explores the concept of wayfinding. Firstly, the definition of wayfinding, its importance on human psychology, its processes and requirements for the activity are stated. Secondly, wayfinding design strategies that are architectural wayfinding design and informational wayfinding design are explained. Layout of the space in the frame of form and configuration, circulation systems and scale, and landmarks that are used in spaces and are identified under the architectural wayfinding design strategies. Signage and orientation aids that constitute the building information systems are identified under informational wayfinding design strategies. The definitions, usages and roles on wayfinding and importance in acquisition of spatial knowledge of these wayfinding design strategies are explained. Thirdly, individual differences in wayfinding skills are given. The effects of familiarity, gender and age differences on wayfinding skills are discussed. Lastly, children's wayfinding abilities are elaborated on with the importance of wayfinding in school environments and route learning process.

In the third chapter, the contribution of color in wayfinding is examined. Firstly, the theory of color is stated with respect to the basic color terminology, perception of color, psychological responses to color and individual differences in preferences of color. Secondly, the usage of color in design is given. The role of environmental color and its purposes in design are stated. Thirdly, color in school environments is discussed with respect to its importance in student's performance and children's wayfinding and spatial abilities in their environment. Lastly, the importance and the effects of color as a design tool in wayfinding are given.

In the fourth chapter, the experiment is described with the aim, research questions and hypotheses. The methodology of the experiment is defined with the identification of the sample group, description of the site and explanation of the experiment procedures. The results are statistically analyzed and evaluated. The research notes are also given to enrich the study. Finally, the results are discussed in relation to previous studies related to the subject.

In the fifth chapter, major conclusions about the study are stated and suggestions for further research are generated.

2. WAYFINDING

2.1. The Definition of Wayfinding

Awareness of the space around is an important issue for finding one's way in environments. Finding one's way around is a purposive, directed, and motivated activity (Golledge, 1999). Wayfinding is the process of reaching a destination, whether in familiar or unfamiliar environments (Arthur & Passini, 1992). Giuliani (2001) defined wayfinding as "the organization and communication of our dynamic relationship to space and the environment" (p.43).

Wayfinding is an activity that requires complete involvement with the environment (Passini, 1984). During this involvement, the wayfinders try to understand the setting they are in and with the information they obtained. According to Giuliani (2001) "successful design should allow people to: determine their location within a setting, determine their destination, and develop a plan that will take them from their location to their destination" (p.43). He also added that identifying, marking, grouping, linking and organizing spaces should be included in the design of wayfinding systems. Pollet & Haskell (1979) stated that wayfinding design involved communication of information to help users of the building find their destinations, understand where they are and maintain a sense of orientation.

Arthur & Passini (1992) state that wayfinding includes three specific but interrelated processes. These processes are; “*decision making* and the development of a plan of action; *decision execution* that transforms the plan into appropriate behavior at the right space; *information processing* understood in its generic sense as comprising of environmental perception and cognition, which, in turn, are responsible for the information basis of the decision-related processes” (p.25).

Unfamiliar, large-scale and complex layout environments are difficult to navigate. Being unfamiliar with immediate surroundings and unable to determine how to correct the situation is an uncomfortable condition (Darken & Peterson, 2002). As Richter & Klippel (2002) asserted orientation in an unknown environment is an important factor for successfully reaching at a specified destination and requires usually external knowledge sources. People need to know where they actually are in complex unfamiliar environments to feel themselves secure and safe. The difficulty of navigating in unfamiliar environments suggests the need to support navigation in real and virtual world spaces by environmental design elements.

Wayfinding necessitates spatial knowledge that contains one’s current location, destination and the spatial relation between them. Without this knowledge, if people do not get totally lost, they become disoriented (Cubukcu & Nasar, 2005). Disorientation can have serious consequences, such as stress. Disoriented people are anxious, uncomfortable and unhappy (Darken & Peterson, 2002). Passini (1984) stated that, disorientation and getting lost are very frustrating experiences for people who are trying to reach a specific destination. Danielsson (2005) stated that for reducing the negative effects, the circulation system of the building should be easy to understand and the internal relations between spaces should be logical. Therefore, design for wayfinding is very important for improving people's wayfinding performances in real environments.

A lost person is defined as "unable to identify or orient his present location with respect to known locations, and has no effective means method for reorienting himself" (Hill, 1998, p.2). Knowing where you are provides feelings of security and safety. Becoming lost is the result of losing one's spatial orientation and is normally accompanied by high emotional arousals such as nausea, stomach pain and fear.

People do not feel themselves lost unless they are uncertain about how to get to their destination. People are considered to know where they are, if they state their location accurately within a frame of references (Cornell & Hill, 2004). Arthur & Passini (1992) state that people feel themselves disoriented "when they can not situate themselves within a spatial representation and when, at the same time, they do not have, or can not develop, a plan to reach their destination" (p.25). Previous experiences, reading and evaluating environmental context and trying to understand the spatial characteristics of the setting are required information for solving wayfinding problems.

There are two types of wayfinding design strategies: architectural wayfinding design and informational wayfinding design (Pollett & Haskell, 1979 ; Giuliani, 2001). These strategies help people to construct their mental map about the environment. Architectural wayfinding design deals with the layout of the space and landmarks that are used in the space. Informational wayfinding design deals with the building information system that are signage and orientation aids. These categorization is about the fundamental distinction between sources of spatial knowledge, whether the information comes directly from the primary source of environment -architectural wayfinding design- or from some other secondary source -informational wayfinding design- (Darken & Peterson, 2002).

2.2. Wayfinding Design Strategies

Architectural wayfinding design and informational wayfinding design are the two types of wayfinding design strategies that provide sources of spatial knowledge to people.

2.2.1. Architectural Wayfinding Design

There are two primary architectural wayfinding design elements: layout of the building and landmarks that used in the building.

2.2.1.1. Layout

The spatial layout and other architectural features are important sources of information for finding one's way, when focusing on wayfinding in large-scale built environments (Werner & Schindler, 2004). Doğu & Erkip (2000) stated that layout of a setting could be defined by its spatial content, form, organization and circulation system. The building tells us everything about its internal organization if these factors are articulated well. Buildings organized around an open core provide an advantage of visual and auditory access to circulation systems.

A building can be considered a design success, if it allows easy and error free navigation from a perspective of function (Werner & Schindler, 2004). Therefore, a building as a source of wayfinding information has to be architecturally legible.

Legibility that means the apparent clarity of the environment is one of the important concepts of environmental psychology and is crucial in environmental setting (Lynch, 1960). Legible environment "not only offers security but also heightens the potential depth and intensity of human experience" (p.5). Legibility means the degree to which a building or groups of buildings facilitate the ability of users to find their way around (Abu-Ghazzeh, 1996). Herzog & Leverich (2003) defined the term as "the ease of finding one's way around in a setting, the ease in figuring out where one is at any given moment, or of finding one's way back to any given point in the setting" (p.461). If the current view in a setting appears well structured, then it is legible. However, inappropriate architectural design might make a setting complex which might cause wayfinding problems.

Complexity in a setting can be described with the amount of different kinds of elements that the scenes contain (Stamps, 2004). People need small amount of changes in a setting and, they do not adapt well to large amount of variations. Therefore, a high level of complexity leads to an overabundance of stimulation (Evans & McCoy, 1998). Clear and organized settings could reduce wayfinding problems by creating spaces for making easy predictions. In complex settings, wayfinders are bombarded with stimulation of all sorts of information and as a result finding relevant information becomes difficult (Arthur & Passini, 1992). O'Neill (1991) found that complexity of floor plan influenced wayfinding performance negatively, when plan complexity was increased, errors were also increased.

People do not comprehend the overall plan of the building. Therefore, providing a legible spatial structure for a building is an important factor in way-finding performance and this is related with geometrical properties. The spatial structure of a building can be analyzed under three important issues: form and configuration, circulation system and scale of the building.

One significant predictor of wayfinding is building configuration that contains spatial content such as form, organization of floor plan configurations and circulation system. Design for wayfinding is based on spatial properties and analyses of floor plans of the built space. Spatial relations and differences in orientation between different parts of a building play an important role on human ability to organize and to integrate spatial knowledge (Werner & Schindler, 2004). Buildings that are organized around a simple orthogonal grid with regular angles are less problematic than irregular designs. Symmetry axes, elongation, use of visible structures such as an atrium, the outside landscape or other prominent features provide comprehensible environments. According to Haq & Zimring (2003), visibility is an important issue in movement as it is easier to find a destination that one can see. According to Başkaya, Wilson & Özcan (2004) the monotony of architectural composition and the lack of reference points increase wayfinding difficulties where visual access to the main destinations makes wayfinding facilities easier. They found that a regular but asymmetrical floor plan was easier to remember than a regular but symmetrical layout and a simple corridor system allowed for easy orientation.

Darken & Peterson (2002) commented that spaces with an understandable structure will have a great effect on the strategies used and resulting performances on navigation tasks. Providing some obvious landmarks can reinforce the shape of space. Environments that represent a logical traffic pattern permits user to move easily from one spot to another. Spatial organization, building layouts, destination zones and information sequence bring along success or failure in wayfinding abilities (Muhlhausen, 2006). Building configuration of an environment is an effective measure to understand wayfinding difficulties in specific areas of complex buildings (Haq & Zimring, 2003). For physical environmental factors, Cubukcu & Nasar (2005) found that environments with simple layout and higher physical differentiation provided better spatial knowledge -lower error scores- than environments with complex layout and lower physical differentiation. The simple layouts also had significantly lower selection, sketching and navigation errors than the complex ones.

The design of spaces affects user behavior and the flow of visitors in an environment. The shapes of spaces orientate the visitors. A simple plan of spaces plays an important orientation role by allowing visitor to concentrate on the purpose of the visit (Bourdeau & Chebat, 2003). Franz & Wiener (2005) supported the ideas that form and configuration of the architectural space influence experience and behavior of users. They also stated that when looking for a specific place especially in unfamiliar environments, during exploration, movement decisions include regular patterns that were caused not only by the shape and configuration of the environment but also by visual characteristics of decision points.

The circulation system is one of the key elements of a building that helps to develop a mental map. A well-designed circulation system provides users an easier understanding of the building (Arthur & Passini, 1992). Circulation system of the building should be identifiable and obvious for easy understanding from the initial contact and important adjacent activities should be exposed to the circulation system (Pollett & Haskell, 1979).

Vertical circulation elements such as stairs, elevators, and ramps should be perceptible for maintaining easy communication to the users (Giuliani, 2001). Giuliani (2001) stated that the entries and circulation spaces were the first contact of people with the building interior. Thus, a sense of openness for improving the acquisition of knowledge about the building layout and social organization should be provided.

Beside the building configuration and circulation system of the building, scale has also an important effect on understanding spaces. It is an important element in the acquisition of spatial knowledge. Scale affects user interactions with the space in navigation, in learning and reconstructing spatial locations, in recall of object location, and in verbal descriptions of spatial locations (Bell, 2002).

2.2.1.1. Landmarks

The content of environmental setting can conveniently be classified into five elements: paths, edges, districts, nodes and landmarks (Lynch, 1960). Those are providing a support to the improvement of wayfinding ability and to the development of route knowledge.

Paths are the channels along which people move potentially, and these are the predominant elements in their cognitive image of a place (Lynch, 1960). Paths include walkways, hallways and corridors, which make the circulation system of the building. Paths are used in two orders: main pathways and secondary pathways in complex buildings. Main pathways are used for connecting major spaces and secondary pathways are used for leading from primary paths to less important destinations. These orders should be different in design to help people remember their journey through pathways (Pollett & Haskell, 1979). Vinson (1999) stated that paths are channels for navigator movement and streets, canals, transit lines are examples for widely used paths in our everyday lives.

Edges as the linear elements are the boundaries between two phases that people use to orient themselves in space and it determines where an area begins or ends (Lynch, 1960; Pollett & Haskell, 1979; Vinson 1999). Edges include not only the built environment like the walls, but also landscape features like the edge of a forest or a river. Besides the micro-scale, strong edges are much more remembered (Pollett & Haskell, 1979).

Districts are the medium-to-large sections of the environment (Lynch, 1960). Districts have two-dimensional extent that people enters mentally inside of and are recognizable. Districts are defined as regions with a noticeable character that help in the general identification of place. Identification of each zone should be unique and different for being memorable (Giuliani, 2001). Vinson (1999) stated that districts worked as reference points and neighborhoods were examples for districts. According to Pollett & Haskell (1979) a particular character such as visual, social or geographic defined districts/zones which were identified with zone prefixes such as letters, colors or cardinal directions.

Nodes are places combining paths and providing information especially for new comers who would need to have the essential information for finding their way (Lynch, 1960; Pollett & Haskell, 1979; Darken & Peterson, 2002). People make decisions at nodes, so they should contain maps, graphic information, whenever possible visual, tactile and auditory indicators to assist with those decisions (Giuliani, 2001). Because nodes are decision-making points, distance and distinctiveness of nodes are crucial for recognizing them in an environment (Haq & Zimring, 2003). Vinson (1999) stated that nodes were focal points for travel and some examples for nodes could be town squares, and public buildings in a cityscape.

Landmarks are type of point-reference (Lynch, 1960). It gives a strong identity to various parts of the built environments. “A landmark is an object that marks a locality, acts as a mental landmark in the wayfinding process and breaks a complex task into manageable parts” (Giuliani, 2001, p. 45). Landmarks have to be unique in a building for not loosing their effectiveness; they can be lighting fixtures, materials, kiosks or art pieces. Location is very important for markers. For example, landmarks that are located at intersections are highly exposed. Landmarks should be perceived from as many directions as possible and should not physically interrupt the path of travel (Pollett & Haskell, 1979).

Landmarks are essential parts of wayfinding cues and are seen as points of reference. Therefore, sensitivity to landmark quality is a critical factor for wayfinding as people use landmarks as reference point at necessary times. Landmarks are the most prominent cues in any environment (Darken & Peterson, 2002). They act as key elements to enhance the ability to orient oneself and to navigate in an environment. Their importance is because of aiding the user in navigating and understanding the spaces (Sorrows & Hirtle, 1999). To mark an object as a landmark among the others is done by the individual. It is not only about the quality of the object itself, but also about perception and about its reflection in mind (Weissensteiner & Winter, 2004). Therefore, “a landmark is an object within a relation to a subject” (p.317). Communicating landmarks is a process that is the basic relation between the subject and an object and results in a completed orientation. Comments about usage of landmarks can be categorized as being used in making directional decisions, in recognition as something familiar on route identification, and in remarking upon passing (Lawton, Charleston, & Zieles, 1996).

Raubal & Winter (2002) reported that landmarks might be used as route instructions and in mental representations of space. In an environment, people get to their destinations by the help of scenes that contain various features and landmarks, as anchors for spatial relationship. People can follow the route by recognizing these features and landmarks as they help to remember the sequence of the route, even when these people do not have a good knowledge of the spatial layout. People improve and use environmental schemata in wayfinding in compensating the lack of information design system to memorize the features and landmarks (Murakoshi & Kawai, 2000). The availability of various landmarks in setting eases encoding the routes verbally, and helps improving the spatial, visual and verbal memory of wayfinding knowledge (Meilinger, Knauff & Bülthoff, 2006). Cubukcu & Nasar (2005) found that people in environments with landmarks acquired better spatial knowledge -lower error scores in direction and sketching process -than environments without landmarks.

According to Vinson (1999), landmarks support the development of route knowledge and route knowledge is essential to navigation. Route knowledge is the ability of person to navigate from one location to another (Ruddle & Peruch, 2004). It is characterized by sequentially organized information about particular routes (Ruddle, Payne & Jones, 1998). Vinson (1999) claimed that it was important:

> to make landmarks distinctive with features of significant height, complex shape, bright exterior and visible signs; to use concrete objects, not abstract ones for landmarks; to make landmarks visible at all navigable scales; to make landmarks easy to distinguish from nearby objects and other landmarks; to make the side of landmarks different from each other; to place landmarks on major paths and at path junctions; to increase memorability of buildings (p.281-282).

A landmark acts as a visual attraction point if it has certain visual characteristics. Therefore, visibility, shape, color, and façade area of landmarks can be used as measures in determining their visual attraction (Raubal & Winter, 2002).To differentiate various landmarks in environments, there are many important attributes of identity available such as color, texture, markings, size and shape (Learmonth, Newcombe, & Huttenlocher, 2001).

For complex cognitive tasks such as route descriptions and navigational behavior, objects at different locations along a route are not equally important (Janzen, 2006). It is important to place landmarks at decision points in a setting. Decision points are places where users need to make decisions to choose their desired direction. They are important because of being areas that wayfinders pause and take in new information (Haq & Zimring, 2003). According to Vinson (1999), landmarks should be placed on major paths, at path junctions, must be easy to distinguish from nearby objects and other landmarks in the same environment, and should be distinctive with features such as significant height, complex shape, and bright exterior or large and visible signs. Janzen (2006) found that objects placed at decision points that referred to route intersections where alternative routes could be chosen, played a specific role for wayfinding; objects at decision points were recognized faster than objects placed at non-decision points.

Sorrows & Hirtle (1999) defined landmarks as significant elements in one's formation of a cognitive map of physical environments. They claimed that landmarks served multiple purposes in wayfinding as an organizing concept and as a navigational tool. They also proposed three categories of landmarks as: "a visual landmark is an object that is a landmark primarily because of its visual characteristics; a cognitive landmark is one in which the meaning stands out because it is atypical in the environment; a structural landmark is one whose importance comes from its role or location in the structure of the space" (p.45-46).

Landmarks have a crucial role in one's ability to find his way around. Landmarks are used as reference points, with their physical features and distinctiveness. Those are not only improving orientation but also contribute to the development of spatial knowledge.

2.2.2. Informational Wayfinding Design

There are two primary informational wayfinding design elements: orientation aids and signage system of the building.

2.2.2.1. Orientation Aids

The major reason to use orientation aids are to find your way and to learn a new environment. Maps, site plans, floor plans, building and floor directories and information desk are the basic types of the orientation aids. Giuliani (2001) stated that orientation devices provide people to develop a mental map of a large complex.

Maps are extremely powerful tools for navigation. They not only provide information about the environment but also influence the ability of users performation of mental rotation required to use the environment. For any map used in any environment, it is important to know when the map will be used and what tasks the map will to be used for. This way it will be possible to understand the location of the user in the environment and the direction that person would face (Darken & Peterson, 2002).

Maps provide information to understand where one is in the building and the whole of the building (Pollett & Haskell, 1979). They enable people to create an understandable mental model of the site and the main routes on it, providing easy orientation in the environments (Miller & Lewis, 1999). The usefulness of maps depends on their relation to the actual environment and to pre-visit information. Interior maps should be located at key nodes in a circulation system and on each floor level with room numbers and tenants identified. Exterior maps should be located so that they are legible from a parked vehicle (Pollett & Haskell, 1979).

Maps may include visual properties of a drawing to represent geographical information of the environment. Maps are generally used for three purposes as guides to exploration, as substitutes for exploration and as the basis for directions (Hunt & Waller, 1999). Using familiar pictograms for reinforcing the text and providing“you-are-here” (YAH) symbols are important for emphasizing information (Giuliani, 2001).

Marquez et al., (2004) stated that “maps are useful because they quickly provide spatial information about the environment beyond what can be seen and depicted in a physical small space” (para. 8). They claimed that you-are-here (YAH) maps were more beneficial than regular maps as they showed users their location within the environment and surrounding areas. “You-are-here” (YAH) maps should include an overall map of the complex and detailed maps of the buildings in specific areas to achieve effective graphic communication (Muhlhausen, 2006).

A YAH map needs to be placed along paths and positioned near decision points. Length of the route and the number of necessary turns play a crucial role in the number of YAH maps to be placed. A YAH map is needed at the entrances as visitors orient themselves at these points and decide their destinations. It should be positioned in an asymmetrical part of the environment for easy identification on the map, it should be perceived from a distance and it should be easily accessible (Richter & Klippel, 2002).

According to Marquez et al., (2004) one should ask these questions in the assessment of the map: “is the map legible, is the end destination identifiable, is the YAH marker identifiable, does it show the viewer’s orientation, is the YAH map oriented properly, e.g. is the right side of the map on the viewer’s right?” (para. 14).

Information desk is another important orientation aid that provides people direct information about the building. The placement of information desk in the building has a crucial role for the visibility and usability of it. Information desks should be located at each public entry that is visible from the front door (Muhlhausen, 2006). Information desks need to be placed near building maps and directories, so personnel can use them to explain directions to visitors (Pollett & Haskell, 1979).

2.2.2.2. Signage

Signs are major elements of information systems. According to O'Neill (1991), signage is used to enhance wayfinding efficiency especially in settings with complex floor plan configurations in which wayfinding is a chronic problem such as subways, hospitals, and large governmental buildings. Richter & Klippel (2002) claim that information provided by a sign is the faster process of receiving information. However, signage can be problematic as it shows just directions, not routes and at every decision point a new sign is needed.

Faulty signs can cause wayfinding problems in unfamiliar environments. Some signs lack visibility because the lettering is not legible when viewed from a distance, some contain inaccurate, ambiguous and unfamiliar messages and some contain reflective surfaces and inappropriate color combinations (Muhlhausen, 2006).

Location, content, illumination and color of signs have an important role in representing beneficial and functional information systems. Location should be visible at transitional areas and at intersections, there should not be more than five messages and five lines of text in a single sign, character height, stroke width, font type, surface characteristics should be considered, artificial and natural illumination should be designed to prevent glare on signage, color schemes used should be described easily by names as blue, orange etc (Pollett & Haskell, 1979). When creating environmental signage, it is important to consider the contrast between the color of the typography and the background for ease of reading and also the impact of color on interpretation and understanding of the content (McLean, 1993). Moreover, importance must be given to the user about their cultural context, the lighting about its levels and the signage materials to prevent reflection (Martinson & Bukoski, 2005).

The content of the signage should be considered in the design process, because the remembrances of signs decrease when the number of contained words increases (Bourdeau & Chebat, 2003). Long horizontal lines should be avoided in the signs. A standard formula for line length is 40 to 50 characters per line. More than 50 characters start to distract visitors' attentions, disturb the eye, tend to lose its place and cause vision to jump line to line (McLean, 1993).

Graphic information used in signs works as a communicator and helps visitors to orient themselves in spaces. "As communicators, graphic information must contain appropriate content and be understandable, and as graphic elements, they must have an appropriate design format and be legible" (McLean, 1993, p.106).O'Neill found that (1991) people using textual signage made the fewest number of wrong turns where people using graphic signage made significantly more wrong turns and people using no signage made the greatest number of wrong turns.

There were various signs that were provided to individuals for reducing the risk of disorientation and for helping them understanding their environments (Bourdeau & Chebat, 2003). Signs provide access to information content of the building. Pollett & Haskell (1979) stated that identification signs, directional signs and descriptive signs were fundamental types of signs. Giuliani (2001) added more types of signs including destination identification, situation and object identification, and orientation.

Identification signs provided for individuals need access to assistive devices to help them get all the information during the events that occur in buildings. Visual and audible alarms, assistive listening system (ALS) are some examples (Pollett & Haskell, 1979). ALS is effective when the individual needs to improve speech reading, listening, and other techniques that help supplement verbal learning (Warick, Clark, Dancer & Sinclair, 1997). ALS provides benefits not only to individuals with minimal, conductive, and fluctuating hearing loss but also to individuals with normal hearing who have additional learning problems (Lewis, 1994). Identification signs provide information at the destination and they generally include names and pictographs (Arthur & Passini, 1992).

Directional signs “guides people along to a destination, and is given after they have had the chance to orient themselves to the general setting. Most often this includes signs with arrows and elevator button panels” (Giuliani, 2001, p.50). Directional signs might work with maps at key decision points for reducing the amount of directional signage (Pollett & Haskell, 1979).

Directional signs differ from others as they include the arrow and some directional indicators for showing people which way they need to go (Miller & Lewis, 1999). Arrows that are positioned too far from the text they refer to, reduce the effectiveness of directional signs. Floor directories in elevator lobbies are an example for directional signs (Arthur & Passini, 1992).

Destination identification involves building signage, floor numbers and room identifiers provided at the point of destination. The used numbering system should be intuitive and simple, and floor numbers should be detectable at each entrance (Giuliani, 2001). These kinds of signs tell people where they are and where they have arrived at their destination (Miller & Lewis, 1999).

Situation and object identification provide information about situations such as local hazards and identify objects such as fire extinguishers. Using dynamic signage like LED displays and repeating the cues can be beneficial for giving information in emergencies (Giuliani, 2001).

2.3. Individual Differences in Wayfinding

Individual differences also influence wayfinding. Various aspects of individual differences such as familiarity, gender and age have been examined through previous studies.

2.3.1. Familiarity

Familiarity is one of the essential factors that influence the use of architectural and graphic design elements and affects the wayfinding process. Prestopnik & Ewoldsen (2000) report that length of time living in an environment is important for developing a sense of familiarity as the most important factor in predicting wayfinding. Familiarity with the environment affects improvement of sense of direction and wayfinding ability. People who rated themselves as more familiar with the environment were more accurate than people who were less familiar with the environment. As familiarity with the environment increases, spatial description tasks become easier. There are significantly fewer errors in familiar route directions in comparison to unfamiliar routes (Lovelace, Hegarty & Montello, 1999). O'Neill (1992) states that as familiarity with an environment increases, performance in wayfinding improve and the degree of complexity of the layout becomes less important.

Familiarity with the environment influences the method used in spatial orientation. As people become familiar with the environment, they first acquire landmarks, the paths and finally develop configurational knowledge of the key locations (Hunt & Waller, 1999). Chebat, Chebat & Therrien (2005) stated that familiar persons used more information stored in their long-term memory and unfamiliar person used external sources more, such as maps, signs, and other people. They also claimed that familiar person asked less help for wayfinding and used fewer maps than unfamiliar person use.

2.3.2. Gender Differences

Gender is an important factor that influences the use of architectural and graphic design elements and affects the wayfinding process. Gender differences have been reported in some studies, while others were not able to demonstrate differences.

Gender differences were found on some measures of wayfinding behavior in Lawton et al., (1996) study. They reported that men were significantly more accurate than women in indicating the direction of the destination. However, there were no gender differences reported in wayfinding patterns. In addition, women expressed greater uncertainty about the wayfinding task because of not being sure of the direction. Cornell, Sorenson & Mio (2003) reported that, males tend to express more confidence in their spatial and geographic abilities when compared to females. In addition, females' performances were poor in wayfinding tasks and they were slower than males in estimation of bearings.

In Osmann & Wiedenbauer's (2004) study, there were no sex differences in the experiment measurements in wayfinding performance, wayfinding behavior and strategies used, and the acquisition of survey knowledge. However, contrary to this study Cubukcu & Nasar (2005) reported that males had significantly fewer direction and navigation errors than females. In addition Meilinger et al., (2006) found that males performed better in wayfinding than females. Schmitz (1999) reported that men were more successful in recalled route directions in maps and descriptions than women were, but they showed a weak preference in the use of landmarks to route directions in comparison to women.

Women and men show differences in the amount of success at finding destinations in three-dimensional environments. Therefore, they use different spatial referents in finding destinations: women use landmarks more than men, while men use cardinal directions more than women (Lawton & Kallai, 2002). In addition, Lawton (2001) reported that women were affected by the absence and presence of landmark cues more than men and men were more accurate than women in judgments of directional relationship. However, Chebat et al., (2005) found that men used significantly more landmarks than women and asked less often for their way.

Galea & Kimura (1993) found significant differences between male and female participants. They reported that males outperformed females in knowledge of Euclidean, which refers to knowledge of the spatial configuration of the map and related parameters such as direction and distance properties, in map studies. Males performed better than females on route-learning process, they made fewer errors than females did. However, females recalled significantly more landmarks both on the route and off the route. It is also reported that boy's accuracy in orientation skills was more than girls and they had a greater proportion of errorless trials than did girls in reaching spaces (Allen, 1999).

The male advantage in solving complex problems and in arithmetical reasoning contribute to the male advantage in spatial cognition and in computational fluency. It is reported that males showed significantly higher mean scores on the arithmetical reasoning and spatial cognition measures than females (Geary, Saults, Liu & Hoard, 2000).

Malinowski & Gillespie (2001) reported that there was a significant difference in the time taken to complete the wayfinding task between female and male. Female spent more time than male for finding their way and they found less wayfinding points than male participants did. In addition, women reported higher levels of nervousness than men did and men outperformed women on spatial skills.

2.3.3. Age Differences

Age is another important factor that influences the use of architectural and graphic design elements. It is reported in Osmann & Wiedenbauer's (2004) study that there were no significant difference between adults, young children (second graders) and old children (sixth graders) in using and getting help from color when finding their way through unfamiliar surroundings. However, map correctness score was significantly higher for adults than younger as well as for the older children. In another study by Cubukcu & Nasar (2005) it is found that age produced a significant effect on navigation errors; as age increased, performance declined.

Galea & Kimura (1993) found that younger participants scored higher than older adults did, not only on landmark selection task but also on scene recognition, distance ranking, map placement, and route execution tasks. In addition, older women had more difficulty than did older men and younger adults in general in selection of the best landmarks from the route. Kirasic (2000) found that, younger adults (18-28 years old) outperformed older adults (60-85 years old) on scene recognition, map placement and route execution tasks.

2.4. Children and Wayfinding

Preschool and primary school were the first public places for most young children that they used and came to know instantly (Orr, 1992). At this time, the experience of school starts to be a dominant force in their lives. It is important to analyze the type of environments provided for young children in the school setting because, the nature and quality of the environment are influential on how and what students learn.

Environmental elements in school buildings have significant effects on students' and teachers' behavior, well-being and attainment. Physical characteristics such as color, landmarks, and layout of the building have an important role on students' perception and navigation (Higgins, Hall, Wall, Woolner, & McCaughey, 2005).

Most school-aged children are able to walk to school, to a friend’s house, and local stores in familiar neighborhoods. This daily walking helps children to improve the concepts and skills they need to remain oriented in environments, therefore few children get lost in their familiar environments. However, it is not the same for unfamiliar environments (Ambrose, 2000). Parents try to provide their children many kinds of instructions to help in everyday wayfinding tasks; such as ‘pay attention’, ‘look around’, etc. (Heth et al., 1997).

A child, around the age of eight, starts to understand the world in which s/he moved as a metric system; a two-dimensional structure that remains constant. Young children (school-aged children) do not have a meta-knowledge that refers to “knowing what you know”. Therefore, they do not know what they do not know, and they could get lost (Hill, 1998). Children understanding and communicating with spatial information can provide critical information on how well spatial concepts are understood (Bell, 2002).

Children under seven have to be watched in their environment as they can get lost, however children under ten can easily become lost as well. Spatial orientation skills develop very rapidly through years. Ten-years-old children can walk about their neighborhood almost as well as adults (Hunt & Waller, 1999). Eight-years-old children can remember the places and events that are at the beginning and end. They are at the beginning of route learning (Cornell et al., 1996).

Especially young children have an inner need to be influenced from their environments. They learn by interacting with their environments. Places that provide positive experiences offer opportunities for children to explore, to manipulate, and to be involved (Wilson, 1997). A disorganized environment suggests to children that they are not valued or respected. These kinds of messages affect children's perception of themselves as learners and explorers, their self-esteem and their feelings of competence. Thus, places that are provided to children have a crucial role in their personal and environmental education.

Gouteux & Spelke (2001) claim that when young children are disoriented, "they appear to reorient themselves by analyzing the shape of the surroundings' surface layout, but not by analyzing either the shapes of configurations of objects or the distinctive coloring of the surface layout" (p.145). It is found that young children reoriented in accord with the shape of a space, however they failed to reorient in accord with a non-geometric property of the layout and failed to reorient in accord with the geometric relationships among objects (Gouteux & Spelke, 2001).

Visual recognition process can inform children that they are not on-route by the absence of familiar or expected cues and by noticing something en route that the child is sure that s/he has never seen it before (Cornell & Hill, 2004). Read, Sugawara & Brandt (1999) stated that children were active perceivers, stimulated by the various source of information that was within their environments and they tried to discover, explore, and attend this information.

Environments are characterized by affordances that have a very important role on children's perception and learning within that environment. Affordance means "the functional qualities of an environment that helps people meet important goals" (Gifford, 2002, p.72). It may be anything that enables it to be used in a particular way by a particular group of people (Lang, 1987).

The ability to control a reference system that refers to select and maintain a consistent frame of reference was studied between 3 to 8 years old children (Allen, 1999). It is reported that there was a period during which children could more easily select and maintain an object as a reference point, between the ages of 3 and 8 years old. The 3-year-old children had more difficulty than did the others in evaluation of feedbacks got form the objects.

The effect of age on a child's awareness of place and on the manner, style, and composition of representation of space was studied by Matthews (1984) with map drawings between ages 6 to 11. It is reported that, with increasing age the young children acquired more information about places and their ability to depict changes in space improved. The sketches of the youngest group were simple with only a few routes, however older children were able to describe the surround area with details.

Spatial competence improves markedly between 2 and 5 years of age. It was studied by Foreman, Warry & Murray (1990) and reported that, there were age differences significantly both in performances of reference memory skills and in accuracy in environmental differentiation of spatial locations. The youngest group (2 years old) performed poorer than the intermediate (3-4 years old) and the oldest group (5 years old).

To compare the performances in spatial knowledge, 10 years old children displayed more confidence while walking, with their knowledge of their environments and the awareness of their location than 6 years olds. However, there was no significant difference between boys and girls in these performances. In addition, it is indicated that, both age groups used landmarks in describing the locations and in the wayfinding process (Ambrose, 2000).

Lehnung, Leplow, Friege, Herzog, Ferstl & Mehdorn (1998) studied the kinds of information children used when orienting in a new environment with given proximal and distal landmarks, with 5, 7 and 10 years old children. The study showed that children with different ages used different orientation strategies. 5-years-olds used cue strategy by orienting towards the proximal cues; 10-years-olds displayed much more complex place strategy by use of distal landmarks; 7-years-olds showed a transition in between cue and place strategy.

The role of landmarks for the development of spatial cognition in children was studied by Osmann & Fuchs, (2006). The differences in the effect of landmark information on wayfinding behavior and spatial knowledge was examined between second graders, sixth graders and adults. It was reported that, the existence of landmarks influenced wayfinding performances of adults and children in the same way. Younger children's performances were poorer than adults and older children; they needed more trials (Osmann & Fuchs, 2006). It was demonstrated that children at school age were able to use landmark information like adults during learning an unknown environmental space.

Heth et al., (1997) examined how children were affected by changes of landmarks - in the position and orientation- by assessing place recognition and path choices at intersections, during a route reversal. 8 and 12 year-old children were firstly escorted on a walk across a university campus and then they escorted the tester to the starting point. Children were instructed to pay attention to the landmarks at intersections and some of the landmarks were moved prior to the child's return trip. 12 year-old children outperformed 8 year-old children on route recognition, navigation accuracy and recognition of changes on landmarks.

7-8 years-old, 11-12 years-old and adults (26 years-old) learned a route by a slide presentation in a computer-simulated environment (Osmann & Wiedenbauer, 2004). They had to recall the inherent landmarks and they had to walk through the empty maze recalling the names and the positions of the landmarks (animals). The age group influenced the numbers of recalled landmark names. 7-8 years-old recalled fewer landmarks than older children and adults. Youngest boys recalled more landmarks than the girls did at the same age but men recalled fewer landmarks than women did.

Bell (2002) reported that although children at 7 and 9 years-old age and adults had difficulties on recalling the location of an arbitrarily selected object, in both 'landmark free' location recall task and 'relative' location recall task, adults recalled object locations better than both 7 and 9 years-old children, and 9 years-old recalled better than 7 years-old children.

Effect of verbal description of spaces on children's ability to make spatial inferences was examined by Ondracek & Allen (2000). Children between 6 to 9 years of age showed very accurate memory in recognizing spatial and non-spatial information after oral description of the spaces.

It is important to study children's cognitive mapping abilities in their natural surroundings rather than laboratory settings. It gives information that is more reliable in their spatial competence about how well they know their environment and how well they find their way around (Lehnung et al., 2003).

2.5. Children and Wayfinding by Route Learning

Route knowledge, which is also called procedural knowledge, means the sequential knowledge of routes between places that were linked to landmarks (Cornell et al., 2003; Cubukcu & Nasar, 2005). It can be thought of as a graph of nodes and edges that are growing as more nodes and edges are added, and developed as landmarks are connected by paths (Darken & Peterson, 2002). "It is a sequence of nodes, together with the segment traveled from one node to another, which the central concept of neighborhoods" (Hunt & Waller, 1999, p.22).

People have to deal with finding a path to a certain goal location, finding way back, finding a short cut and making a detour. For all these tasks, people acquire route knowledge. For finding the same way back, people have to remember not only the objects that were passed through but also the places where they made turns and change of directions (Janzen, 2006).

Route learning task requires a variety of specific skills, such as mental rotation, perception, and visualization to complete (Malinowski & Gillespie, 2001). Route reversal is one of the problems of wayfinding that requires flexible use of available cues and mental representations of the environment (Heth, Cornell & Flood, 2002). Route knowledge can be provided and represented as a set of familiar scenes that the members of the set can be distinguished from the unfamiliar scenes (Cornell et al., 1996). Children learn some things about the order of events along the route and route reversal performance depends upon memories of those events. Events at the beginning and at the end of the tour are more distinctive than events in the middle, for children.

Route based disorientation occurred when people experienced an unexpected scene, path or when they could not find a specific road or landmark. People usually can tolerate these events, but at the same time, they begin to feel lost when the distance of travel increases beyond what is being expected (Cornell & Hill, 2004).

Wayfinding performance is in relation with performance in pointing task and route scene memory. In addition, pointing task performance is correlated with the route memory task and related with peoples' directional senses (Murakoshi & Kawai, 2000).

Sense of direction is fundamental for comprehension of spaces. It is related to the information taken from landmarks and routes. A person with a good sense of direction is better able to look for used information like landmarks and to direct actions at intersections on routes. In addition, they are more accurately able to orient their mental representation of a configuration of landmarks, for matching a scene (Cornell et al., 2003). Heth et al., (2002) add that a good sense of direction provide a reliable reference bearing when a person was navigating by path integration. They found that, compared to adults, children showed poorer knowledge of bearings when they were on-route.

Pointing task that refers to the ability to imagine how one would look from different perspectives is a dimension of spatial orientation. It is important for real-world spatial tasks such as wayfinding or map reading (Malinowski & Gillespie, 2001). In the pointing task, demanding from the participants to point to objects not visible from the test site, is a sensitive measure of spatial competence (Lehnung et al., 2003). It requires indicating property of the mental representation that translates directly into distance or direction on map (Hunt & Waller, 1999).

The task is performed generally using two techniques that are bearing estimations from a stationary position with a compass-like device and the index finger while stretching arm, turning the whole body towards the pointed direction (Lehnung et al., 2001). Pointing is a straightforward method and is advantageous when used with young children.

Pointing accuracy of children was studied by Lehnung et al., (2003) where the participants indicated the direction of prominent landmarks on the school campus, while sitting in their classroom. They found that pointing accuracy was improved with time spent in the environment and with age. 10 years of children outperformed the younger children and boys outperformed girls. Age related spatial orientation performance in children aged 5, 7, and 11 years old with a pointing task was also studied by Lehnung et al., (2001) in a campus building. After taken on a landmark learning tour, children indicated the location of landmarks with a pointing task. They also looked for the difference between two pointing task methods, namely compass like devices and pointing with a finger. No sex differences appeared but a significant effect of age was found. 11-years-old needed less trial than 5-and 7-years-old, to reach the learning criterion. In addition, children pointing with finger outperformed the children pointing with a compass like device.

Beside the architectural and informational wayfinding design strategies, color has also an important effect on individuals' spatial abilities in environments. It is a very important tool in the design of the environments for coding, navigation and wayfinding (Dalke et al., 2005).

3. CONTRIBUTION OF COLOR IN WAYFINDING

3.1. The Theory of Color

Color is the one of the most dominant design element. It affects every part of our lives. Dalke et al., (2005) defined color as “an inherent property of all materials and surfaces including everything from light and paint to art, from aesthetics to functionality and as an inseparable element of design” (p.343). It attracts our attention, is a guide for making sense of our environment and affects our behavior by its informational and cultural role (Martinson & Bukoski, 2005).

3.1.1. Basic Color Terminology

For discussing color effectively it is necessary to understand its basic terminology. Hue, lightness (value) and saturation (chroma) are the three perceptual attributes of color. These are the dimensions to define the ‘sensation’ of color. The chromatic aspect abstracted as *‘hue’* and defined as the perceptual attribute that is associated with the elementary color names. Hue allows us to recognize basic colors such as blue, green, yellow, etc. The light intensity abstracted as *‘lightness’* corresponds to how much light appears to be reflected from a surface in relation to nearby surfaces. Wyszecki & Stiles (1982) defined lightness as “the attribute of a visual sensation according to which the area in which the visual stimulus presented appears to emit more or less light in proportion to that emitted area perceived as a white stimulus” (p.494). It is the most important attribute in making contrast more effective. The colorimetric purity abstracted as *‘saturation’ and* is the degree of intensity associated with a color's perceptual difference from a white, black or gray of equal lightness. In other words, it refers to the amount of pigment in a color (Saunders, 1998; Fehrman & Fehrman, 2000; Shehata, 2000).

The human eye can differentiate ten million colors (Fehrman & Fehrman, 2000). For differentiating color to each other fairly accurately, color order systems were developed. The primary objectives of color ordering systems are to give order to the variables of color and to differentiate and use color in a systematic way (Fehrman & Fehrman, 2000; Martinson & Bukoski, 2005). There are different color ordering systems that are developed such as the CIA Lab System, the Munsell System, the Ostwald System, and Natural Color System (NCS).

In this study, Natural Color System (NCS) was used for the categorization and arrangement of colors. The NCS is based on defining six natural color sensations, which are red, yellow, green, blue, black, and white. The NCS color atlas includes 42 pages and 1750 color samples (Swedish Standards Institution, 1996).The first page shows the NCS color circle with 40 color samples of high chromaticness (saturation), showing the hues selected for the atlas (see Figure 3.1). The second page of the atlas includes color samples for non-chromatic (purely gray) and slightly-chromatic (near-grey) colors. The other 40 pages include NCS triangles that show different hues and relationships to white and black of a specific hue in each page (see Figure 3.2). In NCS "The chromatic hues are arranged in a circle with nine intermediate steps between each, totaling to forty hues. Then, for each hue, a triangular chart is developed showing the pure hue and its relationship to white and black” (Fehrman & Fehrman, 2000, p.205). NCS describes the formal basic elements of the color language and it provides the ability to identify characteristic similarities and relations between colors (Hard & Sivik, 2001).

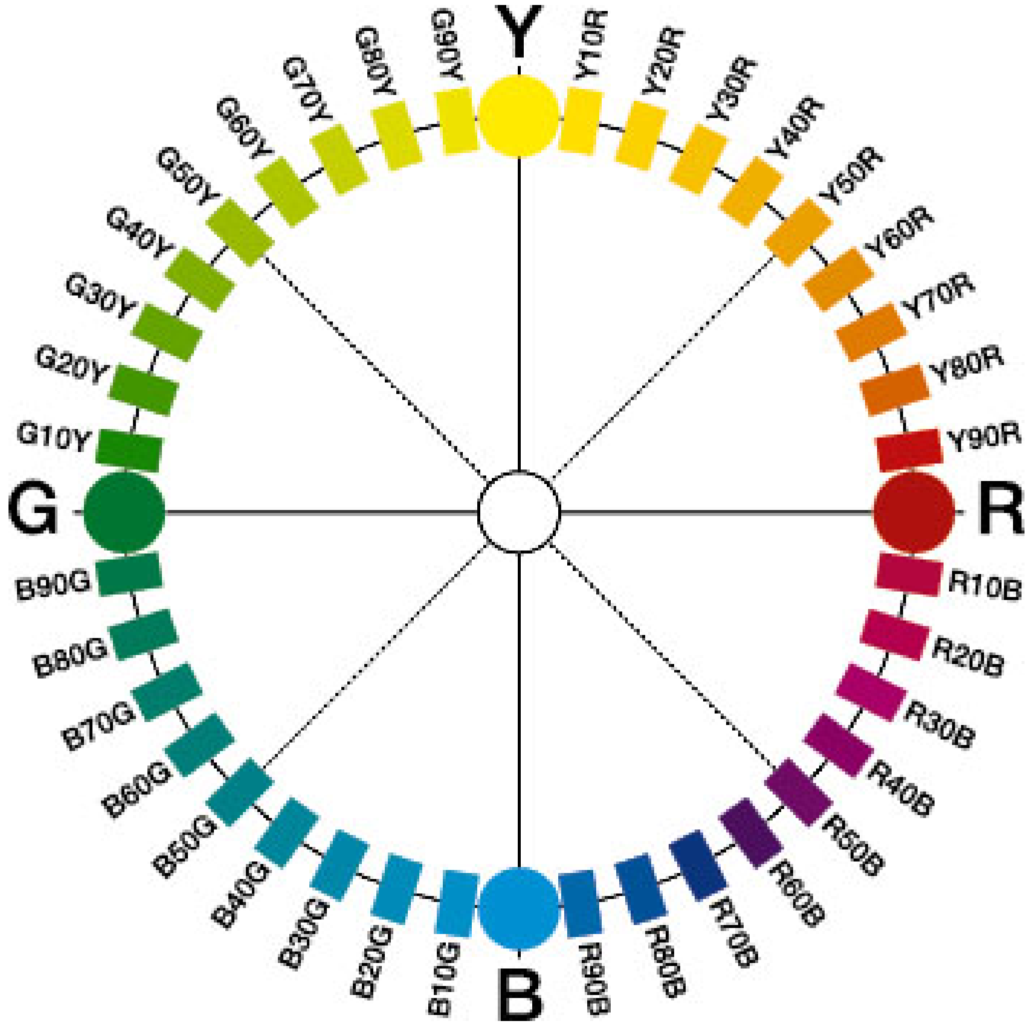

Figure 3.1. A view showing NCS Color Circle
(http://www.byggecentrum.dk/ncs/ncs-images/ncscircl.jpg)

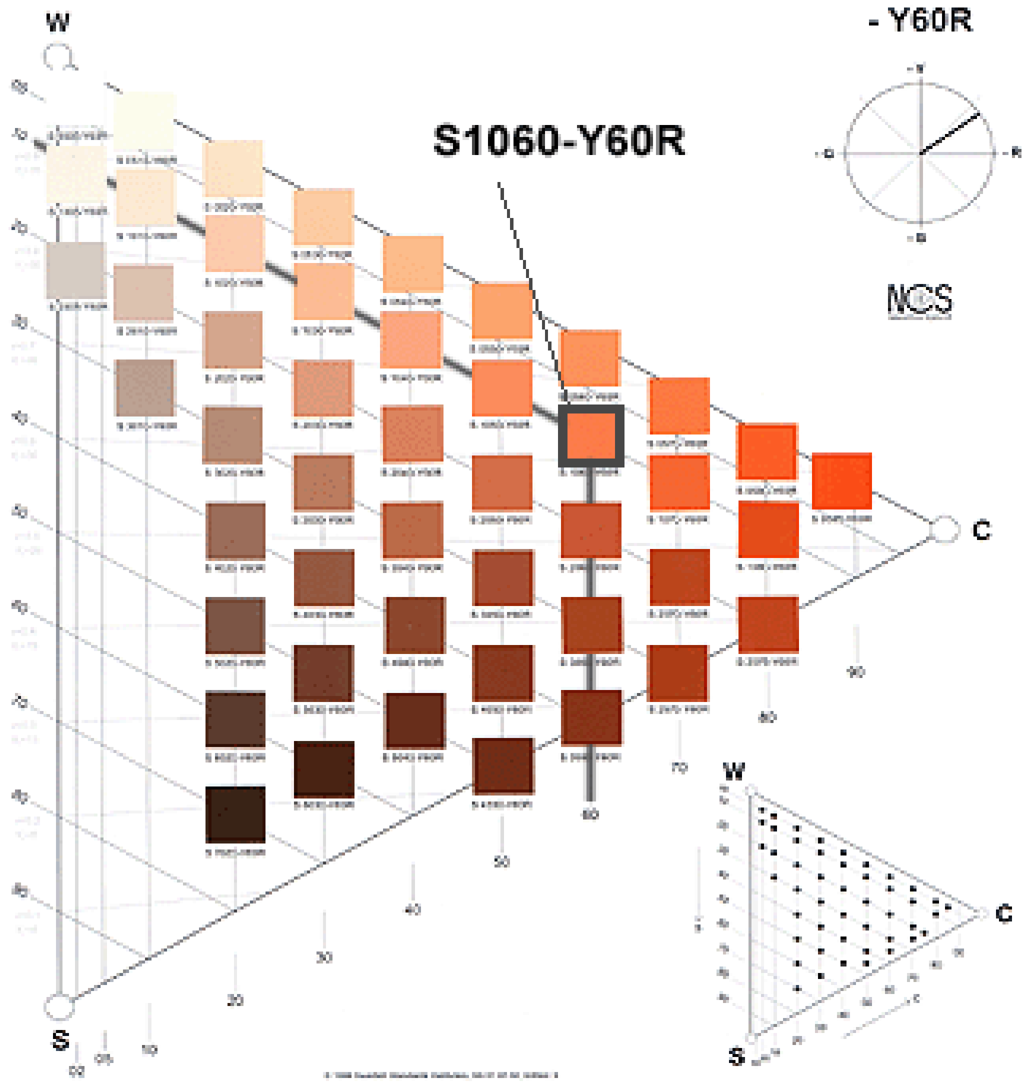

Figure 3.2. A view showing one NCS triangle
(http://www.byggecentrum.dk/ncs/ncs-images/ncscircl.jpg)

3.1.2. Perception of Color

Human perception of color consists of complexities. Color and light are inseparable, color can not exist without light. The perception of color consists of the brain's interpretation of signals that comes through our eyes. Color perception differs greatly from person to person depending on one's brain interpretation of signals that comes through one's eyes and on that person's psychological and cultural biases towards color (Fehrman & Fehrman, 2000).

The perception of color depends on both psychological and physiological responses. In the process of sensation and perception, object, light, eye and brain are all involved. In addition, the human visual system, the material and the surface quality of the object also have a crucial role in the perception of color. All these affect the appearance of a color, for example smooth and glossy surface reflects a hue very differently than a rough surface or transparent materials allow color and light to be seen through them (Martinson & Bukoski, 2005).

3.1.3. Psychological Responses to Color

Colors can have strong influences on people's moods and emotions. Color choices for an environment are highly dependent on emotional associations and individual's feelings about a certain color (Kaya & Crosby, 2006) and on cultural associations (Martinson & Bukoski, 2005).

The psychological responses to color are generally studied with their qualitative descriptions in the literature such as anxiety, aggression, and happiness. Individuals' color associations with different building types were studied with college students between ages 18 to 25 years old (Kaya, et al., 2006). It was indicated that, color associations were based on individual and emotional aspects. It was reported that red represented energy, vitality, power, happiness and joy, purple represented fun and creativity, and blue represented truth, serenity, harmony, relaxation and calmness. Shehata, (2000) claims that orange represented energy, yellow was used for mental stimulation, and green represented harmony and balance.

Color is also influential on making decisions about the surrounding environment. Environmental impressions may expand to various feelings such as excitement, energy, and calmness. Colors or color combinations might evoke such feelings and studies related to this aspect are called color emotion studies. Color emotions are greatly influenced by lightness and brightness (Ou, Luo, Woodcock & Wright, 2004a). Color preferences are strongly correlated with color harmony that is based on an orderly relationship of color that affects color emotions (Ou, et al., 2004c). Color emotions were compared between male and female participants in an experiment, however, color emotions showed no significant difference between genders neither for single color nor for two-color combinations (Ou, et al., 2004a; 2004b).

Boyatzis & Varghese (1994) studied children's emotional responses to colors. They reported their emotional reactions depending on the brightness of colors. Children had positive reactions to bright colors, which were pink, red, yellow, blue, purple and green, and had negative reactions to dark colors, which were brown, black and gray. Children stated their positive emotions by mentioning happiness, strength and excitement, and their negative emotions by mentioning sadness, anger and boredom. The color red created the highest number of emotional responses where pink the lowest. Color not only effects human psychological feelings but also effects human physiological responses.

3.1.4. Physiological Responses to Color

Since people start to spend more time indoors than outdoors, the presence of color in interior environments becomes more and more important. Each color and color combination have their own sensation and certain colors and their relationship to each other may become eye irritants and may cause headaches. On the other hand, appropriate use of color can maximize productivity and relax the whole body (Shehata, 2000). Martinson & Bukoski, 2005 added that color could affect not only people's emotions but also their brain waves, hearth rates, blood pressures, and respiratory rates. Thus, color can play an important role in medical treatments such as depression and cancer.

3.1.5. Individual Differences in Preferences of Color

Mood, age, gender and life experiences play an important role in personal interpretation of color (Engelbrecht, 2003). Color preference is measured by person evaluate dimension, such as pleasantness or unpleasantness. A high pleasantness rating for a given color then becomes synonymous with a high preference rating (Fehrman & Fehrman, 2000). There are differences between genders in preferences for colors. Shehata (2000) stated that yellow had a higher affective value for boys than girls, blue was more and red was less preferred by boys while red was more, blue was less preferred by girls. Boyatzis & Varghese (1994) found that girls and boys aged 5 and 6.5 years old showed positive emotion to bright colors. However, boys were more likely than girls to have positive emotional reactions to dark colors where girls' emotional responses to dark colors were mostly negative. It is reported that blue and red were the favorite colors of boys while girls preferred pink and purple. In addition, at 5 years of age, children had an inclination to show positive emotions for bright colors, but this preference increased with age (Boyatzis & Varghese, 1994). Johnson (1977)reported that the development of color naming for the color of yellow, green, brown, black and white was considerably weaker in pre-school children between age 3 to 5 years old.

Camgöz, Yener & Güvenç, (2002) found that colors with maximum saturation and brightness were preferred the most. In addition, blue was the most preferred color by young adults. However, the results showed that gender did not affect the color preferences. In their other study Camgöz et al., (2004) reported that colors of maximum saturation and brightness also attracted the most attention of young adults. Cyan, magenta, red, yellow-green and green attracted the most attention on any background color. Again, gender did not affect the choice of color samples that attracted attention.

Beside preferences for colors, there are differences between age and gender in color term acquisition. It affects the communication between users and their surrounding environments. Therefore, this was studied with different age groups. Children find it difficult to learn color terms because of several reasons, due to linguistic, attentional, conceptual and perceptual factors (Johnson, 1977; Pitchford & Mullen, 2005; Franklin, 2006; Kowalski & Zimiles, 2006; O'Hanlon & Roberson, 2006). All these factors constrain children's color word learning. After learning their first color word, these factors might no longer have a constraining effect (Johnson, 1977; Franklin, 2006), because they start to learn the category boundaries of colors and conceptualize colors. Davidoff (2006) added that understanding the relation between color terms and abstract color concepts was a critical issue for children. It is different from learning and understanding the objects such as artifacts and animals. Because of their multiple associations and properties, they allow multiple routes for categorization. However, there is not a variety of episodic knowledge for using color in categorization tasks. Therefore, colors need to be categorized in children's minds for easy understanding of abstract color concepts and improvement of their color term knowledge.

Children's difficulty in learning color words is because they fail in conceptualizing color as an abstract property. For example, "to understand conventional meaning of term *red*, children must understand that this term refers to an abstract property possessed equally by objects as diverse as apple and fire engine"(Kowalski & Zimiles, 2006, p.302). However, they usually cannot comprehend color terms as a conceptual task. It develops in years and shows differences between different colors. Pitchford & Mullen (2005) found that primary (red, green, yellow, blue, black and white) and secondary (orange, pink and purple) colors were named by children significantly more accurately than brown and gray. However, there was not a significant difference found in the accuracy of naming of primary and secondary colors. These color terms that were brown and gray appeared significantly less often-in child-directed speech. Their cognition of primary and secondary colors were more developed by cultural and perceptual factors.

3.2. Color in Design

Color is a flexible and powerful design element. It plays an essential role in design and it touches everything. Colors that people perceive work as a kind of language as they serve as tools of communication between people and the objects surrounding those (Hard & Sivik, 2001). Therefore, colors should be used to give the right message to people through the built environment (Kaya & Crosby, 2006).

Environmental color plays a variety of roles in our everyday lives. It has a crucial role not only in the creation of place through its design aspect, but also in improvement of environmental meaning. In the creation of places, it is an aspect to be considered in design as it is used to shape space, enhance and diminish volume or assign position to an object in the visual field. Therefore it combines design process and the creation of place (Smith, 2003). In addition, it is indicated that color is relevant for the perception of space, building form, wayfinding, ambience, and image. It is an indicator of environmental variables such as theme, function, built form, location and direction. Color can be used in design to differentiate different areas, to identify crucial features, to show spaces that are functionally related and to highlight some information in the environment by color-coding. For color-coding, there should be a conservative approach such as using as few colors as possible to prevent confusion (Smith, 2003).

Colors are used in design for different purposes and for showing different meanings in environments such as aesthetic meaning, symbolic meaning and cultural meaning. Harmony of colors is an important subject in an aesthetic point of view because a person wants to see the balance in colors whether they are closely related or opposite. Color can distinguish spaces to make information clearer by which it adds meaning. Cultural meaning is important in design because color has different meanings in different societies. Therefore, it is important not to force a particular color on users (Shehata, 2000). Tradition can also influence the integration of certain colors with certain emotions, such as in many cultures white traditionally symbolizing purity that is why many brides wear white dresses (Kaya & Crosby, 2006). In aesthetic point of view, color has a crucial role in the creation of a pleasant, ambient environment with its different effects on people's emotions (Dalke, et.al., 2005).

A color scheme should not be selected for any facility without considering the aspects of that environment. The atmosphere of the total environment should be considered such as degrees of lightness as light intensity, saturation as amount of pigment in a color and perceived temperature (Thompson, 2003). There is an association between color and temperature in human experience. Perception of the color temperature changing in relation to color as a psychological phenomenon. It is a visual language use of color, such as red and yellow colors associate with warmth, while blue and green associate with cold (Fehrman & Fehrman, 2000). The incorrect use of color can impair the user's ability to interact with their environment seriously. Too much color can have the effect of making something more difficult, rather than easier to use (Shehata, 2000).

3.3. Color in School Environments

Children need their environment to be interesting. Young children make associations with color and shapes rather than form. Therefore, using color in their environment can provide visual interest to supply maximum efficiency in navigation by providing visual dominancy in key building elements (Dalke, et al., 2005). Read (2003) reports that "color is a useful design element for wayfinding, spatial orientation, and space definition in children's environment" (p.233). The application of color is used to improve children's wayfinding and spatial orientation abilities in their environment. Coloring the environment with warm hues and bright accents improves children's sensory stimulation (Read, 2003).

Engelbrecht (2003) stated that color was an important element in school interiors, because;

- It relieves eye fatigue: the end wall colors should be a medium hue, the end wall treatment helps to relieve the visual monotony of a classroom and stimulate students' brain,
- Increases productivity and accuracy: helps the student and teacher stay focused on the task at hand,
- Aids wayfinding: create a system of order and help to perceive important and unimportant elements in the environment. The use of color and graphics to aid wayfinding is particularly important for primary school children who starting at the age of three to recognize and match colors,
- Supports developmental processes (Engelbrecht, 2003).

The choice of color used in schools can either improve or impair learning, morale and behavior. It can reduce absenteeism and vandalism, affect a student's attention span, and perception of time (Thompson, 2003). Engelbrecht (2003) recommended cool colors for upper grade and secondary classrooms to aid their ability to focus while elementary schools prefer warm, bright color schemes. According to Thompson (2003) the function of a space is very important in using colors in school environments. He suggested that in classrooms painting the teaching wall deeper and brighter shade than sidewalls helped to attract attention to the front of the classroom and helped the eyes getting a visual break when looking at the sidewalls; in libraries using warm colors and brighter spaces encouraged students to read; in auditoriums, gymnasium and cafeterias using lighter warm tones or neutral colors helped to prevent the overwhelming effect of the space; in corridors and stairwells using combinations of color for creating color code sections of the building helped navigation and traffic flow.

3.4. Color and Wayfinding

Users' successful wayfinding abilities depend on the availability of environmental information. "Color can be used in clever, creative, and inspiring methods of application for wayfinding and orientation throughout the settings" (Read, 2003, p.237). Color can be used as a visual cue, to help individuals focus on a particular area of the built structure. Color can be applied as a wayfinding tool for not only interiors but also for exterior spaces in environments. Because of it's easy manipulation in a variety of design materials, color is an ideal design element for creating environments that support users' wayfinding abilities (Read, 2003). Color can be applied as a design element for visual identification in environments. It can be used on signage, walls, columns, and architectural features. It can also be added for simplicity, for example, placing large flower planters on any side of the building (Read, 2003).

Color can develop the definition of the architectural environment by reinforcing the hierarchy of spaces and landmarks, and by clarifying the destinations and prominent features. It helps to understand the form and starts to act as a signage in the building (Dalke, et al., 2005). Color also plays a significant role during encoding and the recognition processes. It helps to improve visual memory of images in the building environment. It is reported that color enhances recognition memory by providing an advantage during encoding and strengthening the encoding-specificity effect (Spence, Wong, Rusan & Rastegar, 2006). Especially for the complex buildings, color-coding can be very useful by zoning the spaces of the building. It should be obvious for easy recognition, the used colors should be limited for eliminating confusion and should be unique in their descriptive words (red, blue, yellow are acceptable, but turquoise can be confusing because it contains both blue and green hues) (Dalke, et al., 2005). Evans, Fellows, Zorn, & Doty (1980) reported that, persons in the color-coded condition made significantly fewer errors in wayfinding tasks. They more accurately located specific targets in the building and had higher recall and recognition memory for floor plans of the building when compared to persons in non color-coded condition.

Osman & Wiedenbauer (2004) studied the effect of color on performance in a wayfinding task, the wayfinding strategies used and the acquisition of survey knowledge by comparing the colored and colorless conditions. They found that the structuring of space through coloring helped children at school age and adults in the same manner to find their way around. In addition, it was reported that color had an influence on the wayfinding strategies used, but not on the acquisition of spatial knowledge.

In order to understand the effect of color on children's route learning ability and pointing task performance, and to examine the differences between colors in their memorability in route learning process, an experiment was conducted in school environment.

4. THE EXPERIMENT

4.1. Aim of the Study

The aim of this study is to understand the contribution of color to children's wayfinding ability in school environments. Understanding how color affects children's usage of their environment and their accuracy in wayfinding is important for providing them healthy environments. In addition, this study examines the differences between colors in terms of their remembrance and usability in route learning ability.

4.1.1. Research Questions

1. Is there a significant effect of color on children's route learning ability in terms of;

a) the accuracy of finding the end point?

b) the time spent during finding the end point?

c) getting the landmarks as reference points?

2. Is there a significant effect of different colors in terms of their usage in route learning process?

3. Is there a significant relationship between the colors and their locations in route learning process?

4. Is there a significant effect of color on the pointing task performances?

5. Is there a significant effect of gender on the route learning ability?

4.1.2. Hypotheses

1. There is a significant effect of color on children's route learning ability.
2. There is a significant effect of different colors in their contribution to children's route learning ability.
3. There is a significant relationship between the colors and their locations in route learning.
4. There is a significant effect of color on the pointing task performances.
5. There is a significant effect of gender on route learning.

4.2. Method of the Study

4.2.1. Sample Group

The sample group was a total of 100 students enrolled in the "Ankara Üniversitesi Geliştirme Vakfı Okulları Özel Lisesi" (Ankara University Private High School). Although the school's name just mentions the high school, the Ankara University Private High School consists of a pre-school, a primary school, a secondary school and a high school. For the experiment, children were chosen by stratified quota sampling on the basis of age, gender and familiarity factor (see Table 4.1). The experiment did not concentrate on the effects of age, so all participants were peer: primary school first graders, aged 7-8 years old. As the factor of familiarity has a crucial role in the experiment, only the participants who were unfamiliar to the building were selected. The experiment was conducted with three different sample groups for the three different experiment sets.

Table 4.1. Participant Numbers on the Basis of Experiment Sets and Gender

		GENDER		Total
		Female	Male	
EXPERIMENT SETS	SET 1	13	19	32
	SET 2	18	16	34
	SET 3	14	20	34
Total		45	55	100

4.2.2. Site Description

The experiment was conducted at Ankara University Private High School that is located at İncek, Ankara (see Appendix A, Figure A1.1, A1.2 and A1.3). The school provides pre-school, primary school, secondary school and high school education. All education types are given in different buildings, at the same site. The school was chosen because of its general organization: primary school children who are the sample group are separated from the high school building, the experiment site. This is important as the experiment was conducted in the high school building where primary school children were “unfamiliar” with, thus the factor of “familiarity” was controlled. The primary school students do not use the high school building. In addition, the high school building was designed and constructed originally for primary school students. It was used by these class students up until 3 years ago. After constructing a new school building for primary and secondary school, it was started to be used as high school building. Therefore, the sample group of the experiment did not experience difficulties with the design and dimensions of the experiment site.

The high school building is a four storey building (see Appendix A2, Figures A2.1, A2.2, A2.3, and A2.4). It consists of basement floor, ground floor, first floor and second floor. In the experiment all of the floors except the basement were used. The building contains offices, classrooms, laboratories, a library, a conference hall, meeting rooms, an infirmary, a refectory, maintenance rooms and toilets.

The building is in rectangular form. There is an extended corridor which is repeated on each floor in the same manner. All spaces are lined up around that corridor. While entering the building that corridor orients the user through the spaces (see Appendix A3, Figures A3.1, A3.2 and A3.3). The corridors are dead-ends on each floor. Apart from the main entrance there are two separate entrances to the building which are closed to public usage and are locked at all times. There are three staircases; two of them are at the same side of the corridor and one of them is at the other side (see Appendix A2, Figures A2.2, A2.3 and A2.4). These are repeated on each floor in the same manner and they all lead the users to the same floors and corridors. So, there are no differences between them in respect of their guidance. Because of that situation, especially first comers are confused about the usage of staircases. Especially two staircases which are opposing to each other are confusing. Although there is such confusion, the staircases are not differentiated from each other by any kind of consideration such as color or material diversity.

The signage system of the building lacks an organized and systematic approach. The font sizes of destination identification signs are very small. For example, door numbers are not legible (see Appendix A4, Figure A4.1). In addition, they do not follow a systematic order. In general, room identifiers are not possible to be seen from a distance, but the legible color combination provides easy reading once one is close to them (see Appendix A4, Figures A4.2, A4.3 and A4.4). Directional signs of the building are more legible than destination identification signs. The font size and type of the letters can be read from a distance, although it would have been better to provide lower cap letters together with capitals when writing the words for further legibility. In addition, the usage of contrasting color combination for exit signs and use of dynamic color combinations for fire exit and firebox allows user an effective orientation (see Appendix A4, Figures A4.5, A4.6, A4.7 and A4.8). However, there is a lack of orientation aids in the building. Providing an interior map to the entrance with room numbers and names, optionally with floor plans can supply more beneficial and functional information system for wayfinding problems.

4.2.3. Procedures

4.2.3.1. Planning of the Experiment

Before conducting the experiment a working program was developed with the school management and this program was performed during the experiment days. The sample group had to be removed from their building to another, thus a systematic time schedule was developed. Children were removed from their building to the high school building during their drawing classes in tens, for one week. The tester and two assistants escorted children during this trip for their safety (see Figure 4.1). When children arrived in the building, they waited for their turn in the library. During that time, an assistant told stories and made children play some educational plays to prevent boredom in children.

Figure 4.1. A view shows children being removed from their building to the high school building.

4.2.3.1.1. Selecting the Route

Before the experiment, the layout of the building was analyzed and a route from X point (entrance of the building) to the Y point (biology laboratory) was specified for the experiment (see Figures 4.2, 4.3, and 4.4). The route started from the main entrance of the building. Providing a continuous route was important to prevent dead-ends on the floors during the experiment route learning process. Therefore, using the staircases was an appropriate way to provide the continuation. In addition, it was not an intended situation that, the experiment route ended in a very short time. Otherwise, using the space and understanding the usage of building design elements could not be analyzed. Therefore, using all floors in the experiment became a necessary condition. The route continued with the bigger staircase and then continued with a path leading to the opposite far end towards another staircase. Finally, this staircase was leading the participant to the end point of the route that was the biology laboratory. Six decision points, where students would make a decision to orient themselves through the major paths and floors, were clarified upon that route and six boxes were placed at these decision points before the experiment.

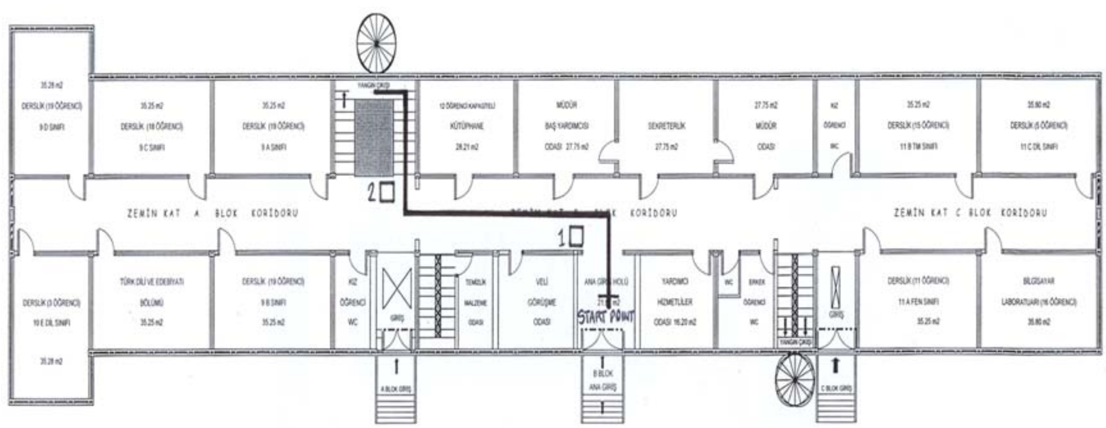

Figure 4.2. Ground Floor Plan of the high school building with selected route

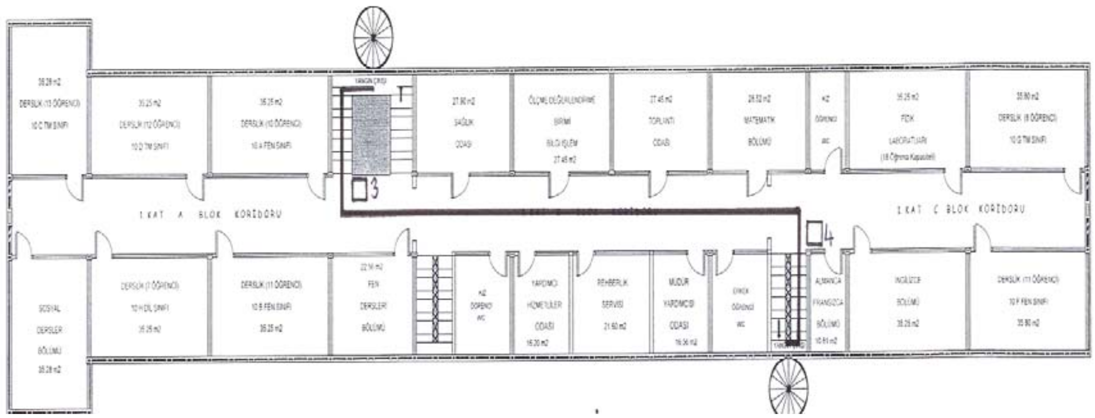

Figure 4.3. 1st Floor Plan of the high school building with selected route

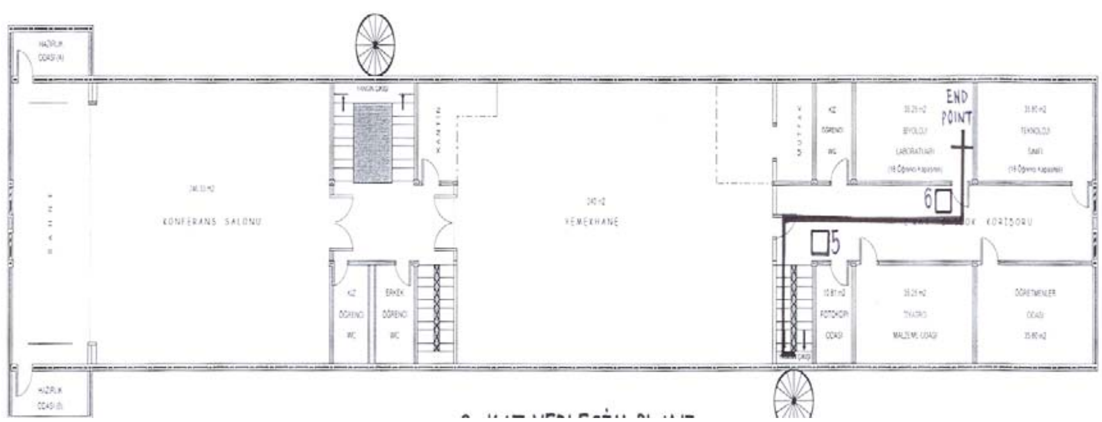

Figure 4.4. 2nd Floor Plan of the high school building with selected route

4.2.3.1.2. Establishing the Landmark Boxes

The boxes were in rectangular form and were placed at vertical direction. They were perceived from different places and distances in the corridor and this was important for the visibility and usability of the boxes as landmarks. They were sized 25x60 cm for keeping the proportional values with the height of the 7-8 years old children (123,5 cm. is the average height of the 7-8 years old children) and for not physically interrupting the pathway (see Figures 4.5 and 4.6).

Figure 4.5 and 4.6. Views of the boxes with the proportion of the 7 year old female and male child height.

4.2.3.2. Sets of the Experiment

There were three different experiment sets. The difference between these sets was in the color and in the location of the boxes. All of the boxes were colored in gray in the first set for understanding the role of color in wayfinding (see Appendix B, Figures B.1). In the second and in the third sets the boxes were colored in yellow, orange, red, purple, blue and green (see Appendix B, Figures B.2, B.3, B.4, and B.5). However the difference between the second and the third sets occurred in the arrangement of the colors upon the route (see Table 4.2). The arrangement of the colors was decided according to the NCS color wheel; those were ordered in clockwise. In the second set, the arrangement of the colored boxes was purple, yellow, orange, blue, green and red. In the third set, the arrangement of the colored boxes was changed into yellow, purple, blue, orange, red and green. It is important to have different color sets in order to understand the effects of location in usage and memory of the boxes and the colors.

Table 4.2. Arrangement of Colors in Three-Experiment Set. (Colors that were used in the experiment were specified from Natural Color System Atlas).

	B1	B2	B3	B4	B5	B6
SET 1	G/y	G/y	G/y	G/y	G/y	G/y
SET 2	P	Y	O	B	G	R
SET 3	Y	P	B	O	R	G

Y: Yellow	P: Purple	G/y: Gray
O: Orange	B: Blue	
R: Red	G: Green	

4.2.3.2.1. Specifying the Colors

Natural Colour System (NCS) was used in specification and selection of the colors. The colors of yellow, orange, red, purple, blue and green were tested in the experiment. These colors were chosen as being primary and secondary colors of the NCS. After primary colors were selected (yellow, red, blue, green), all equal-distant colors between them (orange, purple) were selected as secondary colors (see Figure 4.7). However, although ‘turquoise blue’ and ‘yellow green’ are also secondary colors in the NCS, they were not used in the experiment, as these color names are not commonly used in 7-8 years old children vocabulary. In addition, as Dalke et al., (2005) stated that colors should be used unique in their descriptive words, for eliminating confusion, for example turquoise can be confused because of containing blue and green hues.

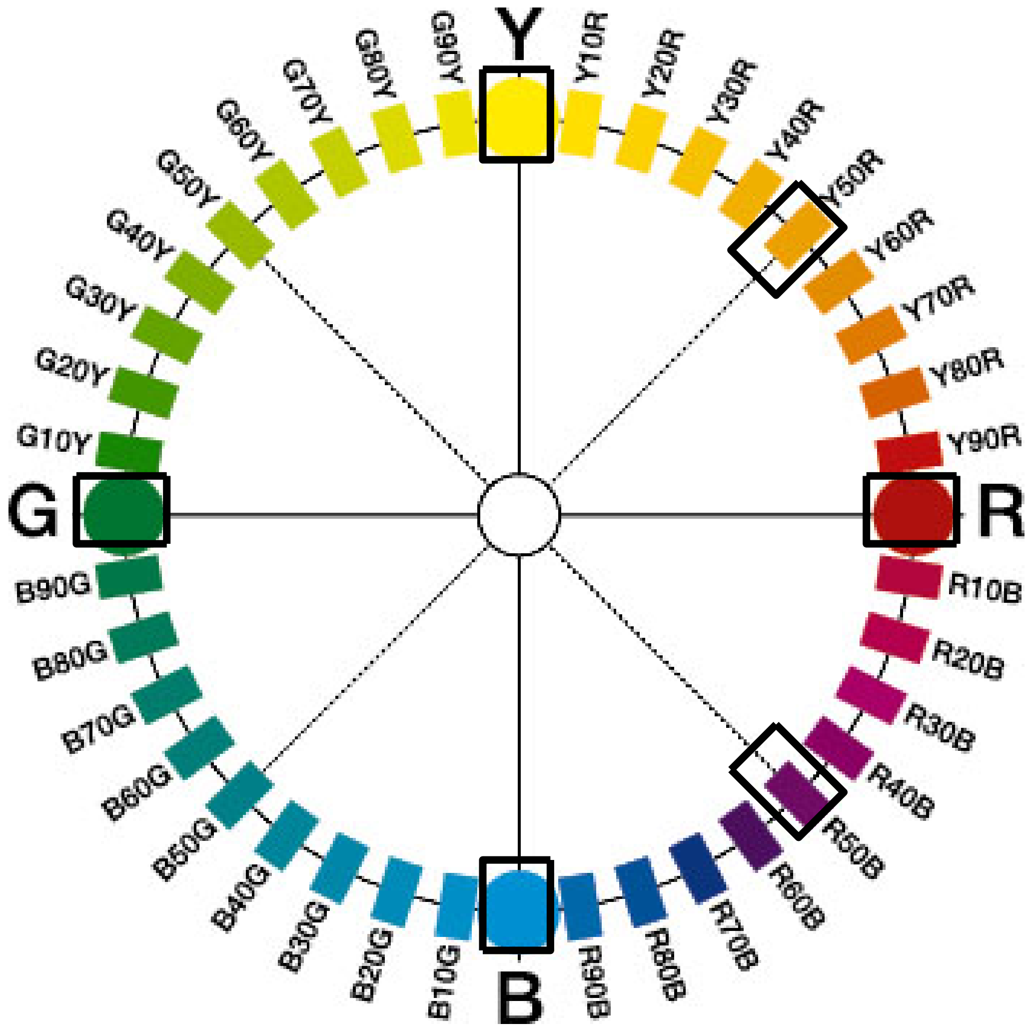

Figure 4.7. A view shows NCS Color Circle with selected colors
(http://www.byggecentrum.dk/ncs/ncs-images/ncscircl.jpg)

It is important to use the colors with the same lightness and chromaticness values for controlling the variables; however, in NCS this was not an easy task. Therefore, the colors were categorized according to the wavelengths, in the experiment. While colors in long wavelengths (yellow, orange and red) have same lightness and chromaticness, colors in middle-short wavelength (purple, blue and green) have same lightness and chromaticness (see Table 4.3).

The gray color was selected taking into consideration the surface colors of the experiment site. The vertical surfaces (walls) were white (S 0500-N; 05% Blackness, 95% Whiteness) and very pale pink (S 0520-R20B; 20% Pink, 5% Blackness, 75% Whiteness) and horizontal surfaces (floors) were very pale beige (S2020-Y30R; 20% Beige, 20% Blackness, 50% Whiteness) (see Figure 4.8). Thus, a gray with a high enough value of whiteness to be clearly distinguished from its surroundings was used in the experiment (S 2500-N; 25% Blackness, 75% Whiteness). All of the boxes were placed in front of the pale pink and because of its paleness, it was accepted as white. That is why, the harmony and contrast between the background color and the color of the boxes were not considered together.

Marshall works with NCS and the selected colors were prepared specially for the experiment according to their codes in NCS and boxes were painted with these paints.

Table 4.3. Selected Colors from NCS for the Experiment

	Colors	Codes in NCS
Long Wavelength	Yellow 	**S 1080-Y;** 80% Yellow, 10% Blackness, 10% Whiteness
	Orange 	**S 1080-Y50R;** 80% Orange (yellow-red), 10% Blackness, 10% Whiteness
	Red 	**S 1080-R;** 80% Red, 10% Blackness, 10% Whiteness
Middle-Short Wavelength	Purple 	**S 3050-R50B;** 50% Purple (red-blue), 30% Blackness, 20% Whiteness
	Blue 	**S 3050-B;** 50% Blue, 30% Blackness, 20% Whiteness
	Green 	**S 3050-G;** 50% Green, 30% Blackness, 20% Whiteness
	Gray 	**S 2500-N;** 25% Blackness, 75% Whiteness

Figure 4.8. A view showing the vertical and horizontal surfaces of the building.

4.2.3.2.b. Specifying the Locations

The site had both artificial and daylight illumination. The artificial lighting was kept achieve during the day hours in the building. All experiments were conducted between 11:00 am. – 13:30 pm. At these hours illuminance of all the floors were measured to understand the lighting situation in the building. Standard Philips (TL 20) fluorescent with a (6200) color temperature (CT) and a (4) color rendering index (CRI) was used in the coves for lighting the experiment site.

Color sequences were decided according to illumination levels of the decision points. Illuminance is the density of the time rate flow of light on a surface and known as lux (Egan & Olgyay, 2002).Illuminances of all the floors were measured and an illuminance map of the building was created before the experiment (see Appendix C). According to the map three of the decision points were more illuminated (had higher illuminance) than the other ones. So in the second set, colors having middle-short wavelengths (purple, blue and green) were located at high illuminance (150-200 lux) points and colors having long wavelengths (yellow, orange and red) were located at low illuminance (50-100 lux) points. In third set, this systematic procedure was reversed, thus middle-short wavelength colors were located at high illuminance points and long wavelength colors were located at low illuminance points. All corridors had 2 boxes and 2 different illumination levels (low and high). The change was done by just changing the place of the pair of boxes in that corridor.

4.2.3.3. Phases of the Experiment

The study was conducted in five phases;

In the first phase, the participants were tested for color vision by using Ishihara's Tests for Color-Blindness. There were no children having color vision problems, thus all were permitted to participate in the experiment. In addition, participants were asked about their vision deficiencies and to wear their corrective equipments -eye glasses- if they had minor vision deficiencies. There were no participants with vision problems.

Some questions about the usage of the building and time spent in the building were also asked to the children, in order to understand their familiarity with that setting. Children who are familiar with the building were not included in the experiment (see Appendix D1).

In the second phase, the children were taken on the experiment route one by one. The tester informed the child about the test. The tester told the child: "I am going to be leading you on a walk in this building today. On this walk you have to look around. Try to pay attention to some details in the building. When we get to the end of the walk, I will lead us back to here. This is our starting point. Then I will be asking you to lead me to the end point. Do you have any questions? This is our starting point, so let's go!".

The child was first escorted on the route and s/he was passed by gray or different colored boxes according to the experiment sets. At the end of this route, the child was returned to the starting point. S/he, then was asked to lead the tester to the end point by the same route. While the child was leading the tester to the end point, the tester asked some questions like, "Why did you turn to the left or right?, What is coming next?" in order to understand the things that were paid attention to. The tester also noted the time spent during the route (see Figure 4.9 and 4.10, see Appendix D2).

 

Figure 4.9 and 4.10. Views from the second phase of the experiment

In the third phase, in-depth interviewing was conducted with the children. The children were asked to verbally describe the route in order to understand their usage of colors, boxes and environmental design elements of the building, and their way of combining these elements with the wayfinding and route learning process. According to responses, the data were categorized under seven questions; were they verbally describe the route accurately, were they mentioned the colors, which colors were mentioned, were they mentioned the boxes, which boxes were mentioned, what were the environmental design elements of the building that they used as reference points, and were they used and directional term in description of the route? In addition, questions about the reasons of using boxes and/or elements were also asked (see Figure 4.11 and see Appendix D3).

Figure 4.11. A View from the third phase of the experiment

In the fourth phase, in-depth interviewing was conducted with the children. A schematically drawn plan of the building with the route was showed to the child. By the help of the tester, child was asked to recognize the specific colors that were placed at specific decision points for understanding if the location of one of the used colors was recognized more accurately than the other ones and for understanding if there was a relation between the location and the color in route learning. In addition, a question about remembering all the used colors was asked to the child for testing if any one of the colors was more memorable than the other ones (see Appendix D4).

In the fifth phase, children performed a “pointing task” one by one. The children were asked to direct the location of the end point with their fingers, while they were positioned at the main entrance of the building. The answers were analyzed for understanding children’s feeling of direction (see Figure 4.12 and see Appendix D5).

Figure 4.12. A View showing the fifth phase of the experiment

4.3. Findings

Statistical Package for the Social Sciences (SPSS) 12.0 was used to analyze the data. In the analysis of the data, the one-way analysis of variance *F*-test (ANOVA), the chi-square goodness-of-fit test, chi-square test, independent-samples *t*-test and frequency tables were used.

Findings from the statistical analyses are given in respect of the stated research hypotheses.

4.3.1. Effect of color on children's route learning ability

The effects of color on children's route learning ability were evaluated and analyzed from three headings that are;

- the accuracy of finding the end point,
- the time spent during finding the end point,
- getting the landmarks (boxes) as reference points.

4.3.1.1. The accuracy of finding the end point

The accuracy in route learning ability of three sample groups (three experiment sets that are Set 1, Set 2 and Set3) were assessed by comparing the number of accurate responses. Because of looking the differences between more than two sample groups, one-way ANOVA test was used (see Appendix D1.2, question form of the 2^{nd} experiment phase, route finding accuracy). The one-way ANOVA indicated that there is a significant difference between sample groups in the accuracy of finding the end point (F=24,207, p=,000) (see Appendix E, Table E.1). After discovering a statistical difference, it should be determined which one of the sample group differs from the others. For this reason, Post Hoc Comparison Test was used. Scheffe is the most conservative type of Post Hoc Comparison Test (Argyrous, 2005). It examines sub-groups formed by various combinations of the sample groups, rather than just pair wise comparisons. Because of all these advantages, Sheffe type of Post Hoc Comparison Test was used. The test pointed out that, Set 1 showed a significant difference when compared with the set 2 and set 3. However, there is not a significant difference between set 2 and set 3 (see Appendix E, Table E.2 for Scheffe Post Hoc Comparison Test; see Table 4.4 for frequency table). Set 1 was the gray set, set 2 and set 3 were the colored sets. All these statistical analyses verified that there is a significant effect of color to children's accuracies on route learning process.

Table 4.4. Frequency of accuracy in route learning ability with sample groups.

		SET 1		SET 2		SET 3	
		Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Inaccurate	23	71,9	9	26,5	2	5,9
	Accurate	9	28,1	25	73,5	32	94,1
	Total	32	100	34	100	34	100

In addition, this hypothesis was further supported with the data from the participants' hesitation values during the route finding process (see Appendix D1.2, question form of the 2nd experiment phase, hesitation). The one-way ANOVA analysis showed that, there is a significant difference between groups, in their amount of hesitations during route finding process (F=24,207, *p*=,000) (see Appendix E, Table E.3). The Post Hoc Comparison test pointed out that, Set 1 showed a significant difference when compared with the set 2 and set 3 (see Appendix E, Table E.4 for Post Hoc Comparison Test; see Table 4.5 for frequency table).

Table 4.5. Frequency for hesitations during route finding process with sample groups.

		SET 1		SET 2		SET 3	
		Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Not hesitate	9	28,1	25	73,5	32	94,1
	Hesitate	23	71,9	9	26,5	2	5,9
	Total	32	100	34	100	34	100

4.3.1.2. The time spent during finding the end point

The time spent during the route finding process was assessed on the ANOVA test (see Appendix D1.2, question form of the 2nd experiment phase, time spent). Time spents during the route finding process showed differences between the experiment sets. Recorded time spent was categorized under three time intervals that were; 30-60 second, 60-90 seconds and 90-120 seconds. 42 second was the fastest time and 118 second was the slowest time recorded. It is indicated that there is a significant difference between sample groups, in their time spent (F=103,062, p=,000) (see Appendix E, Table E.5). The Post Hoc Comparison test pointed out that, Set 1 (gray set) showed a significant difference when compared with the set 2 and set 3 (see Appendix E, Table E.6 for Post Hoc Comparison Test; see Table 4.6 for frequency table). All these statistical analyses verified that there is a significant contribution of color to children's route learning ability as they spent less time finding their way in environments with colored landmarks.

Table 4.6. Frequency for time spent during route finding process.

		SET 1		SET 2		SET 3	
		Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	30-60 second	5	15,6	34	100	34	100
	60-90 second	14	43,8	0	0	0	0
	90-120 second	13	40,6	0	0	0	0
	Total	32	100	34	100	34	100

4.5.1.3. Getting the landmarks (boxes) as reference points

Using boxes as a reference point in route learning process was analyzed for three sample group by comparing the children's verbal descriptions of the route with one-way ANOVA test (see Appendix D1.3, question form of the 3rd experiment phase, question 1). According to the analysis, there is a significant difference between sample groups in using boxes as a reference points during verbal description of the route. (F=58,932, p=,000) (see Appendix E, Table E.7). The Post Hoc Comparison test showed that, Set 1 showed a significant difference when compared with the set 2 and set 3 (see Appendix E, Table E.8 for Post Hoc Comparison Test; see Table 4.7 for frequency table).

Table 4.7. Frequency for using boxes as reference points in verbal description of the route with sample groups.

		SET 1		SET 2		SET 3	
		Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Not used	27	84,4	1	2,9	6	18,2
	Used	5	15,6	33	97,1	27	81,8
	Total	32	100	34	100	33	100

In addition, children's usages of the boxes on their route learning/finding processes were analyzed and compared by using ANOVA test (see Appendix D1.3, question form of the 3rd experiment phase, question 2.a). It is pointed out that there is a significant difference between sample groups, in using boxes as a reference point in route learning process (F=318,807, p=,000) (see Appendix E, Table E.9). These analyses support the hypothesis of effect of color in using landmarks (boxes) as reference points in route learning process. The Post Hoc Comparison test showed that set 1 showed a significant difference when compared with the set 2 and set 3 (see Appendix E, Table E.10 for Post Hoc Comparison Test results; see Table 4.8 for frequency Table).

Table 4.8. Frequency for using boxes in route learning process with sample groups.

		SET 1		SET 2		SET 3	
		Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Not used	29	90,6	0	0	0	0
	Used	3	9,4	34	100	34	100
	Total	32	100	34	100	34	100

All the points that were analyzed under the first hypothesis support the significant contribution of color to children's route learning ability, by showing the significant differences of Set 1, towards Set 2 and Set3.

Beside these three situations that were analyzed under the first hypothesis, the essence of color also supports children's verbal descriptions of the experiment route, related with the used design elements present in the building as reference points. Moreover, the design elements of the building that were paid attention to by children during the route learning process experiment also supported the importance of color on children's route learning ability. Because, children's responses were analyzed and it was found that, the used design elements of the building were mentioned because of their specific colors without asking them specifically about the color or environmental design elements (see Appendix D1.3, question form of the 3rd experiment phase, question 1 & question 3.b) (see Table 4.9 and 4.10 for frequency tables) (see Appendix A4, Figure 4.8, 4.9, 4.10, 4.11 and 4.12).

Table 4.9. Frequency for using building design elements as reference points in verbal description process with sample groups.

		Frequency	Valid Percent
Valid	Not used	63	63,0
	Red fire cabinet	9	9,0
	Contrast colored signage	15	15,0
	Colorful drawing boards	9	9,0
	Blue radiators	4	4,0
	Total	100	100,0
Total		208	

Table 4.10. Frequency for building design elements that were paid attention to on route learning process with sample groups.

		Frequency	Valid Percent
Valid	Red fire cabinet	7	8,6
	Contrast colored signage	7	8,6
	Colorful drawing boards	48	59,3
	Blue radiators	19	23,5
	Total	81	100,0
Total		208	

The used design elements of the building were mentioned in both set 1 (gray set), set 2 and set 3 (colored sets). However, one-way ANOVA test showed that there is a significant difference between sample groups in using reference points from building elements in verbal description of the experiment route (F=11,396, p=,000) (see Appendix E, Table E.11). The Post Hoc Comparison test showed that, Set 1 showed a significant difference when compared with the set 2. However, there is not a significant difference between set 1 and set 3 (see Appendix E, Table E.12 for Post Hoc Comparison Test results). In addition, there is a significant difference between Set 2 and Set 3. Beside participants who did not use any elements from building as a reference point, used elements from building were analyzed and showed in tables (see Table 4.11 for frequency Table).

Table 4.11. Frequency for used building elements as reference points in route learning process with sample group.

		SET 1		SET 2		SET 3	
	Building elements	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Not used	12	29,3	33	97,1	19	55,9
	Red fire cabinet	10	24,4	0	0	2	5,9
	Signage	7	17,1	0	0	8	23,5
	Drawing boards	8	19,5	0	0	5	14,7
	Blue radiators	4	9,8	1	2,9	0	0
	Total	41	100	34	100	34	100

According to ANOVA test, there is a significant difference between sample groups in the building elements that were paid attention to in route learning process (F=6,647, p=,002) (see Appendix E, Table E.13). The Post Hoc Comparison test showed that, Set 1 showed a significant difference when compared with the set 2. However, there is not a significant difference between set 1 and set 3. In addition, there is not a significant difference between Set 2 and Set 3(see Appendix E, Table E.14 for Post Hoc Comparison Test results, see Table 4.12 for frequency table). Furthermore, ANOVA test indicated that there is not a significant difference between sample groups, in the elements that were paid attention to (F=,634 , p=533) (see Appendix E, Table E.15, Table E.16 for Post Hoc Comparison Test result, see Table 5.13 for frequency table).

Table 4.12. Frequency for the sample group that were paid attention to the building elements.

		SET 1		SET 2		SET 3	
		Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Not paid attention	4	12,5	18	52,9	12	35,3
	Paid attention	28	87,5	16	47,1	22	64,7
	Total	32	100	34	100	34	100

Table 4.13. Frequency for the elements that were paid attention to with sample group.

		SET 1		SET 2		SET 3	
	Building Elements	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Red fire cabinet	9	21,4	0	0	2	6,9
	Signage	6	14,3	0	0	1	3,4
	Drawing boards	19	45,2	14	70	19	65,5
	Blue radiators	8	19	6	30	7	24,1
	Total	42	100	20	100	29	100

In addition, the accuracy in verbal description of the experiment route for all three sample groups were assessed by comparing the number of accurate responds on ANOVA test (see Appendix D1.3, question form of the 3rd experiment phase, question 1). It is showed that there is not a significant difference between sample groups in the accuracy of verbal descriptions of the route (F=320, p=,727) (see Appendix E, Table E.17 for ANOVA test and see Appendix E, Table E.18 for Post Hoc Comparison Test). Frequency tables showed that, participants' verbal descriptions of a route was not improved yet in general (see Table 4.14. for frequency table).

Table 4.14. Frequency of accuracy in verbal description of the route with sample groups.

		Frequency	Valid Percent
	Inaccurate	19	59,4
SET 1	Accurate	13	40,6
	Total	32	100,0
Total		42	
	Inaccurate	23	67,6
SET 2	Accurate	11	32,4
	Total	34	100,0
Total		161	
	Inaccurate	23	67,6
SET 3	Accurate	11	32,4
	Total	34	100,0
Total		142	
	Inaccurate	65	65,0
TOTAL	Accurate	35	35,0
(SET 1,2&3)	Total	100	100,0
Total		208	

Directional terms (right – left) usage of the participants in verbal description phase was also analyzed with ANOVA test. According to the test, there is a significant difference between sample groups in usage of the directional terms in verbal description process (F=5,106, p=,008) (see Appendix E, Table E.19 for ANOVA test). The Post Hoc Comparison test pointed out that, Set 1 showed a significant difference when compared with the set 2 and set 3. However, there is not a significant difference between set 2 and set 3 (see Appendix E, Table E.20 for Post Hoc Comparison Test; see Table 4.15 for frequency table). These analyses showed that, there is a significant effect of color on using directional terms.

Children from Set 2 and Set 3 (that were the colorful experiment sets) used generally colors and boxes instead of a directional term as a reference point, in their verbal descriptions. However, children from Set 1 (that were the colorless experiment set) did not use the boxes instead of directional terms in their verbal descriptions.

Table 4.15. Frequency for usages of directional terms in verbal description of the route with sample groups.

		Frequency	Valid Percent
	Not used	25	78,1
SET 1	Used	7	21,9
	Total	32	100,0
Total		42	
	Not used	33	97,1
SET 2	Used	1	2,9
	Total	34	100,0
Total		161	
	Not used	33	97,1
SET 3	Used	1	2,9
	Total	34	100,0
Total		142	
	,00	91	91,0
TOTAL	1,00	9	9,0
(Set 1, 2&3)	Total	100	100,0
Total		208	

4.3.2. Relationship between different colors in their contribution to route learning ability

Chi-square goodness-of-fit test analysis was used to compare different colors in their contribution to children’s route learning ability, by comparing the memorability of the used colors in the experiment (see Appendix D1.4, question form of the 4th experiment phase, question 2). The Chi-square goodness-of-fit test is a non-parametric test and used for multinomial frequency distribution; in the cases of more than two points on the scale (Argyrous, 2005). In this study, the attention is on the frequency distribution of cases across a wide range of categories of variable that are six colors used in the experiment. The chi-square goodness of fit test indicated that, there is not a significant relationship or significant differences between colors in their memorability ($\chi\mathbf{2}$ =1,059, df=5, p=,958) (see Appendix E, Table E.21 for chi-square goodness-of-fit table; see Table 4.16 for frequency table). Therefore, the second hypothesis was that, a significant relationship between different colors in their contribution to route learning performances was not verified by this analysis.

Table 4.16. Frequency for the memorability of the colors.

		Frequency	Valid Percent
Valid	Yellow	32	18,2
	Orange	28	15,9
	Red	26	14,8
	Purple	32	18,2
	Blue	29	16,5
	Green	29	16,5
	Total	176	100,0

In addition, the effects of wavelength of the used colors were assessed by Chi-square goodness-of-fit test; on memorability of colors and on usability of colors. Colors have different characteristics. Colors from the yellow to red are defined as “warm” and indicate “long-wavelength” because of the radiation frequencies below red in the spectrum is sensed as heat. Towards blue colors are defined as “cool” and indicate “short wavelength” (Dean, 1996).

Chi-square goodness-of-fit test was used to compare the memorability of the colors in general, in relation to their wavelengths (see Appendix D1.4, question form of the 4th experiment phase, question 2). The data was grouped under two categories that are long wavelength (yellow, orange, red) and middle-short wavelength (blue, purple, green). It is indicated that, there is not a significant effect of wavelength on color memory ($\chi\mathbf{2}$ =,091, df=1, p=,763) (see Appendix E, Table E.22 for Chi-Square Goodness of Fit Test; see Table 4.17 for frequency table).

Table 4.17. Frequency for the effect of wavelength on memorability of the colors.

		Frequency	Valid Percent
Valid	Long-wavelength (yellow, orange, red)	86	48,9
	Middle-Short wavelength (blue, purple, green)	90	51,1
	Total	176	100,0
Total		293	

The effect of wavelength on usability of colors was analyzed by comparing the usages of the colors as a reference points on verbal description of the experiment route (see Appendix D1.3, question form of the 3rd experiment phase, question 1). Chi-square goodness-of-fit test pointed out that, there is not a significant effect of wavelength on usability of colors on verbal description of a route ($\chi 2$ =,000, df=1, p=1,000) (see Appendix E, Table E.23 for Chi-Square Goodness of Fit Test; see Table 4.18 for frequency table).

Table 4.18. Frequency for the effect of wavelength on usability of the colors.

		Frequency	Valid Percent
Valid	Long-wavelength (yellow, orange, red)	87	50,0
	Short-wavelength (blue, purple, green)	87	50,0
	Total	174	100,0
Total		293	

4.3.3. Relationship between the colors and their locations in route learning

For the analysis of the third hypothesis, data from the fourth phase of the experiment which was about the recognition of colors in their specific locations, was used (see Appendix D1.4, question form of the 4th experiment phase, question 1). The correct identifications of the color of boxes were assessed by comparing number of correct identifications (observed numbers), on the chi-square goodness-of-fit test.

The test pointed out that, there is a significant difference between colors in terms of their correct location identifications ($\chi 2$ =11,412, df=5, p=,044) (see Appendix E, Table E.24 for chi-square goodness-of-fit table; see Table 4.19 for the numbers of correct identification of colors). The number of participants who remembered the colors in their correct places for both sets were statistically analyzed. E.g. participant total for remembering yellow was obtained from the sum of participant number remembering yellow in box 2 for set 1 and participant number remembering yellow in box 1 for set 3. When the specific sequence of the colors on the route is concerned, a significant percent of children did not recognize the specific sequence of the colors (see Table 5.20 for frequency table). According to Independent-Samples t-Test, there is no a significant difference between experiment set 2 and set 3, in recognizing the specific sequence of the colors (t=,353, df=66, two-tailed p=,725) (see Appendix E, Table E.25 for Independent-Samples T Test result).

Table 4.19. Frequency for correct location identification of colors.

		Frequency	Valid Percent
Valid	Yellow	47	23,0
	Orange	31	15,2
	Red	31	15,2
	Purple	42	20,6
	Blue	30	14,7
	Green	23	11,3
	Total	204	100,0

Table 4.20. Frequency for recognizing the specific sequence of the colors.

		Frequency	Valid Percent
Valid	Inaccurate	59	86,8
	Accurate	9	13,2
	Total	68	100,0

It is indicated that, there is a significant difference between boxes in terms of their correct color identifications (χ**2** =14,706, df=5, p=,012) (see Appendix E.26 for Chi-square Goodness of Fit Test; see Table 4.21 for frequency table). The number of participants who remembered the correct colors of the boxes for both sets were statistically analyzed. E.g. participant total for box 1 was calculated by adding the participant number remembering box 1's color (purple) in set 2 and participant number remembering box 1's color (yellow) in set 3.

Table 4.21. Frequency for correct color identification of boxes.

		Frequency	Valid Percent
Valid	Box. 1	49	24,0
	Box. 2	40	19,6
	Box. 3	37	18,1
	Box. 4	24	11,8
	Box. 5	23	11,3
	Box. 6	31	15,2
	Total	204	100,0

According to chi-square goodness-of-fit test, the correct identifications of the specific color and box was depending on their orders (χ**2** =10,088, df=2, p=,006) (see Appendix E, Table E.27 for Chi-square Goodness of Fit Test). The first and the second colors and the boxes from the first floor were more correctly identified, for all that the identification accuracies decreased by the floors (see Table 4.22 for frequency table). All these statistical analyses verified the third hypothesis that there is a significant relationship between colors and their locations in route learning.

Table 4.22. Frequency for correct identification of colors and boxes in relation with the floors.

		Frequency	Valid Percent
Valid	Ground Floor	89	43,6
	1st Floor	61	29,9
	2nd Floor	54	26,5
	Total	204	100,0
Total		302	

In addition to these analyses, data from the children's verbal descriptions of the experiment route was analyzed in respect to the mentioned colors and the boxes, on Chi-square goodness-of-fit test, for understanding if there are significant differences between different colors and boxes in their usages as a reference point on their verbal descriptions of the experiment route (see Appendix D1.3, question form of the 3rd experiment phase, question 1). According to the analyses, there is a significant difference between different colors in their usages as reference points on verbal description process ($\chi\mathbf{2}$ =16,897, df=5, p=,005) (see Appendix E, Table E.28. for Chi- square Goodness of Fit Test; see Table 4.23 for the number of children that used colors on verbal description).

Table 4.23. Frequency for used colors as reference points on verbal description.

		Frequency	Valid Percent
Valid	Yellow	37	21,3
	Orange	26	14,9
	Red	24	13,8
	Purple	45	25,9
	Blue	23	13,2
	Green	19	10,9
	Total	174	100,0

Chi-square goodness-of-fit test indicated that, there is a significant difference between different boxes in their usages as reference points on verbal description process (χ**2** =15,934, df=5, p=,007) (see Appendix D1.3, question form of the 3rd experiment phase, question 1; see Appendix E, Table E.29. for Chi- square Goodness of Fit Test; see Table 4.24 for the number of children that used boxes on verbal description).

Table 4.24. Frequency for used boxes as a reference point on verbal description.

		Frequency	Valid Percent
Valid	Box. 1	36	19,8
	Box. 2	45	24,7
	Box. 3	31	17,0
	Box. 4	19	10,4
	Box. 5	20	11,0
	Box. 6	31	17,0
	Total	182	100,0

According to chi-square goodness-of-fit test, the usages of specific colors and specific boxes on verbal descriptions of the experiment route was depending on their locations ($\chi\mathbf{2}$ =15,207, df=2, p=,000) (see Appendix D1.3, question form of the 3rd experiment phase, question 1; see Appendix E, Table E. 30 for Chi-square Goodness of Fit Test). The first and the second colors and the boxes from the first floor were used more that the other ones, for all that the usages of them decreased by the floors (see Table 4.25 for the numbers of used colors and boxes in relation with the floors). All these statistical analyses verified the third hypothesis as well, that there is a significant relationship between colors and their locations in route learning.

Table 4.25. Frequency for the used colors and boxes on verbal descriptions of the experiment route, in relation with the floors.

		Frequency	Valid Percent
Valid	Ground Floor	82	47,1
	1st Floor	49	28,2
	2nd Floor	43	24,7
	Total	174	100,0

In addition, the effects of wavelength of the used colors were assessed on correct identifications of color. The correct identifications of the colors were assessed by comparing number of correct identifications by children, on the chi-square goodness-of-fit test (see Appendix D1.4, question form of the 4th experiment phase, question 1). It is found that, there is not a significant effect of wavelength on correct identifications of colors ($\chi\mathbf{2}$ =,961, df=1, p=,327) (see Appendix E, Table E.31 for Chi-Square Goodness of Fit Test; see Table 4.26 for frequency table).

Table 4.26. Frequency for the effect of wavelength on correct identification of colors.

		Frequency	Valid Percent
Valid	Long-wavelength (yellow, orange, red)	109	53,4
	Short-wavelength (blue, purple, green)	95	46,6
	Total	204	100,0

4.3.4. Effect of color on the pointing task performance

Children were asked to show the location of the end point with their finger while they were positioned at the main entrance of the building (see Appendix D1.5, question form of the 5th experiment phase). The accuracy in pointing task of three sample group was assessed by comparing children's performances. The hypothesis on the contribution of color to children's pointing performance was verified by one-way ANOVA test. There is a significant difference between sample groups in the accuracy of pointing task (F=19,002 , p=,000) (see Appendix E, Table E.32). For understanding which one of the sample group differed from the others, Post Hoc Comparison Test was used. The test pointed out that, Set 1 showed a significant difference when compared with the set 2 and set 3 (see Appendix E, Table E.33 for Post Hoc Comparison Test; see Table 4.27 for frequency table).

Table 4.27. Frequency for pointing performances with sample group.

		SET 1		SET 2		SET 3	
Pointing Accuracy		Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
Valid	Inaccurate	26	81,3	8	23,5	9	26,5
	Accurate	6	18,8	26	76,5	25	73,5
	Total	32	100	34	100	34	100

4.3.5. Effect of gender on route learning

To determine if there is a significant relationship between gender and the accuracy in route learning process, chi-square analysis tests were conducted. For eliminating the effect of color, sample groups were analyzed separately at first, then the relation was analyzed in total (see Appendix D1.2, question form of the 2nd experiment phase, route finding accuracy in respect to the Appendix D1.1, question form of the 1st experiment phase, sex). According to the analysis, there is not a significant relationship between gender and the accuracy on route learning process in experiment Set 1, Set 2, Set 3 and in total ($\chi\mathbf{2}$ =1,758, df=1, p=,185; $\chi\mathbf{2}$ =,926, df=1, p=,336; $\chi\mathbf{2}$ =,068, df=1, p=,794 and $\chi\mathbf{2}$ =1,313, df=1, p=,252; respectively) (see Appendix E, Table E.34, E.35, E.36 and E.37 for chi-square tables; see Table 4.28 for frequency table). Therefore, the fifth hypothesis was not verified by chi-square tests.

Table 4.28. Frequency for the effect of gender on route learning.

		GENDER		Total
		Female	Male	
SET 1	Inaccurate	11	12	23
	Accurate	2	7	9
Total		13	19	32
SET 2	Inaccurate	6	3	9
	Accurate	12	13	25
Total		18	16	34
SET 3	Inaccurate	1	1	2
	Accurate	13	19	32
Total		14	20	34
TOTAL	Inaccurate	18	16	34
	Accurate	27	39	66
Total		45	55	100

In addition, to determine if there is a significant effect of gender on pointing task performance chi-square analysis tests were conducted. According to the analysis, there is not a significant relationship between gender and pointing task performances. (χ**2** =2,196, df=1, p=,138) (see Appendix E, TableE.38 for chi-square table; see Table 4.29 for frequency table)

Table 4.29. Frequency for the effect of gender on pointing task performance.

		GENDER		Total
		Female	Male	
POINTING	Inaccurate	23	20	43
	Accurate	22	35	57
Total		45	55	100

4.5. Discussion

The effects of color on children's route learning ability were studied in the experiment. It was demonstrated that the use of color in school environments can play a crucial role in children's spatial performances. Read (2003) showed that color helped children to improve their wayfinding and spatial orientation abilities especially in their school environment and Dalke et al., (2005) supported the idea by indicating that using color in children's environment can provide visual interest that affects the efficiency in navigation by providing visual cues in the building. In this dissertation, it was hypothesized that, there is a significant effect of color on children's route learning ability in the accuracy of finding the end point; in the time spent during finding the end point; and in getting the landmarks (boxes) as reference points. The accuracy in route learning ability of three sample groups (experiment sets) were analyzed. There is a significant difference between sample groups in the accuracy of finding the end point (p= ,000; see section *4.3.1.i*) and set 1 showed a significant difference when compared with the set 2 and set 3 (p= ,000; see Appendix E, Table E.2). However, there is not a significant difference between set 2 and set 3 (p= ,102; see Appendix E, Table E.2). As set 1 was the gray set and set 2 and set 3 were the colored sets, it was pointed out that color has a significant effect in children's route learning ability. Because, children who were in colored experiment sets (set 2 and set 3) were significantly more accurate in finding the end point than children in the gray experiment set. Therefore, the results verified that there is a significant effect of color to children's accuracies on route learning process. This finding supports the findings of Osmann &

Wiedenbauer (2004). The time spent during the route finding process of three sample groups were analyzed and it was showed that there is a significant contribution of color to children's route learning ability in time spent. Analyses showed that children in gray experiment set spent more time (60-120 second) during finding the end point than children in colored sets (30-60 second) (*p*= ,000; see section *4.3.1.ii*). Therefore, it can be said that color is a timesaver for wayfinding task. Read (2003) proposed that color can be applied as a design element for visual identification in environments. It can be used as a visual cue to help individuals focus on a particular area of the built structure. Children's usages of the boxes on their route learning/finding processes and as a reference point in route learning process were also analyzed in the experiment. The results are in line with the Read's (2003) proposals. Children in the colored experiment sets were significantly better at recognizing and using the boxes as landmarks then children in the gray set (*p*= ,000; see section *4.3.1.iii*) . Therefore, applying color to building elements arouses user's minds and helps to improve a visual map of the building in their mind.

Dalke et al., (2005) indicated that children need the environment to be interesting. Young children make associations with color and shapes rather than forms. The design elements of the building that were paid attention to by children during the route learning process in this experiment supported the importance of color on children's route learning ability. Children's responses were analyzed and it was found that the used design elements of the building were mentioned because of their specific colors (e.g. red fire cabinet, blue radiators etc.; see section *4.3.1.iii,* Table 4.9, Table 4.10 and Table 4.11). The design elements were the red fire cabinet (see Appendix A4, Figure A4.8), blue radiators (see Appendix A4, Figure A4.9 and A4.10), drawing boards with the colorful pictures and drawings (see Appendix A4, Figure A4.11 and A4.12) and signage with the contrast color combinations (black and white) (see Appendix A4, Figure A4.5 and A4.6).

The effects of yellow, orange, red, purple, blue and green were tested in the experiment and in their contribution to route learning ability was studied. However, according to the results there is not a significant relationship or significant differences between colors in their memorability (*p=,* 958; see section *4.3.2*). No single color was remembered more than the other ones and all of the six colors were remembered almost equally by the children. On the other hand, there is a significant difference between colors in terms of their correct location identifications (*p=,*044 ; see section *4.3.3*). Yellow and purple were the most correctly identified colors (see section *4.3.3*. and Table 4.15). Those two colors were also located either as the first or the second in the experiment sets (see section 4.2.3.2, Table 4.2). The results showed that the correct identification of the colors depended on the order of the boxes (*p=,*006 ; see section *4.3.2*, Table 4.18). Therefore, the correct identifications of the specific color and box were depending on their order. The first, the second colors, and the boxes from the first floor were more correctly identified, for all that the identification accuracies decreased by the floors. However, the color and the box that was located at the end in the experiment set 2 and set 3, were also correctly identified more than the fourth and the fifth color and box (see Appendix E, Table E.20). This is an expected result, because in the literature it is stated that, 8 year old children which was the sample group of the experiment, remember the events that are at the beginning and end (Cornell et al., 1996). Therefore, there is a significant relationship between the colors and their locations in route learning process (*p=,*044 ; see section *4.3.3*).

Although the pointing accuracy of children were studied in the previous experiments (e.g. Lehnung et al., 2003; Lehnung et al., 2001), they did not focus on the effect of color on pointing accuracy. The accuracy in pointing task of three sample groups was assessed by comparing children's performances for understanding the effect of color on the pointing task performance. There is a significant difference between sample groups in the accuracy of pointing task (*p=,*000 ; see section *4.3.4*). Children in the colored experiment sets were more accurate in showing the location of the end point when compared with the children in the gray set (*p=,*000 ; see Appendix E, Table E.26). Therefore, it is showed that there is a significant effect of color on pointing task performances. That may be because of color helping children to visualize the environment in their minds and helping them to improve their mental map through the environment.

There was no relationship between gender and route learning performances at 7 and 8 years-old-aged children. Contrary to the previous studies (e.g. Lawton et al., 1996; Schmitz, 1999; Lawton & Kallai, 2002; Cornell et al., 2003; Cubukcu et al., 2005; Chebat et al., 2005) that found gender differences in navigation accuracies and judgments of spatial directions, males and females in this study showed approximately the same performances in route learning and wayfinding process of the experiment (*p*=,252 ; see section *4.3.5*). The reason for this indifference might be due to familiarity with the experiment site or because they are not adults. Both genders were unfamiliar with the building; therefore, it was their first time to see and try to understand the spatial relationship of the spaces in the building.

5. CONCLUSION

The contribution of color to children's wayfinding performance in school environments, and the differences between colors in terms of their remembrance and usability in route learning process were explored at Ankara University Private High School in Ankara. As suggested by the literature survey, color was expected to affect route learning performances (e.g. Read, 2003; Osmann & Wiedenbauer, 2004; Dalke, et al., 2005). The results of the statistical tests proved not only the effect of color on children's route learning performances, but also the effect of color on children's pointing task performances (see section 4.3.1 & 4.3.4).

In the literature, there is not enough experimental data about the effect of color on wayfinding process. The studies have generally focused on the experiences that were gained through the studies and suggestions about the use of color in spaces (e.g. Shehata, 2000; Engelbrecht, 2003). When it is concentrated on the color studies in the literature, it is seen that most of the studies are about the color emotions and psychological responses to colors (e.g. Boyatzis &Varghese, 1994; Martinson & Bukoski, 2005). However, provided information are not based upon any quantitative analyses, and those generally use qualitative data in the form of suggestions. Remaining studies that are based on statistical tests generally focused on color preferences (Johnson, 1977; Camgöz et al., 2002). Although it is proposed in the literature that color has a crucial effect in the design of environments for coding, navigation and wayfinding (Dalke, et al., 2005), quantitative studies that concentrated on that topic are very limited. Because of that, the general composition of this thesis and statistical results of the research are important to fill the gap in the literature about the contribution of color on wayfinding performances.

It was found that there is not a significant relationship or difference between different colors in terms of their memorability. However, the results showed that there is a significant difference between colors and landmarks, in terms of their correct location identifications (see section 4.3.3). The identification accuracies decreased by the end of the route, except for the very last color and lanmark. The study could be repeated with different color arrangements to increase the validity of this statement.

The results of the statistical analyses showed that, there is a significant contribution of color to children's pointing task performance. However, contrary to the previous studies (e.g. Galea & Kimura, 1993; Lawton, et al., 1996; Schmitz, 1999) there was no gender differences in route learning and pointing task performances. Both genders performed equally accurate in the tasks (see section 4.3.5 & 4.4.3). In future studies, this study could be repeated with the addition of different demographics such as age and socio-cultural factors. Because, the differences between these demographics may be more dominant than the gender, in the performance of spatial abilities as gender differences might increase with age due to cultural and educational impact on individuals.

For most young children, preschool or primary school is the first public place they use. Nature and quality of these environments affect student learning and behavior (Wilson, 1997). Therefore, it is important to analyze carefully the type of environment provided for them in schools since they have spent different amounts of time at their schools at different ages. In line with Lehnung et al., (2003) investigating children's spatial abilities in their natural surroundings, it is important to find out about their spatial competence; the present study was conducted in children's natural environment.

For future studies and experiments, it is important to point out that, the selection of colors that are planned to be used in the experiment is an important issue. At least one of the three dimensions of color, which are hue, lightness, and saturation, should be the same to control the variables. Otherwise, understanding whether the effect of a specific color is because of its hue, its lightness or its saturation can be a difficult analyses. On the other hand, the material of the applied color is another important aspect for the used color ordering system. It is difficult to find a specific color with its specific dimensions in every material. One of the most appropriate and easy way is to produce color by the help of color companies such as DYO and Marshall. Because, these companies have specific color production systems that work and match with established color ordering system (e.g. NCS System). Beside the color, the size and the form of the landmark that used in the experiment is another important aspect. As distinct from using the landmarks in the same size and form, different sizes and forms can be tested to understand their role in perception of objects and influence on the remembrance.

The results and the suggestions should be taken into account to provide more legible and healthy environments to the children. Architects, interior architects, environmental planners, sign makers, educators and parents should communicate and work together for providing safe and aesthetically pleasing environments to young children. Findings from this study can be beneficial to designers who are not only dealing with color and its contribution to design but also to designers who are dealing with developing children's environments that improve their wayfinding abilities and psychology towards lost. In addition, preschool and primary school administrators can benefit from the findings of this study to provide legible environments to children.

6. REFERENCES

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APPENDIX A

APPENDIX A1. Exterior View of School Buildings

Figure A1.1. A view of the primary & secondary school building.

(http://www.ankukolej.k12.tr/ankukolej/ilkogretim/anasayfa/ilkogretim.php)

Figure A1.2. A view of the high school building.

(http://www.ankukolej.k12.tr/ankukolej/lise/anasayfa/res5_b.jpg)

Figure A1.3. A view of the main entrance of the high school building.

APPENDIX A2. Floor Plan of the High School Building

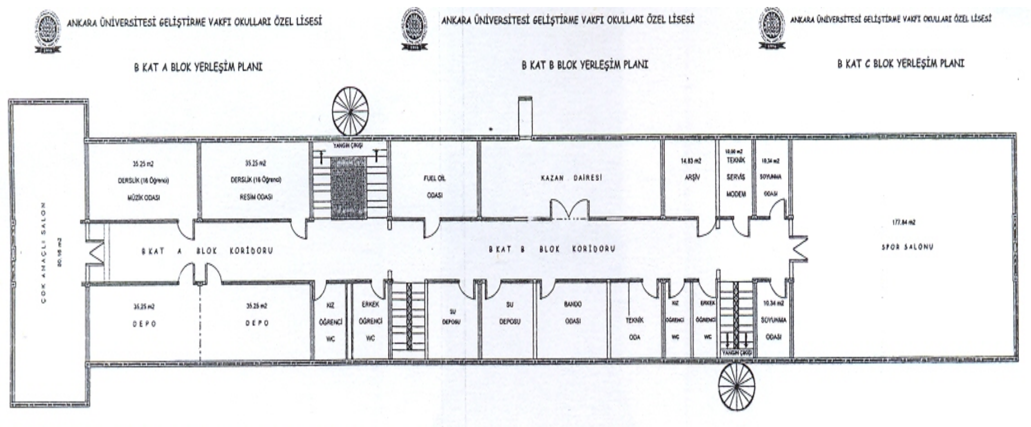


Figure A2.1. Basement Floor Plan of high school building.

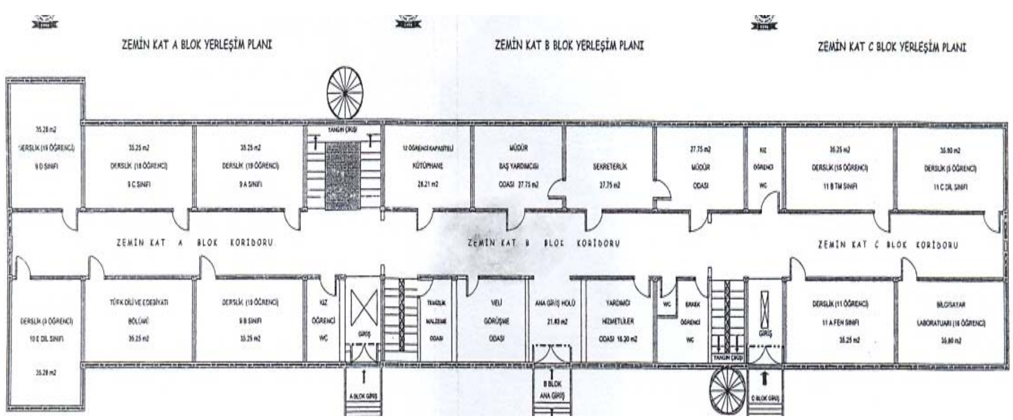


Figure A2.2. Ground Floor Plan of high school building.

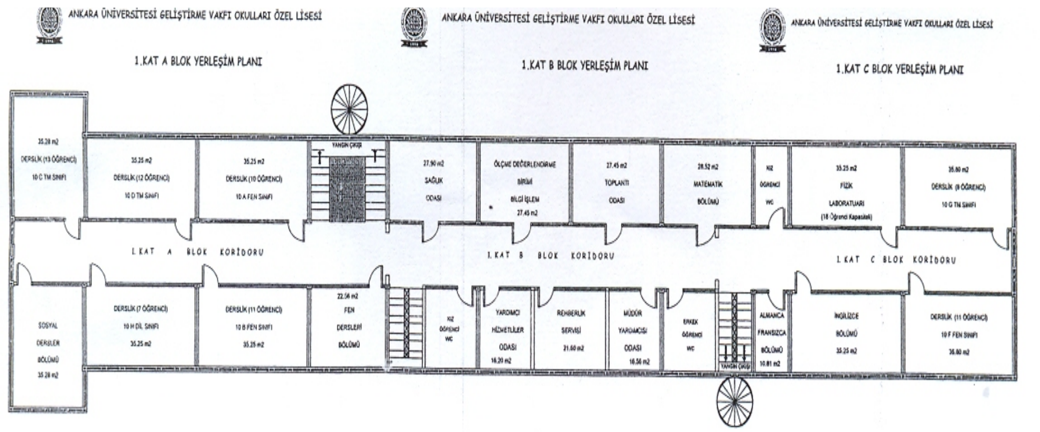


Figure A2.3. 1st Floor Plan of high school building.

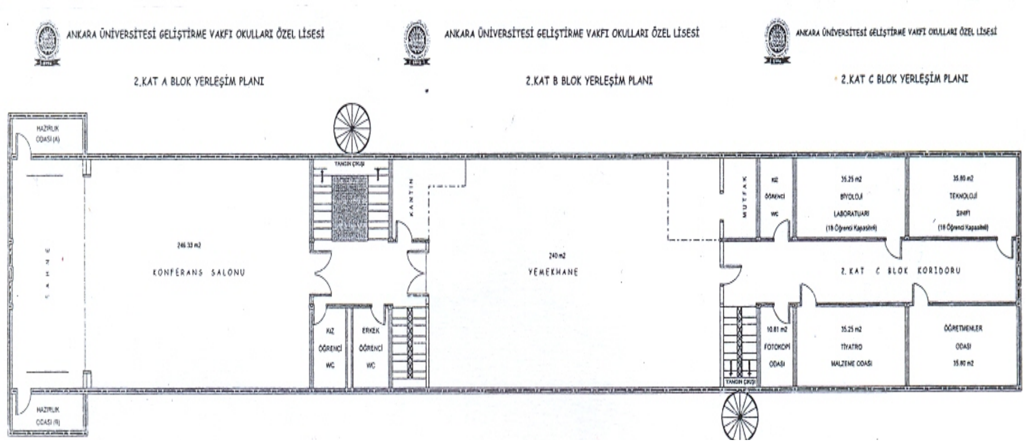


Figure A2.4. 2nd Floor Plan of high school building.

APPENDIX A3. Interior View of the High School Building

Figure A3.1. A view from the main entrance.

Figure A3.2. A view of the corridor.

Figure A3.3. A view of the corridor.

Figure A3.4. A view of the staircases.

Figure A3.5. A view of the staircases.

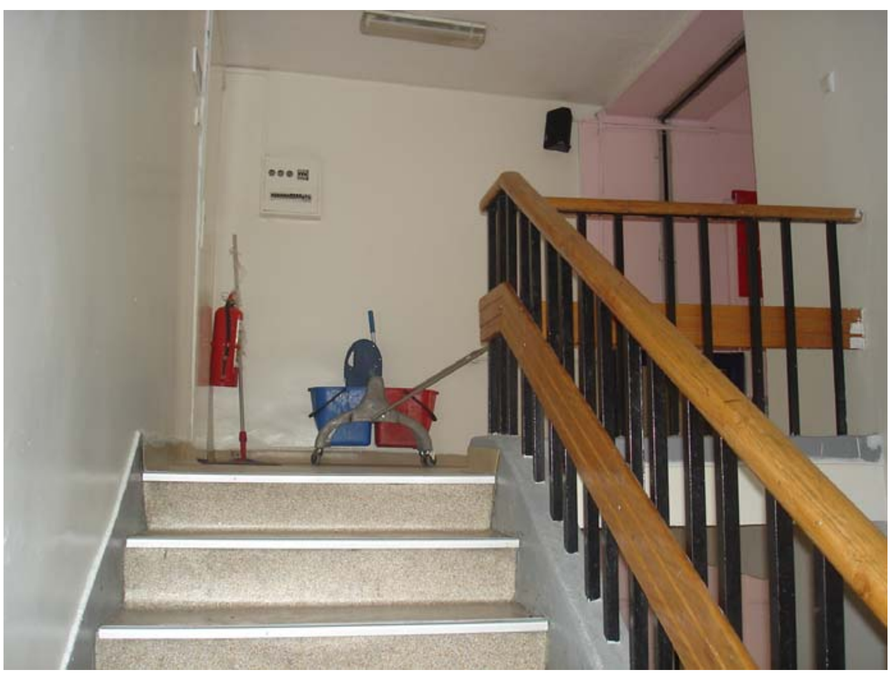


Figure A3.6. A view of the staircases.

APPENDIX A4. Information System of the High School Building

Figure A4.1. A view of destination identification sign (door number) on the door frame on top and the middle.

Figure A4.2. A view of destination identification sign (room identifier) above the light switch on the left.

Figure A4.3. A view of destination identification sign (room identifier).

Figure A4.4. A view of destination identification sign (room identifier).

Figure A4.5. A view of directional sign.

Figure A4.6. A view of directional sign.

Figure A4.7. A view of directional sign (the fire exit).

Figure A4.8. A view of situation object identification sign (the fire box).

Figure A4.9. A view of radiators.

Figure A4.10. A view of radiators.

Figure A4.11. A view of drawing boards.

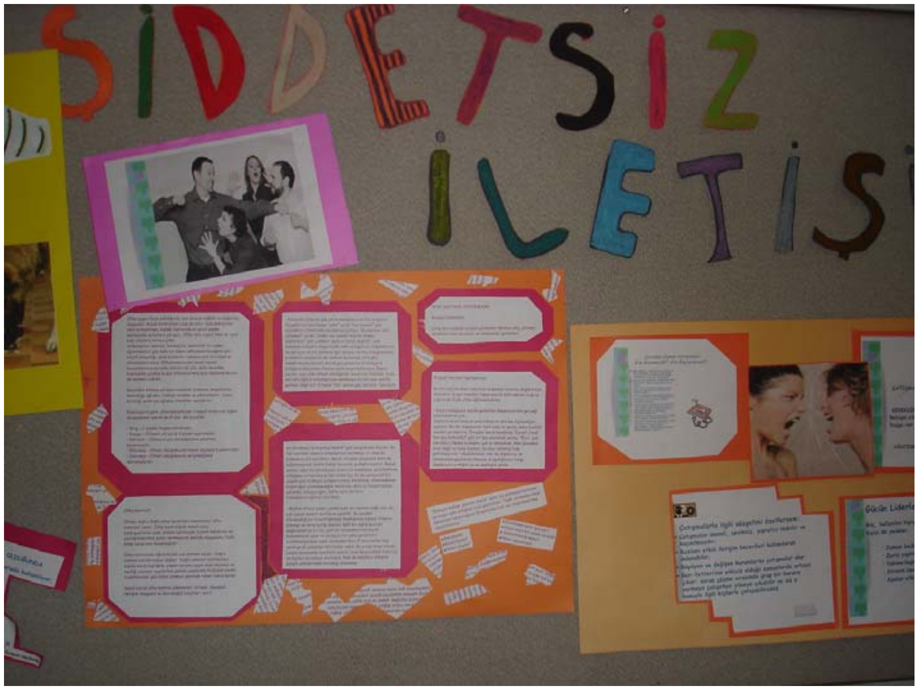


Figure A4.12. A view of drawing boards.

APPENDIX B

Figure B.1. A view showing the situation with gray boxes (Experiment Set 1).

Figure B.2. A view showing the situation with colored boxes

(Experiment Set 2-Set 3).

Figure B.3. A view showing the situation with colored boxes

(Experiment Set 2-Set3).

Figure B.4. A view showing the situation with colored boxes

(Experiment Set 2-Set 3).

Figure B.5. A View showing the situation with colored boxes

(Experiment Set 2-Set 3).

APPENDIX C

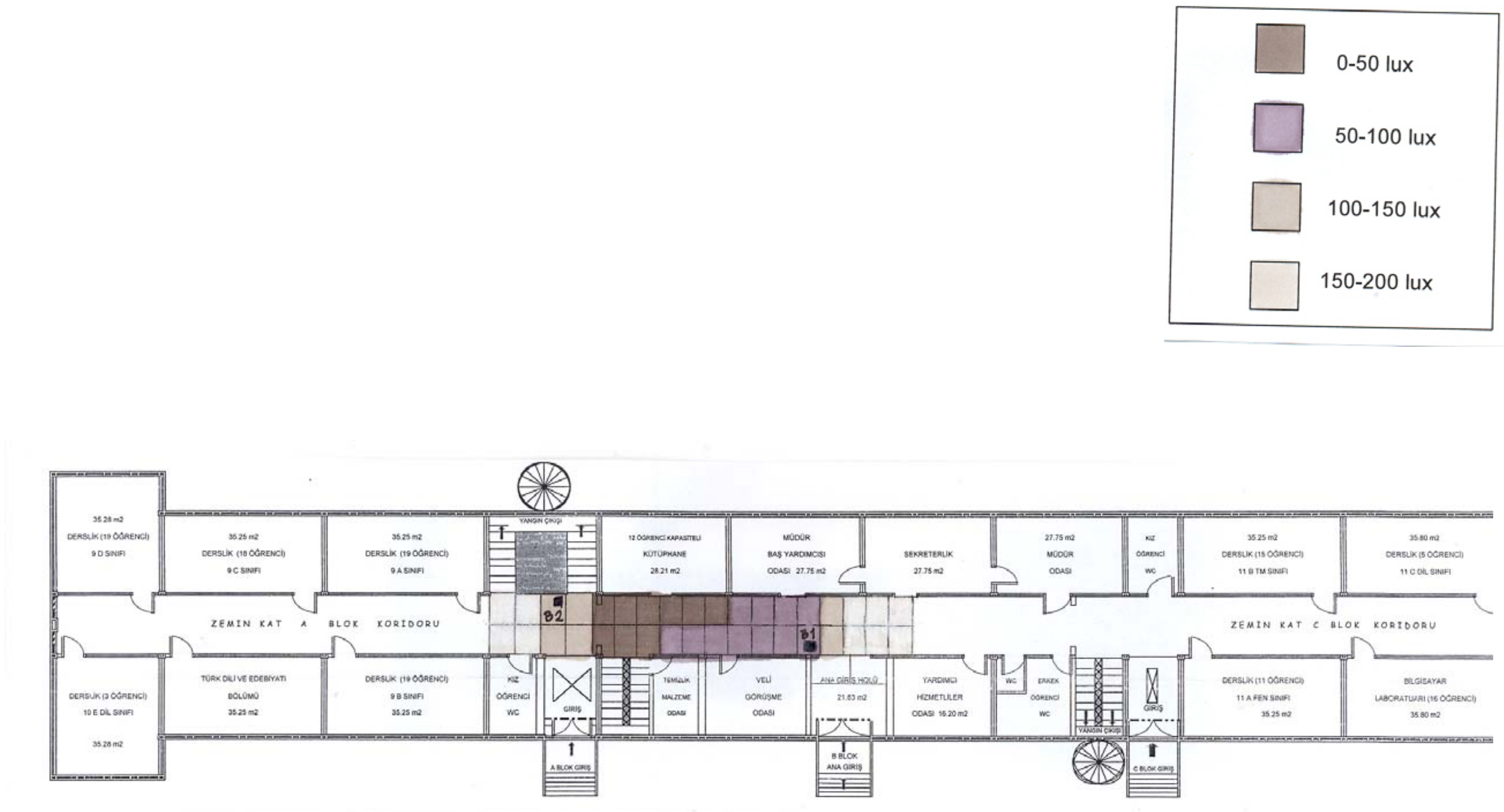


Figure C.1. Illuminance map of the Ground Floor

Figure C.2. Illuminance map of the 1st Floor

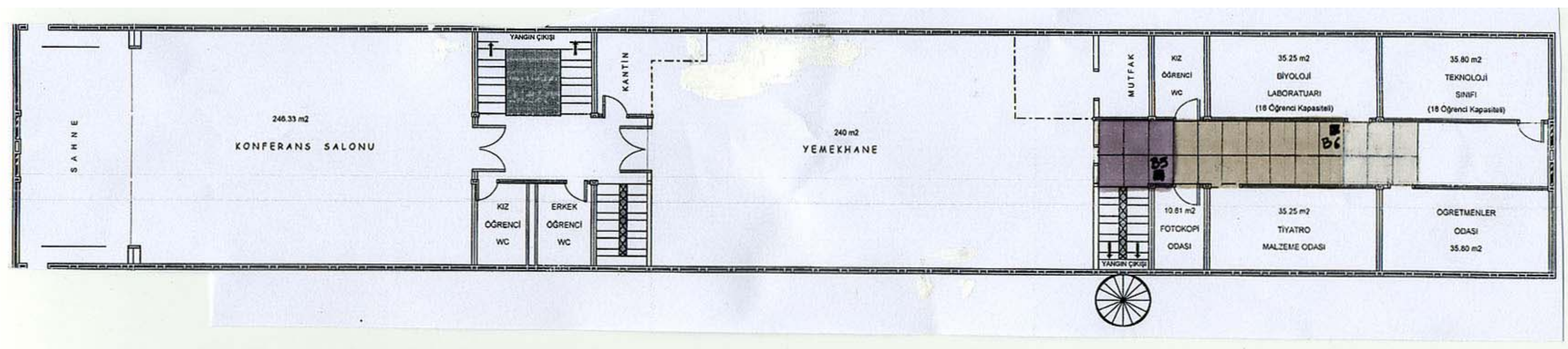


Figure C.3. Illuminance map of the 2nd Floor

APPENDIX D

APPENDIX D1. English Version of the Question Forms

APPENDIX D1.1. Question Form of the1st Experiment Phase

Name, Surname: ___________________________________

Sex: Female ☐ Male ☐

Age: ________

Ishihara's Test for Color-Blindness: Accurate ☐ Inaccurate ☐

Any Color Vision Deficiency: Yes ☐ No ☐

Have you ever been in this building? Yes ☐ No ☐

If yes; when?

____

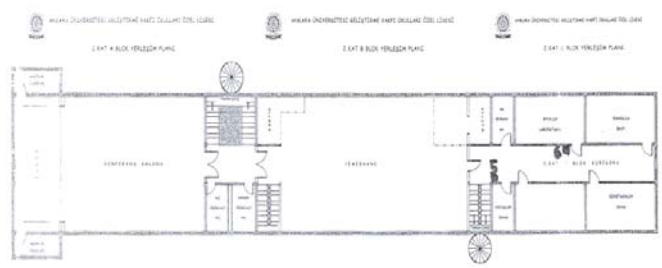
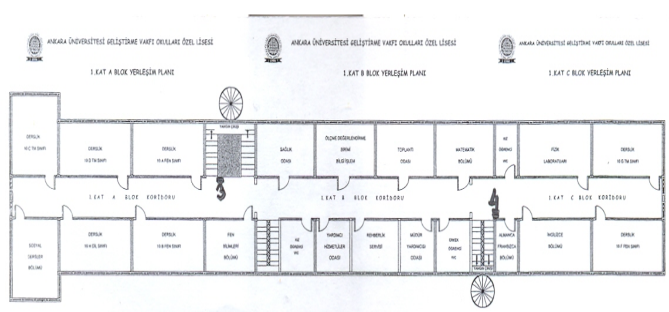
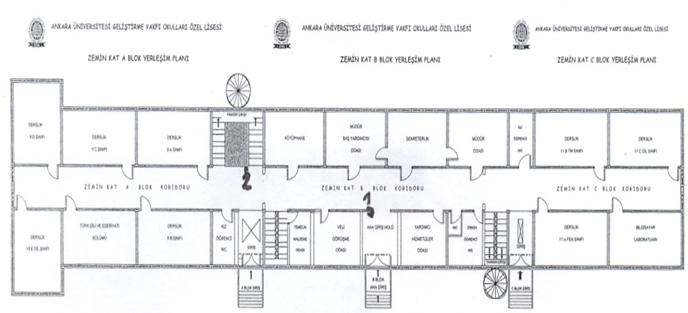
for what reason?

____

Do you know this building? Yes ☐ No ☐

Familiarity: Familiar ☐ Unfamiliar ☐

APPENDIX D1.2. Question Form of the 2nd Experiment Phase

<table>
<tr><td colspan="2" rowspan="3"></td><td><u>Reason of turn</u>
5.
6.</td></tr>
<tr><td><u>What is coming next?</u>
5.
6.</td></tr>
<tr><td>Hesitation (*)
Reason</td></tr>
<tr><td colspan="2" rowspan="3"></td><td><u>Reason of turn</u>
3.
4.</td></tr>
<tr><td><u>What is coming next?</u>
3.
4.</td></tr>
<tr><td>Hesitation (*)
Reason</td></tr>
<tr><td colspan="2" rowspan="3"></td><td><u>Reason of turn</u>
1.
2.</td></tr>
<tr><td><u>What is coming next?</u>
1.
2.</td></tr>
<tr><td>Hesitation (*)
Reason</td></tr>
<tr><td><u>Route finding accuracy</u>

Accurate☐
Inaccurate ☐</td><td><u>NOTE:</u>
____
______________________________</td><td><u>Time Spent:</u>

____________________</td></tr>
</table>

APPENDIX D1.3. Question Form of the 3rd Experiment Phase

1. Can you verbally describe me, the route from starting point (entrance) to the end point (biology laboratory) please? How did you go there?

Accurate ☐ Inaccurate ☐

2. a. Did you use the boxes during your route learning process?

Yes ☐ No ☐

b. How did you use them?

3. a. Was there anything that you paid attention to during your route learning process?

Yes ☐ No ☐

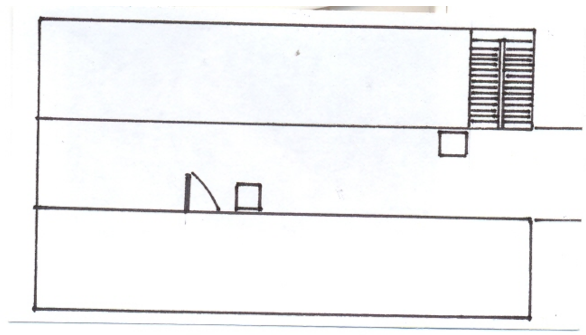
b. What was it?

NOTES:

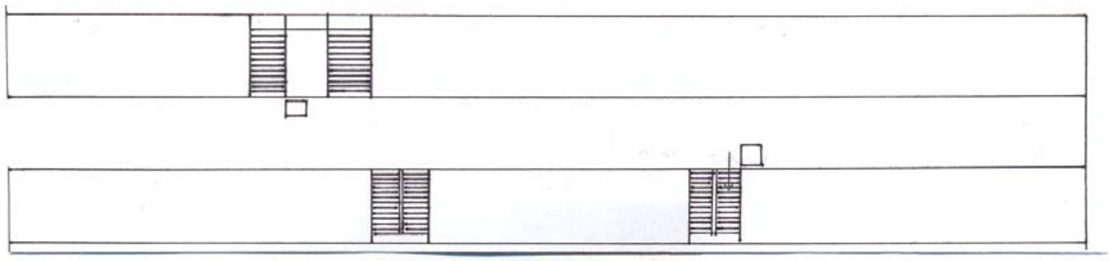
APPENDIX D1.4. Question Form of the 4th Experiment Phase

1. Now, we are going to try to remember, the specific color of the specific boxes.

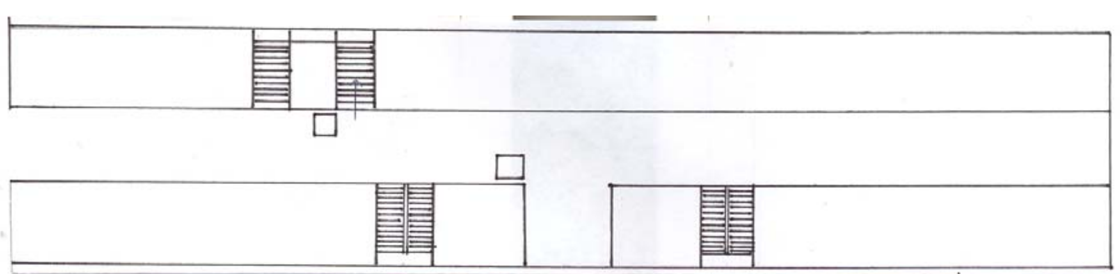
	Color	Accuracy
B1		Correct ☐ Incorrect ☐
B2		Correct ☐ Incorrect ☐
B3		Correct ☐ Incorrect ☐
B4		Correct ☐ Incorrect ☐
B5		Correct ☐ Incorrect ☐
B6		Correct ☐ Incorrect ☐



2nd Floor



1st Floor



Ground Floor

2. What were the colors of the boxes?

____

____

APPENDIX D1.5. Question Form of the 5th Experiment Phase

- Please show me the end point (biology laboratory) of the route with your finger, where is it?

Pointing task Performance:

Accurate ☐ Inaccurate ☐

NOTES:

____

____

APPENDIX D2. Turkish Version of the Question Forms

APPENDIX D2.1. 1. Deney Safhası, Soru Formu

Adı, Soyadı: ___________________________________

Cinsiyet: Bayan ☐ Bay ☐

Yaş: ________

Ishihara'nın Renk Körlüğü Testi: Doğru ☐ Yanlış ☐

Renk Görme Gücünde Yetersizlik: Evet ☐ Hayır ☐

Daha Önce Bu Binada Bulunmuş muydunuz? Evet ☐ Hayır ☐

Evet ise; Ne zaman?

____

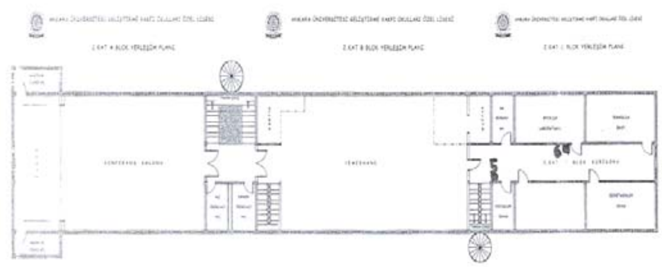
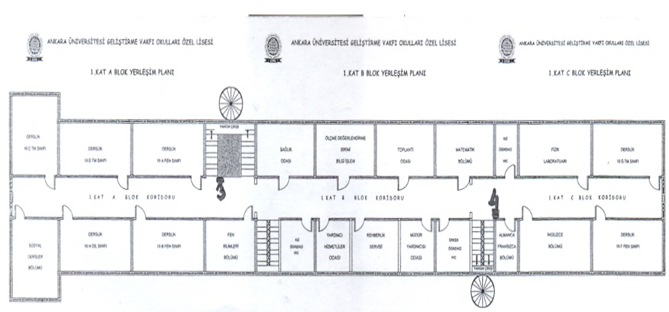
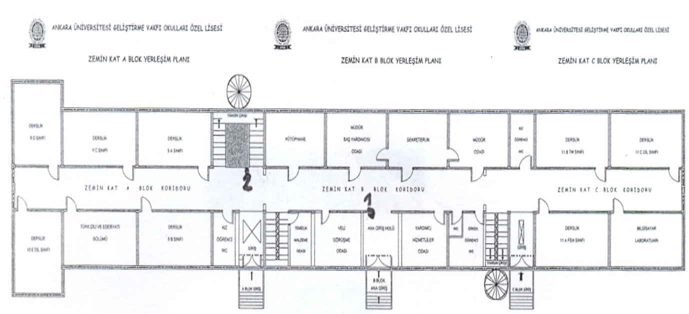
Ne sebeple?

____

Bu Binayı Biliyor musunuz? Evet ☐ Hayır ☐

Aşinalık: Aşina ☐ Aşina değil ☐

APPENDIX D2.2. 2. Deney Safhası Soru Formu

<table>
<tr><td colspan="2" rowspan="3"></td><td><u>Dönüş nedeni:</u>
5.
6.</td></tr>
<tr><td><u>Sırada ne var?</u>
5.
6.</td></tr>
<tr><td>Duraksama (*)
Nedeni:</td></tr>
<tr><td colspan="2" rowspan="3"></td><td><u>Dönüş nedeni:</u>
3.
4.</td></tr>
<tr><td><u>Sırada ne var?</u>
3.
4.</td></tr>
<tr><td>Duraksama (*)
Nedeni:</td></tr>
<tr><td colspan="2" rowspan="3"></td><td><u>Dönüş nedeni:</u>
1.
2.</td></tr>
<tr><td><u>Sırada ne var?</u>
1.
2.</td></tr>
<tr><td>Duraksama (*)
Nedeni:</td></tr>
<tr><td><u>Rota Bulma Doğruluğu</u>

Doğru ☐
Yanlış ☐</td><td><u>NOT:</u>
____
________________________________</td><td><u>Harcanan Süre:</u>

________________</td></tr>
</table>

APPENDIX D2.3. 3. Deney Safhası Soru Formu

1. Rotayı başlama noktasından (ana giriş), bitiş noktasına kadar (biyoloji laboratuarı), sözlü olarak tarif eder misin lütfen? Bitiş noktasına nasıl ulaştın?

Doğru ☐ Yanlış ☐

2. a. Rota öğrenme sürecinde, kutuları kullandın mı?

Evet ☐ Hayır ☐

b. Kutuları nasıl kullandın?

3. a. Rota öğrenme sürecinde, dikkatini çeken herhangi bir şey oldu mu?

Evet ☐ Hayır ☐

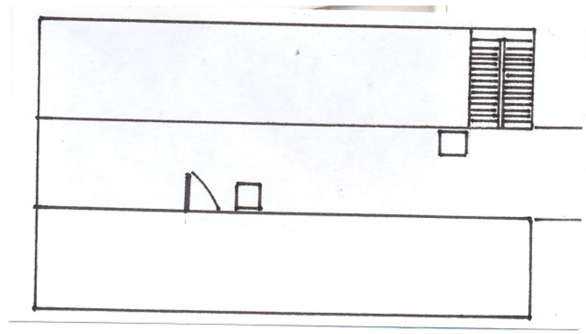
b. Dikkatini çeken ne oldu?

NOT:

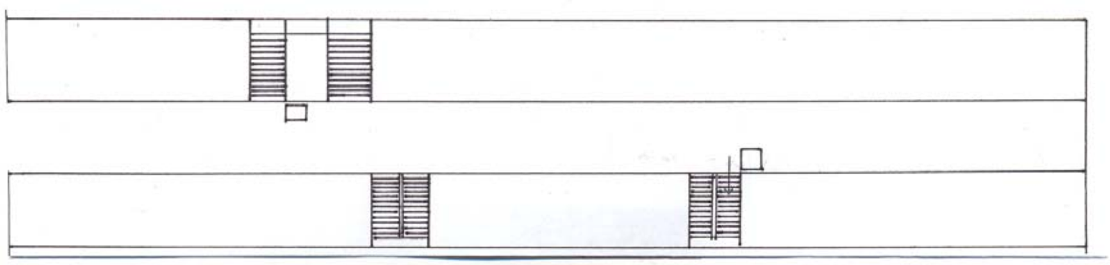
APPENDIX D2.4. 4. Deney Safhası Soru Formu

1. Şimdi, belli kutuların belli renklerini hatırlamaya çalışacağız.

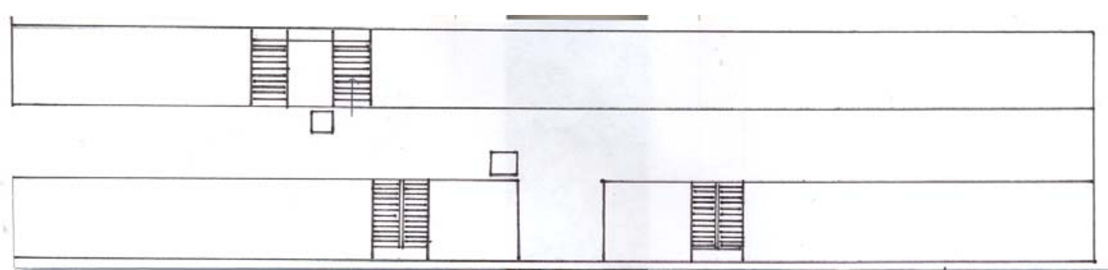
	Renk	Doğruluk
K1		Doğru Yanlış
K2		Doğru Yanlış
K3		Doğru Yanlış
K4		Doğru Yanlış
K5		Doğru Yanlış
K6		Doğru Yanlış



2 . Kat



1 . Kat



Giriş Kat

2. Kutuları renkleri ne idi?

____

____

APPENDIX D2.5. 5. Deney Safhası Soru Formu

- Lütfen bana parmağınla, rotanın bitiş noktasını (biyoloji laboratuarı) gösterir misin, nerede?

İşaret etme performansı:

Doğru ☐ Yanlış ☐

NOT:

____

____

APPENDIX E

Table E.1. ANOVA for the accuracy of route learning ability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7,471	2	3,736	24,207	,000
Within Groups	14,969	97	,154		
Total	22,440	99			

Table E.2. Post Hoc Comparison Test for the accuracy of route learning ability

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	-,4540(*)	,09675	,000	-,6946	-,2135
	SET 3	-,6599(*)	,09675	,000	-,9005	-,4194
SET 2	SET 1	,4540(*)	,09675	,000	,2135	,6946
	SET 3	-,2059	,09528	,102	-,4427	,0310
SET 3	SET 1	,6599(*)	,09675	,000	,4194	,9005
	SET 2	,2059	,09528	,102	-,0310	,4427

* The mean difference is significant at the .05 level.

Table E.3. ANOVA for the hesitations during route finding process

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7,471	2	3,736	24,207	,000
Within Groups	14,969	97	,154		
Total	22,440	99			

Table E.4. Post Hoc Test for the hesitations during route finding process

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	,4540(*)	,09675	,000	,2135	,6946
	SET 3	,6599(*)	,09675	,000	,4194	,9005
SET 2	SET 1	-,4540(*)	,09675	,000	-,6946	-,2135
	SET 3	,2059	,09528	,102	-,0310	,4427
SET 3	SET 1	-,6599(*)	,09675	,000	-,9005	-,4194
	SET 2	-,2059	,09528	,102	-,4427	,0310

* The mean difference is significant at the .05 level.

Table E.5. ANOVA for time spent during route finding process

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34,000	2	17,000	103,062	,000
Within Groups	16,000	97	,165		
Total	50,000	99			

Table E.6. Post Hoc Test for time spent during route finding process

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	1,2500(*)	,10003	,000	1,0013	1,4987
	SET 3	1,2500(*)	,10003	,000	1,0013	1,4987
SET 2	SET 1	-1,2500(*)	,10003	,000	-1,4987	-1,0013
	SET 3	,0000	,09850	1,000	-,2449	,2449
SET 3	SET 1	-1,2500(*)	,10003	,000	-1,4987	-1,0013
	SET 2	,0000	,09850	1,000	-,2449	,2449

* The mean difference is significant at the .05 level.

Table E.7. ANOVA for using boxes as reference points in verbal description of the route

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12,309	2	6,155	58,932	,000
Within Groups	10,131	97	,104		
Total	22,440	99			

Table E.8. Post Hoc Comparison Test for using boxes as reference points in verbal description of the route

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	-,8143(*)	,07960	,000	-1,0122	-,6165
	SET 3	-,6673(*)	,07960	,000	-,8652	-,4694
SET 2	SET 1	,8143(*)	,07960	,000	,6165	1,0122
	SET 3	,1471	,07838	,177	-,0478	,3419
SET 3	SET 1	,6673(*)	,07960	,000	,4694	,8652
	SET 2	-,1471	,07838	,177	-,3419	,0478

* The mean difference is significant at the .05 level.

Table E.9. ANOVA for using boxes as in route learning process

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17,871	2	8,936	318,807	,000
Within Groups	2,719	97	,028		
Total	20,590	99			

Table E.10. Post Hoc Comparison Test for using boxes as reference points in route learning process

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	-,9063(*)	,04123	,000	-1,0088	-,8037
	SET 3	-,9063(*)	,04123	,000	-1,0088	-,8037
SET 2	SET 1	,9063(*)	,04123	,000	,8037	1,0088
	SET 3	,0000	,04060	1,000	-,1009	,1009
SET 3	SET 1	,9063(*)	,04123	,000	,8037	1,0088
	SET 2	,0000	,04060	1,000	-,1009	,1009

* The mean difference is significant at the .05 level.

Table E.11. ANOVA for using building elements as reference points in route learning process

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	50,265	2	25,133	11,396	,000
Within Groups	213,925	97	2,205		
Total	264,190	99			

Table E.12. Post Hoc Comparison Test for using building elements as reference points in route learning process

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	1,6967(*)	,36576	,000	,7874	2,6060
	SET 3	,5202	,36576	,367	-,3891	1,4295
SET 2	SET 1	-1,6967(*)	,36576	,000	-2,6060	-,7874
	SET 3	-1,1765(*)	,36018	,006	-2,0719	-,2810
SET 3	SET 1	-,5202	,36576	,367	-1,4295	,3891
	2,00	1,1765(*)	,36018	,006	,2810	2,0719

* The mean difference is significant at the .05 level.

Table E.13. ANOVA for the sample group that were paid attention to the building elements

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2,705	2	1,352	6,647	,002
Within Groups	19,735	97	,203		
Total	22,440	99			

Table E.14. Post Hoc Comparison Test for the sample group that were paid attention to the building elements

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1,00	2,00	,4044(*)	,11109	,002	,1282	,6806
	3,00	,2279	,11109	,127	-,0482	,5041
2,00	1,00	-,4044(*)	,11109	,002	-,6806	-,1282
	3,00	-,1765	,10940	,277	-,4484	,0955
3,00	1,00	-,2279	,11109	,127	-,5041	,0482
	2,00	,1765	,10940	,277	-,0955	,4484

* The mean difference is significant at the .05 level.

Table E.15. ANOVA for the elements that were paid attention to

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,610	2	,805	,634	,533
Within Groups	99,007	78	1,269		
Total	100,617	80			

Table E.16. Post Hoc Comparison Test for the elements that were paid attention to

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1,00	2,00	-,3500	,32114	,555	-1,1514	,4514
	3,00	-,0603	,28885	,978	-,7812	,6605
2,00	1,00	,3500	,32114	,555	-,4514	1,1514
	3,00	,2897	,32747	,678	-,5275	1,1069
3,00	1,00	,0603	,28885	,978	-,6605	,7812
	2,00	-,2897	,32747	,678	-1,1069	,5275

Table E.17. ANOVA for the accuracy of verbal description of the route

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,149	2	,074	,320	,727
Within Groups	22,601	97	,233		
Total	22,750	99			

Table E.18. Post Hoc Comparison Test for the accuracy of verbal description of the route with sample groups

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	,0827	,11889	,785	-,2128	,3783
	SET 3	,0827	,11889	,785	-,2128	,3783
SET 2	SET 1	-,0827	,11889	,785	-,3783	,2128
	SET 3	,0000	,11707	1,000	-,2910	,2910
SET 3	SET 1	-,0827	,11889	,785	-,3783	,2128
	SET 2	,0000	,11707	1,000	-,2910	,2910

* The mean difference is significant at the .05 level.

Table E.19. ANOVA for the usages of directional terms in verbal description of the route

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,780	2	,390	5,106	,008
Within Groups	7,410	97	,076		
Total	8,190	99			

Table E.20. Post Hoc Comparison Test for the usages of directional terms in verbal description of the route with sample groups

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	,1893(*)	,06807	,024	,0201	,3586
	SET 3	,1893(*)	,06807	,024	,0201	,3586
SET 2	SET 1	-,1893(*)	,06807	,024	-,3586	-,0201
	SET 3	,0000	,06703	1,000	-,1666	,1666
SET 3	SET 1	-,1893(*)	,06807	,024	-,3586	-,0201
	SET 2	,0000	,06703	1,000	-,1666	,1666

* The mean difference is significant at the .05 level.

Table E.21. Chi-square Goodness of Fit Test for memorability and of the colors

	Observed N	Expected N	Residual
Yellow	55	50,5	4,5
Orange	50	50,5	-,5
Red	49	50,5	-1,5
Purple	54	50,5	3,5
Blue	48	50,5	-2,5
Green	47	50,5	-3,5
Total	303		

Test Statistics

	Memorability of colors
Chi-Square(a)	1,059
df	5
Asymp. Sig.	,958

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 50,5.

Table E.22. Chi-Square Goodness of Fit Test for the effect of wavelength on memorability of the colors

	Observed N	Expected N	Residual
Long-wavelength (yellow, orange, red)	86	88,0	-2,0
Short-wavelength (blue, purple, green)	90	88,0	2,0
Total	176		

Test Statistics

	effect of wavelength
Chi-Square(a)	,091
df	1
Asymp. Sig.	,763

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 88,0.

Table E.23. Chi-Square Goodness of Fit Test for the effect of wavelength on usability of the colors.

	Observed N	Expected N	Residual
Long-wavelength (yellow, orange, red)	87	87,0	,0
Short-wavelength (blue, purple, green)	87	87,0	,0
Total	174		

Test Statistics

	effect of wavelength
Chi-Square(a)	,000
df	1
Asymp. Sig.	1,000

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 87,0.

Table E. 24. Chi-square Goodness of Fit Test for correct location identification of colors.

	(number of correct identification) Observed N	Expected N	Residual
Yellow	47	34,0	13,0
Orange	31	34,0	-3,0
Red	31	34,0	-3,0
Purple	42	34,0	8,0
Blue	30	34,0	-4,0
Green	23	34,0	-11,0
Total	204		

Test Statistics

	Correct location identification of colors
Chi-Square(a)	11,412
df	5
Asymp. Sig.	,044

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 34,0.

Table E.25. Independent-Samples T Test for recognizing the specific sequence of the colors

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Accuracy in recognizing the specific sequence of colors	Equal variances assumed	,501	,482	,353	66	,725	,0294	,08335	-,13699	,19582
	Equal variances not assumed			,353	65,418	,725	,0294	,08335	-,13702	,19585

Table E.26. Chi-square Goodness of Fit Test for correct color

	(number of correct identification) Observed N	Expected N	Residual
Box. 1	49	34,0	15,0
Box. 2	40	34,0	6,0
Box. 3	37	34,0	3,0
Box. 4	24	34,0	-10,0
Box. 5	23	34,0	-11,0
Box. 6	31	34,0	-3,0
Total	204		

Test Statistics

	Correct color identification of boxes
Chi-Square(a)	14,706
df	5
Asymp. Sig.	,012

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 34,0.

Table E.27. Chi-square Goodness of Fit Test for correct identification of colors and boxes in relation with the floors.

	(number of correct identification) Observed N	Expected N	Residual
Ground Floor	89	68,0	21,0
1^{st} Floor	61	68,0	-7,0
2^{nd} Floor	54	68,0	-14,0
Total	204		

Test Statistics

	number of correct identification
Chi-Square(a)	10,088
df	2
Asymp. Sig.	,006

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 68,0.

Table E.28. Chi-square Goodness of Fit Test for used colors as reference points on verbal description.

	Observed N	Expected N	Residual
Yellow	37	29,0	8,0
Orange	26	29,0	-3,0
Red	24	29,0	-5,0
Purple	45	29,0	16,0
Blue	23	29,0	-6,0
Green	19	29,0	-10,0
Total	174		

Test Statistics

	used colors as reference points
Chi-Square(a)	16,897
df	5
Asymp. Sig.	,005

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 29,0.

Table E.29. Chi-square Goodness of Fit Test for used boxes as reference points on verbal description

	Observed N	Expected N	Residual
Box. 1	36	30,3	5,7
Box. 2	45	30,3	14,7
Box. 3	31	30,3	,7
Box. 4	19	30,3	-11,3
Box. 5	20	30,3	-10,3
Box. 6	31	30,3	,7
Total	182		

Test Statistics

	used boxes as reference points
Chi-Square(a)	15,934
df	5
Asymp. Sig.	,007

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 30,3.

Table E.30. Chi-square Goodness of Fit Test for the used colors and boxes on verbal descriptions of the experiment route, in relation with the floors

	(number of usages of colors and boxes) Observed N	Expected N	Residual
Ground Floor	82	58,0	24,0
1^{st} Floor	49	58,0	-9,0
2^{nd} Floor	43	58,0	-15,0
Total	174		

Test Statistics

	number of usages of colors and boxes
Chi-Square(a)	15,207
df	2
Asymp. Sig.	,000

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 58,0.

Table E.31. Chi-Square Goodness of Fit Test for the effect of wavelength on correct identification of colors.

	Observed N	Expected N	Residual
Long-wavelength (yellow, orange, red)	109	102,0	7,0
Short-wavelength (blue, purple, green)	95	102,0	-7,0
Total	204		

Test Statistics

	effect of wavelength
Chi-Square(a)	,961
df	1
Asymp. Sig.	,327

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 102,0.

Table E.32. ANOVA for pointing task

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6,900	2	3,450	19,002	,000
Within Groups	17,610	97	,182		
Total	24,510	99			

Table E.33. Post Hoc Comparison Test for pointing task

(I) SET	(J) SET	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SET 1	SET 2	-,5772(*)	,10494	,000	-,8381	-,3163
	SET 3	-,5478(*)	,10494	,000	-,8087	-,2869
SET 2	SET 1	,5772(*)	,10494	,000	,3163	,8381
	SET 3	,0294	,10334	,960	-,2275	,2863
SET 3	SET 1	,5478(*)	,10494	,000	,2869	,8087
	SET 2	-,0294	,10334	,960	-,2863	,2275

* The mean difference is significant at the .05 level

Table E.34 . Chi-Square Test for effect of gender on route learning ability (Experiment Set 1)

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1,758(b)	1	,185		
Continuity Correction(a)	,857	1	,355		
Likelihood Ratio	1,854	1	,173		
Fisher's Exact Test				,249	,178
Linear-by-Linear Association	1,703	1	,192		
N of Valid Cases	32				

a Computed only for a 2x2 table

b 1 cells (25,0%) have expected count less than 5. The minimum expected count is 3,66.

Table E.35. Chi-Square Test for effect of gender on route learning ability (Experiment Set 2)

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,926(b)	1	,336		
Continuity Correction(a)	,328	1	,567		
Likelihood Ratio	,942	1	,332		
Fisher's Exact Test				,448	,285
Linear-by-Linear Association	,898	1	,343		
N of Valid Cases	34				

a Computed only for a 2x2 table

b 2 cells (50,0%) have expected count less than 5. The minimum expected count is 4,24.

Table E.36. Chi-Square Test for effect of gender on route learning ability (Experiment Set 3)

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,068(b)	1	,794		
Continuity Correction(a)	,000	1	1,000		
Likelihood Ratio	,067	1	,795		
Fisher's Exact Test				1,000	,661
Linear-by-Linear Association	,066	1	,797		
N of Valid Cases	34				

a Computed only for a 2x2 table

b 2 cells (50,0%) have expected count less than 5. The minimum expected count is ,82.

Table E.37. Chi-Square Test for effect of gender on route learning ability (Experiment Set 1, Set 2 and Set 3)

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1,313(b)	1	,252		
Continuity Correction(a)	,871	1	,351		
Likelihood Ratio	1,310	1	,252		
Fisher's Exact Test				,292	,175
Linear-by-Linear Association	1,299	1	,254		
N of Valid Cases	100				

a Computed only for a 2x2 table
b 0 cells (,0%) have expected count less than 5. The minimum expected count is 15,30.

Table E.38. Chi-square Test for the effect of gender on pointing task performances

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2,196(b)	1	,138		
Continuity Correction(a)	1,636	1	,201		
Likelihood Ratio	2,199	1	,138		
Fisher's Exact Test				,159	,100
Linear-by-Linear Association	2,174	1	,140		
N of Valid Cases	100				

a Computed only for a 2x2 table

b 0 cells (,0%) have expected count less than 5. The minimum expected count is 19,35.