COLOR PSYCHOLOGY AND ITS APPLICATION IN WORKPLACE
DESIGN FOR A BETTER WORK SATISFACTION: A BIBLIOMETRIC
QUANTITATIVE ANALYSIS ON PUBLICATION ABOUT THE FIELD

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ABSTRACT

The problem for this research paper mentioned the lack of literature that look at workplace as a tool for value communication and lack of consistent evident that color in workplace work. Therefore, the purpose of this quantitative study was to provide an overview of the field of spatial design in workplace using color psychology to encourage development on the topic through bibliometric analysis of Scopus data set of 808 documents to answer 7 research questions which aim to understand the predominate research area of the field, the potential areas and trends for further develop on the topic the most impactful journal, the countries collaboration network so far, the most relevant universities that are doing research about the topic and finally the evolution of the topic overtime. The answer to these questions will form a guiding path for future research that allow effective expansion of the field of spatial design in workplace using color psychology. The result shown to support the problem statement with most academic literature about the topic looks at the learning environment not workplace. For the second research question, there are lack of connection between architectural color and emotional design and interior design. For the second sub research question, biophilic, UX design, aesthetic appeal, indoor environment are the underdeveloped trend. For the third research question, the ranking of the topic three research most impactful make sense when one wants to research about the use of color in workplace design. For the fourth research question Thailand has slow progression about the topic but has one expert on the field of color psychology in workplace design. For the fifth research question ASEAN countries even through have their own publication about the topic but lacks collaboration paper despite their geographical convenient. For the sixth research question Bina Nusantara University from Indonesia is the only university in ASEAN region to be the most top

relevance university to produce about the top. Lastly, for the seventh research question, the progression of the field overtime shown more room to growth as most of the publication is from 2008 to 2024 showing that the field is still young. It is recommended that more publication should be done on the identified trend with focus on the workplace setting with more collaboration between ASEAN countries starting with Indonesia with the rest of ASEAN.

Keywords: Human experience, color, spatial design, workplace design, workplace satisfaction, color psychology, bibliometric, quantitative study, office design, office color, experiential design, R studio

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Le Nguyen Minh Tuan

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

BANGKOK
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LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This chapter aim to introduce the topic through providing background information about the interior design industry and point out the effects of color on interior design. The problems are discussed which mention the lack of studies about using spatial design in workplace to communicate value and the specific problem of no consistent evident that color benefit can be implemented in workplace design. After that the significant of the study are mentioned then follow by the research questions which resolve the problem.

1.1 Background and Context of the Study

1.1.1 Overview of interior design service industry

Mordor Intelligence (n.d.) claim that the size of the interior design services market is projected to be USD 137.93 billion in 2024 and is projected to increase at a compound annual growth rate (CAGR) of 5.13% to reach USD 177.13 billion by 2029. Perspective on our house has shifted dramatically since the COVID-19 pandemic, which has an impact on the whole interior design industry. Furthermore, 51% of designers, according to the American Society of Interior Designers, have already adapted to the new standard. Similar to what happened during the 1918 pandemic, people's purchasing patterns have drastically changed as a result of this one: they are redesigning their bathrooms, kitchens, and bedrooms. As consumers started to envision their living spaces during the pandemic's two years, companies started utilizing augmented reality (AR) technologies as a serious option to highlight their goods and services rather than as a gimmick. Letting customers arrange furniture in their own houses to see how it feels is one of the most evident uses. Real estate investments are rising on a global scale. The most well-liked market investments are co-working spaces and commercial real estate. As the real estate industry grows in the future, there will be a demand for interior design services. The number of interior designers working in tier 1 and tier 2 cities worldwide is increasing because of numerous nations increasing their investments in these areas. Many firms that

specialize in architecture are branching out into interior design. Urban regions are where the interior design industry is concentrated. A large portion of the rise in the adoption of interior design solutions can be attributed to the vast construction industries of China and Japan. In preparation for the Olympic Games, which attracted millions of foreign visitors, hotels and resorts renovated their historic structures. Because of the rising demand for interior design in Japan, the country is one of the biggest and fastest-growing markets for Finnish companies that specialize in furniture and other interior design items (Mordor Intelligence, n.d.).

Sector-wise, the market is dominated by the residential segment, which generated 60.3% of market revenue in 2020 (Gitnux, 2023). This residential sector places a lot of emphasis on kitchen and bathroom renovation projects as homeowners look to update and enhance the usability of these vital areas. The U.S. interior design sector has experienced a minor reduction in growth in recent years, according to statistics provided by Gitnux (2023). Nonetheless, this hasn't stopped new companies from opening; in fact, the number of interior design firms in the United States has increased by 4.2%. This points to a market that may be saturated and experiencing more competition. Another significant factor impacting the sector is e-commerce. Home goods sales online have grown significantly, with 18% of purchases occurring in 2019 (Gitnux, 2023). As customers look for ease and a greater variety of products, this trend is here to stay. Businesses will need to stay on top of these trends and adjust to changing consumer tastes to survive and grow in this cutthroat market.

1.1.2 The effects of color in interior design

Creating constructed spaces that support occupants' psychological well-being is one of architecture's primary functions. Given that over 70% of a person's life is spent indoors in modern society, this position is even more crucial (Al-Akkam, (2013). Ćurčić et.al. (2019) claim that a significant element that influences the way people use a room on a functional, aesthetic, and psychological level is interior design. There is no denying that colors play a fundamental role in the world we live in and have a profound effect on how people perceive it. They are also among the most significant interior design components, which means they play a major role in creating a room that is appropriate for both living and working. Many studies have

demonstrated the profound psychological and physiological effects that colors have on humans; for this reason, it's critical to understand how different colors influence people using a place (Ćurčić et.al., 2019). It is comparable to how joyful and depressed people feel on sunny days and rainy days, respectively (Ćurčić et.al., 2019). Color has the power to affect feelings, emotions are greatly influenced by color hue, saturation, and brightness; the most stimulating colors are green-yellow, blue-green, and green; the most pleasant colors are blue, blue-green, green, red-purple, purple, and purple-blue (Valdez & Mehrabian, 1994).

Additionally, color affects cognitive functions. In achievement contexts, in particular, color can have a slight but important impact on psychological functioning. The results have ramifications for several domains, such as athletics, education, and productivity at work. (Elliot & Maier, 2007). Having familiarity with color is essential when designing an interior environment (Ćurčić et.al., 2019). An interior designer or architect needs to be aware of the psychological affects that specific colors can have on people and how to apply color theory to create combinations that work for different contexts. A viewer's reaction to color combinations and their use in an interior might be either favorable or unfavorable. While colors can evoke feelings of irritation and pain, a place can also radiate peace and tranquility. Because they are such an effective technique in interior design, they can provide a variety of spatial illusions. For example, if the wrong hue is chosen, a tiny room may appear larger or smaller. Colors are one of the most crucial options when the architecture itself does not allow for modifications and flexibility (Ćurčić et.al., 2019). A study of 1000 occupant in 13 office buildings in the US showed that there are many elements that affects correlate to workspace satisfactions such as lighting, noise air quality, heating and drafts as well as amount of space, furniture quality, privacy and color and area of wells and partitions (Maran and Yan, 1989).

1.2 Problem Statement

1.2.1 Problem in spatial design in workplace (on a macro level)

The problem with workplace design today is that the design of the office does not communicate the intended organization value. When we look at using office as a tool to communicate value it is mentioned early in 1995 by Wallis. Wallis (1995) recognized the issue of organization does not design their workplace to communicate value to user and guess of that space. By using color, lighting, and furniture arrangements to promote the company's values and image, an office design may be a very powerful sales tool (Wallis, 1995).

Figure 1.1: Thematic map result showing no connection for Wallis 1995 paper that talk about using office design as a tool to communicate value
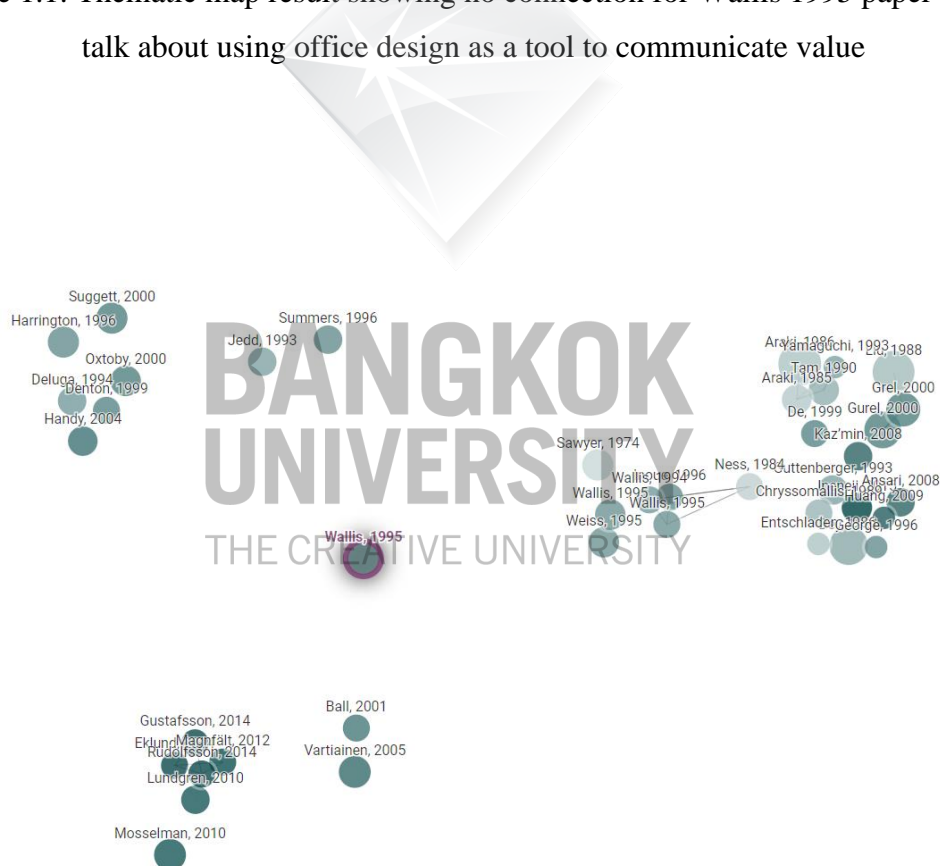
Source: Connected papers. (n.d.). Connected Papers. https://www.connectedpapers.com/main/3450eb0ea29add29cfbd1300e823be103fce2b4b/The-good%2C-the-bad-and-the-ugly-%E2%80%93-what-does-your-office-say-about-your-company%3F/graph

To show the gap in research to point out the problem, this research use Connected Paper, a publication visualization tool that aid in exploring relevant paper in a specific field of research. Figure 1.1 shows the graph of similar paper in form of node based on the input of Wallis's paper in Connected Paper. On how to interpret the graph, a research paper connected to the original work is represented by each node in the graph (Cunff, 2022). The publications are organized based on similarities rather than following a traditional citation tree. A node's size indicates how many citations it has (Cunff, 2022). A node's color indicates the year of publication; lighter indicates an older node (Cunff, 2022). Stronger connecting lines and a tendency to cluster together characterize highly related manuscripts (Cunff, 2022). Thematic map result of other similar publication to Wallis (1995)'s research from Connected Paper shown that there is no connection between other articles and no clustering of articles to Wallis (1995)'s research. This shows no development of topic of using the office to communicate value ever since and no mentioning the problem that other companies do not apply the design for value communication in the workplace.

1.2.2 The problem of using color in workplace design in spatial design (on a micro level)

The problem in spatial design in the workplace using color lies in the lack of consistent evidence supporting claims about the effects of room color on human performance, behavior, or mood (Wiendahl & Reichardt, 2015). Additionally, the relationship between space and organization in workplace environments is complex, with varying conclusions on how spatial layouts influence social interactions and organizational behavior (Sailer & Penn, 2009). Color is crucial for expressing ideas and creating aesthetically stimulating environments in workspaces (Sailer & Penn, 2009). However, the inconsistency in research findings on the impact of color on social interactions and organizational behavior complicates the design process (Кравченко, 2001). Studies show that the physical layout of workspaces influences social interactions and organizational structures, but methodologies for analyzing this relationship vary significantly, leading to contradictory findings (Кравченко, 2001). Additionally, the importance of considering color in public communication and everyday life highlights the significance of understanding the relationship between

color and space for effective design (Reichardt, 2015). The challenge lies in integrating color harmoniously into the spatial layout to promote mental and physical well-being while minimizing health risks in work environments (Schatz & Bowers, 2005). These challenges highlight the need for a more nuanced understanding of how spatial elements, including color, impact workplace dynamics and human experiences.

Color is a small step that allow company to communicate value through showing consistency in color design in workplace however the study on the influence of color in workplace design is lacking and showing inconsistent output. As a result. not a lot of organization are aware of the benefits and taking advantage of color psychology leading to the spaces in organization is underuse due to a lack of design effort to influence/ engage the user of the that space. This Leaving a lot of benefit from the workspace unuse. Missing out the benefit of having a space that support its user increasing productivity, creativity, and satisfaction at work.

1.3 Research Objective and Questions

This study aims to promote/encourage future research on spatial design in workplaces using color psychology through analyzing database of color and spatial design to understand the research gaps using bibliometrics approach. My topic concerns the interior design industry for offices in the workplace. The problem is that there is not enough research about the topic as the focus not about the for design in workplace using color is limiting. There are benefits to be gain with applying color psychology in workplace design if more study about the topic is done then a consistent output will emerge which allow for more real-world application of the idea of using color in workplace design.

The purpose of my research is as followed:

- To explore what is the focus of spatial design is about.
- To point out the gap need to be research in spatial design.
- To give a direction on what to look for when study about color psychology in workplace design.

The research questions and the biblioshinny function use to answer the corresponding research are show in table 1.1 bellow:

Table 1.1: Research question and bibliometric function use for that research question

Research questions	Biblioshinny Function
• What are the predominate research themes surrounding spatial design within the academic literature?	• Co-citation network
• What are the potential areas about color psychology that need more development to further develop the field? • What are the trends in spatial design about color psychology and workplace design?	• Co-occurrence network • Thematic evolution network from 2008 to 2023
• What is the most important journal if one wants to investigate how to improve the workspace using color?	• Most impactful journal ranking by h index • Three field plot between country – keywords – sources
• How has Thailand progressed regarding the whole spatial design and the specific topic of office color design? And who are the experts?	• Research from data set of 808 documents
• How has other countries collaborated with each other regarding the topic?	• Country collaboration network

Table 1.1 (Continued): Research question and bibliometric function use for that
research question

Research questions	Biblioshinny Function
• How has the topic evolved overtime?	• Annual Scientific production • Country production over time • Most relevance sources from 2007 to 2008 • Keywords title bigram analysis using tree map
• What are the top universities that are doing research about the topic spatial design in workplace using color?	• Ranking result of most relevance affiliations

1.4 Research Scope

The scope analyzes the whole spatial field academic publishing on global view
from Scopus data base focusing on the workplace environment in business. The
bibliometric analysis will go through journal articles and conference proceedings in
English language.

1.5 Significance of the Research

Large organizations' future office designs will emphasize technology,
community, sustainability, health, and well-being while incorporating smaller areas
and satellite offices (Nanayakkara et al., 2021). Good color design may help create a
happier atmosphere in the office; when lighting is perceived as optimal, employees'
moods tend to improve as well (Küller et al., 2006). Around 25% of the human brain
cortex is use for processing visual information (Van Essen, 2005). A visual

phenomenon called color is brought about by the body's reaction to light stimulation. It permeates every part of our life, adding beauty and drama to commonplace objects and embellishing ordinary things (Holtzschue, 2002). According to Kamarulzaman et.al. (2011), to ensuring productivity in the workplace, office colors are crucial. The human body reacts differently to each color. Everybody has a unique experience with color. Individuals' responses to various color schemes are influenced by their socioeconomic status, education, genetics, and culture. Therefore, structure, color, activity, lighting, and space all have a big impact on employee behavior and productivity at work (Kamarulzaman et.al., 2011). According to Garris and Monroe (2005), color affects wellbeing and productivity in addition to mood. Syahrul Nizam & Emma Marinie (2010) noted that colors have an impact on the psychological well-being of building inhabitants. Certain hues evoke calmness, others comfort, still others stimulate, and many more have various effects. This implies that color will have an impact on the occupants' mood in the area. Therefore, it is important to choose the right color to ensure that staff are in a positive attitude to promote productivity. Color and productivity are rarely related. The color scheme does, however, have a significant impact on the workplace. Human emotions and behavior are influenced by the characteristics of space (Farshchi & Fisher, 1997). Color is a significant factor in how large or tiny regions are influenced in space configuration or organization (Farshchi & Fisher, 1997). For example, painting the end walls of a long, narrow room in warm, deep, and powerful colors while painting the side walls in lighter, less saturated colors might help the room appear more normal. Light colors will make a low ceiling feel less suffocating, whereas dark blue, gray, or black might make a high ceiling appear lower (Pile, 1997). Comparison of the same size of two room 's results that room with the darker color scheme will appear to be smaller than the other room with a lighter color scheme (Kamarulzaman et.al., 2011). Depending on the prevailing hue of the color, office color interiors affect worker productivity in different ways. These effects are contingent upon individual environmental sensitivity and exposure duration (Kwallek et al., 2007). Office colors influence how well people execute clerical tasks, how they feel, and what color they like. Women perform better than men, and higher saturation levels make people feel more depressed, confused,

and angry (Kwallek et al., 1996). Though more research is required before making firm conceptual claims and recommendations, color has a substantial impact on people's mood, cognition, and behavior (Elliot & Maier, 2014).

In the workplace, color psychology is important for knowledge management procedures. Plants and color in the physical environment positively impact knowledge productivity, with structure, variety, psychological safety, and identity being key factors in fostering energy and different moods for knowledge workers (Bakker, 2014). The use of color in mobile learning platforms improves interface usability and makes knowledge management systems easier to use (Pelet & Uden, 2014). Additionally, it has been discovered that workplace color and space have a significant impact on employees' knowledge sharing (Hsiao et al., 2013). Employee knowledge sharing and work stress are significantly impacted by office space and color, and larger offices and public areas are linked to less role ambiguity (Hsiao et al., 2013). Spaciousness and initiative in an office setting are positively correlated with a higher inclination for sharing knowledge (Hsiao et al., 2013). Social psychological elements, such social identity and norms, have a big impact on how knowledge is shared and processed in companies (Kimmerle et al., 2008). Furthermore, it has been determined that workplace spirituality has the ability to improve knowledge management procedures by encouraging staff members to acquire new skills, adjust to changing circumstances, and make better use of available knowledge resources (Lakshmi & Das, 2021). These results emphasize how crucial it is to take color psychology and other environmental aspects into account when creating systems and workspaces that facilitate efficient knowledge management procedures.

1.6 Definition of Terms

Color psychology: The study of how human psychology and color interact, with a focus on how color influences affect, cognition, and behavior (Elliot & Maier, 2014).

Biophilic design: a design approach that aims to enhance physical and psychological health and wellbeing in built environments (Bolten, 2020)

Color in context theory: Color in context theory, as proposed by Geen (1987), suggests that the influence of color on psychological functioning varies depending on the context in which it is perceived (Geen, 1987).

Environmental Psychology: Environmental psychology is a field that explores the interaction between individuals and their natural and built environments, and the impact of these interactions on human experiences, behavior, and well-being (Steg et al., 2018).

Architectural psychology: Architectural psychology is a field that explores the impact of architecture on human behavior, emotions, and well-being. It is an interdisciplinary subject that draws on principles from psychology and architecture (Zhu et al., 2018).

CHAPTER 2

LITERATURE REIVEW

The purpose of this chapter is to lay the groundwork for the bibliometric examination of color psychology, office spaces, and spatial design. It examines the major ideas, theories, and body of research that shed light on how these components relate to one another. Creating a solid theoretical foundation for interpreting the bibliometric study's results is the aim. The study of color psychology focuses on how colors affect people's emotions, behaviors, and perceptions. Color psychology principles are being used more and more in workplace design to create spaces that support desired outcomes including greater productivity, well-being, creativity, and collaboration.

2.1 Key Theoretical Frameworks

2.1.1 Color in context theory

According to Elliott and Maier's (2012) Color-in-Context Theory, color perception is impacted by the environment and can influence psychological functioning. This is corroborated by Olkkonen (2016), who addresses the ways in which contextual elements like lighting and spatial context can impact the appearance of color. Al-Shaaban (2013) highlights the significance of context in color associations even more, observing that these correlations rely on the particular situation. Adding to this conversation, Volmer (2003) provides a paradigm for context-specific color representation that can be used to improve content-based retrieval application. The color-in-context theory highlights the need for further research in this field by suggesting that color impact psychological functioning through its properties (hue, brightness, and chroma) in different settings (Elliot & Maier, 2012). According to Elliot and Maier's (2012) the psychological impacts of color are reliant upon the situation in which they are viewed, rather than being static. The essence of the Color-in-Context Theory was delineated by Elliot & Maier (2012), who pointed out that the influence of color is influenced by a multitude of elements, such as personal experiences, cultural connotations, and the specific circumstance or

task in question. In a sporting event, for instance, red might excite and exude enthusiasm, but in an academic setting, it might cause worry or avoidance.

2.1.2 Environmental psychology

Environmental psychology examines relationships between people and their physical environments (Gifford 1987). According to Gifford (2012) the study of the interactions that occur between individuals and their physical surroundings on an individual and small-group basis is known as environmental psychology. It looks at basic processes like how people perceive buildings and landscapes, how they think about their surroundings and their spatial cognition, and how they perceive personality; it also looks at social processes like crowding, personal space, the effects of high density, territoriality, and privacy; and it analyzes how people interact with the built and natural environments, including sustainability and architecture. People and their surroundings always interact, both positively and negatively, wherever they are—at home, at school, at work, in parks, or on the street. These interactions take place in behaviors and overall wellbeing in addition to attitudes and emotions (Gifford, 2012).

2.1.3 Architectural psychology

The field of architectural psychology is defined as a subfield of environmental psychology. Its history is brief, having begun only in the late 1950s. Perception/cognition, color, proxemics (the study of people-spacing, congestion, and privacy), navigation, and affect are the five areas of particular significance that are highlighted. (Philip, 2001). By utilizing perceptual and sensory principles, architectural psychology explores how psychology might be integrated into design to improve human well-being and sense of space (Abel, 2021).

2.1.4 Model of human experience

Figure 2.1: Model of human experience
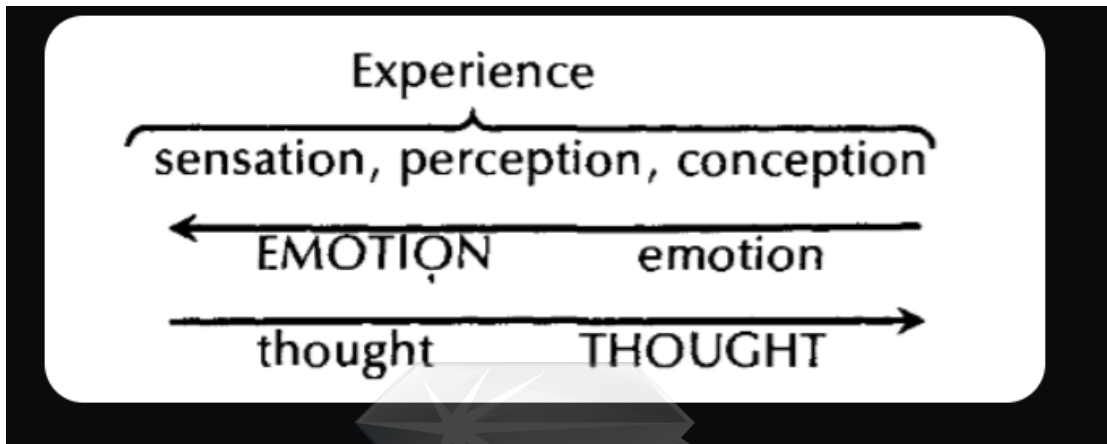
Source: Tuan, Y. F. (1977). Space and place: The perspective of experience. U of
Minnesota P.

In his book "Space and Place: the perspective of experience", Tuan (1977)
mentioned the model of human experience, a framework or representation that
attempts to explain how individuals perceive, interpret, and interact with the world
around them (see figure 2.1). According to Tuan (1977), the model illustrates how our
overall experience is shaped by the dynamic interaction of many factors. Humans
initially absorb sensation as raw sensory data, which is subsequently organized and
interpreted to give meaning (perception). Based on our perceptions, we form concepts
and ideas about the world (conception). Our feelings are influenced by all these
things, and our thoughts can also affect our feelings. The consequence of the ongoing
interaction of sensation, perception, conceptualization, emotion, and thought is our
holistic experience (Tuan, 1977).

2.1.5 Color psychology

The study of how human psychology and color interact, with a focus on how
color influences affect, cognition, and behavior, is known as color psychology (Elliot
& Maier, 2014). Research on color psychology has a long history, going all the way
back to the 19th century. It focuses on topics such as attention, physical strength,

preference, arousal, and time perception (Elliot, 2018). According to Singh et al. (2023) research, color affects mood, wellbeing, and performance in a variety of contexts, including the workplace.

      2.1.6 Workplace design and productivity

      The design, illumination, air quality, and furniture of a workplace can all significantly affect how productive and contented workers are (Chadburn & Smith, 2015). The study looks at the connection between productivity, creativity, and well-being at work and highlights how important it is to design for all three (Croome, 1999). Croome (1999) examines the intricate interactions that exist between psychological elements like motivation, stress, and job satisfaction and physical elements like lighting, acoustics, and spatial arrangement. It also explores how crucial leadership and corporate culture are to establishing an effective workplace. Workplace architecture and design in communication design firms promote efficiency by providing a defined framework for researching, displaying, evaluating, and transforming group information about active projects. (Peponis et al., 2007). According to Peponis et al. (2007), workplace design entails more than just promoting communication and collaboration. Additionally, it offers a "intelligible framework" that facilitates the investigation, depiction, analysis, and modification of communal knowledge. Put another way, an organization's culture and mental processes can be shaped and strengthened by its physical environment. According to Peponis et al. (2007), certain design components—like closeness and visibility—are especially crucial for encouraging knowledge workers to collaborate and communicate with one another. They also stress the significance of designing a range of areas that accommodate various work modes, including casual interaction, group cooperation, and individual focus. According to Peponis et al. (2007), companies may design workplaces that foster and improve their employees' creativity and productivity by thoughtfully planning their physical arrangement and offering a variety of spaces.

      2.1.7 Person-environment fit theory

      This theory provides a framework for evaluating and forecasting how an employee's attributes and the workplace together affect their well-being (ILO Encyclopaedia of Occupational Health & Safety, 2011). Based on this understanding,

it is possible to develop a model for pinpointing areas that could benefit from preventive action (ILO Encyclopaedia of Occupational Health & Safety, 2011). Employing color psychology can help design a workspace that meets the staff's demand. For instance, implementing relaxing hues in high-stress locations might raise satisfaction indirectly while also improving employee well-being (Corley, 2024).

2.2 Literature Review

This section provides a critical synthesis of existing research, organized into thematic areas.

2.2.1 Understanding role and the need for workplace

This section will look at what is workplace? What is it purpose? Why do we need it? A workplace can be any place, from actual buildings like factories and offices to virtual spaces where work is done (Musiała, 2022) and (Jurdak, 2016). Its function goes beyond merely providing a place of employment; by the application of labor law, it plays a vital role in society's operation and helps to realize the public interest and the rule of law (Winch, 2012). In addition to providing a means of support, workplaces are essential for people's development of their sense of self and integration into intricate social networks (Muschalla & Linden, 2011). Furthermore, the notion of a workplace has been broadened by contemporary technological developments to encompass virtual areas that improve productivity and resource management in work processing systems (Cascio & Montealegre, 2016). The office is a great area to encourage physical exercise, and people who think their bosses and coworkers are active are more likely to be active themselves at work or in the workplace (Bennie et.al., 2010). To establish a productive and successful work environment that fosters collaboration and communication, the overall workplace idea takes social, organizational, and design factors into account (Becker & Steele, 1990). Workplaces are essential for sustaining and enhancing people's workplace competency over the course of their careers, and this need is driven by social, economic, and personal factors. (Harteis & Billett, 2008). Although the workplace is an important location to learn, its main function is to produce goods and services that either create profit or are delivered within budget (Rainbird, 2000). Because of social

and economic requirements, workplaces are significant and essential learning environments (Billett, 2010). Employee health and well-being are supported, safeguarded, and encouraged in a healthy workplace as corporate objectives are pursued (McLellan, 2017). The remodeling of an office has a good effect on worker productivity; the relationship is stronger for Generation Y than for older employees, with collaboration and privacy being important considerations (Yunus & Ernawati, 2018). Croome (1999) examines the relationship that exists between well-being, creativity, and productivity in the workplace and emphasizes the significance of designing for all three. Workplace design affects employee productivity by enhancing comfort, focus, and attention, among other aspects. (Croome, 1999). The physical and mental wellness indicators that are directly impacted by workplace design have an impact on employee productivity (Van Der Valk et al., 2015). Office design has a high substantial impact on employees' productivity, with meticulous design ensuring optimal performance and corporate success (Hansika & Amarathunga, 2016).

2.2.2 The impact of color on workplace well-being:

The psychological, physiological, and outcome components of a worker's mood, wellbeing, and performance are greatly influenced by the color of their workplace (Savavibool, 2016). Human perception and behavior are greatly influenced by color in the workplace, which has an impact on worker productivity and well-being (Amani et al., 2020). Effective color schemes for the workplace can improve comfort and visual working capability. (Lebedkova et al., 2012). Employee stress levels and general well-being can be greatly impacted by exposure to various colors at work. Empirical studies have demonstrated the significant impact that color and lighting conditions have on human comfort and physiological reactions, including blood pressure, heart rate, and pupil size (Elbertse & Steenbekkers, 2023). Furthermore, it has been discovered that the colors of the surroundings affect people's stress levels. Different color wavelengths have an effect on people's heart rate variability and stress reactions. Furthermore, it has been discovered that the colors of the surroundings affect people's stress levels. Different color wavelengths have an effect on people's heart rate variability and stress reactions (Ruwana et al., 2021). Additionally, the use of green color at particular wavelengths has been connected to

higher illumination levels, lower blood pressure, and heart rates, all of which improve workers' physical comfort (Oh et al., 2021). Employee happiness is greatly impacted by color in the workplace since it affects their mood, stress levels, comfort, productivity, and creativity (Savavibool, 2016). Human perception and behavior can be influenced by colors, with blue and green environments being especially good for wellbeing (Heath et al., 2022). Additionally, adding varying amounts of indoor vegetation to a workspace can lower stress levels, boost output, and improve workplace satisfaction, all of which will make workers feel happier and more at ease (Elbertse & Steenbekkers, 2023). The significance of holistic approaches to employee wellbeing in work contexts is highlighted by interventions that emphasize plant-based lifestyles and Blue Zones expertise. These interventions can improve mental wellness outcomes, including stress reduction and better sleep quality (Burke et al., 2023).

2.2.3 Good color design might contribute to a more positive mood

The most favored hues are blue and green, with blue linked to emotions of security, comfort, and tenderness (Guilford & Smith, 1959; Wexner, 1954). Moreover, hue green is calming, revitalizing, and relaxing. Happiness is evoked by green, while passivity, cleanliness, and calm are evoked by blue. (Mahnke, 1996). Spielberger et.al (1970) research further supports the idea that blue and green are calming or stress-relieving hues. They discovered that people who saw blue and green on a State Anxiety Inventory scored much lower than those who saw red.

2.2.4 Color and cognitive performance

According to Michaelis (2013), a great deal of study has been done on how color affects cognitive task performance. Due to inconsistent findings, the research is inconclusive overall. Overall, most research has focused on how the colors green, red, and blue affect performance metrics in terms of cognition. As was already established, these trials' findings are contradictory (Michaelis, 2013). Stone & English (1998) discovered no discernible variations in cognitive task performance between the blue and red workspaces. On the other hand, Hatta et.al. (2002) discovered that red on a computer display considerably lowers performance on visual tasks in comparison to blue; nevertheless, they also discovered that blue was detrimental to visual task performance when the workload was extremely hard. On the other hand, Etnier &

Hardy (1997) discovered that employees' performance on cognitive tasks was dramatically enhanced when they worked in green and blue offices. Mehta & Zhu (2009) tried to reconcile the disparities resulting from the inconsistent previous studies in this field Mehta & Zhu (2009) discovered that although blue induced an approach motivation and was proven to enhance creativity, red elicited an avoidance motivation and was found to improve one's recollection of minute details.

Several investigations have been carried out about this matter, and the findings remain equivocal (Michaelis, 2013). Even though there have been differences in the cognitive benefits of color, it has been consistently shown that color does have an impact on our daily life. More precisely, because they make people feel secure, content, and at ease, the hues blue and green are indispensable (Guilford & Smith, 1959; Mahnke, 1996; Wexner, 1954). It has been demonstrated that color affects cognitive function at work. It has been discovered that red, pink, and white noises increase productivity; pink noise improves executive function and continuous performance (Eslami et al., 2023). Blue-enriched white light has been associated with better sustained attention and less drowsiness in shift workers, suggesting that it has a beneficial effect on work output. (Lu et al., 2020). Furthermore, studies indicate that blue light from computer screens may have different impacts on cognitive stress and eye strain, with some even suggesting gains in alertness and focus (Mahmood et al., 2023). Additionally, colors like blue are linked to approach motivation, which may have an impact on cognitive function in accomplishment contexts, whereas red is linked to avoidance motivation, which can impede creativity (Song et al., 2021). Different colors have varying impacts on cognitive performance. Research suggests that colors like red, blue, navy, and purple can enhance cognitive abilities by improving cognitive distance and reducing the time required for route choice (Ryun-Seok et.al., 2023). Colors in the environment have been shown to have a substantial impact on impulsivity and arousal, which in turn affects cognitive function and psychometric test performance (Xia et al., 2021). Color significantly affected cognitive functions such as selective attention, alertness, athletic performance, intellectual performance, evaluations of aggressiveness and dominance, caution and avoidance, attraction, store and company evaluation, eating and drinking, memory,

and time perception (Zarei et al., 2021). Red (as opposed to blue) largely causes an avoidance (as opposed to an approach) drive, and that whereas blue improves performance on a creative activity, red improves performance on a detail-oriented one (Mehta and Zhu, 2009).

 2.2.5 Spatial design and employee behavior:

 For knowledge organizations to increase organizational productivity and individual innovation, space design is crucial (Peponis et al., 2007). The way office spaces are set up, including the layout and privacy features, has a big impact on how people communicate, work together, innovate, and enjoy their jobs. While open offices improve collaboration, they can raise health risks and endanger privacy (Onishi et al., 2021). Higher occupant satisfaction is achieved by academic office designs that strike a balance between seclusion and collaboration (Parkin et al., 2011). Workplace privacy levels have an impact on certain aspects of job happiness both short- and long-term and are linked to overall job satisfaction (Duvall-Early & Benedict, 1992). Perceptions of crowding are influenced by privacy and contentment with living spaces; architectural designs that satisfy occupant expectations reduce crowdedness perceptions (Chan, 1999). The design features of activity-based flexible workplaces, like sound and visual seclusion, affect how satisfied and how people feel about social interactions (Forooraghi et al., 2023). These findings underscore the importance of thoughtful design in creating workspaces that foster effective communication, collaboration, innovation, and job satisfaction.

 2.2.6 Integrating color and spatial design:

 The interplay between color and spatial elements in the workplace has a significant effect on output. Spatial variables like area and height have a substantial impact on the perception of space. These attributes also affect elements like spaciousness, openness, complexity, and order (Savavibool & Moorapun, 2017). In addition, people's physical surroundings have a big influence on their psychological well-being, with situations that support identities having positive effects (Greenaway et al., 2016). Wiendahl & Reichardt (2015) emphasize the need of creating work environments that are visually attractive and well-organized, emphasizing the need to build workspaces that are safe, healthy, and appealing. The research on color's impact

on the workplace highlights how crucial it is to consider how color and spatial elements interact to influence workers' mood, creativity, and output. Developing a better understanding of these synergistic effects might aid workplace designers in enhancing worker productivity and wellbeing. To improve the spatial aspects of work settings, color is essential, and vice versa. According to Cho & Suh (2020) color combinations can elicit various emotional reactions, which can affect how luxurious a room is viewed and how long one wants to stay in it. By putting into practice, a system that uses color psychology tests to assess employees' behavior psychology and color profiles, working behavior may be optimized based on physiological and psychological changes, which will improve job creation, stability, and company image (Jiang et al., 2022). When choosing colors to improve the physical environment, designers should also consider the unique characteristics of a location, such as its history, tradition, and culture. This will help to preserve and modernize traditions and practices (Zennaro, 2016). By understanding these insights, organizations can strategically use color to create work environments that positively influence employees' emotions, behaviors, and overall well-being.

2.2.7 Lighting and color (as important area to enhance color design in workplace)

The state of the workstation is determined by several environmental elements, including as humidity, sound, light, and radiant surface temperature of the fixtures. Although this is not a comprehensive list, previous studies have shown a strong correlation between these elements and the stress they cause to workers (Van Der Valk et al., 2015). Considerable research should be done on light and color as components of the larger, more intricate system that constitutes a healthy building, as they may help create a more upbeat atmosphere (Küller et al., 2006). When the results from four distinct countries—Saudi Arabia, Argentina, Sweden, and the UK—with varying latitudes were combined, it became clear that the light and color of the workplace itself also affected the employees' moods (Küller et al., 2006). When the illumination was perceived as being excessively dim, the employees' mood was at its lowest. (Küller et al., 2006). When the illumination was perceived as being exactly right, the mood then improved and reached its peak; however, when it became too

bright, the mood fell once more. (Küller et al., 2006). However, objective measurements of illuminance at any time of year revealed no discernible effect on mood. (Küller et al., 2006). There was a bimodal association between mood and the distance to the nearest window (Küller et al., 2006). The results also imply that the application of successful color design may promote a more positive outlook. (Küller et al., 2006). It is recommended that further research be done on light and color as parts of the complex system that makes up a healthy building. (Küller et al., 2006).

It has been observed that blue walls with lighting of 300–350 lux lower employee blood pressure, heart rate, and psychological stress (Ruwana et al., 2020). Hoonhout et al. (2009) investigates whether the effects of various light hues, like those of coffee, can affect variables like alertness, mood, and productivity. Hoonhout et al. (2009) explores how employing colored lighting as a tool might improve worker performance and the work environment. Previous research has indicated that the utilization of colorful walls in offices can enhance productivity; nevertheless, the study found no significant effect of colored illumination on task performance (Hoonhout et al., 2009). The results of an experiment by Shahidi et al. (2021) demonstrated that color has a significant influence on a number of visual perception parameters, as well as mood and anxiety, with linked color temperatures having some effect on these variables. However, the hue of the interior surface of the space determines whether warm or cool light is preferred. According to Shahidi et al. (2021), the experiment's conclusion is that people's mood and visual comfort in the workplace are better when white and warm light or blue and cool light are combined.

2.2.8 Color and environment connection to biophilic design

The design concept known as "biophilic design" prioritizes the use of natural materials and encourages the creation of healing spaces (Gillis & Gatersleben, 2015). Colors have an impact on human perception and behavior; blue and green spaces are particularly beneficial to wellbeing (Heath et al., 2022). Furthermore, introducing different amounts of indoor plants to a workspace can increase productivity, reduce stress, and enhance workplace happiness, all of which will help employees feel more content and relaxed (Elbertse & Steenbekkers, 2023). Interventions that emphasize plant-based lifestyles and Blue Zones knowledge highlight the importance of holistic

approaches to employee health in work situations. Stress reduction and improved sleep quality are two benefits of these therapies that can enhance mental wellbeing (Burke et al., 2023). Watching videos of natural settings has also been shown to increase good affect (Ulrich et al., 1991). But when looking at images of natural settings, no such mood boosts were noticed (Berman, 2008). Even if focused attention is limited in humans, research has shown that exposure to natural environments can promote cognitive restoration (Berman, 2008). Furthermore, research has shown that people prefer the cheerful and tranquil colors blue and green (Guilford & Smith, 1959; Mahnke, 1996; Wexner, 1954). Research from various studies highlights the restorative effects of different environmental types on cognitive functioning. It has been demonstrated that exposure to green infrastructure improves cognitive repair, especially in terms of focused attention and decreased cognitive effort (Fu & Xue, 2023). Seeing genuine or digitally presented nature scenery has been repeatedly associated with a stronger restoration of working memory capacity than either urban or no landscape at all (Van Oordt et al., 2022).

    2.2.9 Utilization of technology of VR and AR

    By utilizing color psychology concepts, virtual reality (VR) and augmented reality (AR) have found major uses in spatial design, especially in office situations. Using virtual reality technology, color palettes in interior spaces have been analyzed for their emotional impact. This has allowed architects to establish a correlation between color ranges and users' emotional reactions and overall appreciation of the place (Deng & Wu, 2023Furthermore, real-time generation of curved and line surfaces utilizing virtual brushes and palettes is made possible by VR applications in spatial painting systems, which improves workspace design (Novak-Marcincin & Janak, 2013). Additionally, AR systems have been used in a number of industrial sectors, like as manufacturing and aeronautics, by combining virtual and actual surroundings in a reciprocal manner to provide powerful and natural human-computer interactions (Ko et al., 2019). By utilizing color psychology to create immersive and emotionally engaging settings, these technologies are revolutionizing spatial design in workplaces. There are several uses for virtual reality (VR) and augmented reality (AR) in color psychology in the workplace. Furthermore, immersive worlds with

color designs that affect mood and productivity in work situations can be created via VR/AR systems (Mehra et al., 2020). Through the integration of virtual reality technology and psychological counseling, people can partake in color-based therapies aimed at improving their overall well-being and lowering workplace stress (Liu, 2023). Additionally, based on the user's current mood and heartbeat detection, VR function glasses with color projection panels and music can be employed for psychological pacification, offering a practical and scientific solution to controlling psychological states in work situations (Novak-Marcincin & Janak, 2013).

2.2.10 The studied color in color psychology

Blue and green were consistently and in most studies the most favored colors out of the eighteen research that looked at color priority (Amani et al., 2020). However, color preference is not universal (Taylor et al., 2013). Age, gender, and cultural factors all have an impact on color preference. (Park & Guerin, 2002); (Sorokowski et al., 2014). Moreover, experience and background also influence one's choice of color. (Baniani & Yamamoto, 2014). Employees favor working in a predominantly white setting. (Kwallek & Lewis, 1990); (Kwallek et al., 1996). The most calming colors are blue, blue-green, green, red-purple, purple, and purple-blue, whereas the most stimulating colors are green-yellow. Saturation and brightness also have a significant impact on moods (Valdez & Mehrabian, 1994). While yellow and white are more frequently linked to positive emotions and emotion-laden phrases, respectively, red is typically associated with negative emotions and emotion-laden words (Sutton & Altarriba, 2015). Emotions are strongly influenced by colors, and hue, saturation, and brightness all play important roles in evoking different emotions. According to Valdez and Mehrabian (1994), the most calming colors are blue, blue-green, green, red-purple, purple, and purple-blue. Saturation and brightness also have a significant emotional impact. Wilms and Oberfeld (2017) further emphasize that saturated and bright colors are associated with higher arousal levels, while the hue also affects arousal, increasing from blue and green to red. Additionally, the interaction of hue, saturation, and brightness dimensions plays a vital role in emotional responses to colors. Additionally, Kaya and Epps (2004) discovered that distinct hues stimulate diverse emotional reactions. For example, green, because of its

association with nature, evokes feelings of comfort and relaxation, but green-yellow is associated to negative emotions like disgust and sickness. Creating surroundings that elicit desirable emotional reactions can be made easier by having an understanding of these color-emotion correlations. There are substantial differences in the preferred colors for different types of locations, gender, age, education, and personality types. White is the most common hue for living rooms and work environments. (Van Der Voordt et al., 2017). In contrast to a white office setting, which is more distracting and where females do better on proofreading chores, a red office setting lowers errors and increases efficiency (Kwallek & Lewis, 1990). Comparing red and blue meeting rooms to reference rooms, there are no discernible changes in terms of productivity, social cohesiveness, or perceived well-being (Bakker et al., 2013). Individuals often have unique color preferences (black, pink, and yellow), with gender and age having a minor impact on these choices (Kodžoman et al., 2021). Putra et al., (2023) emphasizes the intended effect of yellow on employee performance and stresses the significance of choosing colors carefully to increase productivity. Studies conducted across cultural boundaries show that the colors red, blue, and green are linked to pleasant emotions, black and gray to negative emotions, and brightness to both positive and negative potency (Adams & Osgood, 1973). White, red, and blue-green office interior colors can all affect employee productivity, depending on the stimulus screening capacity of the individual and the length of time they are exposed to the hues (Kwallek et al., 2007).

2.2.11 Contradicting finding about color psychology in work environment

According to Olsen (2010) there were no observed interactions between valence and color. The background's hue had no bearing on the cognitive task. The hue had no bearing on how well the assignment was completed. The study demonstrates that when a person's attention is divided, the likelihood of remembering something drops (Olsen, 2010). After that, individuals are less likely to recall having previously seen a word. The results call into question the idea that color strongly influences cognitive task performance (Olsen, 2010). Research on the impact of color on cognitive function in the workplace has yielded mixed results. While Mehta & Zhu (2009) proposed that blue computer monitors can improve creative work while red

might improve detail-oriented jobs, Hatta et al. (2002) discovered that both red and blue computer monitors can have negative effects on visual task performance. Ru et.al. (2019) discovered that although the impact of color temperature was less evident, high illumination levels can enhance mood and performance. Caschera (2015) found no discernible change in participants' performance who were exposed to green or red ink. These studies highlight the complexity of the relationship between color and cognitive function, and the need for further research in this area.

2.1.12 The potential of color to enhance brand identity and company culture and it influence on employee in office design

Studies have repeatedly demonstrated the powerful effects of color on happiness, health, and productivity at work (Savavibool, 2016). This influence also extends to corporate branding, where color is essential in establishing brand awareness and image (Chang & Lin, 2010). The utilization of color in office design is essential for improving business culture, brand identification, and staff performance. Color plays a crucial role in brand identification, supporting both visual communication and brand image (Caivan & Lopez, 2007). The colors used in a workplace can influence human behavior and perception in addition to contributing to aesthetic qualities and branding (Smollan & Morrison, 2019). Research shows that office buildings' color schemes should take workers' demands and productivity into account, however this is an area where knowledge is lacking (Cheung & Zhang, 2020). Additionally, how offices are designed, particularly color schemes, affects how creatively individuals can work in conjunction with personal characteristics like diversity ideologies and intrinsic motivation (Kamaruzzaman & Zawawi, 2010). In the end, a thoughtful and collaborative approach to redesigning office spaces can result in favorable opinions of the working environment, encouraging candid communication, teamwork, and inclusivity among staff members.

2.1.13 The role of color in wayfinding and zoning

In the settings of architecture and interior design, color is vital for navigation and zoning. The application of color elements can aid in the creation of distinctive zones within a space, improving both its aesthetics and functionality while serving as visual cues for various locations and activities (Yi & Jeon, 2022). Moreover, color

conspicuity should always take precedence over harmony when developing signage for navigation to guarantee clear visibility and usability—especially in a variety of environmental contexts. (Jansen-Osmann & Wiedenbauer, 2004). In general, color is an effective tool in architectural and interior design that helps people navigate around spaces, identify distinct regions, and improve their overall experience. When it comes to improving navigation and zoning in workplace design, color is important. Architectural spaces become more readable and user-friendly when color is used to highlight key layout elements and landmarks. (Rangel & Mont'Alvão, 2011). Users can more easily identify different areas and their objectives in an office setting by applying diverse colors to different regions, which also helps create zoning and functions (Tsaqif & Hanafiah, 2020). Moreover, color can act as a landmark and convey important architectural details that affect people's choices when they are navigating (Chen, 2012). The employment of color in the signaling system in public healthcare facilities can enhance patients' comfort and mental health, which benefits their general well-being (Coughlan & Manduchi, 2007). All things considered, the deliberate use of color in office design improves not just aesthetics but also has a big impact on zoning, navigation, and user experience.

2.2.14 Color psychology in the digital workspace

A key component of UX design for digital workplaces is color psychology. Empirical studies reveal that deliberate selection of colors in user interfaces can have a noteworthy impact on user behavior, emotions, and perceptions (Huang, 2024). The effects of color on cognitive task performance depend on the nature of the task, with red being more beneficial for tasks requiring vigilant attention and blue being more beneficial for tasks requiring creativity and imagination. This was demonstrated in a research study by manipulating the computer screen's background between red and blue and neutral color while maintaining chroma and value constant (Mehta & Zhu, 2009). A study demonstrating that black backgrounds led to more negative interpretations of chat messages compared to white backgrounds shows how backdrop colors in user interfaces might affect sentiment perception (Löffler et al., 2017). The user-friendliness of interfaces and the improvement of knowledge management are directly related to the use of color in mobile design (Pelet & Uden, 2014).

2.3 Conclusion

The groundwork for interpreting the bibliometric results has been laid in this chapter. It gives a conceptual model to organize the study, highlights the theoretical foundations, lists knowledge gaps, and summarizes the current level of knowledge. To sum up, chapter 2 of this bibliometric analysis has given a thorough summary of the corpus of literature on workplace spatial design, with an emphasis on the use of color. Important research clusters, well-known authors, noteworthy publications, and important trends in this field have all been identified by the analysis. The results show that there is increasing interest in learning how color affects worker productivity, well-being, and the general work environment. Numerous facets have been investigated by researchers, such as the psychological impacts of various colors, the function of color in zoning and wayfinding, the relationship between lighting and color, the integration of color in workplace design, and the possibility of using color to improve company culture and brand identity. Additionally, this chapter has pointed out gaps in the literature and offered ideas for further investigation and study. Several empirical studies are needed to fill in these gaps, including ones that look at the long-term effects of color on workplace behavior, the cultural nuances of color perception in diverse workforces, and the potential uses of color in emerging technologies like virtual and augmented reality to enhance the workplace experience. All things considered, this chapter advances knowledge of the intricate connection between color, spatial design, and workplace dynamics. The knowledge gained from this study can help guide evidence-based design choices, resulting in the construction of workplaces that not only look good but also support the success of the company and the well-being of its employees.

CHAPTER 3
RESEARCH DESIGN AND MEDTHODOLOGY

The methodological strategy used to carry out a thorough bibliometric analysis of the literature on the application of color in spatial workplace design is described in this chapter. The goal of the study is to pinpoint important developments, well-known writers, significant works, and changing research topics in this area. The intellectual landscape can be mapped in a methodical and quantitative way using bibliometric tools, which also highlight linkages and trends that conventional literature studies could miss. Figure 3.1 bellow shows an overview of the methodical approach to reach the objective of the research.

Figure 3.1: Methodical approach to reach the objective of the research

3.1 Research Setup

The method used for this research paper is bibliometric analysis, a method of quantitative analysis that first coined by Alan Pritchard in 1969 (Pritchard, 1969). Herubel explained bibliometric as "a quantitative analysis of publication for the purpose of ascertain specific kinds of phenomenon" (Herubel, 1999).

3.1.1 Bibliometric analysis

Bibliometrics is a technique that examines patterns in bibliographies to analyze the literature of a chosen field using statistical and mathematical methodologies (Lawani, 1981). An institution's number of publications or citations produced is counted to analyze the discipline profile (Ellegaard & Wallin, 2015). An institution's research outputs may be approximated or proxied by bibliometrics (Melkers, 1993). James McKeen Cattell came up with the idea for bibliometrics in the

early 1900s (Godin, 2006). Cattell was driven by the need to evaluate psychologists based on their achievements (Cattell, 1903). Cattell (1903) used both quantity and quality as metrics for measuring performance while quality was meant to represent performance through peer assessment, quantity was meant to serve as a proxy for productivity as determined by counting the number of scientists. De Solla Price (1963) and Garfield et.al. (1964) were the first to create bibliometric indicators. Since 2000, the field of bibliometric analysis research has broadened to include text mining, which looks at a document's abstract and entire text (Porter et.al., 2002). A corpus of information can be analyzed using these analytical techniques, and the results can be beneficial for practitioners and scholars alike. They can assist researchers, for example, in mapping and characterizing their whole field of study (Börner et.al., 2003; Pei and Porter 2011; Porter, Kongthon, and Lui 2002; Porter and Youtie 2009). According to Porter and Detampel (1995) and Watts and Porter (1997), managers can gain from the analysis since the findings offer insight into market trends and ability development targets. In the domains of research, strategic management, and strategic planning, expanded text mining approaches like research profiling and tech mining are employed (Porter, 2007; Porter and Cunningham, 2004). Bibliometrics is the study of publication patterns using statistical techniques (McBurney and Novak, 2002). Bibliometric analyses are based on three basic principles: activity measurement, which counts publications, impact measurement, which counts citations of a publication after it has been published, and connecting measurement, which counts co-citations and keywords used from paper to paper (Kongthon & Porter, 2004). A bibliometric analysis's primary goal is to achieve a more comprehensive understanding from the "body" of literature as opposed to the constrained perspective that may be attained by analyzing individual works (Porter et.al., 2002). In the global context of related and surrounding subjects, bibliometric analysis can offer a macroscopic view of the entire field. Having a clear knowledge of the larger picture will enable someone to logically select a particular place to begin additional in-depth research (Kostoff et al. 2001). To extrapolate knowledge from a corpus of literature, bibliometric techniques are employed (Porter and Cunningham 2004). Moreover, it facilitates the communication of the advancement and transformation of knowledge

within a particular field (Daim et.al., 2005). Various researchers in different domains have used the technique of profiling the body of knowledge in a field. Examples include research profiling (Nerur et.al, 2008), modern science topics (Saka and Igami 2007), technology management (Pilkington, 2004; Porter & Cunningham, 2004), marketing (Baumgartner & Pieters, 2003), and mapping the development of the intellectual structure in operations management (Porter & Detampel, 1995).

3.2 Sampling and Data Collection

The SCOPUS database was used to find possible sources for this research paper. It is a popular database for building datasets for research systematic reviews (Zupic & Čater, 2015); (Mongeon & Paul-Hus, 2016). Book chapters, scholarly journals, and conference proceedings are all included in SCOPUS, the biggest abstract and citation database of peer-reviewed literature (Scopus, n.d). Compared to other scientific databases such as the Web of Science, SCOPUS has a broader coverage (Moingeon & Lehmann-Ortega, 2010). Making it a superior choice for a management research review (Falagas et.al., 2007). Additionally, compared to other databases like Google Scholars, handling the data exportation from SCOPUS is easier and better fits bibliometric tools (Zupic & Cater 2015). "It contains data for all authors in cited references, making author-based citation and co-citation analysis more accurate," is one benefit of using SCOPUS (Zupic & Cater 2015). Numerous research paper have also favored SCOPUS as the database for the bibliometric analysis of a specific research field (Hallinger & Suriyankietkaew, 2018); (White & McCain 1998); Gerdsri et.al. (2013); (Schaller & Vatananan-Thesenvitz, 2019); (Hallinger, 2020). According to Schiavi and Behr (2018), the selection of this database was warranted since SCOPUS has a significant influence on scholarly writing because it provides access to a vast array of journals and sources across a variety of subject areas (such as business management). Since a better level of quality control can be achieved, only journal articles and conference proceedings papers are used in this paper (Hallinger & Suriyankietkaew, 2018); (Gerdsri et.al., 2013). The subject area was limited to Social Sciences; Arts & Humanities; Material Science; Business, Management, & Accounting; Environmental Science; Psychology; Decision Sciences; Economic,

Econometrics, & Finance due to the topical focus of this research. Articles listed in the SCOPUS database were reviewed in alignment with the research questions and overall objective.

Keyword search on SCOPUS using boolean operators of "AND" and "OR" were combined into one search string to query the titles, keywords or abstracts: TITLE-ABS-KEY (color* OR colour*) AND TITLE-ABS-KEY ("spatial design*" OR placemaking OR "environmental design*" OR "architectural design*" OR "interior design*" OR "interior decoration*" OR "experiential design*" OR "emotional design*" OR "sensory design*" OR "environmental psycholog*" OR "environment and behavio*" OR "industrial psycholog*" OR "organi?ational psycholog*" OR "occupational psycholog*" . This resulted in 2037 document found. Limited to 8 Subject areas (Social Sciences; Arts & Humanities; Material Science; Business, Management, & Accounting; Environmental Science; Psychology; Decision Sciences; Economic, Econometrics, & Finance): 1,143 documents. Limited to Document type (article and conference paper); Source type (journal and conference proceedings); Language (English): 808 documents. The time frame of the data set is from 1925 to 2024

3.2.1 Data Extraction

In order to use the dataset extracted from SCOPUS for the bibliometric analysis, the data as a .bib (BibTeX Bibliographical Database) file were downloaded. The extracted data comprised the author's name, author affiliation, article title, keywords, abstracts, and multiple citation data. The .bib file format is used with Bibliometrix (R Studio).

Figure 3.2: PRISMA flow diagram detailing steps in identification and screening of sources
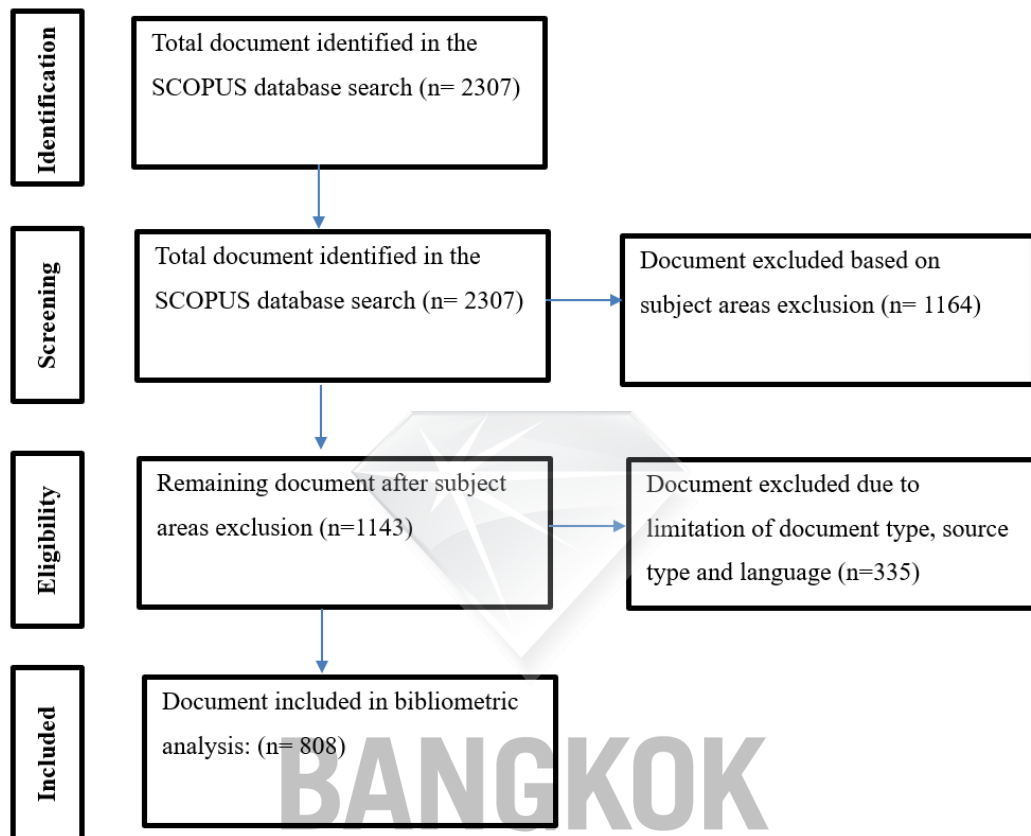
To better interpret and visualize the data a process of removing noise was done which utilize the filter function in R studio to remove words and combine synonym when analyzing the keywords in the data base. In R studio, a list of bigram keyword of the most frequent keyword function from the title of each article from the data base were downloaded. Each keyword in the list were classified in 5 categories of trend, method, application, technology and others regarding the topic spatial design in workplace. This bibliometric analysis only focuses on the trend, application and technology. Hence a remove file as a .csv (comma delaminated) consisted of the keywords about methods and others category were created. The result of keywords categorization revealed keywords that has similar meaning which were grouped together in relevant with the research topic. This allows the creation of a synonym list to input in the filtering function in R studio.

3.3 Research Methods

From using the bibliometric approach this research paper will focus only on quantitative approach. This is done through interpretation of output from R studio software from bibliographic metadata (titles, abstracts, authors, keywords, citations…) from databases for the 808 SCOPUS documents pertaining to spatial design in the workplace, with a focus on the use of color. Employing Bibliometrix package in R studio to standardize data, remove duplicates, and handle inconsistencies in the data set.

3.4 Data Analysis Overview

The data analyses in this review relied on descriptive statistics and bibliometric analysis. The base feature of the body of literature such as volume, development, and geographical distribution was documented with the help of descriptive analyses, which was conducted partly in Bibliometrix (R Studio). The following bibliometric analysis were performed from using R studio (see table 2.1):

Table 3.1: Description of analysis methods regarding RQs

Type of analysis	Description of analysis types from R studio (Bibliometrix)
Thematic Map Evolution	Visualizes the evolution of research themes over time.
Co-Citation Network	Reveals relationships between publications based on how often they are cited together.
Most Impactful Journal (Based on H-Index)	Identifies journals with the highest impact within a field based on h index.
Three-Field Plot (Country – Keywords – Sources)	Illustrates the relationship between countries, keywords, and publication sources.
Country Production	Shows the quantity of publications produced by different countries
Thematic Map	Presents a visual overview of the main themes or topics within a field.
Keywords Title Bigram Analysis Using Tree Map	Explores the most frequent combinations of two keywords in publication titles.
Country Collaboration Network	Displays collaborations between researchers from different countries.
Co-occurrence network	Display how frequently specific keywords or terms appear together across the literature.
Most Relevant Affiliations	Pinpoints the institutions that are the most active and influential in a particular research field.

CHAPTER 4
RESULTS

The extracted dataset from SCOPUS contains 808 articles from 397 journals published between 1925 and 2024. Overall, the extracted articles were published by over 2063 different authors, of which only 224 documents were single authored. The results of the bibliometric analysis based on this dataset are presented according to the foci of the four research questions. The research questions will be each answered independently, starting with RQ1 in section 4.1, RQ2 in section 4.2, RQ3 in section 4.3, and RQ4 in the last Section 4.4 RQ5 in section 4.5 RQ6 in section in section 4.6. RQ7 in section 4.7.

1. What are the predominate research themes surrounding spatial design within the academic literature?

2.What are the potential areas about color psychology that need more development to further develop the field?

2.1. What are the trends in spatial design about color psychology and workplace design?

3.What is the most important journal if one wants to investigate how to improve the workspace using color?

4.How has Thailand progressed regarding the whole spatial design and the specific topic of office color design? And who are the expert?

5.How has the topic evolved overtime?

6.What are the top universities that are doing research about the topic spatial design in workplace using color?

7.What are the countries that have worked on the topic and how has other countries collaborated with each other regarding the top?

4.1 The predominate research themes surrounding spatial design within the academic literature.

Result from co-citation network analysis reveals relationships between publications based on how often they are cited together allow us to have interesting result on the predominate theme that are shared throughout the whole dataset. Each nodes represent a cited document. The size of the node represents how many time that documents is mentioned in the whole data set. The distance between each node represent how often does each node get cited together with the closer the node the more frequented the two documents are getting cited together. The color of each node determines the theme of each node which form a cluster.

Figure 4.1: Co-citation network diagram

Figure 4.2: Co-citation network diagram heatmap density

From figure 4.1, the red cluster has the most co citation authors. In the red cluster, we can see Plass J.L. 2014 -1 is the most mentioned authors. His paper of that time in 2014 was about how color affects the emotion in multimedia learning (Plass, 2014). His research at the time was relevant color psychology but the context that he done his research is about multimedia learning which is not about the workplace. Other paper in the same cluster as Plass J.L. 2014 -1 also work on the same topic about the learning environment. Upon research on Plass J.L. historical works on Google Scholar, Plass J.L. mostly work on the topic about learning environments making him the expert in the field of education but not in the work environment. The blue cluster that is connected by Mayer to Plass's studies also look at learning and the influence of color on learning with example of Munchow h. 2017 study about how warm color affect learning in multimedia learning (Munchow, 2017). Mayer r.e. 2005 can be seen connecting two field of research of red and blue cluster with Mayer r e . 2005 research about cognitive theory for multimedia learning. From this, we can conclude that majority of the citation is from learning journal field this mean spatial design is focus on the learning and education from student not workplace which shown the potential to looking into workplace design with color psychology application.

4.2 The potential area about color psychology that need more development to further progress the field

Figure 4.3: Co-occurrence network result of the title using the bigram
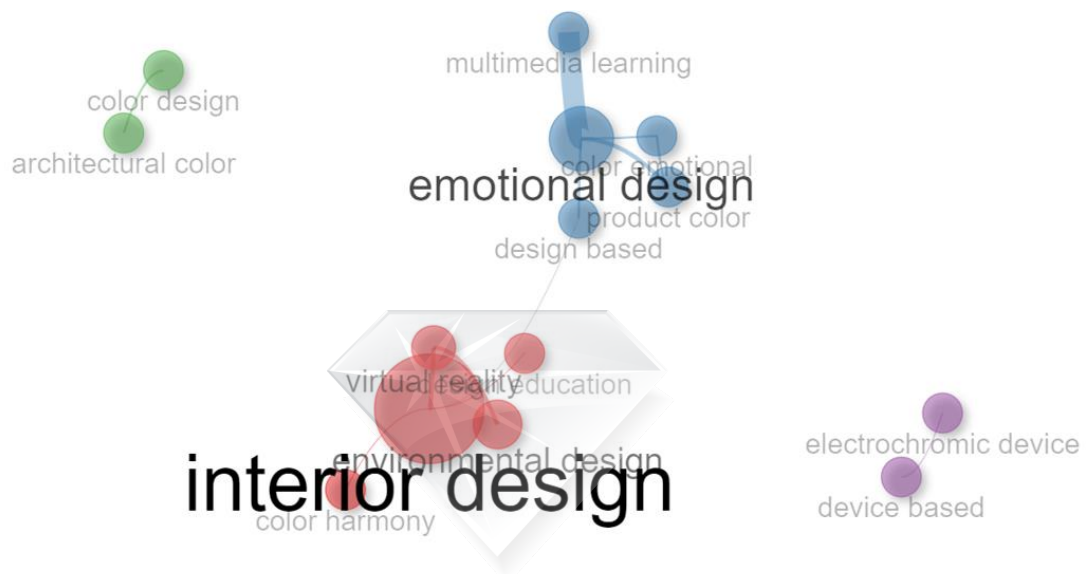
Result from co-occurrence network reveal how frequently specific keywords or terms appear together across the literature. Links and nodes serve as a representation of the relationships between words. The size of the nodes, which stand in for the keywords, is correlated with how frequently those keywords occur in the documents; a higher size indicates a higher frequency of appearance (and vice versa). The relationships between two nodes are represented by links, or edges. The width of the link indicates the strength of the relationship; a wider link indicates a stronger relationship.

From co-occurrence network of the title using the bigram which visualizes relationships between keywords based on how often they appear together in documents, we can see 4 distinctive cluster. The purple cluster is concern about device research rather than device application, the red cluster look at the interior design and the surrounding aspect and application of VR, the blue cluster looks at emotional design for multimedia learning with concern on how color affect the emotion, which is a common connecting with interior design, the green cluster do also

look at color but color design for architectural (see figure 4.3). From this, you can see color design and color architectural does not have any connections with inferior design and emotion design this open potential for study to connect the three cluster together.

4.2.1 The trend in spatial design about color psychology and workplace design

Figure 4.4: The thematic evolution network from 2008 to 2023
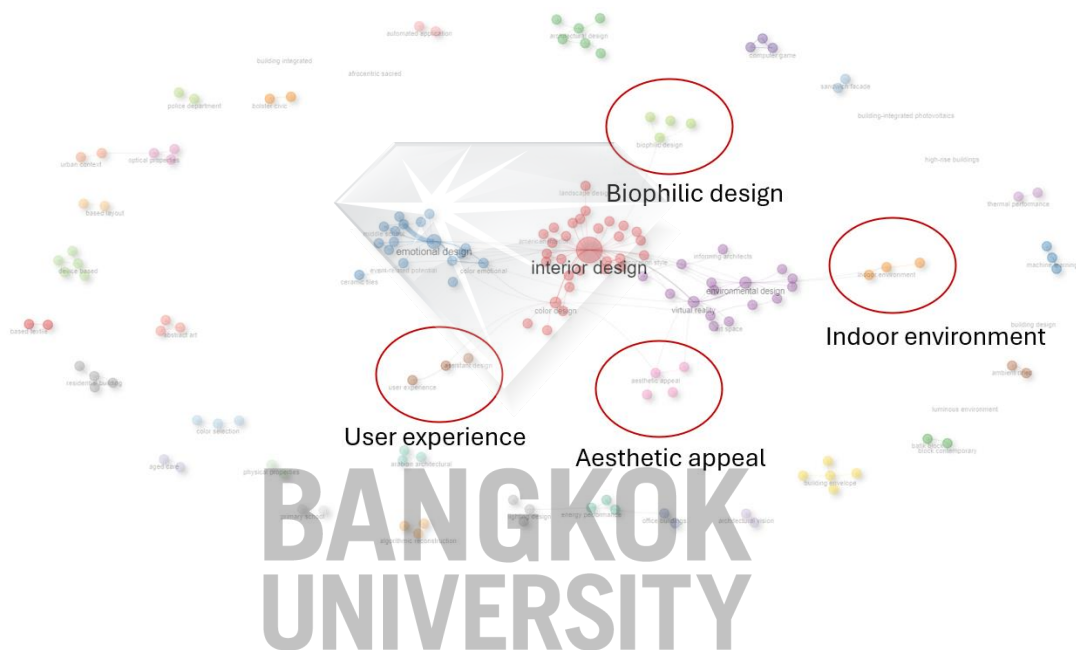
The thematic evolution network from 2008 to 2023, the period has the most research done about the topic of 78% of the data set is shown 4 under research areas that are connected to the main topic of interior design and highly relevant to spatial design for workplace which are: biophilic design (green cluster), user experience (brown cluster), in door environment (orange cluster) and aesthetics design (pink cluster) (see figure 4.4). These 4 areas should be explored more to expand the topic as this allow for exploring under searched area that still relevant to the main industry. Biophilic design, which focuses on integrating natural elements into indoor spaces, is a highly relevant trend in workplace design (Aristizabal et al., 2021). This approach has been shown to reduce stress, enhance creativity, and improve overall well-being (Aristizabal et al., 2021). The use of color is crucial in biophilic design, with natural hues like greens, blues, and earth tones being employed to evoke nature and create a

calming and restorative environment (Tekin & Gutiérrez, 2023). Color can also be used to simulate natural light, mimic organic patterns, or highlight natural materials (Isapour & Lattuada, 2018). Aesthetic design, with its focus on creating visually pleasing and harmonious spaces, plays a crucial role in workplace environments. Research has shown that aesthetics can significantly impact employee morale, engagement, and productivity (Dutton, 2003). A fundamental tool in aesthetic design is color, which can be used to set the mood and atmosphere of a workspace (Kwallek et al., 1996). Warm colors like reds and oranges have been associated with energy and excitement, while cool colors like blues and greens are linked to tranquility and focus (Lakshmi, 2023). Furthermore, color can be strategically employed to delineate zones, highlight architectural features, or create a brand identity (Foroudi et al., 2019). UX design, with its focus on the needs and experiences of users, is increasingly important in workplace design. This involves considering how employees will interact with and navigate their environment (Cobaleda-Cordero & Babapour, 2021). Color, as a key element of UX design, can guide wayfinding, enhance visibility, and create visual hierarchy (Siyanbola et al., 2023). Research has shown that the strategic use of color can also evoke specific emotions, improve accessibility, reduce visual fatigue, and create a more intuitive and enjoyable workspace (Lottridge et al., 2011). Indoor environmental design, which focuses on creating healthy and comfortable indoor environments, is crucial in workplace settings. This includes factors like air quality, lighting, acoustics, and thermal comfort, all of which significantly impact employee well-being and productivity (Sundstrom, 1986). Color plays a significant role in indoor environmental design, as it can be used to manipulate the perception of light and space, influencing the overall ambiance of a workplace (Berman et al., 2008). Research suggests that light colors can make a space feel larger and airier (Mehta & Zhu, 2009), while dark colors can create a sense of intimacy and warmth (Oberfeld et al., 2010). Moreover, color can be strategically employed to control glare, enhance natural light, and create a visually stimulating environment (Veitch, 2001). The integration of these four trends through the strategic use of color in spatial design has the potential to transform workplaces into environments that are not only aesthetically

pleasing but also conducive to productivity, well-being, and overall employee
satisfaction.

**4.3 The most important journal if one wants to look into how to improve the
workspace using color**

Figure 4.5: Ranking result of most impactful journal sources by h-index
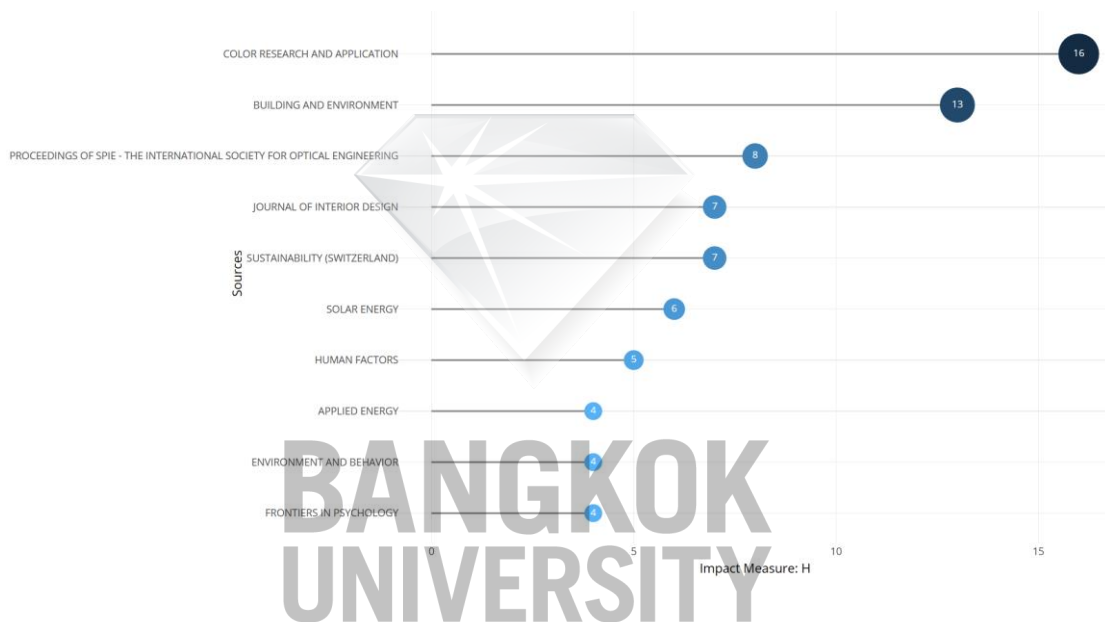
Figure 4.5 show the output of most impactful journal sources by h-index
ranking. According to Svider et al. (2012), the h-index is an objective metric that is
used to assess the significance and volume of a single author's scientific contributions.
According to Rad et al. (2010), the h index is a useful metric for evaluating the
influence of an author's publications and is strongly correlated with academic rank.
When look at the H index of most impactful journal, journal of color research and
application has the most impact. Journal of color research and application is a color
science journal publishing high quality peer-reviewed research on the science,
technology, and application of color in multiple disciplines. Building and
environment journal come second. Building and environment journal is about
building science and its applications. The third position is from proceeding of SPIE

journal which is about the science and application of light and light-based technologies. We can see that the topmost impactful journal make sense for a list of journals to research about spatial design and color. For example, when doing research about the topic spatial design and color, you first want to see what and how of applying color then you need to look how color can be incorporated in building and environment and lastly you can look at what technology can help you application of color in spatial design.

Figure 4.6: Three field plot between country – keywords – sources showing journal of color research and application has the most keywords connection
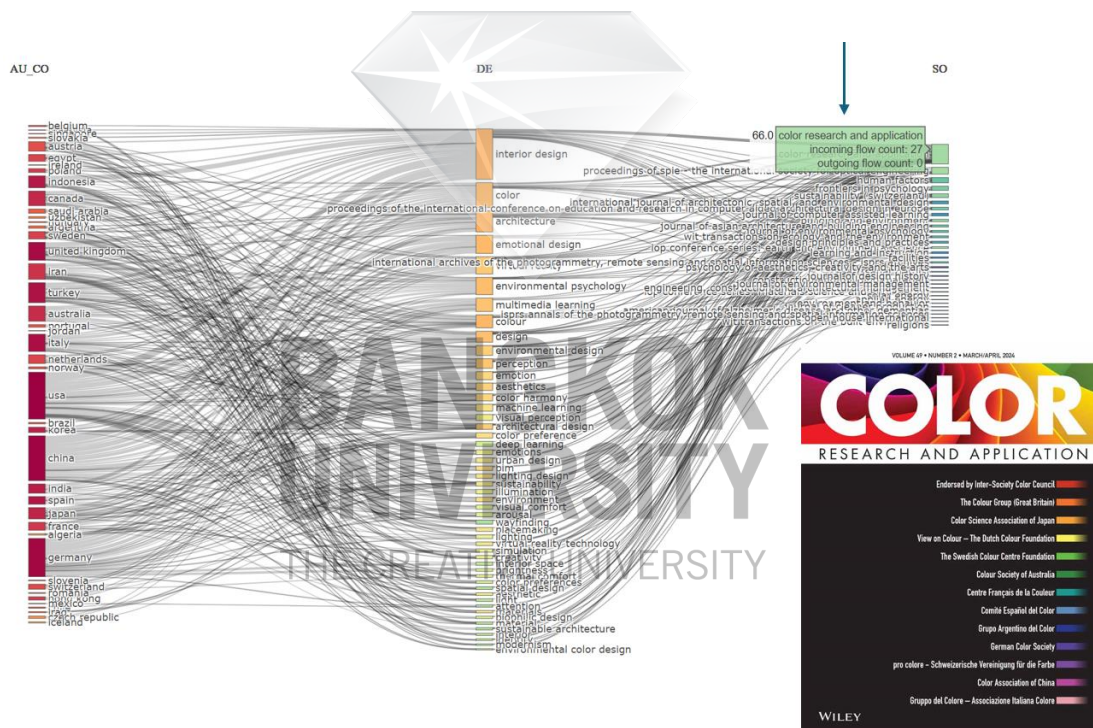
To further support that color research and application journal should be first to look at, from the three-field plot analysis, color research and application journal has the strongest representation of sources, with 27 out of 50 title keywords connected to it (see figure 4.6). This means this journal cover a while range of material about spatial design using color.

4.4 How has Thailand progressed regarding the whole spatial design and the specific topic of office color design? And who are the expert?

From the data set of 808 documents, Thailand has 3 articles about spatial design, however only 1 article addressed the workplace design and colors which is from Nattha Savavibool. Her paper, "The Effects of Colour in Work Environment: A systematic reviews" examines the existing research on how colors in the workplace affect workers' mood, well-being, and overall work performance. Savaviobool (2016) claim that workplace color significantly influences mood, wellbeing, and performance, with potential implications for productivity, performance, and creativity. Savaviobool (2016)'s systematic review provides valuable insights into the potential of color to influence the workplace experience. While there is evidence of a significant impact, more research is needed to explore the specific mechanisms and to develop tailored color strategies for different work environments and tasks.

Nattha Savavibool is a researcher with a focus on environmental psychology and interior design. Her work delves into the impact of the built environment on human perception and behavior, with a specific interest in how color influences workplace dynamics. Savavibool's research in color psychology is specifically focused on its practical applications within workplace environments. Through a comprehensive systematic review, she has synthesized existing research on the effects of color in the workplace, highlighting its significant impact on various aspects of employee well-being and performance. This review underscores the profound influence that color can have on mood, overall well-being, and work productivity, while also acknowledging the complexity of these relationships and the need for further investigation. In addition to the systematic review, Savavibool has conducted experimental studies exploring the intricate ways in which color interacts with other spatial factors like area and height, and how these interactions influence individuals' perception of space. These studies contribute to a more nuanced understanding of how color can be strategically and purposefully utilized in the design of workspaces. A consistent theme throughout Savavibool's research is her keen interest in bridging the gap between theoretical knowledge and practical applications. Her findings offer valuable insights that can be directly implemented by designers and employers to

create work environments that foster a positive atmosphere, enhance employee well-being, and boost productivity through the intentional and informed use of color. While specific details about Savavibool's personal experiences with color in the workplace might not be publicly available, her research contributions clearly establish her as an expert in this field. Her work provides valuable insights for anyone interested in leveraging the power of color to create more positive and productive work environments.

4.5 Countries collaboration with each other regarding the topic?

Figure 4.7: The collaboration network between countries that publish about the topic

Looking at countries collaboration, you can see strong collaboration between China and the rest of the world with very strong collaborations between China and US also a lot of branches be between China and others neighboring nations like China – Korea, China – Japan, and China – Malaysia. There are also some collaboration in the middle east there like Turkey and Spain but not as strong as collaboration between China and the US. Some of the European countries like Italia, Germany, Switzerland, France and Belgium that are neighboring to each other of also collaborate on publication. Indian Iran also has some collaborations. For the US, aside from China US also collaborating with Canada the most. US also work with others European

countries like Italia, Germany, UK and Austria. We can see many countries neighboring to each other tend to collaborate on publication. When looking at the Southeast Asia side of the map, there are publication in ASEAN country but no collaboration between ASEAN countries. This show potential for future collaboration between ASEAN country to further expand their publication. Despite a small subject many countries that are neighbor do collaborate with each other. However, while do having publication, ASEAN country even neighboring to each other don't do so. This could be potential areas for future collaboration to expand on the topic.

4.6 The top universities that are doing research about spatial design using color

Figure 4.8: Ranking result of most relevance affiliations base on numbers of articles published
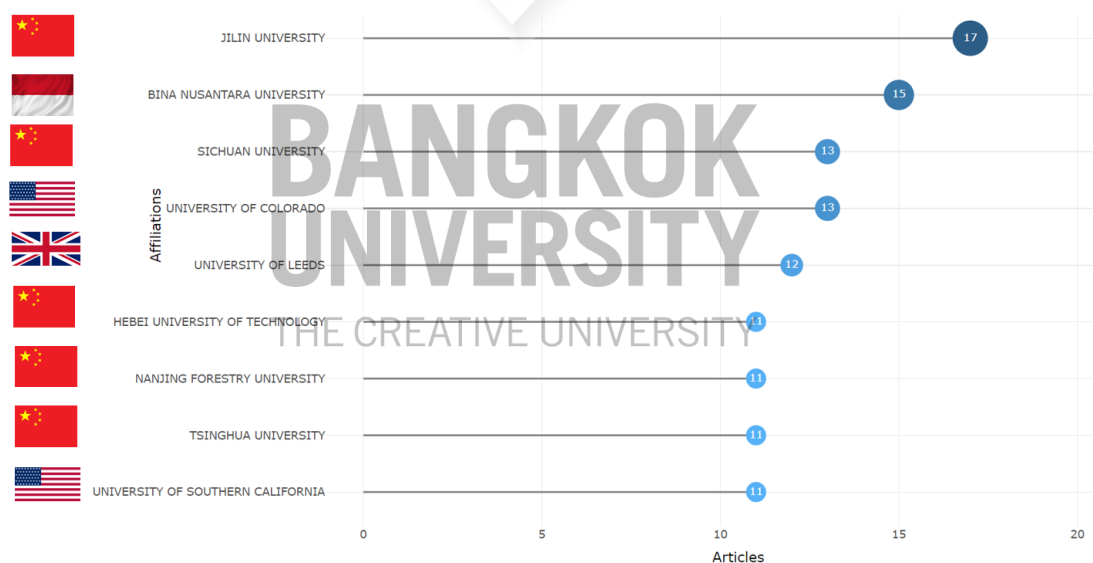
From figure 4.8, we can see that the top university that produce the most about the topic is Jilin University from China with 17 publications. Bina Nusantara University from Indonesia come second with 15 publications. At third place, we have 2 universities with 13 publication each about the topic which are Sichuan university from China and university of Colorado from the US. University of Leeds from UK

takes the fourth place with 12 publications. Fifth place belongs to 4 universities with 11 publication each which are Hebei university of technology from China, Nanjing forestry university from China, Tsingua university from China and university of southern California from US. Most of the university that researching about the topic is from China. Bina Nusantara university from Indonesia is the only university in ASEAN to be in the top 10 universities that is producing publication about the topic spatial design using color. With rank number 2 and having the top publication rivaling US and China, Bina Nusantara university from Indonesia is the only university in ASEAN to be in the top 10 universities that is producing publication about the topic spatial design using color. This can be the place for other ASEAN countries like Thailand to start collaboration for future research about the topic for geographical convenient and culture similarity.

4.7 The topic evolution over time

Figure 4.9: Annual scientific production output

Figure 4.10: Country production over time output
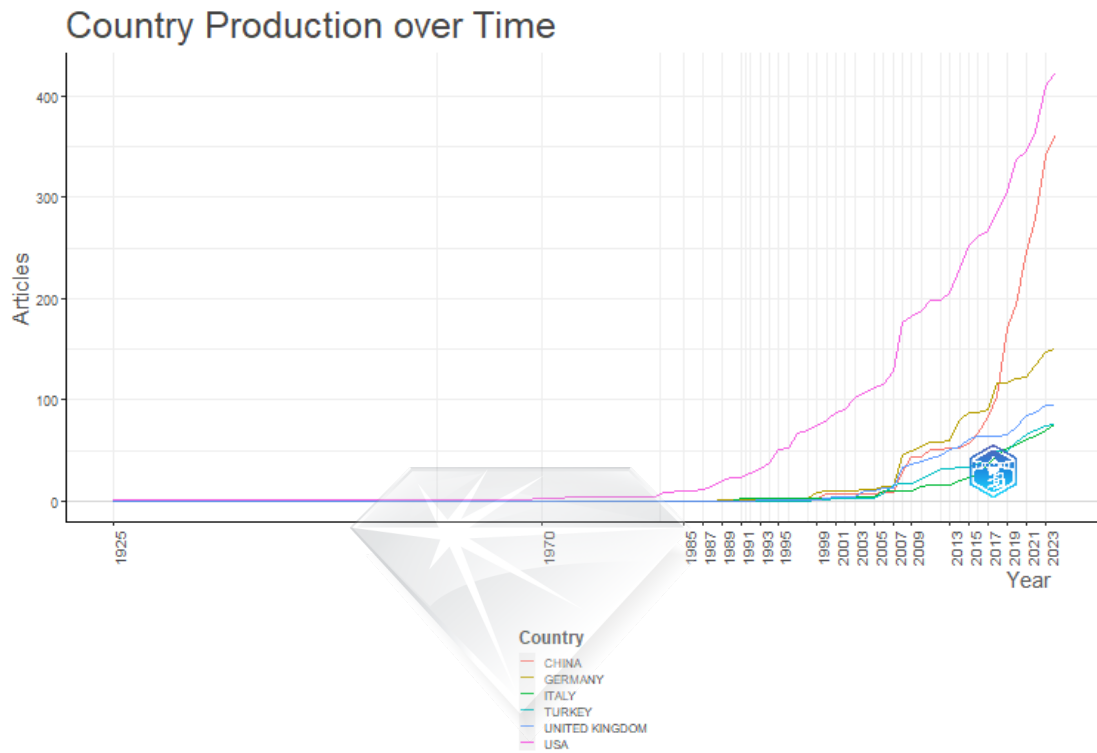
The annual scientific productions show three major peaks in 2001 with 31 documents, 2008 with 45 document and in 2023 with 83 documents in a year. It was not until the year 2000 the publication about the topic reach 10 articles in a year. Looking up the country production, The USA start off research since 1925, with no competition till the late 1990s, countries like Germany, China, and Italy began to catch up. The graph shows an exponential growth trend between 2007 and 2008 for the US, Germany, United Kingdom, and China in spatial design and color affecting human behaviors. This trend seem is not currently due to the financial crisis, but rather to the advancements in these countries.

Figure 4.11: Most relevance sources output from 2007 to 2008
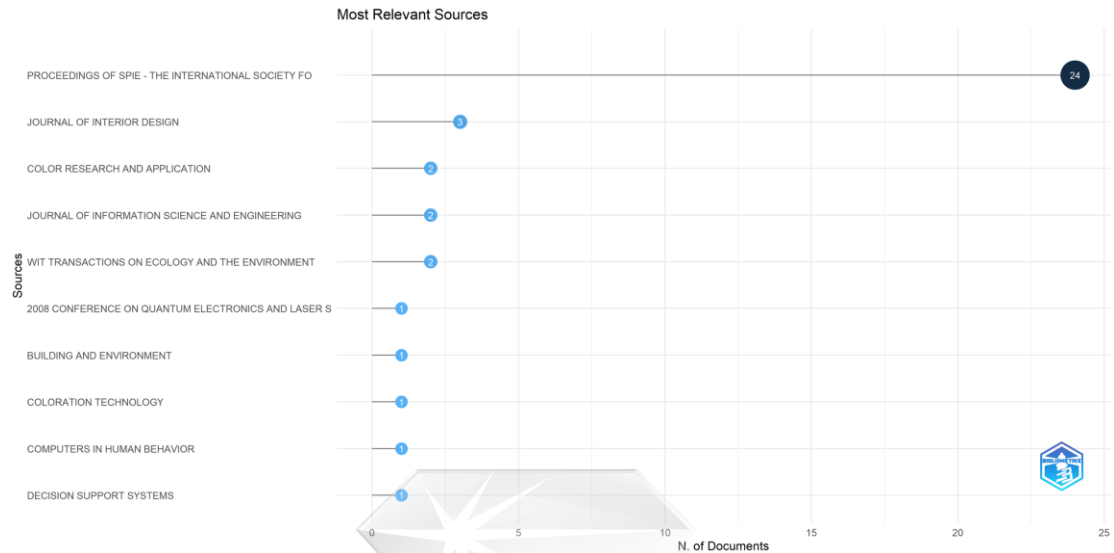
To some what explain the growth of publication using the exiting data set, when looking at the most relevant sources from 2007 to 2008, proceeding of SPIE take the top position in term of publication with 24 documents while others journal at time only has 1 or 2 or 3 documents at most. When look the most cited document of that time, we have 1 document from Human Factors and Ergonomics in Manufacturing & Service Industries journal that look at how office environment can stimulate manager creativity (Ceylan et al., 2008). The remaining two articles are from proceeding of SPIE journal with one document look at the color spectrum (Fairchild, 2008) and one document look at estimation of printer color (McElvain et al., 2008).

Figure 4.12: Tree map of bigram title keywords from 1925 to 1999

The tree map analysis of title keywords in spatial design research from 1925 to 2024 reveals a dynamic and multifaceted evolution of focus areas within the field. In the early stages of research, from 1925 to 1999, the primary concerns were centered on color design and the utilization of concrete as a construction material, with no mention of emerging technologies. This indicates a foundational emphasis on the aesthetic and structural aspects of spatial design. Some of the notable publications of this period was:

"Professional Viewpoints of Competencies for Interior Design Entry–Level Positions" (Hernecheck et al., 1983).

"The continuity of colour, design, art, and science. I. The philosophy of the total appearance concept and image measurement" (Hutchings, 1995).

Figure 4.13: Tree map of bigram title keywords from 1999 to 2001

The first peak period, spanning from 1999 to 2001, saw a continuation of interest in precast concrete and color design, highlighting the enduring relevance of these early concerns. However, this period also marked the emergence of advertising as a standout application of spatial design principles, suggesting a growing recognition of the field's potential to influence consumer behavior and brand perception. Some of the notable publications of this period was:

"What color is the red house? An invitation for multicultural research on color and architecture" (Anter, 2002).

"RED or READ: the built environment is colored" (Smith, 2002).

"Aesthetic and commercial value of color" (Walch, 2002).

Figure 4.14: Tree map of bigram title keywords from 2001 to 2008

The second peak period, from 2001 to 2008, ushered in a wave of innovation, with a notable focus on innovative design, environmental design, and the nascent concept of biophilic design. This period also saw color design ascend to become a major focus, surpassing interior design in prominence, signaling a growing appreciation for the psychological and emotional impact of color in shaping spatial experiences. Some of the notable publications of this period was:

"The Potential Role of the Physical Environment in Fostering Creativity" (McCoy & Evans, 2002).

"Environmental colouration and/or the design process" (Smith, 2003).

Figure 4.15: Tree map of bigram title keywords from 2008 to 2024

The most recent period, from 2008 to 2024, has witnessed the continued prominence of interior design, color design, and environmental design, underscoring their enduring importance in the field. Additionally, there has been a reemergence of interest in emotional design, highlighting the ongoing exploration of how spatial design can evoke and shape emotional responses. This period has also seen the solidification of emerging technologies such as virtual reality (VR), augmented reality (AR), and machine learning (ML) as integral tools in spatial design research and practice. Furthermore, biophilic design, lighting design, and aesthetic appeal have emerged as key trends, reflecting a growing emphasis on sustainability, well-being, and the creation of aesthetically pleasing and human-centric spaces. Some of the notable publications of this period was:

"Emotional design in multimedia learning: Effects of shape and color on affect and learning" (Plass et al., 2014).

"Emotional design in multimedia learning: Differentiation on relevant design features and their effects on emotions and learning" (Heidig et al., 2015).

"Benefits of emotional design in multimedia instruction" (Mayer & Estrella, 2014).

Overall, the tree map analysis paints a rich and complex picture of the evolution of spatial design research over nearly a century. It reveals a significant shift from early concerns about color and concrete to a broader and more nuanced focus on technological advancements, innovation, sustainability, well-being, and the multi-sensory experience of space. This shift underscores the field's responsiveness to evolving societal needs and technological capabilities, as well as its ongoing commitment to creating spaces that enhance human well-being, productivity, and overall quality of life. The result indicates that the topic of color psychology in workplace design is still niched and are underdeveloped as focus mostly in learning and classroom setting. This shown potential for more room to grow from this topic and using the result from this bibliometric analysis will allow studies to expand in the relevant emerging field for a more impactful growth.

CHAPTER 5
DISCUSSION & CONCLUSION

In this research paper, we have looked at the topic of workplace color design in spatial design industry. We used science mapping, more precisely bibliometric analysis, to identify leading journals, authors, and research articles on spatial design literature. Moreover, we employed bibliometric analysis to unfold the origin of the knowledge base and improve the insight into the research area's intellectual structure. For this, we considered 808 SCOPUS-indexed articles published between 1925 and 2024. The next two sections suggest our interpretation of the results and provide an overview of the analysis's limitations along with the next step on for future recommendation on the topic.

5.1 Summary of the key findings

1.Majority of the citation is from learning journal field this mean spatial design is focus on the learning and education from student not workplace which shown the potential to looking in workplace design with color psychology application

2. From this you can see color design and color architectural does not have any connections with inferior design and emotion design. There is potential for more study color design and color architecture with interior design and emotional design as current study about these topics together is lacking.

3. The thematic evolution network from 2008 to 2023, the period has the most research done about the topic which consist of 78% of the data set is shown 4 under research areas that are connected to the main topic of interior design and highly relevant to spatial design for workplace which are: Biophilic design, user experience, in door environment and aesthetics design. These 4 areas should be explored more to expand the topic as this allow for exploring under search area that still relevant to the main industry.

4. When look at the H index of most impactful journal, journal of color research application has more impact. Building and environment journal which is

about Building Science and its Applications come second. The third position is from SPIE journal which is about the science and application of light and light-based technologies. We can see that the topmost impactful journal make sense for a list of journals to research about spatial design and color. For example, when doing research about the topic spatial design and color, you first want to see what and how of applying color then you need to look how color can be incorporated in building and environment and lastly you can look at what technology can help you application of color in spatial design.

5. Thailand has 3 articles about spatial design, however only 1 article addressing workplace design and colors from Nattha Savavibool. Savavibool's systematic review provides valuable insights into the potential of color to influence the workplace experience. While there is evidence of a significant impact, more research is needed to explore the specific mechanisms and to develop tailored color strategies for different work environments and tasks. Thailand has 0 collaboration of publication between countries, with the same goes for other countries in the ASEAN region even though there are publication in those countries.

6. Despite the topic spatial design using color is a small subject, many countries that are neighboring to each other to collaborate to publish paper about the topic. However, while ASEAN countries do have publication, ASEAN country even neighbor to each other do not.

7. With rank number 2 and having the top publication rivaling US and China, Bina Nusantara university from Indonesia is the only university in ASEAN to be in the top 10 universities that is producing publication about the topic spatial design using color. This can be the place for other ASEAN countries like Thailand to start collaboration for future research about the topic for geographical convenient and culture similarity.

8. The annual scientific productions show three major peaks in 1999, 2008, and 2023. Looking up the country production, The USA start off research since 1925, with no competition till the late 1990s, countries like Germany, China, and Italy began to catch up. The graph shows an exponential growth trend between 2007 and 2008 for the US, Germany, United Kingdom, and China in spatial design and color

affecting human behaviors. This trend seem is not currently due to the financial crisis, but rather to the advancements in these countries.

9. The tree map analysis of title keywords in spatial design research (1925-2024) reveals the following:

- Technology trends: VR, AR, and machine learning are emerging technologies in this field.

- Emerging design trends: Biophilic design, lighting design, and aesthetic appeal are gaining attention, with potential impact on workplace design.

- Early focus (1925-1999): Color design and concrete were primary interests, with no mention of technology.

- First peak (1999-2001): Interest in precast concrete and color design persisted, with advertising as a standout application.

- Second peak (2001-2008): Innovative design, environmental design, and biophilic design emerged. Color design became a major focus, surpassing interior design.

- Most publications (2008-2024): Interior design, color design, and environmental design remained prominent. Emotional design reappeared. VR, AR, and machine learning solidified their presence. Biophilic design, lighting design, and aesthetic appeal emerged as key trends. Office design is first mentioned showing the lack of focus in workplace design using color.

Overall, the analysis highlights a shift from early concerns about color and concrete to a broader focus on technology, innovation, and environmental considerations in spatial design. The result indicates that the topic of color psychology in workplace design is still niched and are underdeveloped as focus mostly is on learning and classroom setting. This shown potential for more room to grow from this topic and using the result from this bibliometric analysis will allow studies to expand in the relevant emerging field for a more impactful growth.

5.2 Implications and Recommendations

5.2.1 Implication

The implications of this spatial design research are extensive and far-reaching, promising significant advancements in the field. The existing focus on learning environments within spatial design research reveals a vast, untapped potential for applying color psychology principles to workplace design. This could revolutionize workplaces, enhancing not only productivity and efficiency but also employee well-being and overall satisfaction. Additionally, the research highlights a notable lack of connections between color design/architecture and interior/emotional design. Addressing this gap by fostering interdisciplinary collaboration could lead to groundbreaking approaches that consider the holistic impact of color on workplace environments, moving beyond aesthetics to address the psychological and emotional needs of employees. The thematic evolution network further identifies four critical areas for future research: biophilic design, user experience, indoor environment, and aesthetics design. Deeper investigation into these areas can inform the development of comprehensive and effective workplace design strategies that go beyond traditional approaches. By understanding the intricate relationship between these factors and color, designers can create spaces that promote health, well-being, and productivity. Furthermore, the H-index analysis emphasizes the importance of prioritizing research that aligns with the most impactful journals. This strategic approach ensures that findings have a broader reach and influence within the field of spatial design, accelerating the adoption of evidence-based practices and driving innovation. The research also reveals limited collaboration within ASEAN countries, particularly with Indonesia, a high-publishing country in this field. This presents a significant opportunity for knowledge sharing and collaborative research initiatives, which could rapidly advance the understanding and application of color in spatial design within the region. Finally, the historical analysis of research trends underscores a clear shift from basic color design to more complex considerations involving technology, innovation, and environmental factors. This evolution should guide future research priorities and funding allocations, ensuring that resources are directed towards the most promising and impactful areas of inquiry. In conclusion, this research not only reveals the

current state of spatial design research but also charts a course for its future, emphasizing the importance of color as a strategic tool for creating workspaces that optimize human experience and performance.

    5.2.2 Recommendation

    To advance the field of spatial design and harness the power of color to its fullest potential, a multifaceted approach is required, encompassing research, collaboration, and technological integration. First and foremost, funding and prioritizing research specifically focused on the impact of color in workplaces is paramount. This research should not be limited to a single methodology but should encompass a diverse range of approaches, including experimental studies, case studies, and surveys. By utilizing various methodologies, researchers can comprehensively assess the effects of color on various workplace metrics, such as productivity, creativity, collaboration, stress levels, and overall well-being. This data-driven approach will provide a robust foundation for evidence-based design decisions.

    Equally important is the fostering of interdisciplinary collaboration between color experts, interior designers, architects, psychologists, ergonomists, and other relevant professionals. This can be achieved through a variety of platforms, including conferences, workshops, and joint research projects. By bringing together diverse perspectives and expertise, we can unlock innovative and holistic solutions that consider the multifaceted impact of color on workplace environments. This collaborative approach will ensure that design decisions are not only aesthetically pleasing but also address the psychological, emotional, and physiological needs of employees. Furthermore, research funding should be strategically directed towards key areas identified in the thematic evolution network, namely biophilic design, user experience, indoor environment, and aesthetics design. These areas represent significant opportunities for advancing our understanding of how color interacts with various aspects of the workplace environment. Encouraging exploration of sub-topics within these areas, such as the impact of specific colors on employee mood, the use of color in wayfinding, and the integration of biophilic design principles with color strategies, can further refine our knowledge and inform practical applications. Collaboration should not be limited to individual disciplines but should also extend

across regions. Establishing regional networks and partnerships within ASEAN, with a particular focus on engaging Indonesia as a high-publishing country in this field, can facilitate knowledge sharing, collaborative research, and the development of region-specific design solutions. By leveraging the diverse cultural and environmental contexts within ASEAN, we can create a richer and more nuanced understanding of how color can be used to enhance workspaces across different settings. In addition to traditional research methodologies, the integration of emerging technologies like virtual reality (VR) and augmented reality (AR) can revolutionize the way we study and implement color in spatial design. These technologies allow for immersive and interactive experiences, enabling researchers and designers to test color schemes and assess their impact on users before implementing them in real-world settings. This not only reduces the risk of costly design errors but also allows for more personalized and tailored solutions. Finally, ensuring widespread dissemination of research findings through publications in high-impact journals, presentations at relevant conferences, and workshops for industry professionals is essential for bridging the gap between research and practice. By making research accessible and actionable, we can empower designers, architects, and employers to make informed decisions based on the latest evidence. This will lead to the creation of healthier, more productive, and more aesthetically pleasing workspaces that enhance the well-being and performance of employees.

5.3 Limitations of the Research

While science mapping offers valuable insights into the academic landscape of spatial design research using color, this study acknowledges several limitations that may affect the comprehensiveness and generalizability of its findings. Firstly, the exclusive focus on academic publications within the realm of spatial design using color may inadvertently exclude valuable insights from industry reports, case studies, and practical applications that have not been formally published. This scoping bias could lead to an incomplete picture of the field's actual progress, challenges, and innovative solutions emerging from real-world practice. Secondly, the reliance on the SCOPUS database, while offering a vast repository of scholarly articles, does not

encompass all publications within the broader domain of spatial design and color design. This limitation could result in overlooking relevant research published in journals not indexed by SCOPUS, potentially impacting the overall representation of the field. Additionally, the exclusion of non-English articles further narrows the scope of the research, potentially missing valuable contributions from diverse linguistic and cultural contexts. Moreover, the research primarily employs a quantitative approach, emphasizing bibliometric analysis and statistical methods. While valuable for identifying trends and patterns, this approach does not delve into the nuances and complexities that can only be uncovered through qualitative research. Conducting qualitative studies, such as interviews or focus groups with designers and users, could provide rich insights into real-world experiences, challenges, and the subjective impact of color in spatial design. Finally, it is crucial to recognize that color is just one of many factors that influence employee effectiveness and efficiency in the workplace. Other environmental factors, such as lighting, noise, air quality, furniture, and spatial layout, also play significant roles in shaping the workplace experience (Maran and Yan, 1989). Therefore, while this research focuses on color, it is important to acknowledge the complex interplay of various factors that contribute to overall workplace well-being and performance. In conclusion, this research provides valuable insights into the field of spatial design using color, but it is not without its limitations. By acknowledging these limitations and considering the potential biases and exclusions, researchers can build upon this foundation to conduct more comprehensive and nuanced investigations that encompass both academic and practical perspectives, quantitative and qualitative approaches, and a broader range of influencing factors.

5.4 Future Research and Next Steps

Future research in color psychology and spatial design should prioritize a multi-faceted approach to further our understanding and application of color in workplace environments. Firstly, rigorous experimental studies should be conducted to quantify the impact of color on specific workplace outcomes. This includes measuring productivity through tasks completed or time on task, assessing employee

well-being through surveys or physiological indicators like heart rate variability, and tracking absenteeism rates in relation to different color schemes. Such quantitative data will provide concrete evidence of the impact of color and inform evidence-based design decisions. Additionally, longitudinal studies are essential to investigate the long-term effects of color exposure in workplaces. These studies can help determine whether the initial benefits of specific color schemes persist over time or if individuals adapt to their surroundings. Understanding the long-term effects can guide design updates and refresh cycles, ensuring that workspaces remain stimulating and supportive of employee well-being. Delving deeper into the neurological mechanisms underlying the effects of color on cognition, emotion, and behavior in workplace settings is another crucial avenue for research. Neuroimaging studies can identify brain regions activated by different color schemes, providing insights into the physiological basis of color's impact on human behavior. Furthermore, research should explore cross-cultural differences in color perception and preference in workplace environments. Understanding whether certain colors evoke universal responses or if there are culturally specific interpretations is essential for designing workspaces that resonate with diverse workforces. This includes considering the cultural context of ASEAN countries, where color symbolism and preferences may differ from Western norms. Investigating how individual characteristics, such as personality traits, age, and gender, moderate the effects of color in the workplace is also crucial. By understanding individual differences, designers can create personalized environments that cater to the diverse needs of employees, maximizing the positive impact of color on well-being and performance. Finally, embracing technology-driven design through the use of VR and AR technologies can revolutionize the design process. By creating immersive simulations of workplace environments with different color schemes, designers can rapidly prototype and test design concepts before implementation. This allows for greater flexibility and customization, ensuring that the final design is optimized for the specific needs of the workforce. Future research should adopt a holistic approach that combines quantitative analysis, longitudinal studies, neurological investigations, cross-cultural considerations, individual differences, and technology-driven design. This

comprehensive approach will unlock the full potential of color psychology in creating workspaces that not only enhance productivity and well-being but also foster a sense of belonging and satisfaction among employees.

5.5 Concluding Remarks

The research landscape of spatial design using color is evolving rapidly, shifting from a focus on basic color theory to a more nuanced understanding of how color interacts with technology, culture, and individual preferences. While the existing body of research provides valuable insights, there remain significant gaps in our understanding, particularly in the context of workplace design. Addressing these gaps through targeted research will not only advance our knowledge but also unlock the potential of color to transform the modern workplace into a more productive, engaging, and fulfilling environment. The future of spatial design with color is bright, and by embracing interdisciplinary collaboration, emerging technologies, and culturally sensitive approaches, we can create workplaces that truly enhance the human experience.

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