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Research Article

The impact of color on furniture preference in the context of user emotions: The case of the Thonet No. 14 Chair

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Abstract
This study examines emotional responses evoked by colors and how these emotions influence furniture design, focusing on the iconic Thonet No. 14 Chair. An interactive simulation using PHP and JavaScript allowed potential consumers to perform a color-emotion matching task. Users viewed a 360-degree-rotatable Thonet No. 14 chair across 16 emotional contexts and chose from 12 color options. The primary aim is to explore the emotional effects of furniture color on users and incorporate these insights into the design process. Specifically designed for this research, the simulation represents an innovative model for future studies by integrating 3D visualization with user interaction. The research compares two groups: participants with formal color education and those without. A mixed-methods approach combining qualitative and quantitative techniques was employed to evaluate how color influences visual perception in furniture design. Data were securely serialized and stored in JSON format to ensure integrity and ease of analysis. Despite limitations regarding age range, sample size, and the absence of real spatial context, the study demonstrates that color significantly shapes users' affective responses to furniture. The results contribute to product design by highlighting the role of affective cognition and offering a replicable, scalable digital method for future studies.

Keywords: Furniture design, Thonet No. 14 Chair, Color perception, User perception, Interactive simulation

Extended Abstract

Introduction: Color emerges as a structural element that goes beyond mere visual componentry, establishing a strong relationship between the user and the object. In the fields of art and design, color plays a critical role in creating meaning, conveying emotion, and generating aesthetic impact. Moreover, it is regarded as a fundamental perceptual factor in the interpretation and processing of information from the environment through vision in everyday life. The concept of color emotion refers to the feelings that arise in an individual's mind upon perceiving a color; in this context, scientific studies have shown that colors can directly stimulate emotional areas of the human nervous system. The psychological and emotional effects of color on individuals have long been a subject of investigation across various disciplines. However, most of these studies have focused on interior design, architectural color use, or general environmental arrangements. The specific impact of furniture color on users' emotional states has received comparatively limited attention. As a fundamental design element that directly influences the atmosphere of space and furniture, particularly their color, furniture should be considered a significant variable in shaping the user experience.

Purpose and scope: This study analyzes the emotional and psychological effects of color, a key factor influencing visual perception in furniture design, using the iconic Thonet No. 14 chair without requiring any physical interaction with the product. To achieve this objective, the research employs a mixed-methods approach that integrates qualitative and

quantitative methodologies. The Thonet No. 14 chair was selected as the subject of the experiment due to its historical significance, widespread use, and cultural recognition. The version with a wooden seat surface was chosen to isolate the color variable, eliminating the influence of material and texture differences and thus focusing solely on the perceptual impact of color variations. To investigate users' emotional responses, a set of adjectives from Jordan's Product Personality Assignment method was cross-referenced with color-emotion associations identified in the literature. A semantic intersection set was established, from which the final selection of colors was derived. Using a custom-developed simulation program, participants were asked to colorize the Thonet chair by matching 16 specific emotional descriptors with one of 12 pre-defined colors. This setup enabled the assessment of affective responses solely from visual stimuli, without tactile interaction.

Method: A combined research methodology was used in this study. Both qualitative and quantitative research methods were employed to collect and analyze data. The study was carried out using a Thonet No. 14 chair as the experimental object; this chair was selected for its long history and formal significance in the world of furniture design. The research was performed through the development of a custom online simulation interface. The digital platform was designed using PHP and JavaScript, which were available to participants and enabled them to view the Thonet chair from any angle, repaint it according to 60 emotion/descriptor pairs referenced in the study, and finally select 4 pairs of the most suitable phrases. Participants used emotional descriptors to recolor the chair, and chair rotation was a visual variable. Both the background and the chair color were kept constant using RGB standards, as no colors other than these were available on the screen. Also, the users were prompted to complete the activity on a single screen to ensure the application would not be affected by color differences across different screen technologies. Participants were selected through purposive sampling and consisted of undergraduate students aged 18 to 25. The sample was divided into two experimental groups: the first comprised interior architecture students who had received formal color education, while the second comprised social sciences students with no such background. Each group included 30 participants, with equal gender distribution maintained. All collected data were serialized and securely stored in JSON format by the simulation software. In this respect, the study offers a novel user-centered method for color analysis, facilitating the measurement of the relationship between furniture design and user psychology in a digitally controlled environment.

Findings and conclusion: The data obtained in the study were analyzed using Python software specifically developed for this research. A total of 60 participants were divided into two groups, those with and without color education, while maintaining a balanced gender distribution. Participants were aged 18-25 years and grouped by educational background. The color-educated group mainly consisted of interior architecture students, whereas the non-color-educated group included participants from the social sciences and business administration. The findings revealed that participants without color education showed greater conformity with the color-emotion associations found in the literature. This can be attributed to the fact that most studies in the literature employ random sampling methods involving participants who generally lack formal color education. Conversely, the preferences of the color-educated group showed limited alignment with the literature, establishing meaningful associations only within specific emotions and adjectives. The hypothesis that positive adjectives would be associated with warm colors and negative adjectives with cool colors was only partially supported by participants' preferences. Among the color-educated group, only the adjective "bright" was closely associated with warm colors, and the rest of the positive adjectives displayed weaker and more evenly distributed correlations with warm colors. In the non-color-educated group, there was a tiny majority who saw only "kind" and "pure" as warm colors. Negative adjectives, on the other hand, were mainly tied to neutral colors like black and grey by both groups and did not have a clear relationship with cool colors. The use of a simulation environment and a purposive sampling technique in this research provided reliable opportunities for data collection and analysis. The findings offer valuable insights into how color selection in furniture design affects user psychology. It is recommended that future studies increase sample sizes, diversify color-adjective variables, and incorporate technologies such as virtual reality. This would enable more comprehensive research with immersive spatial experiences.

Keywords: Furniture design, Thonet No. 14 Chair, Color perception, User perception, Interactive simulation

INTRODUCTION

Color is one of the most influential elements in shaping the user-object relationship and serves as a fundamental component of design sectors where meaning and emotional expression are especially involved. Beyond its aesthetic function, it is also crucial in how we process and interpret visual information from our surroundings. Color emotion refers to the feelings evoked by the perception of color, which can directly stimulate emotional areas in the nervous system. According to Cheng (2020: 622-624), different color components evoke various emotional responses. While color itself doesn't carry emotions, it can trigger sensory reactions through visual stimuli. Puhalla (2005: 2) describes color as a key perceptual process that awakens visual awareness. Klem

(2013: 79-80) highlights that perception includes not only artistic but also physical, psychological, and cultural aspects. Since color perception and its meanings vary across cultures and individuals, color experience is highly subjective.

In product design, visual appeal is crucial not only for its visual appeal but also for the emotions it evokes in users. As a central element of visual communication, color conveys ideas and feelings that influence users both physically and emotionally (Hunjet & Ivancic, 2018: 10). Understanding the connection between emotion and design helps explain why some products are preferred and supports a user-centered design approach. Moreover, product personalization and consumer involvement in design decisions, such as color choices or feature customization, have become increasingly popular, positively influencing purchasing behavior. In this study, participants act as consumers, selecting colors that reflect their emotional preferences and thereby actively shaping the design process. The literature encompasses a diverse range of studies examining the relationship between color and space, with a particular focus on emotional aspects. However, investigations specifically examining the emotional impact of furniture color on users remain limited. Furniture is a crucial design element in establishing an overall atmosphere, and selecting furniture, along with color, is a critical aspect of interior design. Adopting a "from the part to the whole" perspective, the present study underscores that color-furniture-space interactions are integral to creating the desired ambiance.

In this study, a review of the existing literature identified the emotions evoked by various colors and the colors associated with these emotions. These identified color-emotion pairs were then presented to potential consumers through a participatory framework, allowing them to perform their own color-emotion matchings. For this purpose, an online simulation environment was created using PHP and JavaScript, enabling an interactive experience in which participants were integrated into the design process. Given its familiarity in contemporary consumer settings, the Thonet chair was chosen as the representative piece of furniture. Within this simulation, two experimental groups, one with formal color education and one without, colored the Thonet chair using 12 distinct color options and 16 emotional descriptors.

Theoretical Framework and Research Hypotheses

Color has been extensively studied in literature, attracting the attention of scholars and practitioners in fields such as the visual arts, design, architecture, cinema, psychology, engineering, and medicine. Despite the large body of research on color, investigations into the emotional effects of furniture-specific color choices on users appear limited. In design-oriented research, studies of color generally focus on its use in interior spaces. Kwallek et al. (1996) explored the impact of color red, green, and white on the mood and productivity of men and women working in differently colored office environments. A total of 222 participants (an equal number of men and women) spent time in offices painted in these three colors. Findings indicated that participants in the red office made the fewest errors, whereas those in the white office made the most. In a subsequent study, Kwallek et al. (2007) examined how the colors used in work environments affect user performance. Three actual office spaces identical in dimensions, geometry, and furnishings but differing in color schemes were employed as experimental settings. Ninety participants were recruited and initially grouped by attentiveness level; over four consecutive workdays, from 9:00 a.m. to 5:00 p.m., they performed various tests and proofreading tasks. Results revealed that, in terms of work performance, highly attentive participants in both the white and red offices outperformed those with medium or low attentiveness.

Jiang et al. (2020) investigated how the color preferences of adolescents (ages 12-16) in China influence the furniture choices in their bedrooms and study rooms. A total of 508 participants were involved in a two-stage online survey. In the first stage, participants indicated which colors they preferred for the presented furniture options; in the second stage, they were asked to rank their top three most and least favorite colors. The results revealed that children's color preferences influenced their furniture color choices in both their sleeping and study environments, though the effect was somewhat limited across product categories. Ouankhamchan and Fujinami (2020) conducted a study to assess user preferences for a sofa model using EEG devices. Twelve participants (seven men and five women) actively seeking to buy furniture took part. They evaluated four sofa models in 12 different colors using a Likert scale. The study involved collecting demographic data and favorite colors, followed by EEG measurements while viewing sofa color variations. Results showed that participants'

initial favorite colors did not always align with the colors they ultimately preferred, highlighting a difference between conscious preference and subconscious responses.

Insights gleaned from these and similar studies confirm that the first environmental stimulus individuals receive from the external world is visual, and one of the initial factors perceived by the eye is color. Accordingly, this research focuses on examining the emotions evoked in users by color when applied to a commonly used piece of furniture chair. To achieve this goal, experimental groups were formed and included in the study, leading to the following research hypotheses:

Hypothesis 1: The chairs colored by the experimental group that has received formal color education will align with the color-emotion pairings documented in the literature.

Hypothesis 2: The chairs colored by the experimental group that has not received formal color education will deviate from the color-emotion pairings documented in the literature.

Hypothesis 3: Both experimental groups will associate positive descriptors with warm colors.

Hypothesis 4: Both experimental groups will associate negative descriptors with cool colors.

METHOD

In this study, which analyzes affective responses to the color factor, which directly influences visual perception, through a selected piece of furniture without physical experience, both qualitative and quantitative research methods were employed. The sub-sections of this chapter provide a detailed explanation of the processes involved in the study.

Selection of Furniture for the Experimental Environment

In this study, the product selected for the experiment is a seating element, chosen based on the historical trajectory and significance of furniture design. Seating elements are among the most extensively researched and analyzed components in the history of furniture design. Many iconic furniture pieces, recognized by their era or designer, have garnered significant consumer interest at the time of their production. Some of these historically influential seating elements have retained their popularity and remain widely preferred by contemporary consumers. One such piece is the globally renowned “Thonet No.14” chair, designed by Michael Thonet. Owing to its formal simplicity and strong historical associations, this chair remains a versatile design element, seamlessly integrated into both modern and classical interior spaces (Figure 1).

Figure 1. No.14 Chair, Michael Thonet

Since its initial design, numerous variations of the Thonet No. 14 chair have emerged. The most common variations are distinguished by the material used for the seat surface, including wood, textile, and perforated woven cane (Figure 2).

Figure 2. Variations in seat surface materials

As seen in this figure, No. 14 chairs share a common structure in their backrests, legs, and seat-surface materials, while varying in specific details. For this reason, the study will be based on the original Thonet form as the primary reference.

In the experimental environment, the No.14 chair with a wooden seat surface was selected to measure the perceptual impact of different colors. This chair is most commonly found in the food and beverage industry, particularly in cafés and restaurants. Given the high human traffic in such venues, designers and business owners tend to prefer the wooden-seated version for its lower maintenance costs and greater durability. The widespread use of this variation has led to greater familiarity and user experience, making it a suitable selection for inclusion in the study. The No. 14 chair, with its wide range of applications, has been adapted into numerous variations by varying its material, texture, form, and color, while preserving the original Thonet structure. Within the scope of this study, the wooden-seated No. 14 chair was selected, as it is available in a broad range of color variations in contemporary design (Figure 3).

Figure 3. Examples of No.14 Chairs with different color applications

Selection of Colors to be Applied and Survey Design

Color can be scientifically defined as an optical property of radiation that enables an observer to distinguish objects of the same dimensions, shapes, and structures. This definition reduces color to the assessment of radiation power at different wavelengths within the visible spectrum. When considered as a physical quantity, color is a fundamental characteristic of light sources, objects, and their interactions. Furthermore, as a physical stimulus, it is closely linked to the psychophysical effects that mediate between human perception and emotional response. This is because color is not an intrinsic property of optical radiation or objects; rather, it is a perceptual phenomenon that forms an integral part of visual experience (IESNA, 2000: 6.1, 6.7).

In this study, which aims to investigate users' psychological responses and affective impacts of color, attitude scales were used. In the literature, attitude is defined as a positive or negative predisposition toward an object or idea and is considered to encompass emotional, behavioral, and cognitive components (Köklü, 1995). This study uses Patrick W. Jordan's "Product Personality Dimensions Method" to assess emotional responses to color variations in furniture without direct interaction with the product. The method uses pairs of opposing adjectives to assess users' immediate feelings, explore links between product preferences and personality traits, and gauge user satisfaction. Although originally applied to industrial products, this approach helps us understand how potential users emotionally perceive design elements, such as color changes. Table 1 presents the adjective pairs utilized in Jordan's study (Jordan, 2002).

Table 1. The product personality dimensions method scale was developed by Jordan

Positive Adjective	1	2	3	4	5	Negative Adjective
Kind						Unkind
Honest						Dishonest
Serious-minded						Light-hearted
Bright						Dim
Stable						Unstable
Humble						Narcissistic
Flexible						Inflexible
Liberal						Authoritarian
Value-driven						Non-value-driven
Extrovert						Introvert
Naive						Cynical
Moderate						Excessive
Conformist						Rebel
Energetic						Unenergetic
Gentle						Violent
Simple						Complex
Optimistic						Pessimistic

In this study, a participatory approach is employed, where individuals are expected to determine the colors of their own Thonet chairs based on specific emotional states. To facilitate this process, a computer-based simulation program has been developed. In this simulation, participants are presented with a selection of colors and emotions/adjectives to choose from. To determine the colors to be presented to participants, the study draws upon Hilliard's (2016) doctoral dissertation, titled "Optimizing Viewer Comprehension and Shaping Impressions and Attention". Hilliard conducted a semantic analysis by reviewing the works of various color theorists and extracting design and psychological paradigms related to color. As a result of this analysis, a color-emotion matching system was established that represents the general meanings associated with specific colors. This color-emotion association is presented in a list below, organized by emotion/adjective number for each color, while the selected colors are provided in Table 2.

1. Grand, noble, exciting (Pralle, 2007); Harmonizing, wisdom, luxury, spiritual, exotic, creative, artistic, inspiring (Reynolds, 2010); Magnificent, honorable, dignified (Madden et al., 2000).
2. Calming (Singh, 2006); Compassionate, attentive, pleasant, relaxing (Crozier, 1996); Attractive (Kauppinen-Räisänen & Luomala, 2010); Lively, emotional, affectionate (Pralle, 2007); Honorable, professional, successful, loyal, peaceful, calm, positive, depressive (Reynolds, 2010); Wealthy, honest, sensitive, kind, soothing (Madden et al., 2000); Cold, pale, dull, peaceful (Manav, 2007).
3. Calm, honest, righteous, philosophical, non-threatening, peaceful, benevolent, serene (Pralle, 2007).
4. Primitive, intuitive, ancient, historic, strong, free (Pralle, 2007).
5. Analytical, composed, intelligent, goal-oriented, expressive (Pralle, 2007).
6. Bright, luxurious, infinite, magnificent (Pralle, 2007).
7. Mature, strong, restless, wise, ancient (Pralle, 2007).
8. Fresh, pure, clean, youthful (Pralle, 2007).
9. Soothing, relaxing (Crozier, 1996); Attractive, neutral (Kauppinen-Räisänen & Luomala, 2010); Healthy, natural, safe, vibrant, confident (Pralle, 2007); Natural, balanced, harmonious, healthy, calm, persistent,

lucky, reborn, spring, jealousy (Reynolds, 2010); Lively, dull, frightening, comforting, exhausting, annoying (Manav, 2007); Nature, trees, ease, serenity, happiness, tranquility (Kaya & Epps, 2004).

10. Attention-grabbing (Singh, 2006); Cheerful, exciting, affectionate, impulsive (Crozier, 1996); Stimulating (Elliot & Maier, 2007); Cheerful, eye-catching (Kauppinen-Räisänen & Luomala, 2010); Anxious, sharp, surprising (Pralle, 2007); Optimistic, cheerful, happy, peaceful, sunshine, inspiring, summer (Reynolds, 2010); Cheerful, energetic (Madden et al., 2000); Lively, energetic, positive, happy (Kaya & Epps, 2004); Warm, simple, dynamic, pleasant, classic (Manav, 2007).
11. Rich, sunny, cheerful, warm, associated with power (Pralle, 2007).
12. Soft, abundant, comfortable, authentic (Pralle, 2007).
13. Delicious, nourishing, associated with danger (Pralle, 2007); Warmth, affection, excitement, enthusiasm, energetic, playful, fun (Reynolds, 2010); Distressed, uneasy, sorrowful (Madden et al., 2000).
14. Wild, fiery, explosive, out of control, prominent (Pralle, 2007).
15. Natural, earth-related, solid, strong, reliable, comfortable, rough, soft, ordinary (Reynolds, 2010).
16. Desirable, persuasive, friendly, dramatic, warm (Singh, 2006).
17. Strong, aggressive, threatening, demanding attention (Pralle, 2007).
18. Stimulating (Singh, 2006); Adventurous, extroverted, powerful, protective, exciting (Crozier, 1996); Danger, passion (Elliot & Maier, 2007); Attention-grabbing, very strong (Kauppinen-Räisänen & Luomala, 2010); Distracting (Belizzi & Hite, 1992); Dangerous, exciting, noisy (Pralle, 2007); Assertive, strong, bold, urgent, fiery, passionate, dangerous, evil (Reynolds, 2010); Exciting, encouraging (Madden et al., 2000); Exhausting, striking (Manav, 2007).
19. Adorable, sensitive, feminine (Pralle, 2007); Romantic, soft, calm, passive, health, love, romance, joy (Reynolds, 2010); Warm, cheerful, romantic (Manav, 2007).
20. Bold, elegant, impressive, cultured, classic (Pralle, 2007).
21. Serious, thoughtful, spiritual (Pralle, 2007).
22. Elegant, formal, artistic, simple, power, death, fear, loss, distress, mourning (Reynolds, 2010); Unhappy (Madden et al., 2000).
23. Neutral, respectful, humble, static, wise, simple, determined, blurred, dull, depressive, negativity (Reynolds, 2010).
24. Pure, innocent, clean, new, simple, fresh, cool winter, soft, ordinary, sterile (Reynolds, 2010).

Table 2. Adjectives/emotions derived from the color paradigms of color theorists in the literature

No	Color (RGB)	Visual Repres.	No	Color (RGB)	Visual Repres.	No	Color (RGB)	Visual Repres.
1	Purple 160-32-240		9	Green 0-255-0		17	Crimson 220-20-60	
2	Blue 0-0-255		10	Yellow 255-255-0		18	Red 255-0-0	
3	Sky blue 135-206-250		11	Gold 255-215-0		19	Pink 255-192-203	
4	Teal 0-128-128		12	Amber 255-126-0		20	Mauve 224-176-255	
5	Cyan 0-255-255		13	Orange 255-165-0		21	Violet 238-130-238	
6	Emerald 80-200-120		14	Coral 255-127-80		22	Black 0-0-0	
7	Sea Green 46-139-87		15	Brown 165-42-42		23	Grey 128-128-128	
8	Lime 50-205-50		16	Scarlet 255-36-0		24	White 255-255-255	

Within the scope of the study, the emotions identified by color theorists through a literature review were compared with the emotions and adjectives used in Jordan's Product Personality Dimensions Method. As a result, the overlapping adjectives and emotions were identified (Figure 4).

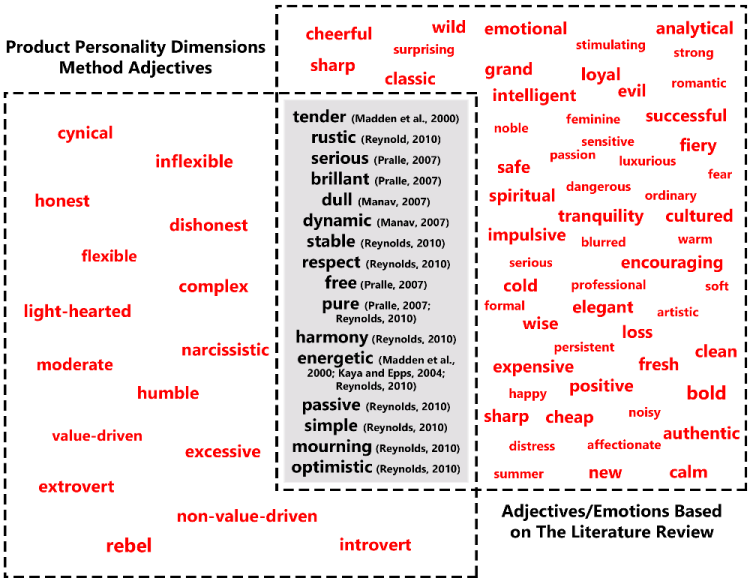

Figure 4. Intersection of emotions/adjectives derived from color paradigms in the literature and those used in the product personality dimensions method

The colors corresponding to the emotions/adjectives identified in the intersection set were selected for use in the study. These colors, along with their associated emotions/adjectives, are presented in Figure 5.

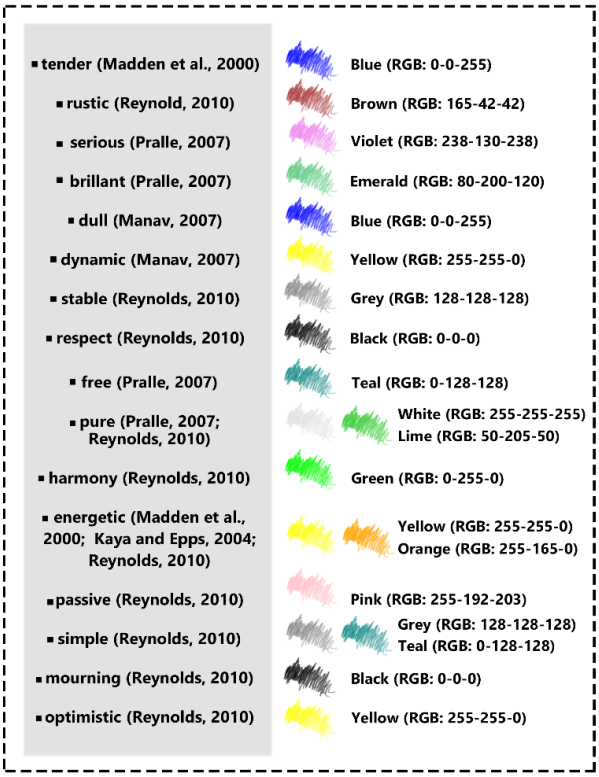

Figure 5. Colors and adjectives derived from the intersection set

Among the presented colors, repetitive colors were removed, and white was excluded because the simulation program's background was white. As a result, 12 colors were selected for use in the study (Table 3).

Table 3. Information on colors to be used in the study

No	Color	Visual Repres.	No	Color	Visual Repres.	No	Color	Visual Repres.
1	Blue 0-0-255		5	Yellow 255-255-0		9	Green 0-255-0	
2	Brown 165-42-42		6	Grey 128-128-128		10	Orange 255-165-0	
3	Violet 238-130-238		7	Black 0-0-0		11	Pink 255-192-203	
4	Emerald 80-200-120		8	Teal 0-128-128		12	Lime 50-205-50	

As a result, participants will color the Thonet chair in the simulation environment using 12 selected colors, based on their personal perceptions and affective responses, and will use the 16 emotions/adjectives identified in the intersection set. These colors are represented in the RGB color space as shown in Figure 6.

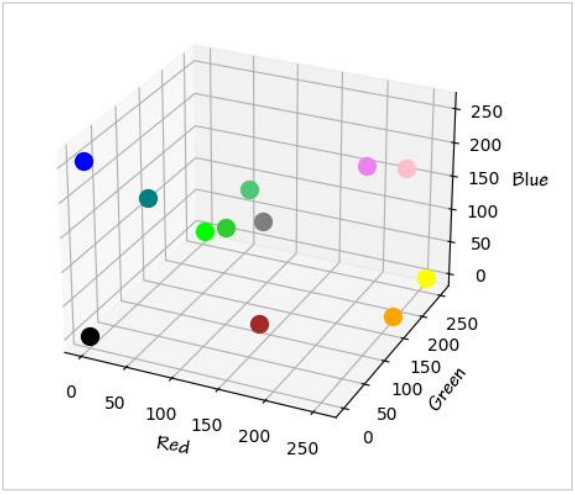

Figure 6. Representation of colors in the RGB color space

Since the colored furniture will not be rated later by the participants themselves or another experimental group, the Likert scale used by Jordan was excluded from the study. At the beginning of the study, a demographic information screen is included to systematically categorize the two different experimental groups. While no personal data is collected, participants are asked to provide information on age, gender, field of study, and whether they have received any formal education in color theory. After entering this information, participants gain access to the simulation environment. At the beginning of the study, a demographic information screen is included to systematically categorize the two different experimental groups. While no personal data is collected, participants are asked to provide information on age, gender, field of study, and whether they have received any formal education in color theory. Once they enter this information, they gain access to the simulation environment.

Study Group

In qualitative research, the focus is on deep analysis of specific individuals or situations rather than generalizing results, so purposeful sampling is commonly used (Creswell, 2009: 112). Based on this perspective, purposeful sampling was chosen for this study to align with the nature of qualitative research and the study's objectives. The research aims to measure affective responses to colors among individuals with formal education in color theory and those without, as well as among individuals of different genders. To best represent the target population, the sample was structured into two distinct experimental groups:

- The first experimental group consists of third- and fourth-year students from Marmara University's Interior Architecture Department, who have received formal color education. These students have been exposed to art and design education that involves both direct and indirect use of color since the beginning of their undergraduate studies, and they have taken advanced courses in color theory in the later stages of their education.
- The second experimental group comprises students from various social science disciplines who have not received formal education in color theory.

This comparative approach aims to assess differences in affective responses to colors based on educational background and gender. Colors can be categorized into innate (inborn) reactions and learned responses based on human responses. Innate reactions can be explained through the identification of universal emotional associations with colors, whereas learned responses are shaped by specific demographic factors such as age, gender, and culture, leading to subjective color experiences (Hilliard, 2016). For this reason, in this study conducted with individuals raised within the same cultural context, demographic factors such as age and education level were controlled to ensure consistency. Specifically, the experimental group consisted of undergraduate students aged 18-25, with a particular focus on third- and fourth-year students who were known to have similar levels of color education. After determining the sampling area, another critical aspect to address is the sample size. In qualitative research, the sample size should be determined not in terms of quantity but in terms of its ability to best represent the population qualitatively (Neuman & Robson, 2014). Instead of analyzing large groups, qualitative studies require selecting samples that yield rich, detailed data aligned with the research objectives (Coyne, 1997). For this study, the sample size was not excessively expanded, as the study design involved 16 emotion sets and 12 colors, requiring an in-depth analysis to obtain rich, high-quality data. Therefore, two experimental groups, each comprising 30 participants, were deemed appropriate. Since the study aims to analyze responses by gender and color knowledge, an equal distribution of participants was ensured by keeping the number of participants equal across both experimental groups. Additionally, within each group, an equal number of male and female participants contributed to the study to maintain balanced representation.

Research Environment

In this study, the virtual environment-based assessment method, which has been widely used in various studies (Slatter & Whitfield, 1977; Park & Guerin, 2002; Stone, 2003; Babin et al., 2003; Wang et al., 2007; Müezzinoğlu et al., 2021; Yıldırım et al., 2011; Odabaşıoğlu & Olguntürk, 2020; Tantanatwin & Inkarojrit, 2016), was also implemented. A web-based simulation environment, developed by a contributing researcher using PHP and JavaScript, was designed to facilitate online access. The study's demographic data were collected using this software prior to the simulation phase. To prevent data loss, the research findings were serialized in JSON format and stored by the software. This method ensured that the data were securely recorded and structured for further analysis. The results obtained from the data analysis are detailed in the Findings section. In accordance with the study's purpose and scope, the simulation program allows participants to view a 360-degree-rotatable Thonet chair with 12 color switches, as shown in Figure 7.

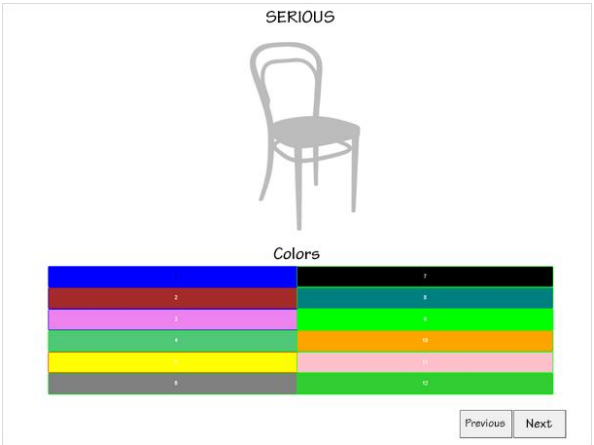

Figure 7. The simulation environment used in the study

The simulation environment is the part that is exemplary and belongs to, or is installed specifically for, the present investigation. It has significant implications for further research as a trend-setting method. Unlike the traditional approach of only showing furniture or space visuals, this method of actively involving testers in the research harnesses participants' power to conduct interactive evaluations in a three-dimensional simulation environment. This feature enhances the study's originality and offers a unique methodological framework for future research. In particular, the ability to collect data from many participants simultaneously allows the test to be administered globally in real time, increasing the generalizability of the findings and the diversity of the participant pool. With these distinctive attributes, this study makes a significant methodological contribution to the literature, offering a novel approach that can be applied in future studies.

Since the study focuses solely on the color variable in furniture, other design elements such as lighting, background, and reflections were kept constant throughout the simulation. To ensure colors were perceived as accurately as possible, the background color was set to RGB: 255-255-255, HSB: 0-0-100, while the furniture's initial state before coloring was set to RGB: 128-128-128, HSB: 0-0-50. At this stage of the study, the adjectives included in the experiment appeared on the screen, and participants were asked to reflect on their emotional association with each adjective before selecting a color for the furniture. Using the "Next" button, participants proceeded to the next adjective, continuing this process until all 16 adjectives had been assigned a corresponding color selection. Given that computer monitors vary in resolution, color accuracy, and brightness, the experiment was conducted on a single standardized monitor. This approach minimized potential variations in color perception, thereby enhancing the study's reliability.

FINDINGS

The data stored in the research environment described in the previous section were analyzed using Python, a widely used programming language for modern data analysis. A custom-developed Python script, tailored specifically for this study, was used to process the data and generate original visual representations in the form of graphs and charts. The findings obtained from the data analysis are presented and explained in the following sections.

Demographic Results of the Experimental Groups

A total of 60 participants contributed to the study, and their distribution by education status (whether they received formal education) and gender is shown in the graph in Figure 8.

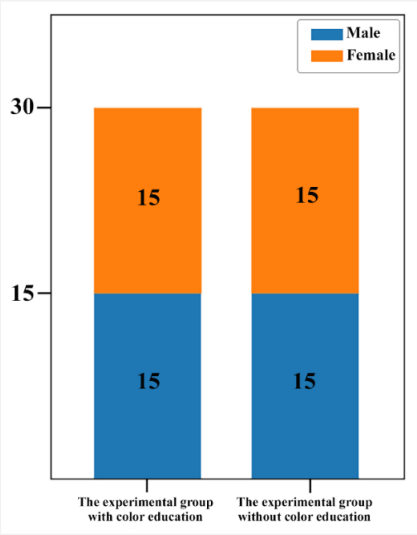

Figure 8. Demographic distribution of participants

In accordance with the study's objective, participants were equally distributed between those who had received formal color education and those who had not, as well as between male and female participants. Additionally,

since the study does not include an analysis based on the age variable, the age range of participants was restricted to 18-25 years. The collected data on age distribution is presented in Figure 9.

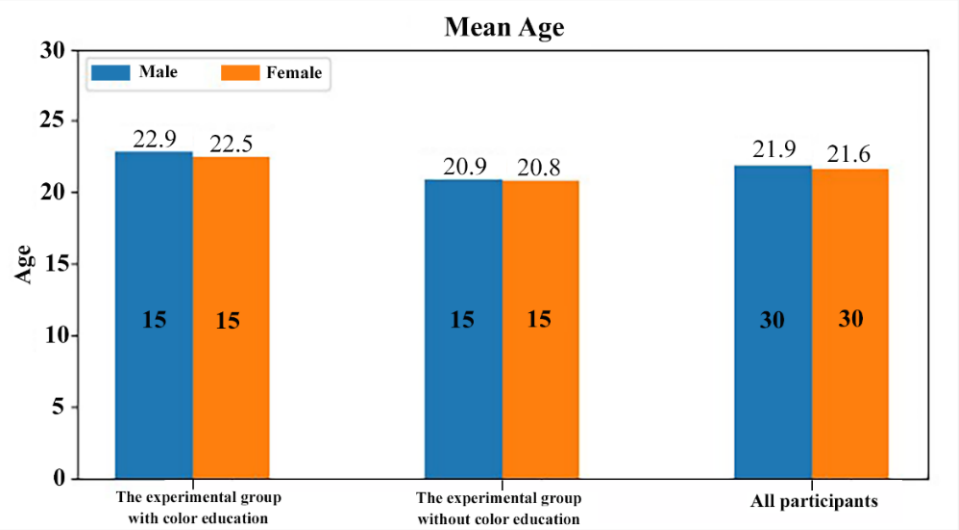

Figure 9. Mean age of participant groups

In the 30-person experimental group that received color education, 26 participants were from the Interior Architecture Department, and 4 were from the Interior Architecture and Environmental Design Department. In the 30-person experimental group without color education, 19 participants were studying Business Management, 8 were in International Trade, 1 was in Primary School Teaching, and 1 was in Turkish Language Teaching.

Results of Color Selections in Experimental Groups

In the study, Hypothesis 1 states: "The chairs colored by the experimental group with color education will align with the color-emotion associations found in the literature." Similarly, Hypothesis 2 states: "The chairs colored by the experimental group without color education will not align with the color-emotion associations found in the literature." To verify these hypotheses, the graphs presented in Figures 10 and 11 were generated.

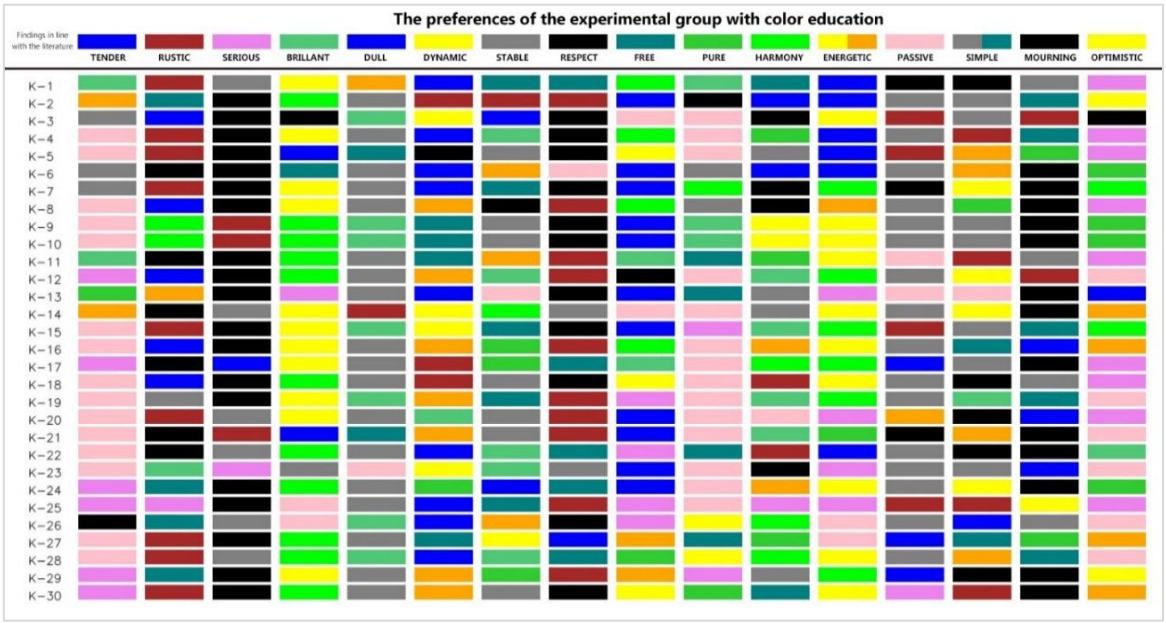

Figure 10. Color preferences of the experimental group with color education

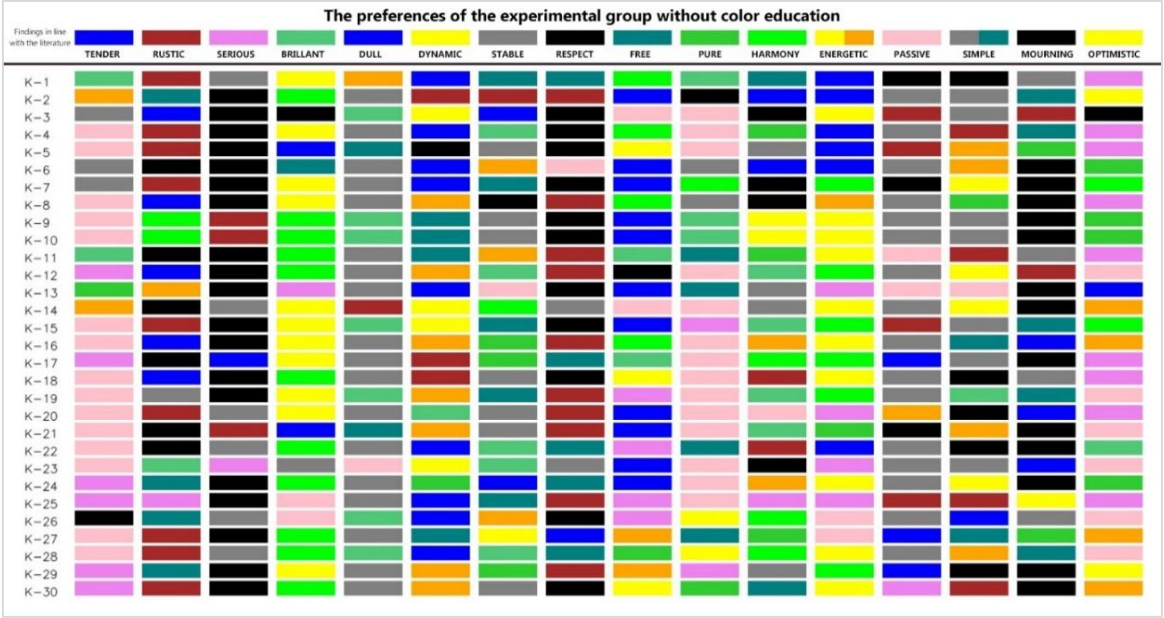

Figure 11. Color preferences of the experimental group without color education

Here, participants have been coded from K-1 to K-30. The top row represents the colors associated with emotions and adjectives in the literature. The colors selected by the participants are cumulatively displayed in the graphs below (Figures 12 and 13).

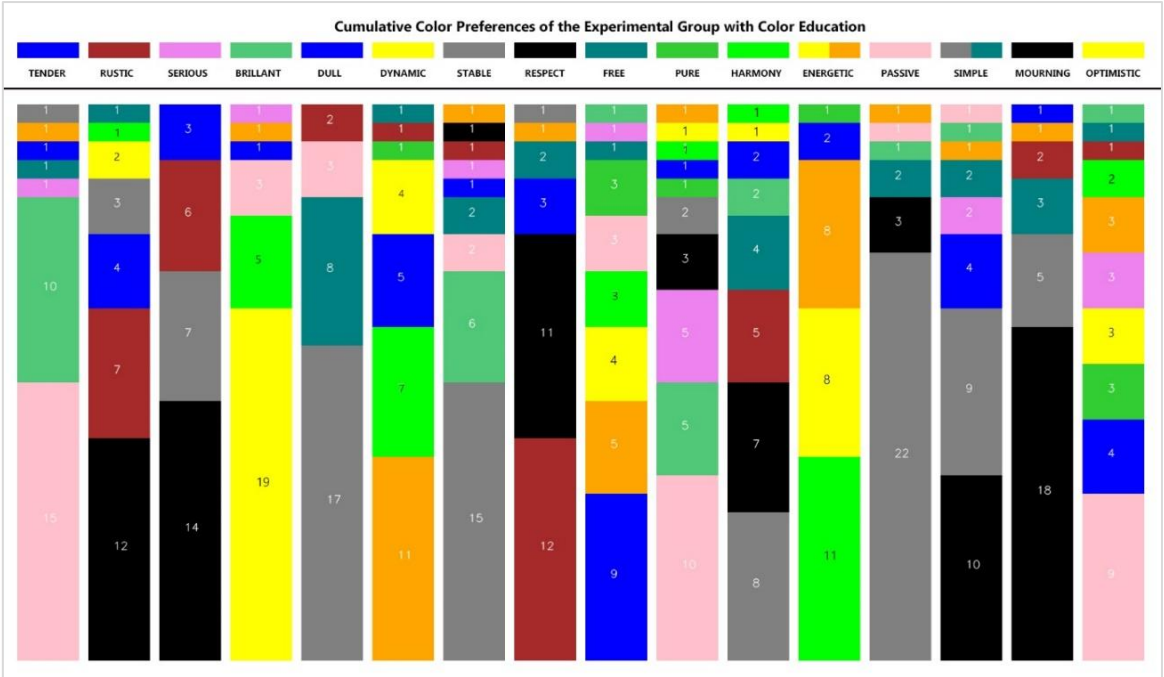

Figure 12. Cumulative color preferences of the experimental group with color education

When analyzing the cumulative values presented in the graphs, it was observed that among the 16 adjectives, only the emotions static, energetic, and pessimistic showed statistically significant associations with the color-emotion relationship for participants who had received color education. Additionally, the most strongly associated adjective-color pairs identified by participants were:

- “Dull” with gray,
- “Bright” with yellow,
- “Lifeless” with gray.

A particularly notable finding was that most participants associated the adjective “bright” with sunlight and daylight, leading them to select yellow, as expected. Similarly, the dominant association of the color gray with “lifeless” was understandable, as it is the most neutral among the provided alternatives.

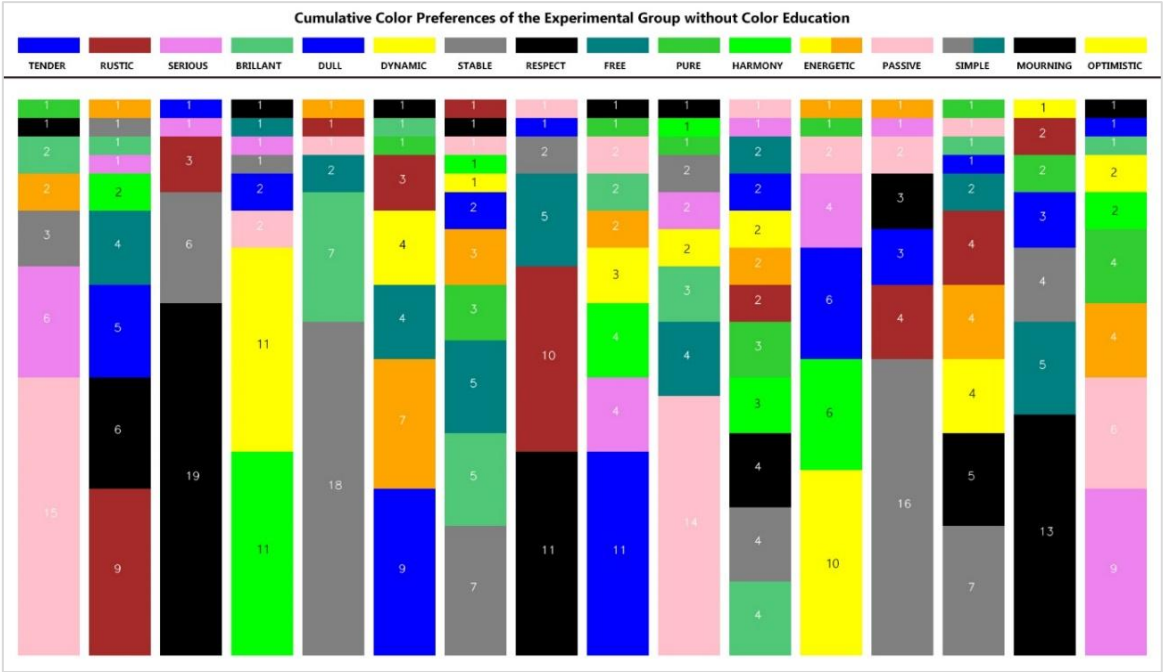

Figure 13. Cumulative color preferences of the experimental group without color education

When the cumulative color preferences of participants without color education were examined in relation to the color-emotion associations reported in the literature, the emotions *rough*, *static*, *energetic*, *simple*, and *pessimistic* were found to be statistically significant within the existing color-emotion relationships. Furthermore, although some color-adjective pairings were not statistically significant, they were still strongly associated with and preferred by the participants. These include:

- “Bright” being associated with green and yellow,
- “Dull” being associated with gray,
- “Lifeless” is associated with gray.

When the two experimental groups were compared, most adjective-color associations were not statistically significant. However, the experimental group without color education demonstrated greater alignment with established color-emotion associations. A possible explanation for this result is that participants in previous color-emotion studies were typically selected through random sampling, meaning that the majority lacked formal color education, which may have led to stronger alignment with the preferences of participants in the non-color-educated group in this study. To verify Hypothesis 3, which states: “Both experimental groups associate positive adjectives with warm colors,” graphs were generated in Figures 14 and 15. Figure 14 presents the warm color-positive adjective associations for participants with color education. Figure 15 shows the same associations for participants without color education. This situation can also be explained by the fact that individuals who have received color education reject more common standard associations by applying the knowledge acquired during their training. Furthermore, this difference may be attributed to variations in aesthetic and sensory experience, as well as associative perception, since individuals with color education are exposed to a greater number of color-related studies throughout their education than the other experimental group.

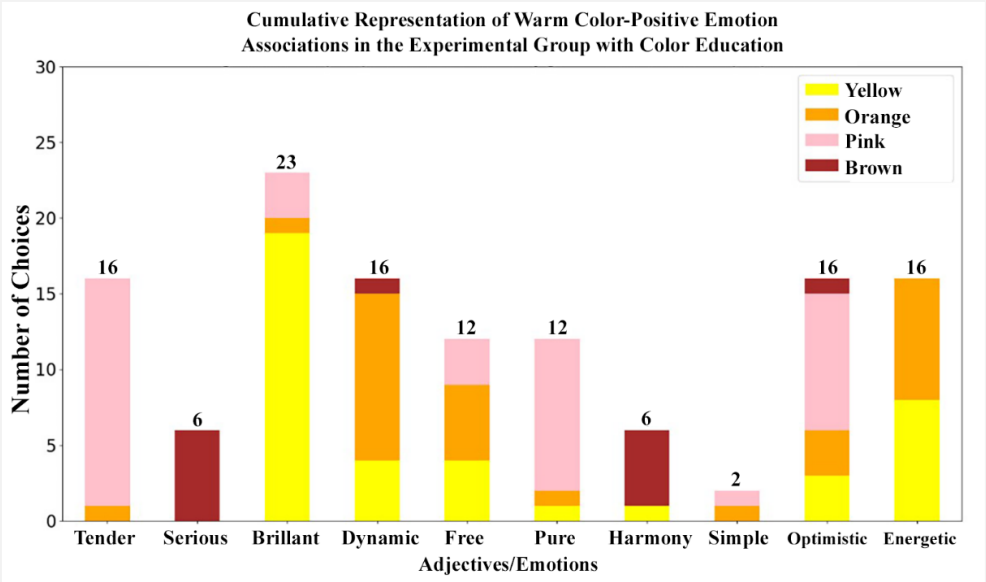

Figure 14. Cumulative representation of warm color-positive emotion associations in the experimental group with color education

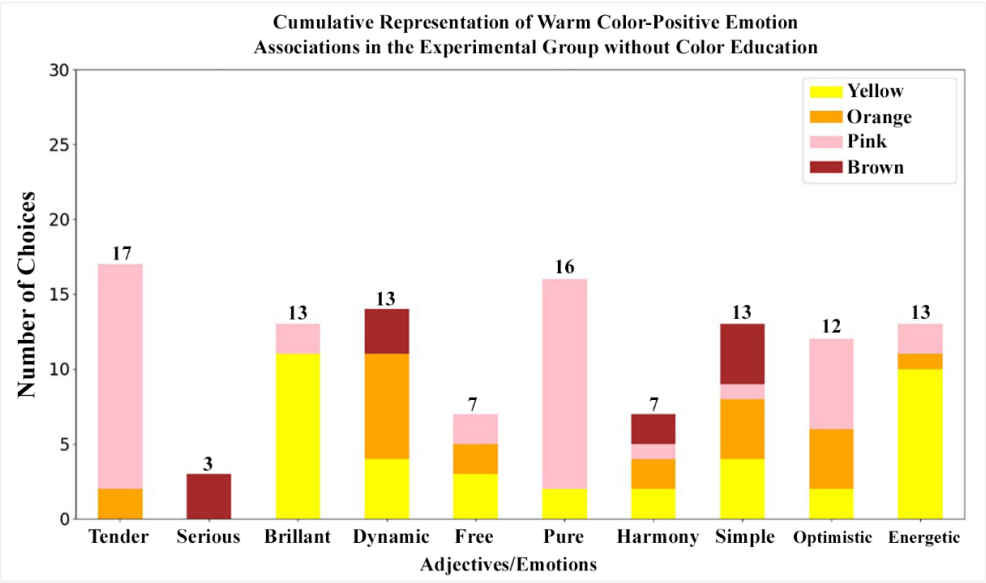

Figure 15. Cumulative representation of warm color-positive emotion associations in the experimental group without color education

Within the scope of the study, the 10 positive adjectives were incorporated into the graphs presented in the figures. Additionally, when examining the colors in the study, only four warm colors are observed: yellow, orange, brown, and pink.

The hypothesis states that positive emotions will be more strongly associated with warm colors in both experimental groups. However, in the color-educated experimental group of 30 participants, only the adjective “bright” was predominantly associated with warm colors by 23 participants. Apart from “bright,” the adjectives “polite,” “dynamic,” “energetic,” and “optimistic” were associated with warm colors by slightly more than half of the participants (16 individuals) in the color-educated group.

When examining the associations between positive adjectives and warm colors in the non-color-educated experimental group, notable differences were observed compared to the color-educated group. As seen in the graph, within this 30-participant group, only the adjectives “polite” and “pure” were associated with warm

colors by slightly more than half of the participants. Apart from these two adjectives, none of the other positive adjectives were predominantly associated with warm colors by most participants in this group.

To test Hypothesis 4, which states: "Both experimental groups associate negative adjectives with cool colors," graphs were generated in Figures 16 and 17. Figure 16 presents the cool color-negative adjective associations for participants with color education. Figure 17 displays the same associations for participants without color education.

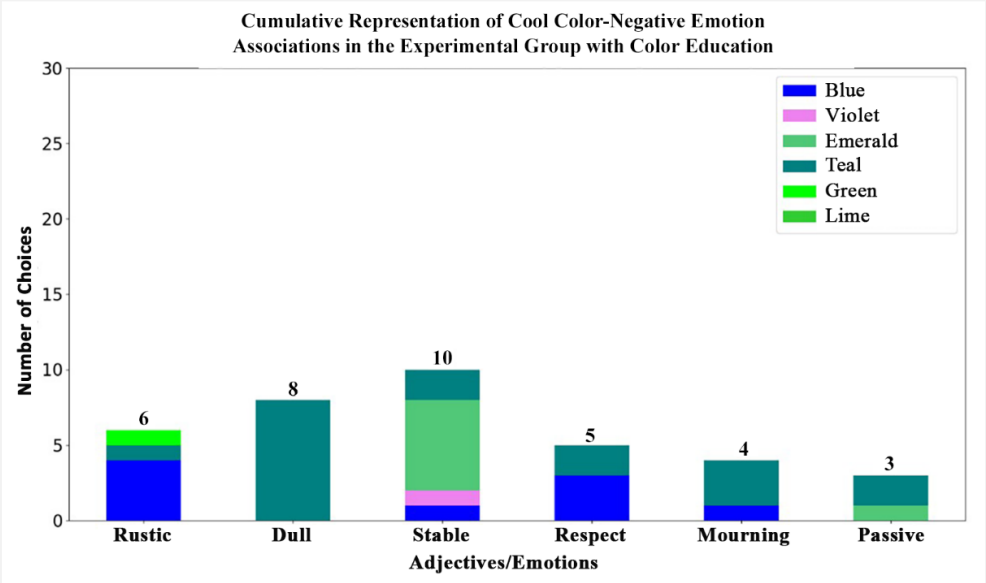

Figure 16. Cumulative representation of cool color-negative emotion associations in the experimental group with color education

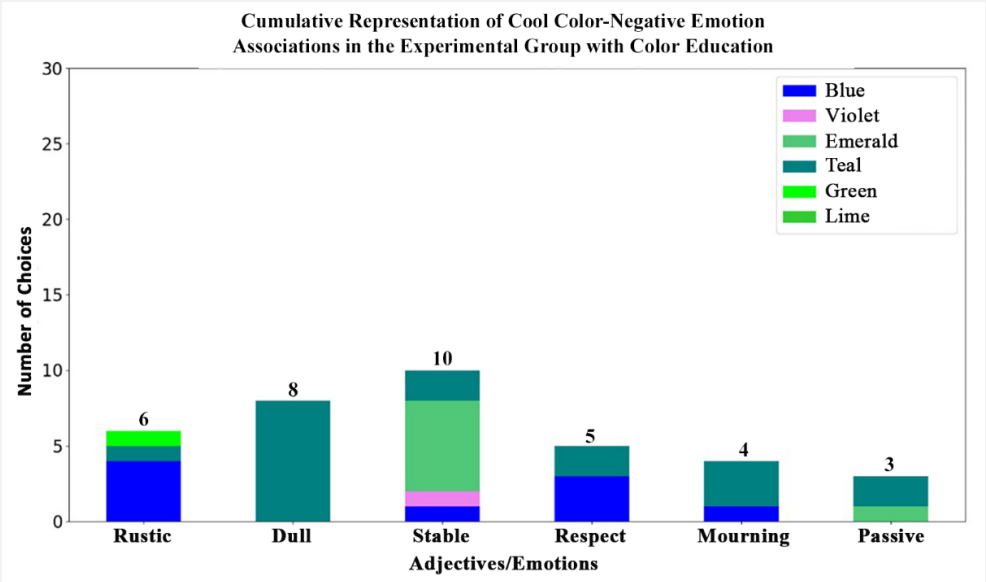

Figure 17. Cumulative representation of cool color-negative emotion associations in the experimental group without color education

Within the scope of the study, six of the presented adjectives represent negative emotions, and these have been incorporated into the graphs shown in the figures. Additionally, among the colors used in the study, the following belong to the cool color category: Blue, Violet, Emerald, Turquoise, Green, and Lime. The hypothesis suggests that negative emotions will be more strongly associated with cool colors in both experimental groups. However, when analyzing the graph for the color-educated experimental group, none of the negative adjectives were represented in cool colors at an above-average level. In the non-color-educated

experimental group, only the adjective "static" was associated with cool colors by slightly more than half of the participants. As a result, in both experimental groups, negative adjectives such as "rude," "dull," "static," "authoritative," and "lifeless" were predominantly associated with achromatic colors, such as black and gray. In such an experimental study, conducting research based on a specific composition rather than a single piece of furniture may be more appropriate to enhance the validity of color perception and interpretation. This approach would allow participants to evaluate colors not only in relation to a single object but also within environmental contexts and in terms of contextual integrity. Future studies may further investigate the effects of this approach in greater detail.

CONCLUSION

This study presents a comprehensive and detailed investigation into the impact of color on the furniture design process and its effects on user emotions. The primary focus areas of the study include examining users' emotional responses to colors, identifying relationships between colors and emotions, comparing participants with and without color education, and conducting the experiment using a specific furniture example: the Thonet No. 14 chair. The study's methodology, which used a simulation environment, enabled participants to engage interactively in the experimental process, thereby enhancing the study's reliability. Additionally, the purposeful sampling technique was employed with precision to select the sample group, ensuring a balanced participant profile. This careful selection contributed to the generalizability of the research findings.

When analyzing the study's findings, it is evident that differences exist in the color-emotion associations between the two experimental groups, those with and without color education. For instance, according to Hypothesis 1, the color-educated experimental group's coloring choices should align with the color-emotion associations found in the literature. Meanwhile, Hypothesis 2 suggests that the non-color-educated group's color choices should deviate from these established associations. However, upon examining the graphs, it was observed that the color-educated participants demonstrated alignment with the literature only for certain adjectives. In contrast, the non-color-educated group's color choices exhibited greater alignment with color-emotion associations from previous studies. Ultimately, while both groups' choices generally did not align with the literature, the non-color-educated group's preferences showed a stronger correlation with existing color-emotion pairings. This finding may be explained by the fact that previous studies on color-emotion associations in the literature were conducted with participants who were predominantly individuals without formal color education. Hypothesis 3 proposed that both experimental groups would associate positive adjectives with warm colors. However, when analyzing the graphs, it was observed that in the color-educated group, only the adjective "bright" was strongly associated with warm colors. The adjectives "polite," "dynamic," "optimistic," and "energetic" were only weakly associated with warm colors, while the other positive adjectives were distributed inconsistently across various colors. In the non-color-educated group, only the adjectives "polite" and "pure" were linked to warm colors, and even then, this preference was only observed in a small majority of participants. Hypothesis 4 suggested that both experimental groups would associate negative adjectives with cool colors. However, in the color-educated group, none of the negative adjectives were clearly associated with cool colors. In contrast, in the non-color-educated group, only the adjective "static" was associated with cool colors by a slight majority (16 participants). Overall, both experimental groups frequently associated negative adjectives with achromatic colors, such as black and gray. The findings indicate that neither experimental group showed a strong, consistent association between positive adjectives and warm colors or between negative adjectives and cool colors. Therefore, Hypotheses 3 and 4 could not be confirmed.

The findings of this study indicate that the color factor plays a crucial role in the furniture design process and significantly influences users' emotional responses. In particular, the observation that individuals with color education exhibit preferences more aligned with the color-emotion associations found in the literature provides valuable insights for designers and industrial product developers.

In conclusion, this study makes a significant contribution to understanding how color influences the furniture design process in the context of user emotions. It emphasizes the crucial role of colors in design perception and user experience, offering valuable guidance for future design projects. In product design, the importance

of considering the emotional impact of color in decision-making processes targeting specific user groups has been clearly demonstrated. Furthermore, the interactive simulation method employed in this study stands out as a repeatable, scalable tool for advancing research in design and user psychology. The findings can be used in product design practices for target audiences, and the simulation program developed within the scope of this study may also be adopted by furniture design, manufacturing, and marketing companies as a consumer-oriented tool.

For future research, it is recommended that the simulation environment be enhanced with technological tools, such as virtual reality, to allow users to engage in a spatial experience. Additionally, the use of computer software to create simulated environments and to collect, store, and analyze data would further improve the reliability of the study and its contribution to the literature. This study serves as a foundation for future research by expanding the sample size, increasing the number of variables, creating color compositions, and diversifying the presented color-adjective pairings.

Authors' Contributions

The 1st author contributed 50%, the 2nd author contributed 25%, and the 3rd author contributed 25% to the study.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

Ethics committee approval dated 03/07/2024 and numbered 2024-4/2 was obtained by Marmara University Social Sciences Research Ethics Committee.

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Authors' Biographies

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Research Article

Evaluation of environmental design students' sectioning skill with the Turkish version of the Santa Barbara Solids Test

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Abstract
Given the significance of sectioning skill in higher education and its malleability through training, it is imperative to measure this spatial skill and track its development by using an appropriate instrument. The *Santa Barbara Solids Test* is a spatial test that can be used for this purpose. However, it has been tested or used mainly with English-speaking science students. To determine whether a Turkish version of this test can be used in a culturally distinct population of design students, a two-phase study was therefore undertaken. The test's validity and reliability were initially evaluated in 173 students. Next, another sample of 200 students took the test to assess whether test scores varied by student characteristics, as in the previous studies. The results demonstrated that the psychometric properties of the Turkish version were satisfactory. A significant correlation between students' test scores and perceived spatial ability levels was found. Additionally, the test scores varied significantly by students' experience, department, and gender. From these findings, it can be concluded that the Turkish version of the test is psychometrically sound and can be used to measure and monitor the development of sectioning skill in Turkish design students.

Keywords: Design education, Environmental design, Sectioning skill, Spatial ability, The SBST

Extended Abstract

Introduction: Spatial ability is an amalgam of somewhat separate abilities or skills and plays a critical role in many professions and scientific disciplines. In addition to the importance of spatial ability, it has been demonstrated that spatial thinking and reasoning can be improved across different student populations through various training procedures. Therefore, it is essential to identify less able students using appropriate tools and to provide opportunities for them to develop their spatial skills. Given that all spatial tests may not be equally effective measures of the spatial skills critical to different fields, it is also crucial that the skills required for a specific field or domain should be measured using a relevant *domain-specific* test. One spatial skill that is more closely associated with fields such as architecture, geology, medicine, and engineering is sectioning. The *Santa Barbara Solids Test* is one of the spatial tests that can be used for measuring this skill. While this test is valid and reliable, it has been tested or used mainly with English-speaking science students. It has not been psychometrically evaluated in architecture and other environmental design students, for whom sectioning skill is deemed necessary. Moreover, it is not clear whether this test can be effectively used in culturally distinct populations.

Purpose and scope: To determine the appropriateness of this test for measuring sectioning skill in Turkish environmental design undergraduates, a study was conducted at three departments of an architecture and design faculty in Ankara, Türkiye. Since this test had not been thoroughly adapted for use in Türkiye, the test was initially translated into Turkish. Subsequently, the translated version was evaluated for validity and reliability. Moreover, student test scores were analyzed to determine whether they varied significantly by student characteristics, as in the earlier studies.

Method: The study was undertaken in two phases. In the first phase, the Santa Barbara Solids Test was translated from English to Turkish and then back to English to produce a translated version of the test. Following this translation process, 10 first-year interior design students were asked to rate whether the instructions and items of the translated version were clear. For further assessing the conceptual equivalence of the translated test, a panel of eight experts was also asked to rate the instructions and items. After making the necessary changes, a revised version of the translated test was obtained. To evaluate the content validity of individual items, the panel was asked to rate the items again. After concluding that there was no need to make additional revisions on the test, this version of the test and the *object manipulation spatial ability* subscale of the *Spatial Ability Self-Report Scale* were administered to a sample of 163 undergraduate environmental design students to assess the *construct validity, criterion validity, internal consistency,* and *convergent validity* of the obtained version. The construct validity was assessed by conducting a confirmatory factor analysis. To determine the criterion validity, the correlation between the test and the object manipulation spatial ability subscale scores was calculated. To evaluate the internal consistency and convergent validity, alpha coefficients and values for construct reliability and average variance extracted were determined. In the second phase, the test was administered to another sample of 200 undergraduate environmental design students to assess whether their scores would vary by student characteristics, namely students' year of education, department, and gender, and to conclude whether the test can be used for measuring and monitoring the development of sectioning skill in Turkish design students. To analyze the obtained test scores, one-way ANOVA for independent samples was used.

Findings and conclusion: The results of the confirmatory factor analysis that was undertaken to validate both the two- and three-factor model of the test verified the construct validity of the translated version. In addition, the significant positive correlations between participants' test scores and their reported spatial ability scores were consistent with previous research on spatial self-efficacy. They both confirmed the test's criterion validity and provided additional support for it. Moreover, the obtained Cronbach's alpha, construct reliability, and average variance extracted results were within the recommended ranges. These findings suggested that the psychometric properties of the translated version were satisfactory and that the whole test and its subscales could reliably assess sectioning skill in design students. The findings of the second phase demonstrated that the test was challenging for environmental design students. On average, the participants answered 68% of the test items correctly. Furthermore, the findings indicated that some students were significantly less successful in mentally visualizing sections. It was observed that the test scores of less- and more-experienced students differed significantly. In addition to students' experience, the test scores also varied by gender and department. While the male students scored consistently higher than their female peers, the differences in the scores reached statistical significance only for the *simple* and *embedded* subscales of the test. According to the results, the architecture students significantly outperformed their peers in the interior design and city planning departments. It was also observed that the test scores of interior design students were significantly higher than those of city planning students. Even though further research is needed to confirm these findings, several conclusions can be drawn. Firstly, it can be concluded that the translated version of the Santa Barbara Solids Test is a valid and reliable test for assessing sectioning skill in Turkish environmental design students. Secondly, some of these students may be less able to section three-dimensional objects in their minds and may be at greater risk of academic underachievement. Therefore, assessing environmental design students' sectioning skill and monitoring their progress by using the translated version would be beneficial. Thirdly, educational strategies for improving students' spatial skills by increasing their spatial self-efficacy can use this test version for sectioning skill assessment and, thus, evaluate the effectiveness of the adopted strategies. Lastly, sectioning skill can be developed through adequate departmental training for environmental design students.

Keywords: Design education, Environmental design, Sectioning skill, Spatial ability, The SBST

INTRODUCTION

A broad definition of spatial ability is "the ability to generate, retain, retrieve and transform well-structured visual images" (Lohman, 1994: 1000). A vast body of empirical evidence shows that spatial ability differs from general intelligence and that it is not a unitary construct, but rather an amalgam of somewhat separate abilities or skills (for a review, see Hegarty and Waller, 2005). While there is not a complete agreement on the structure of spatial ability (Halpern, 2012; Hegarty & Waller, 2005; Newcombe & Shipley, 2014), it is acknowledged that spatial thinking and reasoning are crucial to many professions and scientific disciplines,

such as architecture, engineering, medicine, physics, and chemistry (Hegarty & Waller, 2005; Kerkman et al., 2000; Shea et al., 2001). Given its importance, it seems reasonable to assume that spatial ability is directly linked to major choice and subsequent career success. To date, longitudinal research on intellectually precocious youth has provided clear scientific evidence to support this connection. A series of studies has shown that proficiency in spatial abilities is linked to interest in science and mathematics and to pursuing a career in science and engineering (Humphreys et al., 1993; Shea et al., 2001; Webb et al., 2007). Moreover, another group of studies focusing on educational and vocational outcomes showed that earning an advanced degree in "science, technology, engineering, and mathematics" (STEM) education (Wai et al., 2009), developing innovative knowledge (Kell et al., 2013) and achieving extrinsic career success pertaining to pay and income (Lang & Kell, 2020) are related to spatial ability.

Apart from the importance of spatial ability, it has been shown that spatial thinking and reasoning can be improved across different populations through various training procedures (Uttal et al., 2013). Therefore, particular emphasis should be placed on identifying less able students and developing curricula to improve the spatial skills of those at risk. To achieve these goals, it is imperative to assess and track students' spatial abilities quantitatively using standardized tests. Given this requirement, the question arises as to whether existing spatial tests are equally effective measures of the spatial skills critical to different fields. A plausible answer to this question is that the skills needed for a specific field or domain should be measured using a relevant "domain-specific" test (Berkowitz et al., 2021; Cho & Suh, 2021; Cohen & Hegarty, 2012).

One spatial skill that is more closely associated with various STEM fields is inferring the two-dimensional (2D) sections of a three-dimensional (3D) solid object. In medicine, this skill is essential for educational attainment and for the comprehension of 2D medical images, such as X-rays (Hegarty et al., 2007; Hegarty et al., 2009). The ability to mentally visualize sections is also vital in geology, where it is termed "visual penetration ability" (Atit et al., 2015; Kali & Orion, 1996). Additionally, having trouble with sectioning 3D objects in mind is disadvantageous for engineers and is associated with poor academic performance (Cohen & Bairaktarova, 2018; Ha & Brown, 2017). Moreover, there is evidence that sectioning skill is important in architecture and more relevant to this field than other spatial skills (Berkowitz et al., 2021; Gerber et al., 2019). Given the significance of sectioning skill in several fields, it is crucial to assess it by using a suitable spatial test.

The *Santa Barbara Solids Test* (Cohen & Hegarty, 2007, 2012) is one of the spatial tests that can be used to measure sectioning skill. Even though this test has been shown to be valid and reliable, it has been tested or used mainly amongst undergraduate science, engineering, and psychology students (Cohen & Bairaktarova, 2018; Cohen & Hegarty, 2007, 2012; Ha & Brown, 2017). It has not been psychometrically evaluated in architecture and other environmental design students, for whom sectioning skill is necessary, to the best of our knowledge. Moreover, given that it is not appropriate to merely translate a measure and make it possible to use it in a different country, or more specifically, cultural context (for further information, see Beaton et al., 2000), it is not clear whether this test can be used in a culturally distinct population. Research in Western industrialized countries consistently demonstrated that males outperform females on standardized sectioning skill tests, including the Santa Barbara Solids Test (Berkowitz et al., 2021; Cohen & Hegarty, 2012; Tsutsumi et al., 2005). In these countries, it was also observed that sectioning skill varies considerably amongst university students and tends to be greater in more experienced students (Berkowitz et al., 2021; Gerber et al., 2019; Tsutsumi et al., 2005). Given these findings, it is necessary to address whether the Santa Barbara Solids Test can be effectively used to quantify possible differences in sectioning skill in another population, such as Turkish design undergraduates, and to take reasonable precautions to ensure the quality of education.

Acknowledging the importance of measuring sectioning skill and the need to determine the appropriateness of the Santa Barbara Solids Test for design students in other cultures, a study was undertaken across three departments of an architecture and design faculty in Ankara, Türkiye. Since this test had not been thoroughly adapted for use in Türkiye, the test was initially translated into Turkish. Subsequently, the translated version was evaluated for validity and reliability. Moreover, student test scores were analyzed to determine whether they varied significantly across different student characteristics. The current paper presents and discusses the results of these analyses.

METHOD

Participants

In total, 373 undergraduate students (mean age ± SD: 21.05 ± 1.74 years), studying architecture, city planning, and interior design at TED University in Ankara, Türkiye, voluntarily participated. As per the ethical clearance issued by TED University on 08 December 2023 (document number: 2023-20), all students consented to participate after being informed about the study and its objectives. Apart from speaking Turkish as their first language, there were no other inclusion criteria. At an early stage of the study, 10 first-year interior design students (5 men and 5 women) evaluated the first Turkish version of the Santa Barbara Solids Test for clarity. To assess the psychometric properties of its final Turkish version, 163 architecture and interior design students who did not participate in the first stage took the test. The descriptive statistics of these students (second-stage participants) are presented in Table 1. In the last stage, 200 students (see also Table 1 for more information on these third-stage participants) who did not participate in the previous two stages were used to evaluate the test's use among architecture and design students.

Table 1. Descriptive statistics of the second- and third-stage participants

		Second-stage participants		Third-stage participants	
		n	%	*n*	%
Gender	Female	116	71.17	145	72.50
	Male	47	28.83	55	27.50
Department	Architecture	90	54.21	84	42.00
	City planning	0	0.00	52	26.00
	Interior design	73	44.79	64	32.00
Year of education	1st	41	25.15	64	32.00
	2nd	43	26.38	59	29.50
	3rd	41	25.15	38	19.00
	4th	38	23.32	41	20.50
Total		163	100.00	200	100.00

Measures

The Santa Barbara Solids Test (SBST): A Turkish version of the SBST (Cohen & Hegarty, 2007, 2012) was used to evaluate participants' sectioning skill. The SBST is an achievement test that consists of 30 items with four answer options. The test items vary in difficulty based on the complexity of the sectioned solid and the orientation of the cutting plane. In the items, there are 10 *simple, joined,* and *embedded* solids. The *simple* solids are cylinders, cones, cubes, pyramids or prisms. The *joined* solids are made up of two simple solids that touch each other externally. *Embedded* solids are more complex solids formed by inserting two simple solids horizontally or vertically. In the test, half of the items have *orthogonal* cutting planes that are oriented perpendicularly to the vertical or horizontal axis of the solids. The remaining 15 items have *oblique* cutting planes. A total SBST score is calculated by summing the scores for all items. Alternatively, individual scores can be calculated for each sub-dimension: *simple, joined, embedded, orthogonal,* and *oblique*. In a sample of 59 psychology students, Cohen and Hegarty (2007) demonstrated that the SBST had good criterion validity and internal consistency reliability. Participants' total SBST and sub-dimension scores significantly correlated with their composite test score, calculated from two spatial ability tests. Additionally, a *Cronbach's alpha* of 0.86 was found for the overall test. In a later study with a larger sample composed mainly of undergraduate science students, Cohen and Hegarty (2012) obtained an alpha coefficient of 0.91 for the entire test and values ranging from 0.73 to 0.85 for the sub-dimensions. Moreover, participants' Scholastic Aptitude Test (SAT) mathematics scores predicted their SBST scores better than their SAT Reading scores. In addition, males significantly outperformed females in the SBST.

The Spatial Ability Self-Report Scale (SASRS): The SASRS (Turgut, 2015) was used to demonstrate convergent validity by examining correlations between participants' SBST scores and their self-reported level of *object manipulation spatial ability* (OMSA). The SASRS consists of 18 items that are rated on a 5-point scale. The responses to these items are used to quantify OMSA, *spatial navigational ability* (SNA), and *visual memory* (VM). In a sample of Turkish undergraduates, Turgut (2015) demonstrated that the SASRS had good psychometric properties. The validity analyses confirmed the scale's three-factor structure and criterion

validity. Alpha coefficients for the SASRS and its OMSA, SNA, and VM subscales were reported to be 0.88, 0.88, 0.80, and 0.62, respectively. Since OMSA encompasses a wide range of skills related to spatial ability (Turgut, 2015) and can be linked with sectioning skill, only the OMSA scores were used in our analyses.

Procedure

Since there was a need to adapt the SBST for use in Türkiye, the test was adapted to the local culture and context, following the guidelines of Hambleton and Patsula (1999). Initially, two independent translators fluent in both English and Turkish translated the SBST from English into Turkish. While one translator was familiar with technical drawing terminology and was aware of the construct measured by the test, the other translator had no prior knowledge of the construct or subject matter. Both translations were reviewed by another bilingual translator and compared with the original SBST. Several inconsistencies were resolved by the translators with input from the principal investigator. After reaching a consensus, the initial translated version of the test (I-TV) was obtained. The I-TV was then translated back into English by two other translators with similar professional backgrounds. To avoid bias, both translators were completely blind to the original version of the test. Following the back-translation process, all translators and the principal investigator reviewed all translated versions of the SBST and compared them with the original version. After reconciling any discrepancies, the second translated version (S-TV) was synthesized. A sample of 10 first-year interior design students, whose first language is Turkish, was asked to rate the clarity of the S-TV's instructions and items. The instructions and items were found to be clear by 100% and 90% of the students, respectively. To further evaluate the conceptual equivalence of the S-TV, a panel of eight specialists in architectural education and one specialist in educational sciences, all native Turkish speakers, was asked to rate both the instructions and the items of the test. Since more than 80% of the panel rated the instructions as unclear, the S-TV was revised in accordance with the panel's recommendations. It was suggested to clarify that the correct answer would only represent the surface or surfaces cut by the cutting plane, as the visible surfaces beyond the cutting plane were not included in some of the answer sets. After making the necessary changes, the panel evaluated the revised S-TV (R-TV). Conceptual equivalence was achieved at this stage.

To evaluate the *content validity* of the individual items, the panel was then asked to rate the R-TV items. Based on the ratings, the items were classified as either relevant or irrelevant for computing the *item-level content validity index* (I-CVI). While the I-CVI for 29 items was 1.00, it was 0.89 for the 19th item. Furthermore, the average of the I-CVIs (S-CVI/Ave) for the items was calculated and shown to be 0.996. Given that an I-CVI of 0.78 or above for nine experts and an S-CVI/Ave of 0.90 or above are considered as satisfactory indices (Polit & Beck, 2006), it was concluded that the items did not need another revision. To further establish the psychometric properties of the R-TV, the R-TV and the OMSA subscale of the SASRS were administered to a sample of 163 students in the second stage of the study to assess *construct validity, criterion validity, internal consistency, and convergent validity.* Construct validity was assessed through a *confirmatory factor analysis.* To determine the criterion validity, the correlation between the test and OMSA subscale scores was calculated. For evaluating the internal consistency and convergent validity, alpha coefficients and values for construct reliability and average variance extracted were determined. After conducting analyses for the reliability and validity of the test, the R-TV was also administered to 200 students to demonstrate whether the test scores would vary by student characteristics in the final stage and conclude whether the test can be effectively used for measuring and monitoring the development of sectioning skill in Turkish design students. To analyze students' test scores, *one-way ANOVA for independent samples* was used. LISREL (version 8.72) was used for the confirmatory factor analysis. The remaining statistical analyses were performed by using the Statistical Package for the Social Sciences (SPSS, version 22.0).

FINDINGS

Confirmatory factor analysis (CFA)

In addition to evaluating content validity in the initial stage of the study, construct validity was assessed through a CFA. Before conducting the CFA, the suitability of the collected data for further psychometric testing was determined. First, the *Kaiser-Meyer-Olkin* (KMO) test was used to ascertain whether the sample

size was adequate. There was no missing data. The KMO value for the whole sample was 0.85. Given that KMO values between 0.80 and 1.00 indicate adequacy (Shrestha, 2021), the sample size was deemed sufficient. Secondly, to identify outliers in the dataset, the raw scores for each variable were converted to *z-scores*. Since z-scores out with −3.00 or +3.00 are regarded as unsatisfactory (Yan & Su, 2009), there were no extreme values. Moreover, kurtosis and skewness values were calculated to check normality. The obtained kurtosis and skewness values ranged from −0.857 to 0.520 and from −0.587 to −0.064, respectively. Because both kurtosis and skewness values fall within the acceptable range of -2.00 to +2.00 (George & Mallery, 2020), the assumption of normality was confirmed. Since the items of the SBST were developed and categorized according to both the complexity of the sectioned solid and the cutting plane orientation, two different CFAs were performed. The first analysis was undertaken to validate the two-factor model for the two different cutting plane orientations. The CFA path diagram for the two-factor model is presented in Figure 1. Table 2 shows that the computed factor loadings for the two-dimensional structure of the adapted SBST range from 0.29 to 0.90, and that the observed variables had significant factor loadings at the 0.05 significance level in explaining the latent variables. Only Item 5 (T5) has a relatively modest loading, just below the minimum recommended loading of 0.30 (Field, 2013). Given that removing this item had a minimal effect on the overall model and that it had a significant factor loading, this item was retained.

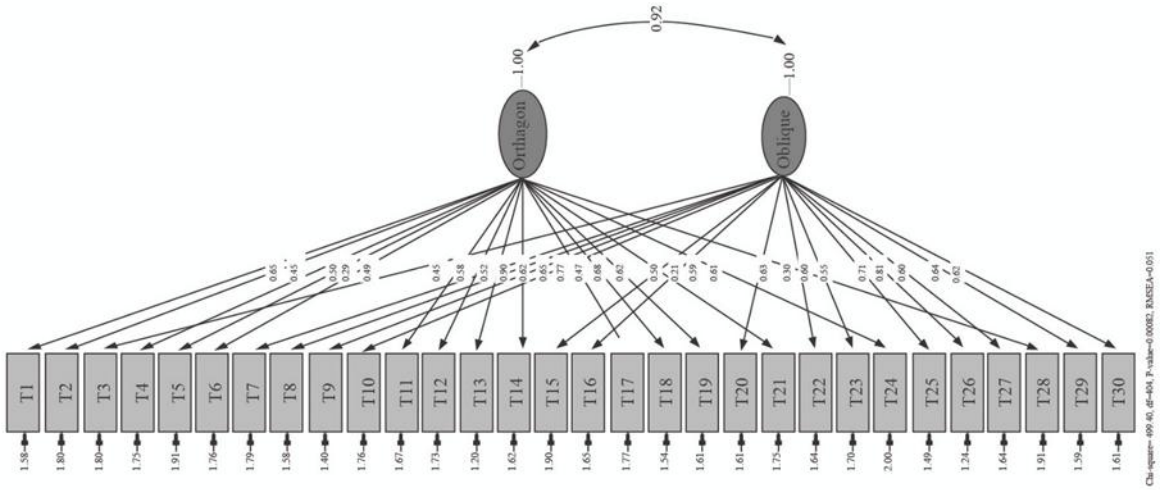

Figure 1. The obtained path diagram for the two-dimensional structure of the Turkish SBST

Table 2. Factor loadings for the two-dimensional structure of the Turkish SBST

Orthogonal		Oblique	
T1	0.65*	T3	0.45*
T2	0.45*	T7	0.46*
T4	0.50*	T8	0.65*
T5	0.29*	T9	0.77*
T6	0.49*	T10	0.49*
T11	0.58*	T15	0.31*
T12	0.52*	T16	0.59*
T13	0.90*	T20	0.63*
T14	0.62*	T22	0.60*
T17	0.47*	T23	0.55*
T18	0.68*	T25	0.71*
T19	0.62*	T26	0.81*
T21	0.50*	T27	0.60*
T24	0.61*	T29	0.64*
T28	0.30*	T30	0.63*

To assess the fit of the two-factor model, the following *goodness-of-fit* measures were employed: *chi-square to degrees of freedom ratio; comparative fit index (CFI); goodness-of-fit index (GFI); standardized root mean square residual (SRMR);* and *root mean square error of approximation.* For these measures, the recommended cut-off criteria are: $1 < x^2/df < 3$ (Carmines & McIvar, 1983); CFI ≥ 0.90 (Lai & Green, 2016); GFI > 0.90 (Schumacker & Lomax, 2010); SRMR < 0.10 (Schermelleh-Eugel et al., 2003); and RMSEA < 0.06 (Hu &

Bentler, 1999). The results of our analysis demonstrated an acceptable fit and, thus, verified the construct validity of the two-dimensional structure of the adapted SBST. All values obtained for the goodness-of-fit measures (Table 3) met the cut-off criteria.

Table 3. Goodness-of-fit analysis results for the two-factor model

X^2	*df*	x^2/df	CFI	GFI	SRMR	RMSEA
499.40*	404	1.23	0.90	0.94	0.07	0.05

* $p < 0.001$

A second CFA was also conducted to validate the three-factor model for the three different types of sectioned solids. The CFA path diagram is presented in Figure 2. Table 4 shows that the computed factor loadings for the two-dimensional structure of the adapted SBST range from 0.29 to 0.86, and that the observed variables had significant factor loadings at the 0.05 significance level in explaining the latent variables. Items 5 (T5) and 28 (T28) have slightly low loadings of 0.29, which are just below the minimum recommended loading. Given that removing these two items had a minimal effect on the overall model and that they had significant factor loadings, it was decided to retain them rather than modify the test.

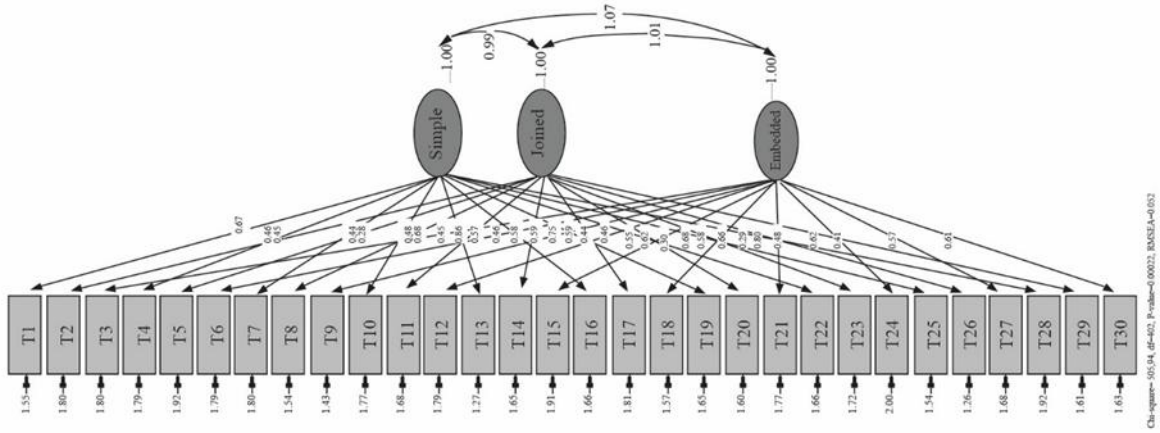

Figure 2. The obtained path diagram for the two-dimensional structure of the Turkish SBST

Table 4. Factor loadings for the three-dimensional structure of the Turkish SBST

Simple		Joined		Embedded	
T1	0.67*	T2	0.45*	T3	0.45*
T4	0.46*	T5	0.29*	T6	0.46*
T7	0.44*	T8	0.68*	T9	0.75*
T10	0.48*	T11	0.57*	T12	0.46*
T13	0.86*	T14	0.59*	T15	0.30*
T16	0.58*	T17	0.44*	T18	0.66*
T19	0.59*	T20	0.63*	T21	0.48*
T22	0.59*	T23	0.53*	T24	0.41*
T25	0.68*	T26	0.80*	T27	0.57*
T28	0.29*	T29	0.62*	T30	0.61*

* $p < 0.001$

To assess the fit of the three-factor model, the aforementioned *goodness-of-fit* measures and their cut-off criteria were used. All fit indices for the three-factor model were within the recommended ranges (Table 5). The obtained x^2/df ratio ranged from 1 to 3. While the CFI value was not lower than 0.90, the GFI value exceeded the acceptable threshold of 0.90. The SRMR and RMSEA values were both lower than the suggested cut-off values of 0.10 and 0.06, respectively. These results showed adequate fit between the data and the three-factor model tested, and they further supported the construct validity of the translated SBST.

Table 5. Goodness-of-fit analysis results for the three-factor model

X^2	*df*	x^2/df	CFI	GFI	SRMR	RMSEA
505.94*	402	1.25	0.90	0.95	0.07	0.05

* $p < 0.001$

Criterion validity

To determine the *criterion validity* of the adapted SBST, the correlation of participants' SBST scores with their OMSA scores was analyzed by calculating *Pearson's product-moment correlation coefficients*. Although the results of this analysis demonstrated that the obtained correlation coefficients, between 0.261 and 0.367 (Table 6), indicated either weak or moderate associations (Pallant, 2007), participants' SBST scores positively correlated with their reported spatial ability scores at statistically significant levels. These results confirmed the criterion validity of the R-TV and further supported the test's validity.

Table 6. Pearson's product-moment correlation coefficients for the relationship between the second-stage participants' (n = 163) SBST and OMSA scores

	SBST total	SBST simple	SBST joined	SBST embedded	SBST orthogonal	SBST oblique
OMSA	0.357*	0.261*	0.325*	0.367*	0.283*	0.350*

* $p < 0.05$

Internal consistency and convergent validity

While the *Kuder-Richardson 20* (KR-20) is generally used for estimating the reliability of dichotomous measures (Villaume & Weaver, 1996), Cronbach's alpha can also be used for binary items and yields the same result as the KR-20 (Meyer, 2010). Given the suitability of utilizing "Cronbach's alpha" for the adapted SBST, alpha coefficients were calculated for the whole test and its subscales. It can be seen from Table 7 that all alpha coefficients for the adapted test are not below the threshold value of 0.70 (Taber, 2018) and, thus, indicate the internal consistency of the adapted SBST. It is also evident from Table 7 that the alpha coefficients for the adapted test are comparable to those obtained for the original test, except for the coefficient for the *orthogonal* subscale.

Table 7. "Cronbach's alpha" coefficients, CRs, and AVEs for the SBST and its subscales

	SBST total	SBST simple	SBST joined	SBST embedded	SBST orthogonal		SBST oblique
alpha	0.85	0.76	0.78	0.70	0.70		0.81
	Two-dimensional structure			Three-dimensional structure			
	SBST orthogonal	SBST oblique	SBST total	SBST simple	SBST joined	SBST embedded	SBST total
CR	0.97	0.98	0.99	0.92	0.92	0.89	0.91
AVE	0.31	0.36	0.34	0.34	0.33	0.28	0.32

Since Cronbach's alpha may underestimate reliability (Hair et al., 2019), the construct reliability (CR) value, considered to be a more suitable alternative (Hair et al., 2019; Netemeyer et al., 2003), was also calculated. In addition to CR value, *average variance extracted* (AVE), a better criterion for internal consistency or stability (Netemeyer et al., 2003), was computed as well. Table 7 also shows that all CR values range from 0.89 to 0.99. Given that these values are above the acceptable CR threshold of 0.70 (Hair et al., 2019), they indicate an adequate convergence or internal consistency. Table 7 also shows that the AVE values range from 0.28 to 0.36. Although the minimum value for AVE is 0.50 (Hair et al., 2019), these values are still acceptable for two reasons. Firstly, for a new measure, an AVE of 0.25 or higher can be considered satisfactory (Wang et al., 2023). Secondly, if CR values exceed the threshold, an AVE below 0.50 is still deemed adequate and an indicator of convergent validity (Shrestha, 2021). Therefore, it is reasonable to conclude that the Turkish version of the SBST has an acceptable internal consistency and convergent validity.

To further confirm our findings on the internal consistency of the adapted SBST, alpha coefficients for the whole test and its subscales were calculated from the dataset for the 200 third-stage participants. Before this analysis, the adequacy of sampling was determined by the KMO test. There was no missing data. A KMO value of 0.85 was found for the whole sample. Since this value fell within the range of 0.80 to 1.00, the sample size was deemed adequate. Moreover, to identify outliers in the dataset, the raw scores for each variable were converted to *z-scores*. Given that the obtained z-scores were between −3.00 and +3.00, there were no extreme values. Also, kurtosis and skewness values were calculated to check normality. The obtained kurtosis and skewness values ranged from −0.876 to 0.342 and from −1.506 to 0.172, respectively. Because both kurtosis and skewness values were within the range of −2.00 to +2.00, the assumption of normality was confirmed. The reliability analysis demonstrated that all alpha coefficients were above the 0.70 threshold and thus indicated

satisfactory reliability. The coefficient for the whole scale was 0.87. The coefficients for the *simple, joined, embedded, orthogonal,* and *oblique* subscales were 0.75, 0.71, 0.72, 0.79, and 0.81, respectively.

Test score differences in the participants

To assess the use of the R-TV among Turkish design students, we also examined whether third-stage participants' test scores varied significantly by year of education, department, and gender. The descriptive statistics for participants' correct answers in the R-TV are given in Table 8. On average, the participants answered 68% of the R-TV items correctly. While they successfully answered 79% of the items with *orthogonal* cutting planes, they correctly answered 56% of the items with *oblique* cutting planes. The success rate for the items with *simple, joined,* and *embedded* solids were 68%, 70%, and 65%, respectively. Approximately 83% (165) of students had an average score of 15 or more.

Table 8. Descriptive statistics for the correct answers in the R-TV

	Mean	*SD*	%
SBST simple	6.76	2.48	67.60
SBST joined	6.97	2.31	69.70
SBST embedded	6.48	2.14	64.80
SBST orthogonal	11.86	3.03	79.07
SBST oblique	8.35	3.83	55.67
SBST total	20.51	6.23	68.37

To ascertain whether the SBST scores of less and more experienced students significantly differed, participants' test scores were analyzed by using the "one-way ANOVA for independent samples". The analysis results are presented in Table 9. The results indicated that the scores for the whole test [$F(3,196) = 9.780$, $p < 0.001$] and *simple* [$F(3,196) = 5.995$, $p < 0.001$], *joined* [$F(3,196) = 9.150$, $p < 0.001$], *embedded* [$F(3,196) = 8.362$, $p < 0.001$], *orthogonal* [$F(3,196) = 8.446$, $p < 0.001$] and *oblique* [$F(3,196) = 7.865$, $p < 0.001$] subscales varied significantly by the year of education or students' experience. According to the post-hoc test results (Table 9), the more experienced students significantly outperformed their less experienced peers. The fourth-year students had the highest test scores. They were followed by the third-, second-, and first-year students, respectively.

Table 9. One-way ANOVA and post-hoc test results for students' year of education

		Sum of squares	*df*	Mean square	*F*	Significant differences
SBST simple	Between groups	103.07	3	34.35	5.995*	$1^{st} < 2^{nd} < 3^{rd} < 4^{th}$ year
	Within groups	1123.40	196	5.73		
	Total	1226.48	199			
SBST joined	Between groups	131.55	3	43.85	9.150*	$1^{st} < 2^{nd} < 3^{rd} < 4^{th}$ year
	Within groups	939.32	196	4.79		
	Total	1070.87	199			
SBST embedded	Between groups	104.15	3	34.71	8.362*	$1^{st} < 2^{nd} < 3^{rd} < 4^{th}$ year
	Within groups	813.76	196	4.15		
	Total	917.92	199			
SBST orthogonal	Between groups	209.64	3	69.88	8.446*	$1^{st} < 2^{nd} < 3^{rd} < 4^{th}$ year
	Within groups	1621.71	196	8.27		
	Total	1831.35	199			
SBST oblique	Between groups	314.98	3	104.99	7.865*	$1^{st} < 2^{nd} < 3^{rd} < 4^{th}$ year
	Within groups	2616.51	196	13.35		
	Total	2931.50	199			
SBST total	Between groups	1007.20	3	335.73	9.780*	$1^{st} < 2^{nd} < 3^{rd} < 4^{th}$ year
	Within groups	6728.55	196	34.32		
	Total	7735.75	199			

* $p < 0.001$

The obtained scores on the R-TV and its subscales were also analyzed by using the one-way ANOVA for independent samples to assess the possible effects of different design fields on participants' sectioning skill. The analysis results are presented in Table 10. The scores for the whole test [$F(2,197) = 14.280$, $p < 0.001$] and *simple* [$F(2,197) = 12.297$, $p < 0.001$], *joined* [$F(2,197) = 9.473$, $p < 0.001$], *embedded* [$F(2,197) = 12.493$, $p < 0.001$], *orthogonal* [$F(2,197) = 8.778$, $p < 0.001$] and *oblique* [$F(2,197) = 14.325$, $p < 0.001$] subscales

varied significantly by participants' department. According to the post-hoc test results (Table 10), the architecture students significantly outperformed the interior design and city planning students. Also, the SBST scores of the interior design students were significantly better than those of the city planning students.

Table 10. One-way ANOVA and post-hoc test results for the students' department

		Sum of squares	*df*	Mean square	*F*	Significant differences
SBST simple	Between groups	136.12	2	68.06	12.297*	City planning < Interior design < Architecture
	Within groups	1090.36	197	5.53		
	Total	1226.48	199			
SBST joined	Between groups	93.95	2	46.97	9.473*	City planning < Interior design < Architecture
	Within groups	976.92	197	4.95		
	Total	1070.875	199			
SBST embedded	Between groups	103.31	2	51.65	12.493*	City planning < Interior design < Architecture
	Within groups	814.60	197	4.13		
	Total	917.92	199			
SBST orthogonal	Between groups	150.01	2	75.00	8.788*	City planning < Interior design < Architecture
	Within groups	1681.34	197	8.53		
	Total	1831.35	199			
SBST oblique	Between groups	372.20	2	186.10	14.325*	City planning < Interior design < Architecture
	Within groups	2559.29	197	12.99		
	Total	2931.50	199			
SBST total	Between groups	979.51	2	489.75	14.280*	City planning < Interior design < Architecture
	Within groups	6756.24	197	34.29		
	Total	7735.75	199			

* $p < 0.001$

To determine whether participants' SBST scores significantly differed between the male and female participants, the test scores were analyzed by using the independent samples t-test. The analysis results are presented in Table 11. While the males scored consistently higher than their female peers, the differences in the scores reached statistical significance only for the *simple* [t(198) = −2.071, p = 0.040] and *embedded* [t(198) = −2.127, p = 0.035] subscales.

Table 11. Independent samples t-test results for students' gender

		n	Mean	*SD*	Mean difference	*t*	*df*	*p*
SBST simple	Female	145	6.53	2.42	−0.80	−2.071	198	0.040
	Male	55	7.34	2.54				
SBST joined	Female	145	6.91	2.39	−0.21	−0.571	198	0.569
	Male	55	7.12	2.11				
SBST embedded	Female	145	6.28	2.05	−0.71	−2.127	198	0.035
	Male	55	7.00	2.30				
SBST orthogonal	Female	145	11.71	3.10	−0.56	−1.172	198	0.243
	Male	55	12.27	2.82				
SBST oblique	Female	145	8.02	3.64	−1.17	−1.942	198	0.054
	Male	55	9.20	4.22				
SBST total	Female	145	19.73	6.12	−1.73	−1.766	198	0.079
	Male	55	21.47	6.40				

CONCLUSION

This study highlights the relevance of spatial ability and skills for academic achievement and learning. The objectives of this study were both exploratory and confirmatory. Since a psychometrically sound Turkish version of the SBST was unavailable, the first objective was to translate it. The second objective was to evaluate the validity and reliability of the Turkish version of the test in a sample of Turkish undergraduates. Given the absence of evidence on the use of the SBST among environmental design students for whom sectioning skill is crucial, a sample of architecture, city planning, and interior design students was utilized. In addition to assessing the adapted test for validity and reliability, another objective was to determine whether specific student characteristics could explain any marked differences in SBST scores.

The analyses verified the validity and reliability of the Turkish version of the SBST. The CFA results demonstrated that items with three different solid types and those with two different cutting planes loaded on separate factors. These results confirm both the three-factor and two-factor structures of the test, for which its items were developed and categorized according to the complexity of the sectioned solid and cutting-plane orientation, and thus the test's construct validity. Furthermore, students' perceptions of their spatial ability, or more specifically, spatial self-efficacy, were significantly correlated with their actual performance on the SBST. This finding aligns with previous research on spatial self-efficacy (Power et al., 2016; Safadel et al., 2023; Towle et al., 2005) and provides additional support for the validity of the adapted SBST. The reliability results suggest that the entire adapted test and its subscales can reliably assess sectioning skill in our sample. Moreover, the results demonstrated that the adapted SBST was a challenging test for the participants. On average, our third-stage participants answered roughly 20 of the 30 items correctly. This finding is comparable with that of Cohen and Hegarty (2012). They found that about 68% of the answers were correct in their sample, mainly composed of science and engineering students. Apart from the use of the adapted test in environmental design students, the results point to the importance of boosting students' spatial self-efficacy. This requires a holistic approach for improving spatial ability rather than focusing solely on students' actual ability. In addition to providing opportunities to develop students' spatial skills, incorporating educational strategies, such as offering help and giving positive feedback on students' performance, can be more beneficial and thus more appropriate.

The results also indicated that some students were significantly less successful in mentally visualizing the 2D sections of the 3D solids. The subscale and whole test scores of the students varied significantly by the year of education. This finding is consistent with those of the earlier studies on the differences in sectioning skills between experienced and inexperienced students (Berkowitz et al., 2021; Gerber et al., 2019; Tsutsumi et al., 2005) and the influence of design training and instruction on the development of spatial cognition (Berkan et al., 2020; Gomez-Tone et al., 2021; Lin, 2016). In addition to student experience, the SBST scores also varied by gender. Although all SBST scores for male participants were higher than those of their female peers, the significant differences were limited to the "simple" and "embedded" subscales. These findings offer some empirical support for the previously reported outperformance of males relative to females in sectioning skill tests (Berkowitz et al., 2021; Cohen & Hegarty, 2012; Tsutsumi et al., 2005), and they align with Cohen and Hegarty's (2012) findings. While the root cause of these differences remains to be elucidated and warrant further investigation, it has been proposed that the combined effects of various biological, psychological and societal factors can account for the observed differences in spatial skills and other cognitive abilities (for this discussion, see Halpern, 2012) and that "the co-construction of gender and spatial ability" can also explain the gender differences (Bartlett & Camba, 2023). It is important to note that we should not focus solely on these differences but also on a much more fundamental issue. Given that both genders can benefit from training and develop their spatial skills equally (Baenninger & Newcombe, 1989; Newcombe et al., 2002; Uttal et al., 2013), future studies should place a greater emphasis on how to maximize spatial competence in both genders to facilitate learning and enhance academic performance. Another finding of the present study that warrants further exploration is the observed differences in SBST performance among students from the three departments. While it needs to be confirmed, the significant differences between the city planning students and those of architecture and interior design students may stem from the curricula of the degree programs. In addition to the compulsory technical drawing and design courses available across all programs, a wide variety of both compulsory and elective courses in architectural design-related subjects, such as structure and construction technologies, are offered to architecture and interior design students. Since these extra courses may have fostered spatial ability development, the SBST performance of the city planning students was found to be comparatively low. Given the demonstrated relationship between mathematics achievement and overall SBST score (Cohen & Hegarty, 2012), one reason for the differences between architecture and other environmental design students may be the admission criteria used for architecture programs in Türkiye. Unlike the interior design and city planning programs, which admit students only based on their university entrance examination scores, the architecture programs also require students to rank among the top 250,000 examinees. Since almost one-third of the examination is composed entirely of mathematics questions, architecture students can be expected to be relatively more successful in mathematics and, thus, in the SBST.

Several limitations of our study should be noted here and considered in interpreting our findings and planning future research. Firstly, the study sample comprised environmental design students from a single faculty. To generalize the findings to other design- and STEM-related disciplines, for which sectioning skill is particularly important, additional research across diverse samples appears beneficial. Secondly, the sample was composed mainly of females due to the scarcity of males in those departments. While this imbalance has been reported in the psychometric assessment of the SBST amongst undergraduate science students (Cohen & Hegarty, 2012) and thus is not unexpected in design-related disciplines, possible gender effects on the study outcomes should also be considered and investigated further. Lastly, the development of sectioning skill in our sample was determined by comparing students' SBST scores across different years of study. Even though this comparison provides some support for the benefits of training in spatial skills, monitoring students' progress by measuring their sectioning skill at multiple points may further improve our understanding of training effects.

Evidently, there is insufficient empirical evidence to fully understand the impact of sectioning skill and other spatial skills on educational outcomes, or to evaluate the potential use of the SBST for quantifying sectioning skill across different student populations. Nevertheless, we can draw some conclusions from the existing findings. Firstly, it can be concluded that SBST's Turkish version is a psychometrically sound test. Secondly, some students may encounter greater difficulty visualizing 2D sections of 3D objects than their peers and be at a greater risk of academic underachievement. Therefore, it can also be concluded that these students need to be identified and monitored by using standardized instruments, such as the SBST, to take all reasonable precautions. Thirdly, future attempts to improve students' spatial self-efficacy can use this version of the SBST as a diagnostic tool to identify students who are not highly skilled at sectioning and, thus, are likely to benefit more from educational strategies to boost spatial self-efficacy. Lastly, given that students' SBST scores varied significantly by the year of education, sectioning skill can be developed through adequate departmental training in environmental design students.

Authors' Contributions

All authors contributed to the study conception and design. Material preparation and data collection were performed by Kenan Eren Şansal and Güliz Taşdemir. Data analysis was performed by Merve Şahin Kürşad. The first draft of the manuscript was written by Kenan Eren Şansal and Merve Şahin Kürşad and edited by Güliz Taşdemir. All authors commented on the previous versions of the manuscript. All authors read and approved the final manuscript.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

Ethics committee approval dated 08/12/2023 and numbered 2023-20 was obtained by Human Research Ethics Committee of TED University.

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Research Article

Mekân ve hareket: Mekânsal konumlanma ile tigmotaktik eğilim ilişkisi üzerine bir vaka çalışması

Place and movement: A case study of the relationship between spatial positioning and thigmotactic tendency

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Özet

Tigmotaksi (thigmotaxis), sınırlara yakın olma tercihi olarak tanımlanabilir. Yüzeylerle dokunsal teması içeren tigmotaksi; konfor, navigasyon ve güvenlikle ilgilidir ve mekânsal davranışa bağlıdır. Bazı çalışmalar çevre topolojisinin hareket ve sosyal davranışı nasıl etkilediğini araştırırken, tigmotaksi üzerine araştırmalar sınırlıdır. Mimari ortamlardaki mekânsal konumlanma tercihlerinin; bireylerin tigmotaktik eğilimleri, algıladıkları güvenlik duygusu ve agorafobiye yatkınlıkları tarafından nasıl şekillendirildiği sorusunu bu çalışmanın temel sorusudur. Bu araştırma, mimari mekânlarda bireylerin konum seçimlerini etkileyen psikolojik yönelimlerin, özellikle tigmotaksi ve agorafobik eğilimler bağlamında gerçek mekânlarda nasıl gözlemlenebileceğini incelemeyi amaçlamaktadır. Araştırmanın kapsamı, kontrollü inşa edilmiş ortamlarda kapalılık ve açıklık gibi mekânsal özelliklere verilen davranışsal tepkilerin incelenmesini içerir. Çalışmada, üniversite öğrencilerinden oluşan 34 katılımcının iki farklı sınıf ortamında konumlanma (oturma) tercihleri gözlemlenmiş, ardından Likert tipi anketlerle tigmotaktik eğilim, agorafobi ve güvenlik algıları ölçülerek bu değişkenler arasındaki ilişkiler ele alınmıştır. Katılımcıların konumlanma seçimleri, psikolojik tepkileri ve kendi bildirdikleri agorafobi yatkınlık puanları kaydedilip analiz edilmiştir. Bulgular, katılımcıların kapalı alanlarda daha güçlü tigmotaktik eğilimlere sahip olabileceğini göstermektedir. Mekânın, hareket ve konumlanmayı etkileyebildiği tartışılmıştır. Sonuçlar, mekân tasarımında psikolojik ve davranışsal çeşitliliğin dikkate alınması gerektiğini vurgulamaktadır. Tigmotaksi konusun ele alınması, özellikle açık veya belirsiz sınırlı alanlara duyarlı kişiler için psikolojik olarak destekleyici mimari mekânları yaratabilmesi konusunda faydalı olacaktır.

Anahtar Kelimeler: Tigmotaksi, Mekânsal davranış, Algılanan güvenlik hissi, Barınma-gözlem kuramı, Mimari tasarım

Abstract

Thigmotaxis is the tendency to remain close to environmental boundaries. Involving tactile interaction with surfaces, thigmotaxis is associated with comfort, navigation, and perceived safety, and is linked to spatial behavior. While some studies have examined how environmental topology shapes movement and social behavior, research on thigmotaxis remains limited. The central question of this study is how spatial positioning preferences in architectural environments are shaped by individuals' thigmotactic tendencies, perceived sense of security, and predisposition to agoraphobia. Accordingly, this research aims to investigate how psychological orientations influencing spatial choices -particularly thigmotaxis and agoraphobic tendencies- can be observed in real architectural settings. The scope of the study includes examining behavioral responses to spatial characteristics, such as enclosure and openness, within controlled built environments. In this study, the seating (positioning) preferences of 34 university students were observed in two different classroom settings. Subsequently, Likert-type questionnaires were used to measure thigmotactic tendency, agoraphobia, and perceived safety, and the relationships among these variables were analyzed. Participants' spatial choices, psychological responses, and self-reported agoraphobia scores were recorded and evaluated. The findings indicate that participants showed stronger thigmotaxis in enclosed environments. The results also suggest that spatial configuration may be associated with movement and positioning patterns. The findings highlight the importance of considering psychological and behavioral diversity in spatial design. Addressing thigmotaxis may help create psychologically supportive architectural environments, particularly for individuals sensitive to open or poorly defined spaces.

Keywords: Thigmotaxis, Spatial behavior, Perceived sense of security, Prospect-refuge theory, Architectural design

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Extended Abstract

Introduction: This study investigates the relationship between spatial positioning preferences and thigmotactic tendencies in architectural environments. Thigmotaxis, the tendency to remain close to boundaries or surfaces, has been widely studied in animal behavior but remains underexplored in human spatial behavior within built environments. Existing research in environmental psychology suggests that spatial preferences are shaped by evolutionary mechanisms related to safety, threat perception, and navigation. In particular, prior theoretical frameworks emphasize that individuals tend to favor positions that offer both environmental visibility and physical protection, which aligns with the principles of the Prospect-Refuge Theory. These dual needs -being able to observe one's surroundings while maintaining a sense of shelter- are thought to influence how people navigate and occupy space. However, empirical evidence demonstrating how these tendencies manifest in real architectural settings is still limited. This study addresses this gap by examining how individuals position themselves within interior spaces and how these choices relate to perceived safety, agoraphobic tendencies, and thigmotactic behavior. By bridging behavioral theory with spatial analysis, the research contributes to a deeper understanding of how psychological predispositions interact with architectural form.

Purpose and scope: The primary aim of this study is to explore how spatial positioning preferences in architectural environments are influenced by psychological tendencies, particularly thigmotaxis, perceived safety, and agoraphobia. The research focuses on understanding whether individuals prefer edge (boundary-adjacent) or central positions within interior spaces and how these preferences vary across different spatial configurations. Additionally, the study seeks to determine whether environmental transparency, enclosure, and visual permeability shape these preferences. The scope of the study includes controlled real-life classroom environments with varying degrees of openness and enclosure, providing a practical, observable context for human spatial behavior. By comparing a glass-dominated (open/transparent) classroom and a closed (enclosed) classroom, the study aims to identify how environmental characteristics interact with psychological responses and shape spatial behavior. Furthermore, the research considers individual differences in perception, acknowledging that not all users experience space uniformly. Through this approach, the study contributes to both architectural design practice and environmental psychology by offering insights into how space can be structured to accommodate varying comfort levels and behavioral tendencies.

Method: The study used a between-subjects experimental design with 34 university students. Participants were randomly assigned to one of two different classroom settings: a glass classroom (transparent and open) and a closed classroom (enclosed with solid walls). Each participant entered the space individually and was asked to freely choose a seating position without guidance or prior instruction regarding preferred locations. After selecting their seat, participants remained seated for approximately 2-3 minutes to ensure that their choice reflected an initial, instinctive spatial preference rather than a temporary or exploratory decision. Their seating locations were recorded through direct observation and subsequently mapped onto spatial diagrams representing each classroom layout. Following the behavioral observation, participants completed a Likert-scale questionnaire measuring three key variables: perceived safety, agoraphobia, and thigmotactic tendency. The questionnaire was designed to capture subjective psychological responses corresponding to the observed spatial choices. Data were analyzed using independent-samples t-tests to compare differences between the two environments and Pearson correlation analyses to examine relationships between psychological variables and seating positions. Additionally, spatial distribution patterns were visualized through heat maps and clustering diagrams to support the interpretation of behavioral tendencies. This mixed-method approach, combining quantitative statistical analysis with spatial visualization, enabled a comprehensive evaluation of both behavioral patterns and underlying psychological factors.

Findings and conclusion: Participants generally preferred boundary-adjacent positions over central locations, demonstrating a clear thigmotactic tendency in real architectural settings. A significant concentration of seating choices was observed along walls, corners, and near structural elements such as columns, suggesting that proximity to physical boundaries provides a sense of comfort and control. Individuals who selected edge positions reported higher perceived safety and stronger thigmotactic tendencies, whereas those in central positions reported lower scores on these dimensions. The results also show that physical contact with environmental boundaries-such as sitting with one's back against a wall-significantly enhances the sense of security. In contrast, the openness or transparency of the space alone does not produce a statistically significant difference in perceived safety. This suggests that tactile and spatial enclosure may be more influential than visual openness in shaping comfort levels. Correlation analyses further reveal that feelings of vulnerability in open or central positions are strongly associated with agoraphobic tendencies and a perceived loss of control over the environment. Participants with higher agoraphobia scores were more likely to avoid central areas and gravitate toward edges, reinforcing the link between psychological disposition and spatial behavior. The study demonstrates that spatial behavior in architectural environments is shaped not only by physical layout but also by underlying psychological mechanisms. The findings highlight the importance of incorporating boundary elements, transitional zones, and semi-enclosed areas within architectural design. Providing a balance between openness and refuge can accommodate diverse user preferences and enhance overall spatial experience. Designing environments that respond to these behavioral tendencies can improve user comfort, increase perceived safety, and support more inclusive, psychologically responsive architectural solutions.

Keywords: Thigmotaxis, Spatial behavior, Perceived sense of security, Prospect-refuge theory, Architectural design

GİRİŞ

Mekânsal davranış, bireylerin bilişsel, duygusal ve evrimsel eğilimleriyle farklılaşan çok katmanlı bir deneyimdir (Rushton, 1969; Hen vd., 2004; Rollero & De Piccoli, 2010; Casakin & Bernardo, 2012; Peri Bader, 2015; Grütter, 2020). Özellikle iç mekânlarda kullanıcı bireylerin konumlanma tercihleri, sadece işlevsellik, konfor veya estetik değer gibi sebeplerle değil, aynı zamanda içgüdülerine de dayanır. Mimari tasarım ve çevresel psikoloji kesişiminde yapılan güncel çalışmalar, bu mekânsal tercihlerde güvenlik arayışının belirleyici olduğunu göstermektedir. Mekânsal tercihlerimiz, diğer yandan bilişsel eğilimlerle de şekillenir (Ruso vd., 2003; Romice, 2017; Sussman & Hollander, 2021). Bireylerin bir mekân içerisinde nerede bekleyeceği ya da oturacağı tercihi; tehdit algısı, sosyal anksiyete ve yön bulma gibi psikolojik süreçlere dayanır (Zhao, 2020; Tafti vd., 2025).

Tigmotaksi davranışı, canlı organizmanın açık alanlardan kaçınarak çevresel sınırlara yönelme eğilimini ifade eder ve hem hayvanlar hem de insanlar için evrimsel bir strateji olarak kabul edilir (Kallai vd., 2007). Tigmotaksi davranışı ilk olarak kemirgenler ve balıklarda gözlemlenmiş, açık alanlardan kaçınarak çevresel sınırlara yönelme stratejisi olarak tanımlanmıştır (Grossen & Kelley, 1972; Martinez & Morato, 2004; Maximino vd., 2010; Schnörr vd., 2012). Bu davranış, yüksek kaygı seviyeleri ve tehdit algısı ile ilişkilendirilmiş olup açık alan paradigması gibi deneysel yöntemlerle ölçülmüştür. Benzer şekilde, bazı kuş türleri de yeni ortamlarda tanıdık veya korunaklı alanlara yönelerek tigmotaktik stratejiler sergiler. Bu bulgular, tigmotaksinin evrimsel olarak korunduğunu ve türler arasında ortak psikobiyolojik temellere dayandığını göstermektedir (Delprato, 1980; Weitz vd., 2012; Jeanson vd., 2003).

İnsanlarda tigmotaksi, özellikle açık alan testleri *(open field test)* (Weiss & Greenberg, 1998) ile incelenmiş ve bireylerin çevresel tehdit altında korunaklı bölgelere yönelme eğilimleri doğrulanmıştır (Gromer vd., 2021). Bu davranışların kaygı bozuklukları, özellikle agorafobi ile ilişkili olduğu gösterilmiştir (Walz vd., 2016; Gromer vd., 2021). Beyin görüntüleme çalışmaları, tigmotaktik tercihlerin insular lob ve amigdala bölgelerindeki aktivite artışıyla ilişkili olduğunu ortaya koymuştur (Kallai vd., 2009; Morland vd., 2015). Tigmotaksi, yalnızca korku temelli değil, aynı zamanda çevresel kontrol ve kaçış ihtiyacıyla da bağlantılıdır (Kallai vd., 2007; Walz vd., 2016; Harriott vd., 2021).

Jay Appleton'un *Prospect-Refuge Kuramı (Prospect-Refuge Theory)* (1975), güvenlik arayışının çevresel tercihler üzerindeki evrimsel kökenlerini açıklar. Bireylerin hem çevreyi gözlemleyebilecekleri alanlara (prospect), hem de tehdit anında saklanabilecekleri alanlara (refuge) yöneldikleri görülür (Appleton, 1975). Bu kuram, çevresel tercihlerin güçlü bir açıklayıcısı olarak kabul edilmiş ve agorafobik davranış çalışmaları ile de desteklenmiştir. Mimari mekânların düzeni, bireylerin bu stratejik dengeyi sağlamasına olanak tanıyarak güvenlik ihtiyacını karşılar (Ramanujam, 2006; Walz vd., 2016; Dosen, 2016; Akcelik vd., 2024). Tigmotaksi ve agorafobik eğilimler, bireylerin mekânsal tercihlerinde belirleyici faktörlerdir. Duvara yaslanma, köşeyi tercih etme ya da sırtı koruyacak şekilde konumlanma, yalnızca psikolojik değil, aynı zamanda mekânsal bir deneyim üretir (Walz vd., 2016; Hollander vd., 2020). Mimari mekânların tasarımı (ışık, sınır elemanları, mobilya yerleşimi vb.) bu eğilimleri etkiler. Tigmotaktik yönelim, özellikle kalabalık ya da belirsiz mekânlarda güvenlik ihtiyacına yanıt olarak ortaya çıkar (Romice, 2017; Brielmann vd., 2022).

Literatürde ağırlıklı olarak hayvan deneyleri aracılığıyla incelenen bu yönelimlerin, insanların yapılı çevredeki iç mekân davranışlarına etkisi yeterince araştırılmamıştır. Alan çalışması, üniversite öğrencilerinin ders işlediği gerçek sınıf ortamlarında yürütülerek, kullanıcı deneyimi temelli deneye ve gözleme dayalı veriler sunmakta ve bu yönüyle mevcut çalışmalardan ayrışmaktadır. Araştırma kapsamında, biri geniş cam cephelere sahip, diğeri ise dışarıya görsel olarak kısmen kapalı olan iki farklı fiziksel sınıf ortamı karşılaştırmalı olarak ele alınmıştır. Katılımcıların, oturma tercihleri ile birlikte çevresel tehdit algısı, mekânsal kaygı düzeyi ve güvenlik hissi gibi psikolojik faktörleri değerlendiren üç ölçekten elde edilen veriler doğrultusunda mekânsal ve psikolojik değişkenler arasındaki ilişkiler analiz edilmiştir. Bireylerin yalnızca beyan ettikleri duygular değil, aynı zamanda sınıf içerisinde konumlandıkları yerler üzerinden yorumlanabilen mekânsal tercihler de incelenmiştir.

Çalışmada test edilen hipotez, bireylerin çevresel sınırlara (örneğin duvar kenarı veya köşeler) yakın konumlanma eğilimlerinin güvenlik arayışı, mekânsal kaygı ve tehdit algısı gibi psikolojik faktörlerle ilişkili olduğu varsayımına dayanmaktadır. Ayrıca bu tercihlerin farklı fiziksel özelliklere sahip iç mekânlarda anlamlı

düzeyde farklılaşacağı öngörülmüştür. Bu yönüyle araştırma, tigmotaktik davranışları yalnızca klinik ya da deneysel ortamlarla sınırlı bırakmayıp gündelik yaşamın parçası olan mimari mekânlarda da inceleyerek özgün bir katkı sunmayı hedeflemektedir.

KURAMSAL ÇERÇEVE

Tasarımda Tigmotaksi

Tigmotaksi, Yunanca "dokunma" ve "hareket" anlamına gelen köklerden türemiştir ve ilk olarak 1900'lü yılların başında kullanılmıştır (Kallai vd., 2007). Tigmotaksi, hareketin yüzeylerle fiziksel temasla yönlendirildiği bir davranışı tanımlanmış ve ilk olarak duvarlara yakın durma ya da onları takip etme eğiliminde olan hayvanlarda gözlemlenmiştir. Hayvan çalışmaları, tigmotaksinin genellikle organizmanın yeni bir kapalı alanın çevresine yönelmesi ve iç kısmından kaçınması şeklinde ortaya çıktığını göstermektedir (Creed Jr & Miller, 1990; Harris vd., 2009).

İnsanlarda tigmotaktik davranışlar, insanların bilinmeyen alanlarda gezinirken sıklıkla duvarlara yakın durduklarını göstermektedir. İnsanlarda tigmotaksinin bilişsel ve duygusal yönleri, bu davranışın mekânsal öğrenmenin ilk aşamalarında daha belirgin olduğunu göstermektedir (Kallai vd., 2007; Juneja, 2016). Agorafobisi olan ya da yüksek kaygı duyarlılığına sahip bireylerin hem kontrollü açık alan ortamlarında hem de pazar yerleri gibi doğal ortamlarda duvarlara yakın durarak tigmotaktik eğilimler gösterdiği ortaya konulmuştur (Walz vd., 2016). İnsanlarda tigmotaksi, kaygı ve açık alanlardan kaçınma ile ilişkili, evrimsel olarak korunmuş bir savunma davranışı olarak kabul edilir. Bu davranışın mimari ortamlardaki varlığı, insanların inşa edilmiş alanların kenarlarına ve çevrelerine doğal olarak yönelmesiyle kendini gösterir. Bu da duvarlara yaslanma ya da kenar arama eğilimi yoluyla güvenlik ve yön bulma duygusunu artıran ve mimari tasarımı etkileyen bir davranıştır (Hollander vd., 2021; Sussman & Hollander, 2021; Hollander, 2023).

Tigmotaksi kavramı, insan davranışının -özellikle tanıdık olmayan mekânlarda kenarlara, sınırlara ve duvarlara yönelme gibi içgüdüsel eğiliminin- yapılı çevre tasarımını etkileyip şekillendirebileceğini ifade etmektedir. Tigmotaksi, bireylerin yeni bir mekânda çevreye yakın kalarak hareket ettiği içgüdüsel bir mekânsal strateji olarak açıklar; bu davranış genellikle "duvar takip etme" olarak adlandırılır (Gray & Novacevski, 2015; Raj & Patil, 2023). Bu strateji, mekânsal deneyimde kritik bir rol oynar; çünkü çevrede dolaşmak, mekânsal sınırların tanımlanmasına yardımcı olur ve bilişsel haritaların oluşturulmasını destekler. Tigmotaksi, vücudun en az bir tarafının korunuyor olması sayesinde güvenlik hissi sağlar ve kaçış yollarının tespitini kolaylaştırır (Sussman & Hollander, 2021). Mekânsal davranış ile tigmotaktik eğilim birbiriyle bağlantılıdır, tigmotaksi, bir organizmanın mekânsal keşfe nasıl yaklaştığını önemli ölçüde etkileyebilir. Örneğin güçlü tigmotaktik eğilime sahip bireyler açık alanlardan kaçınır ve genellikle mekânların kenarlarında kalırlar. Bu davranış, kullanıcının mekânı keşfetmesini engelleyebilir; bu da mekânsal bellek ya da bilişsel haritalama gerektiren görevlerde performansı etkileyebilir. Yüksek tigmotaktik eğilimler genellikle kaygı veya korkuya işaret eden bir durum olarak yorumlanır. Bu nedenle kaygı temelli davranışlar, merkez veya açık alanları keşfetme istekliliğini azaltabilir ve dolayısıyla mekânsal öğrenme veya bellek ölçümlerini etkileyebilir. Düşük tigmotaktik eğilim genellikle daha düşük kaygı seviyelerine ve çevreyle daha yüksek etkileşime işaret eder. Bu da organizmanın daha etkili mekânsal bilgi toplamasını ve mekânsal görevlerde daha iyi performans göstermesini sağlar (Kallai vd., 2007; Juneja, 2016; Hollander & Anderson, 2020).

Tigmotaksi, *Barınma-Gözlem Kuramı* (*Prospect-Refuge Theory*) ile birçok açıdan örtüşür. İnsanlar içgüdüsel olarak, yön bulmak için geniş bir görüş alanı sağlayan görünüm ile arkadan koruma sunan sığınak noktalarını ararlar. Bu sığınak noktaları koruma ve görsel kontrol sağlayarak yön bulmayı kolaylaştırır. Çalışmada, insanların açık ve savunmasız mekânlardan kaçınıp, kendilerini daha güvende ve yön bulma açısından daha rahat hissettikleri kenarlarda toplandıkları belirtilir. Mekân kullanıcılarının açıklık (görünmesi kolay mekân) ile güvenlik (sığınılan mekân) arasında bir denge sunan mekânları tercih etmeye eğilimli olduğunu öne sürer (Appleton, 1975).

Psikolojik açıdan, kenarlara yapışma eğilimi evrimsel bilişsel mekanizmalarla açıklanır: kenarlar yalnızca güvenli hissettirmekle kalmaz, aynı zamanda beynimizin yeni çevreleri zihinsel olarak haritalandırmasında bir tür yön bulma yardımcısı olarak işlev görür. Tigmotaksi ilkeleri insanların nasıl hareket ettiğini, nerede

durmayı tercih ettiğini ve çevreyi nasıl algıladığını etkiler; dolayısıyla yapıların fiziksel özellikleri ve mekânsal kavrayışımızla yakından ilgilidir (Tullis, 2020; Mehaffy vd., 2023). Çalışmalar, mekânların fiziksel ve algısal niteliklerinin -örneğin tavan yüksekliği, açıklık ya da hareket temelli geçirgenlik gibi unsurların- duygusal tepkileri nasıl etkilediğini incelemişlerdir. Duvara sırtı dayalı banklar konfor hissi yaratabilir, yön bulmaya yardımcı olabilir, güvenlik ihtiyacını karşılayabilir ve sosyal etkileşimi artırabilir. Koridor boyunca insan hareketlerinin ölçüldüğü bir çalışmada, bireylerin doğal olarak kenarlara yöneldiği gözlemlenmiş ve bu davranışın sadece gözleme dayalı değil, ölçülebilir bir davranışsal temeli olduğu ortaya konmuştur. Restoranlarda duvar kenarındaki masalar bireylerin içgüdüsel konfor ve etkileşim ihtiyaçlarını karşılar. Bu tür düzenlemeler kullanıcıyı psikolojik olarak mekâna "demirleyerek" kamusal veya ortak alanlarda dahi mekânsal deneyimi geliştirir (Rais & Che Amat, 2019; Hollander vd., 2020; Tullis, 2021; Hollander vd., 2025).

Peter Zumthor'un *Therme Vals* yapısı, taş duvarlarla sığınak hissi sunarken, belirli açıklıklarla manzarayı çerçeveleyerek görsel bir açıklık sağlar (Woo, 2010). Frank Lloyd Wright'ın *Fallingwater* binası, kayalıklar içine yerleştirilmiş yüksek bakış noktaları ile hem görsel açıklık hem de zemine bağlı olmanın verdiği koruma hissini sunar (Vaughan & Ostwald, 2022). Geleneksel Japon mimarisindeki *engawa (veranda)*, iç ve dış mekân eşiklerinde tigmotaksi ilkeleri ile örtüşür (Fujii, 2015). Bireyler içgüdüsel olarak açık alanlardan kaçınarak korunma hissinin daha güçlü olduğu kenarlarda toplanma eğilimindedirler. Tarihî meydanlarda yayaların genellikle binaların önlerinde toplanıp meydanın ortasına fazla girmemeleri buna örnektir (Steen, 2015). Tigmotaksi, yapılı çevrenin topolojisi ve geometrisinin, hareket ve sosyal davranış üzerindeki etkilerinin anlaşılmasına yardım eden çalışmalarda da ele alınmıştır. Bu alandaki araştırmalar, yaya hareketlerinin genellikle en az açısal sapma içeren güzergâhları takip ettiğini göstermiştir. Bu da mekânsal yapılandırmanın diğer unsurlardan bağımsız olarak yaya hareketi desenlerini güçlü şekilde yönlendirebildiğini ortaya koymaktadır (Hollander vd., 2020; Brielmann vd., 2022).

İnsanlar güvenliği ve mekânsal tutarlılığı bilinçsizce kenarların varlığı üzerinden değerlendirir. Bu kenarlar hem bir sığınak hem de yön bulma işlevi görür. Belirsiz veya tamamen soyut geometrilere sahip mekânlar ise huzursuzluk veya kaygı hissi uyandırabilir ve bu nedenle kaçınılabilir. Tokyo'daki *Hamarikyu bahçeleri* üzerine yapılan çalışmalarda, ziyaretçilerin, sığınma hissi net olarak belirgin olmasa bile görünüm (açıklık) sunan alanlara bu alanları tercih ettikleri gösterilmiştir. Bulgular, görünüm ve sığınak dengesinin değişebileceğini ve öznel mekân tercihinde açıklık hissinin koruma duygusundan daha belirleyici olabileceğini göstermektedir (Taylor, 2018; Senoglu vd., 2018).

Tigmotaksi kentsel tasarım açısından da önemli ilkelerle bağdaşır. Mimari açıdan bakıldığında, cadde ve meydan gibi kamusal alanlar, tigmotaksi ilkelerini benimseyen tasarımlardır. Açık alanlara karşı duyulan örtük korku ile kenar ve sınırların sunduğu güven duygusu, insanların mimariyi nasıl algıladığı ve nasıl içinde yaşadığı üzerinde önemli olmuştur. Yön bulma ve mekânsal oryantasyon tigmotaksi kavramı ile ilgilidir (Hollander vd., 2021; Brielmann vd., 2022). Mekânda gezinirken insanların kenarlara yönelme içgüdüsü, yani tigmotaksi, kentsel tasarım stratejilerinde hem güvenlik hem de yön bulma açısından önemli ipuçları sunar. Kenar arama davranışı, kullanıcıların mekânsal sinyallere karşı verdiği bilinçdışı bir tepki olarak yorumlanır. Bu noktada beden, bilinçli düşünceden ziyade konforu ve yön bulmayı belirler. Belirsiz ya da soyut geometrilere sahip mimari formlar, tutarlı kenarlar sunmadığında insanların orada kalma eğilimini azaltabilirken; dikkatlice tanımlanmış sınırlar, insan davranışlarıyla uyum sağlar (Sussman & Hollander, 2021).

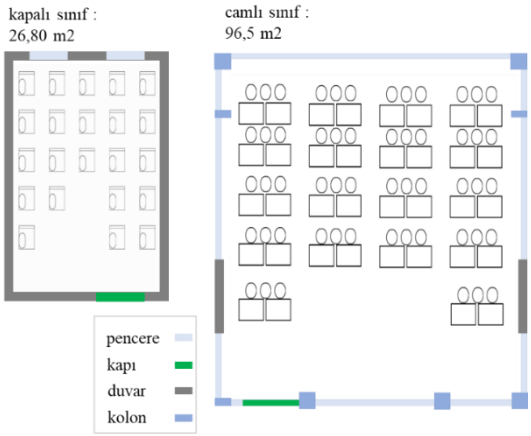
Tigmotaksi davranışı kentsel ortamlarda kullanıcıların hareketi ve davranışı nasıl şekillendirdiğini tartışır. İnsanlar, büyük ve belirsiz açık alanlar yerine belirgin sınırları olan kenarları tercih etme eğilimindedir. Bu eğilim, kentlerin nasıl deneyimlendiği ve içinde nasıl dolaşıldığı konusunda önemli sonuçlar doğurur. İnsanların açık alanların ortasından kaçınıp kenarlara yönelme eğilimleri evrimsel hayatta kalma stratejilerine dayanır ve ilkel organizmalardaki kenar takibi davranışıyla karşılaştırılabilir. Kenarlar güvenlik hissini artırır, zihinsel haritaların oluşumuna katkı sağlar ve bu nedenle insanların hareket biçimlerini ve mekân kullanımını etkiler. İnsanların kenar arama içgüdüsünü görmezden gelen tasarımlar, yönsüzlük, rahatsızlık veya algısal karmaşa yaratabilir. Bu temel kavram, mimarlık ve kentsel tasarımda kenar odaklı tasarım düşüncesinin büyük bir bölümüne temel oluşturur (Sussman & Hollander, 2021).

YÖNTEM

Bu çalışma, uluslararası etik standartlara ve bilimsel araştırma kurallarına tam uyum içerisinde gerçekleştirilmiştir. Çalışma öncesinde gerekli etik kurul onayı alınmış olup, tüm katılımcılar araştırmanın amacı ve süreci hakkında bilgilendirilmiş, gönüllülük esasına dayalı olarak aydınlatılmış onamları temin edilmiştir. Bu araştırma, Mimar Sinan Güzel Sanatlar Üniversitesi Fen ve Mühendislik Bilimsel Araştırma ve Yayın Etik Kurulu tarafından 07 Mayıs 2025 tarihli ve 218832 numaralı kararla onaylanmıştır.

Alan çalışması mekânları

Alan çalışması, 2 çeşit mekândan oluşmuş olup, bunlar "camlı sınıf" (dört tarafı cam yüzey/cephe ile çevrili sınıf) ve "kapalı sınıf" (3 yüzeyi duvarlardan oluşan ve bir cephesinde pencereleri bulunan sınıf) olarak tanımlanmıştır. Camlı sınıf 96,5 m² olup, kapalı sınıf 26,80 m²dir. Camlı sınıf olarak nitelendirilen mekân, cam yüzeylere ve şeffaf bir mekân algısına sahip iken kapalı sınıf olarak adlandırılan diğer alan az sayıda cam yüzeye sahip, duvarlarla çevrili bir mekândır. Her iki sınıfta da benzer oturma düzenleri bulunmakla birlikte, sandalyelerin konumu sabit değildir (Görsel 1).



Görsel 1. Kapalı ve camlı sınıfın krokileri

Katılımcı Profili

Bu araştırma kapsamında toplam 34 gönüllü katılımcıdan veri toplanmıştır. Katılımcılar, bir üniversitenin mimarlık fakültesinde öğrenim görmekte olan lisans öğrencilerinden oluşmaktadır. Örneklemde, kapalı sınıf ortamında 17 katılımcı (14 kadın, 3 erkek), camlı sınıf ortamında ise 17 katılımcı (12 kadın, 5 erkek) yer almıştır. Katılımcıların yaşları 18 ile 23 arasında değişmektedir. Çalışmaya katılım tamamen gönüllülük esasına dayanmış ve tüm katılımcılardan bilgilendirilmiş onam alınmıştır.

Veri toplama ve Analiz

Araştırmada olasılık dışı örnekleme yöntemlerinden *maksatlı örnekleme* (*convenience sampling*) (Golzar vd., 2022) stratejisi benimsenmiştir. Katılımcılar, araştırmacının erişiminin kolay olduğu bir hedef grubu temsil etmektedir. Çalışma, iki farklı katılımcı grubunun farklı mekânlarda (kapalı ve camlı sınıf) gözlemlenmesine dayanan bir *between-subject* tasarım ile yürütülmüştür.

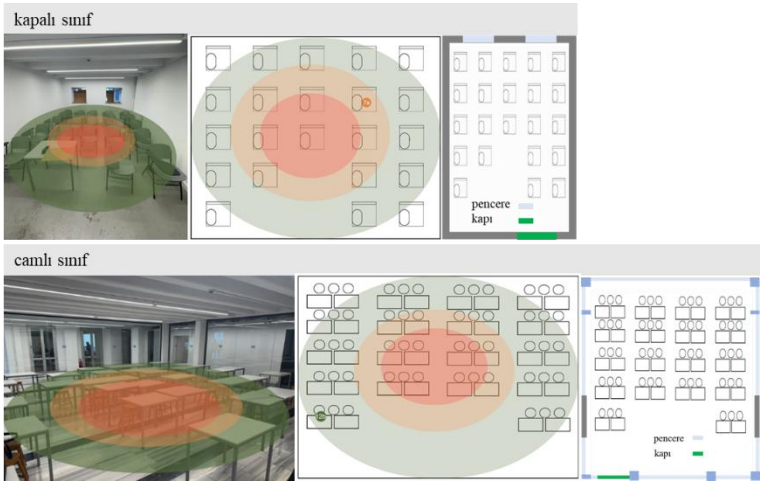
Veri toplama sürecinde Google Forms üzerinden hazırlanmış çevrim içi bir anket kullanılmıştır. Anket formunda, üç farklı ölçekte toplam 11 adet 5'li Likert tipi madde (1: Kesinlikle katılmıyorum, 5: Kesinlikle katılıyorum) yer almıştır. Kullanılan ölçekler şunlardır:

- Algılanan Güvenlik Hissi Ölçeği (5 madde) (Nasar & Jones, 1997)
- Agorafobiye Yatkınlık Ölçeği (3 madde) (Walz vd., 2016)
- Tigmotaktik Eğilim Ölçeği (3 madde) (Kallai vd., 2007)

Anketin başında katılımcılardan cinsiyet ve yaş bilgileri de alınmıştır. Katılımcıların oturma konumlarının mekânsal dağılımını analiz edebilmek amacıyla, her sınıf için basit bir kroki şeması hazırlanmıştır. Alan

çalışması yapılan sınıflarda, kolon ve kiriş aksları, oturma düzeni, duvara yakınlık ya da merkeze yakınlık esas alınmıştır.

Katılımcıların oturma konumları, anket uygulaması sırasında çekilen fotoğraflar ve gözlemler yardımıyla belirlenmiştir. Katılımcılara anket uygulaması sırasında rastgele sayısal bir kod atanmıştır. Bu sayılar, oturdukları sınıfın türüne göre A (kapalı sınıf) (Görsel 2) veya B (camlı sınıf) (Görsel 2) harfleriyle birleştirilerek tanımlanmıştır. Örneğin 7A kodu, kapalı sınıfta bulunan 7 numaralı katılımcıyı, 12B kodu ise camlı sınıftaki 12 numaralı katılımcıyı temsil etmektedir. Bu kodlar krokilerde birebir oturulan pozisyonlar üzerinde işlenmiş, toplamda 1A–17A ve 1B–17B şeklinde 34 farklı katılımcıya ait yerleşim görselleştirilmiştir.



Görsel 2. Kapalı sınıfa ve camlı sınıfa ait oturma konumları

Bu şekilde oluşturulan 1A–17A ve 1B–17B kodları, katılımcıların bireysel ölçek verileriyle eşleştirilerek krokide birebir oturdukları yerin üzerine işaretlenmiştir. Mekânsal eğilimleri daha net ortaya koymak adına, duvara yakın (kenar) konumlar yeşil, merkezi konumlar ise kırmızı renk kodlaması ile görselleştirilmiştir. Bu renkli ayrım, mekânsal güvenlik algısı ve oturma tercihlerinin değerlendirilmesi için destekleyici bir analiz aracı olarak kullanılmıştır.

Her iki sınıf ortamında da deneyler gündüz saatlerinde, benzer aydınlatma koşullarında gerçekleştirilmiştir. Katılımcılar, deney sırasında tek başlarına mekâna alınmış ve kendilerinden, istedikleri herhangi bir yere oturarak yaklaşık 2–3 dakika süreyle beklemeleri istenmiştir. Bu süreçte herhangi bir yönlendirme yapılmamış ve bireysel tercihlerini sergilemeleri sağlanmıştır. Katılımcının seçtiği oturma pozisyonu, araştırmacı tarafından kaydedilmiştir. Deneyin ardından, katılımcılar ilgili anket formunu doldurarak veri sağlama sürecini tamamlamıştır. İlgili sorular ve ölçekleri aşağıdaki tabloda özetlenmiştir (Tablo 1).

Tablo 1. Sorular ve ölçekleri

No	Soru	Ölçek
1	Yaşınız?	Demografik
2	Cinsiyetiniz?	Demografik
3	Bu mekânda kendimi güvende hissettim (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Güvenlik
4	Bulunduğum konumdan çevremi kolayca gözlemleyebildim (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Güvenlik
5	Tehdit hissi yaşamadım (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Güvenlik
6	Acil durumda çıkışı rahatlıkla bulurum (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Güvenlik
7	Bulunduğum yer beni korunaklı hissettirdi (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Güvenlik
8	Geniş ve açık alanlar beni huzursuz eder (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Agorafobi
9	Ortada olmak beni rahatsız eder (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Agorafobi
10	Açık alanlarda kendimi kontrolsüz hissederim (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Agorafobi
11	Duvara/kolona yaslanmak güven verdi (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Tigmotaksi
12	Fiziksel yüzeye yakınlık kontrol sağladı (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Tigmotaksi
13	Sınırda olmayı tercih ettim (1 = Kesinlikle katılmıyorum, 5 = Kesinlikle katılıyorum).	Tigmotaksi
14	Bu yeri neden seçtiniz? Kendinizi nasıl hissettiniz? Kısaca bahsediniz.	Açık uçlu

Deney tasarımını ve sürecinin ilerleyişi aşağıdaki diyagramda (Tablo 2) gösterilmiştir.

Tablo 2. Deney tasarımı ve süreci

Bileşen	Açıklama
Örnekleme yöntemi	Maksatlı örnekleme (convenience sampling)
Kaynak	Golzar vd., 2022
Katılımcı grubu	Araştırmacının erişiminin kolay olduğu bireyler
Toplam katılımcı	34 kişi
Sınıf türleri	Kapalı sınıf (A) / Camlı sınıf (B)
Katılımcı kodlama	A: 1A–17A, B: 1B–17B
Veri toplama aracı	Google Forms çevrim içi anket
Ölçek tipi	5'li Likert (1=Kesinlikle katılmıyorum – 5=Kesinlikle katılıyorum)
Demografik veriler	Yaş, cinsiyet
Mekânsal veri	Oturma konumu (kroki + gözlem + fotoğraf)
Deney zamanı	Gündüz
Ortam koşulları	Benzer aydınlatma koşulları

Aşama	İşlem	Açıklama
1	Ortam hazırlığı	Sınıf krokileri oluşturuldu (kolon, kiriş yerleri belirlendi, oturma düzeni kuruldu)
2	Katılımcı alımı	Katılımcılar tek tek mekâna alındı
3	Serbest yer seçimi	Katılımcılardan istedikleri yere oturmaları istendi
4	Bekleme süresi	2–3 dakika
5	Müdahale durumu	Herhangi bir yönlendirme yapılmadı
6	Oturma kaydı	Araştırmacı tarafından konum kaydedildi
7	Kodlama	Katılımcılara rastgele sayısal kod + sınıf harfi (A/B) verildi
8	Mekânsal eşleştirme	Kodlar kroki üzerinde birebir işaretlendi
9	Görselleştirme	Kenar = yeşil, merkez = kırmızı
10	Anket uygulaması	Deney sonrası Google Forms dolduruldu
11	Veri eşleştirme	Mekânsal veri + ölçek verileri birleştirildi

Toplanan anket verileri 2024 Microsoft Excel yazılımı kullanılarak analiz edilmiştir. Öncelikle her bir ölçek için ortalama puanlar ve standart sapmalar hesaplanmıştır. İki sınıf ortamı arasında tigmotaktik eğilim, algılanan güvenlik hissi ve agorafobiye yatkınlık puanlarının karşılaştırılması amacıyla bağımsız örneklem t-testi uygulanmıştır. Ayrıca, tigmotaktik eğilim, güvenlik algısı ve agorafobi skorları arasındaki ilişkileri incelemek üzere Pearson korelasyon analizi gerçekleştirilmiştir. Mekânsal tercihlere yönelik analiz için her iki sınıfın krokileri hazırlanmış ve katılımcıların oturma pozisyonları görselleştirilmiştir. Aşağıda 4 tane örnek bireyin (kapalı sınıfta kenarda oturan, kapalı sınıfta merkezde oturan, camlı sınıfta kenarda oturan ve camlı sınıfta merkezde oturan) (Tablo 3) konum ve ölçek skorları karşılaştırmalı olarak değerlendirilmiştir.

Tablo 3'de sunulan örnek karşılaştırmalı veriler, sınıf ortamlarında ve mekânsal konum tercihlerine göre tigmotaksi, agorafobi ve güvenlik hissi skorlarının nasıl değiştiğini göstermektedir.

Tablo 3. Örnek katılımcılara ait konum, sınıf türü ve üç ölçek skorlarının karşılaştırmalı dağılımı

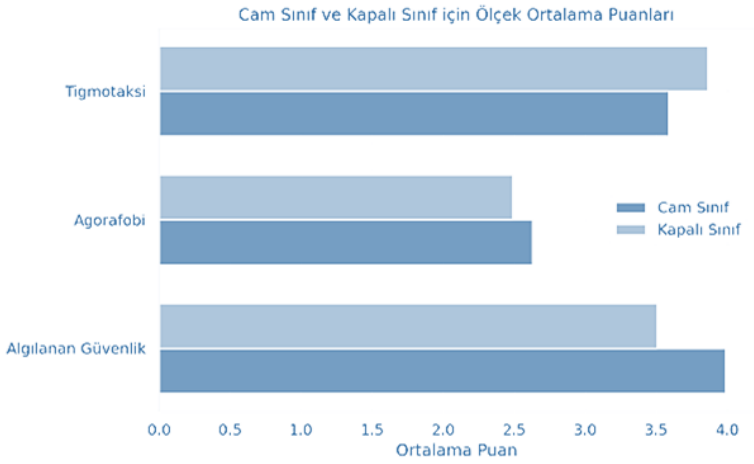
Katılımcı Kodu	Sınıf Türü	Oturma Konumu	Tigmotaksi Skoru (1-5)	Agorafobi Skoru (1-5)	Güvenlik Skoru (1-5)
1A	Kapalı Sınıf	Kenar (Yeşil)	4.8	3.9	4.5
3B	Kapalı Sınıf	Merkez (Kırmızı)	2.1	2.2	2.5
2A	Camlı Sınıf	Kenar (Yeşil)	4.5	3.8	4.7
4B	Camlı Sınıf	Merkez (Kırmızı)	2.3	2.4	2.6

Yalnızca 4 katılımcıya yer verilmesi, tüm örneklemi temsil eden kapsamlı bir veri sunumundan ziyade araştırmanın temel desenini anlaşılır biçimde ortaya koymaya yönelik bir durumdur. Seçilen bu dört katılımcı, iki farklı mekân türü (kapalı ve camlı sınıf) ile iki farklı konumlanma biçimini (kenar ve merkez) temsil eden yapıyı yansıtmaktadır. Böylece tigmotaktik eğilim, algılanan güvenlik hissi ve agorafobiye yatkınlık

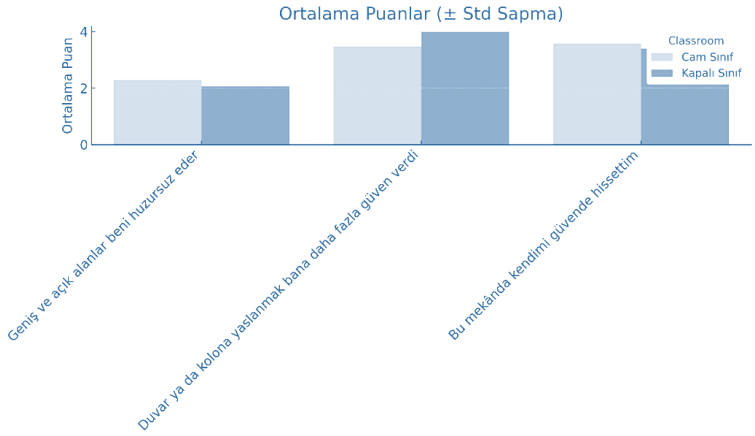
arasındaki ilişkiler, karmaşık veri seti içinde kaybolmadan, karşılaştırmalı ve kavramsal olarak net bir biçimde gösterilebilmektedir. Bu tablo analizlerin kendisini değil, elde edilen bulguların mantıksal örüntüsünü somutlaştıran açıklayıcı bir örnek sunumudur. Nitekim çalışmanın istatistiksel değerlendirmeleri (t-testleri ve korelasyon analizleri) tüm 34 katılımcının verileri üzerinden gerçekleştirilmiş olup, söz konusu tablo yalnızca bu genel bulguların mikro düzeyde nasıl tezahür ettiğini görselleştiren bir araç olarak kullanılmaktadır.

BULGULAR

Bulgular, katılımcıların sınıf ortamına göre (camlı sınıf/kapalı sınıf) verdikleri yanıtların ortalamaları ve standart sapmaları temel alınarak değerlendirilmiştir. Her iki sınıf ortamına ilişkin olarak uygulanan anketler sonucunda elde edilen üç temel ölçeğe (algılanan güvenlik hissi, agorafobiye yatkınlık ve tigmotaktik eğilim) ait ortalama puanlar ve standart sapmalar Görsel 4 ve Görsel 5'de sunulmuştur. Görsel 4'de, her bir ölçeğin (algılanan güvenlik, agorafobi, tigmotaksi) camlı ve kapalı sınıf ortamındaki ortalama puanları görselleştirilmiştir. Görsel 5'de ise üç farklı ölçekteki seçilmiş maddelere ilişkin ortalama puanlar ± standart sapma değerleriyle birlikte gösterilmektedir.



Görsel 4. Algılanan güvenlik, agorafobi, tigmotaksi düzeylerinin camlı ve kapalı sınıf ortamındaki ortalama puanları



Görsel 5. Farklı ölçekler için ortalama puan ve standart sapma değerleri

Bağımsız örneklem t-testi sonuçları, üç farklı maddede camlı sınıf ve kapalı sınıf grupları arasında anlamlı farkların olup olmadığını test etmek amacıyla gerçekleştirilmiştir. "Bu mekânda kendimi güvende hissettim" maddesi için camlı sınıf (M = 3.91, SD = 0.83) ve kapalı sınıf (M = 3.54, SD = 0.76) ortalamaları arasında anlamlı bir fark saptanmamıştır (t (32) = 1.32, p = 0.196). "Duvar ya da kolona yaslanmak bana daha fazla güven verdi" maddesinde kapalı sınıf (M = 4.00, SD = 1.00) lehine anlamlı bir fark bulunmuştur (t (32) = 2.10,

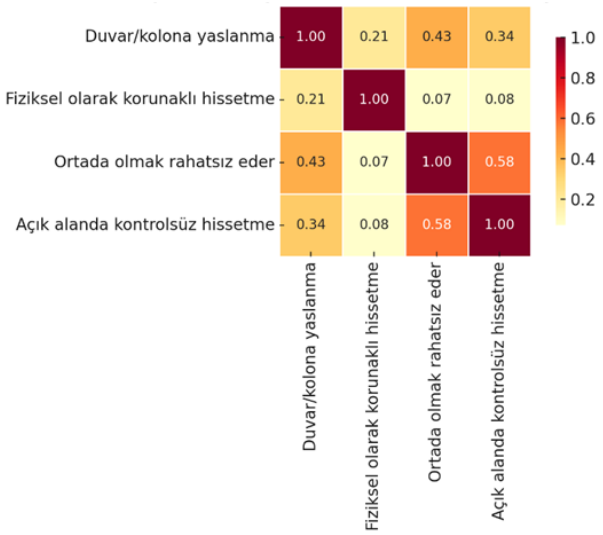
p = 0.044). “Geniş ve açık alanlar beni huzursuz eder” maddesi için ise camlı sınıf (M = 3.48, SD = 1.16) ve kapalı sınıf (M = 3.81, SD = 1.13) grupları arasında anlamlı bir fark bulunmamıştır (t (32) = 1.01, p = 0.32).

Bağımsız örneklem t-testi bulguları, camlı ve kapalı sınıf ortamlarının katılımcıların mekânsal deneyimlerine nasıl yansıdığını karşılaştırmalı olarak ortaya koymaktadır. Elde edilen sonuçlar, iki mekân türü arasında algılanan güvenlik hissi açısından belirgin bir ayrışma olmadığını göstermektedir. Katılımcılar, camlı sınıfta kendilerini ortalama olarak biraz daha güvende hissettiklerini ifade etmiş olsalar da bu fark istatistiksel olarak anlamlı bir düzeye ulaşmamıştır. Bu durum, mekânın şeffaf ya da kapalı oluşunun tek başına güvenlik algısını belirleyici bir unsur olmayabileceğine işaret etmektedir. Buna karşılık, “duvar ya da kolona yaslanma” ile ilişkilendirilen güvenlik hissinde kapalı sınıf lehine anlamlı bir farklılaşma gözlenmiştir. Katılımcıların kapalı sınıf ortamında bu tür fiziksel sınırlarla temas ettiklerinde kendilerini daha güvende hissettiklerini belirtmeleri, mekânsal çevreyle kurulan bedensel ilişkinin güvenlik algısını güçlendiren önemli bir bileşen olabileceğini düşündürmektedir. Bu bulgu, özellikle çevresel psikoloji ve tigmotaktik eğilimler bağlamında, sınır elemanlarının bireyler için bir tür korunaklılık hissi yarattığını destekler niteliktedir. Öte yandan, geniş ve açık alanların huzursuzluk yaratıp yaratmadığına ilişkin değerlendirmelerde iki grup arasında anlamlı bir fark ortaya çıkmamıştır. Her iki mekân türünde de katılımcıların benzer düzeylerde huzursuzluk bildirmesi, açıklık hissinin tek başına kaygı ya da rahatsızlık üretmediğini, bu algının muhtemelen başka çevresel ya da bireysel değişkenlerle bağlantılı olabileceğini göstermektedir. Bulgular mekânsal özelliklerin kullanıcı deneyimini çok boyutlu biçimde etkileyebildiğini; özellikle fiziksel sınırlarla kurulan temasın güvenlik hissini artırırken, mekânın açıklık/kapalılık düzeyinin tek başına belirleyici olmadığını ortaya koymaktadır.

Dört madde arasında gerçekleştirilen Pearson korelasyon analizleri sonucunda, “Duvar ya da kolona yaslanmak bana daha fazla güven verdi” ve “Bulunduğum yer beni fiziksel olarak daha korunaklı hissettirdi” maddeleri arasında orta düzeyde pozitif korelasyon saptanmıştır (r = 0.47, p <0.01). “Ortada ve görünür bir konumda olmak beni rahatsız eder” ile “Açık alanlarda kendimi kontrolsüz hissederim” maddeleri arasında ise güçlü bir korelasyon bulunmuştur (r = 0.61, p <0.001).

Korelasyon analizi bulguları, katılımcıların mekânsal deneyimlerinin yalnızca tekil ifadeler üzerinden değil, birbiriyle ilişkili algı kümeleri üzerinden yapılandığını göstermektedir. Elde edilen ilişkiler, özellikle “korunaklılık” ve “açıklık karşısında duyulan huzursuzluk” olmak üzere iki temel deneyim eksenine işaret etmektedir. İlk olarak, “duvar ya da kolona yaslanmak” ile “mekânın fiziksel olarak korunaklı hissettirmesi” arasındaki orta düzeyde pozitif ilişki, güvenlik hissinin önemli ölçüde mekânın fiziksel sınırlarıyla kurulan temas üzerinden üretildiğini düşündürmektedir. Bu bulgu, bireylerin yalnızca görsel ya da genel mekânsal özelliklere değil, doğrudan bedensel olarak deneyimledikleri sınır elemanlarına duyarlı olduklarını ortaya koyar. Başka bir ifadeyle, duvar ya da kolon gibi elemanlar yalnızca fiziksel yapı bileşenleri değil, aynı zamanda psikolojik olarak “dayanak” ve “korunak” işlevi gören unsurlar olarak deneyimlenmektedir. İkinci olarak, “ortada ve görünür bir konumda olma” ile “açık alanlarda kontrolsüz hissetme” arasındaki güçlü ilişki, açıklık ve görünürlük deneyiminin doğrudan bir kırılganlık algısıyla bağlantılı olduğunu göstermektedir. Bu iki ifadenin yüksek düzeyde birlikte değişmesi, katılımcıların merkezde olmayı yalnızca mekânsal bir konum olarak değil, aynı zamanda maruz kalma ve denetim kaybı hissiyle ilişkili bir durum olarak algıladıklarını düşündürmektedir. Bu bağlamda, açıklık yalnızca fiziksel genişlik değil, aynı zamanda “göz önünde olma” ve “savunmasızlık” anlamlarını da içeren çok katmanlı bir deneyime karşılık gelmektedir. Genel olarak değerlendirildiğinde, bu korelasyon örüntüsü mekânsal deneyimin iki karşıt yönlü ancak birbiriyle ilişkili boyut etrafında organize olduğunu göstermektedir: bir yanda sınırlarla temasın sağladığı korunaklılık ve güvenlik hissi, diğer yanda ise açıklık ve görünürlükle birlikte artan kontrol kaybı ve huzursuzluk algısı. Bu bulgular, mekân tasarımında yalnızca fiziksel düzenlemelerin değil, bu düzenlemelerin kullanıcıda uyandırdığı bedensel ve algısal deneyimlerin de belirleyici olduğunu güçlü biçimde ortaya koymaktadır.

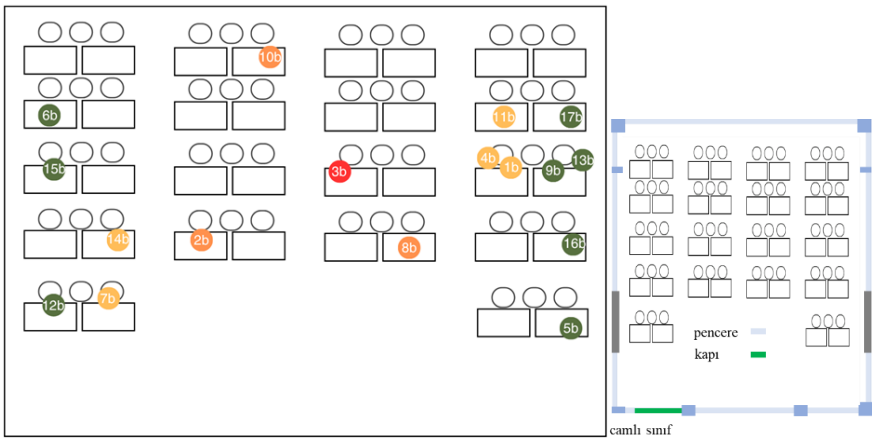
Korelasyon analizine ilişkin sonuçlar Görsel 6’da sunulmaktadır. Şekilde dört sınıflama arasındaki pozitif ve anlamlı korelasyonlar izlenmektedir.



Görsel 6. Seçili maddeler arası korelasyon matrisi

Katılımcıların mekânlardaki oturma tercihleri, deney sırasında hazırlanan kroki üzerinde görselleştirilmiştir. Kenar bölgeleri tercih eden bireylerin tigmotaktik eğilim ve güvenlik hissi puanlarının daha yüksek olduğu, merkez bölgeleri tercih eden bireylerin ise bu değerlerde daha düşük skorlar sergilediği gözlemlenmiştir. Kapalı ve camlı sınıf ortamlarında benzer bir örüntünün ortaya çıkması, mekânsal konum tercihlerinin bilişsel süreçlerle bağlantılı olduğunu gösterebilmektedir.

Görsel 7. Kapalı sınıf katılımcılarının mekânsal tercihleri



Görsel 8. Camlı sınıfı katılımcılarının mekânsal tercihleri

Görsel 7 ve Görsel 8'de sırasıyla kapalı sınıf ve camlı sınıf ortamlarında katılımcıların mekânsal konum tercihleri görselleştirilmiştir. Kenar bölgeleri tercih eden katılımcılar yeşil ile, merkez bölgeleri tercih eden katılımcılar kırmızı ile gösterilmiştir.

Bulgular genel olarak değerlendirildiğinde, katılımcıların mekânsal konumlanma tercihlerinin yalnızca fiziksel düzenlemelerle değil, aynı zamanda psikolojik eğilimlerle yakından ilişkili olduğu görülmektedir. Katılımcıların önemli bir kısmının mekânın kenar bölgelerini tercih etmesi, tigmotaktik eğilimlerin gerçek mekânlarda da belirgin biçimde ortaya çıktığını göstermektedir. Bu tercih, özellikle duvar veya kolon gibi fiziksel sınırlarla temasın, bireylerde korunaklılık ve güvenlik hissini artırmasıyla ilişkilidir. Nitekim hem nicel bulgular hem de mekânsal dağılım görselleştirmeleri, kenar konumları tercih eden bireylerin daha yüksek tigmotaksi ve güvenlik algısı skorlarına sahip olduğunu ortaya koymaktadır. Buna karşılık, merkezi konumları tercih eden bireylerin daha düşük güvenlik hissi ve tigmotaktik eğilim sergiledikleri gözlemlenmiştir. Ayrıca, açıklık ve görünürlük ile ilişkili deneyimlerin bireylerde huzursuzluk ve kontrol kaybı algısıyla bağlantılı olduğu anlaşılmaktadır. Camlı ve kapalı sınıf ortamları arasında bazı farklılıklar gözlenmekle birlikte, mekânın açıklık/kapalılık düzeyinin tek başına belirleyici olmadığı; bunun yerine, fiziksel sınırlarla kurulan bedensel ilişkinin ve bireysel psikolojik duyarlılıkların mekânsal deneyimi üzerinde etkili olabileceğini ortaya konmuştur. Bu bulgular, mekânsal davranışın çok boyutlu bir yapıya sahip olduğunu ve tasarım kararlarının kullanıcıların algısal ve duygusal ihtiyaçlarıyla birlikte ele alınması gerektiğini göstermektedir.

Çalışmanın pozitif yönleri ve eksiklikleri

Bu çalışmanın güçlü yönlerinden biri hem nicel hem de mekânsal gözlemlere dayanan verilerin bir arada kullanılarak, tigmotaktik eğilim ve mekânsal davranışlar arasındaki ilişkinin ele alınmış olmasıdır. Kullanıcıların mekânsal tercihleri konum seçimleri üzerinden analiz edilmiştir. Bu yöntemsel bütünlük, çalışmanın mimarlık ve çevresel psikoloji disiplinlerini kesiştiren özgün yapısını güçlendirmektedir. Bununla birlikte, bireylerin yer seçimi kararlarını etkileyebilecek kişilik özellikleri, önceki deneyimleri ya da anlık duygusal durumlar bu araştırmada kontrol edilmemiştir. Bu durum, yorumların daha genel eğilimler üzerinden yapılmasına neden olmakta ve bireysel farklılıkların etkisini göz ardı etme riski taşımaktadır.

Araştırmanın temel sınırlılığı, örneklem büyüklüğünün sınırlı oluşu ve alan çalışmasının yalnızca iki sınıf ortamında uygulanmasıdır. Ayrıca, veri toplama süreci farklı günlerde gerçekleştirildiğinden, çevresel değişkenlerin sonuçlar üzerindeki olası etkileri tamamen izole edilememiştir. Gelecek araştırmalarda, farklı yaş grupları ve disiplinlerden bireyleri kapsayan daha geniş örneklemlerle çalışmak, bulguların genellenebilirliğini artırabilir. Ayrıca, farklı mekân tiplerinin (örneğin ofis, fuaye, kütüphane, alışveriş merkezi gibi) incelenmesi ve mekânsal tercihlerin değişken koşullar ile (kalabalık düzeyi, ses yoğunluğu, ışık değişimi gibi) nasıl şekillendiğinin araştırılması, bu alandaki bilgi birikimini derinleştirecektir. Aynı zamanda bireysel psikolojik değişkenlerin kontrollü biçimde incelendiği yeni araştırmalar, mekân-psikoloji ilişkisine dair daha bütüncül sonuçlar sunabilir.

Araştırma, iki farklı katılımcı grubunun farklı mekânlarda gözlemlenmesine dayanan bir *between-subject* tasarım ile yürütülmüş olup, katılımcıların mekânlara rastgele atanmamış olması, gözlemlenen farklılıkların yalnızca mekânsal özelliklerden mi yoksa bireysel farklılıklardan mı kaynaklandığının kesin olarak ayrıştırılmasını güçleştirmektedir. Bu durum, özellikle kişilik özellikleri, kaygı düzeyi ya da mekânsal alışkanlıklar gibi kontrol edilmeyen değişkenlerin sonuçlar üzerindeki potansiyel etkisini artırmaktadır.

Karşılaştırılan iki sınıf ortamı yalnızca açıklık/kapalılık bakımından değil, aynı zamanda fiziksel büyüklük (96,5 m² ve 26,80 m²), mekânsal hacim ve algılanan yoğunluk gibi birden fazla çevresel değişken açısından da farklılık göstermektedir. Bu durum, çalışmada hedeflenen mekânsal değişkenin (şeffaflık/kapalılık) diğer fiziksel özelliklerle birlikte değişmesine yol açarak, etkilerin izole biçimde yorumlanmasını sınırlandırmaktadır. Her ne kadar her iki sınıfta da benzer oturma düzenleri bulunmakla birlikte, sandalyelerin sabit olmaması katılımcıların mekânsal seçimlerini daha esnek biçimde gerçekleştirmelerine olanak tanımış, bu da bir yandan doğal davranışın gözlemlenmesini desteklerken, diğer yandan mekânsal yapı ile davranış arasındaki ilişkinin daha kontrollü bir deneysel çerçevede değerlendirilmesini zorlaştırmıştır.

TARTIŞMA VE SONUÇ

Bu çalışmada öne sürülen temel hipotez, bireylerin mekânsal konumlanmalarının davranışsal eğilimlerle ilişkili olduğu yönündedir. Özellikle çevresel sınırlara yakın bölgelerde oturmayı tercih eden bireylerin daha yüksek düzeyde tigmotaktik eğilim ve güvenlik ihtiyacı sergileyeceği öngörülmüştür. Sunulan oturma konumu görselleştirmeleri, katılımcıların büyük çoğunluğunun mekânın sınırlarında, özellikle arka ve yan duvarlara yakın pozisyonlarda yer aldığını göstermektedir. Bu eğilim tigmotaksis davranışının mekânsal tercihlere yansıdığını ortaya koymaktadır.

Kapalı sınıf ve cam sınıf ortamları arasında yapılan bağımsız örneklem t-testi sonuçları çalışmanın hipotezini destekler niteliktedir. Kapalı sınıfta yer alan katılımcıların algılanan güvenlik hissi puanlarının cam sınıftakilere kıyasla anlamlı düzeyde daha yüksek olduğu gözlemlenmiştir. Bu bulgu, mimari açıklığın algılanan güvenliği nasıl etkileyebileceğine dair literatürle uyumludur. Öte yandan, tigmotaktik eğilim ile algılanan güvenlik hissi arasında pozitif yönlü, anlamlı bir korelasyon bulunması; mekânsal konumlanmanın sadece fiziksel değil, aynı zamanda psikolojik dinamiklerle ilişkili olabildiğini göstermektedir.

Hem nicel analizler hem de mekânsal dağılım haritaları, çalışma hipotezini desteklemektedir. Farklı mekânsal özellikteki sınıf tiplerinin psikolojik etkileri, bireylerin güvenlik ihtiyaçları ve çevresel kontrol arayışları doğrultusunda mekânla kurdukları ilişki ile birlikte değişmektedir. Özellikle sınıf gibi günlük ve işlevsel kullanıma sahip alanlarda bu eğilimlerin gözlemlenebilmesi, mekân algısının yalnızca mimari ile değil, bireylerin bilişsel yönelimleriyle de yakın etkileşim içinde olduğunu göstermektedir.

Bu araştırmada ortaya çıkan sonuçlar, bireylerin sınıf ortamlarında çevresel sınırlara yakın pozisyonları daha çok tercih ettiklerini göstermektedir. Bu eğilim özellikle tigmotaktik davranışla ilgili önceki çalışmalarla örtüşmektedir. Örneğin yüksek anksiyete düzeyine sahip bireylerin sanal ortamlarda bile çevresel kenarlara yönelme eğiliminde olduklarını belirtilmiştir (Gromer vd., 2021). Bu bulgu gerçek mekânlarda yapılan gözlemlerimizle de tutarlılık göstermektedir. Benzer şekilde, tehdit duyarlılığı yüksek bireylerin daha stratejik ve korunaklı alanlara yöneldiğini saptanmıştır (Brielmann vd., 2022). Bu çalışmada cam cepheli sınıfta merkezi pozisyonlardan kaçınılması da bu durumu destekler niteliktedir. Mekânsal tercihler yalnızca fiziksel güvenlikle değil, aynı zamanda sosyal etkileşim ve görünürlük gibi faktörlerle de ele alınmalıdır. Appleton'un Barınma-Gözlem Kuramına göre, güvenlik algısı sosyal uyarıcılardan kaçınma davranışını da içermektedir. Bu kuram, mekânsal seçimlerin görsel hâkimiyet ve sosyallik açısından da değerlendirilmesi gerektiğini ileri sürmektedir. Bireyler hem çevreyi gözetleyebilecekleri hem de tehditten sakınabilecekleri pozisyonlara yönelme eğilimindedir. Bu çalışmada da bazı katılımcıların merkezi bölgeleri seçmesi, görsel kontrol ve korunma ihtiyacının birlikte değerlendirilebileceğini göstermektedir.

Katılımcıların mekânsal sınır elemanlarına yakın konumları tercih etme eğilimi, tasarım süreçlerinde duvar, bölücü elemanlar veya yarı kapalı oturma düzenleri gibi kenar tanımlayıcı unsurların kullanıcıların algılanan güvenlik ve konfor düzeylerini artırabileceğini göstermektedir. Açıklık ile korunma hissi arasında dengeli bir mekânsal kurgu oluşturulması, farklı psikolojik eğilimlere sahip kullanıcıların mekânı daha rahat deneyimlemesine olanak sağlayabilir. Bu bağlamda hem merkezi hem de kenar odaklı oturma alternatifleri sunan esnek yerleşim düzenleri, kullanıcı çeşitliliğine duyarlı tasarım yaklaşımlarını desteklemektedir. Bu bulgular özellikle sınıf, bekleme alanı ve yarı kamusal iç mekânlar gibi kullanıcı davranışlarının mekânsal düzenle doğrudan etkileşim içinde olduğu ortamlarda önem kazanmaktadır. Dolayısıyla, mekânsal tasarım kararlarına psikolojik ve davranışsal eğilimlerin entegre edilmesi, daha kullanıcı odaklı ve destekleyici çevrelerin oluşturulmasına katkı sağlayabilir.

Bu açıdan bakıldığında, bu araştırma yalnızca nicel değil, görsel ve mekânsal analizleri de içeren katmanlı yapısıyla literatüre katkı sağlamaktadır. Ayrıca duygusal ve çevresel etkenlerin eşzamanlı etkisine vurgu yapması, çalışmanın mekânsal kararlarımıza ilişkin bir yorum sunmasına olanak tanır. Elde edilen bulgular hem mevcut kuramlarla uyumlu sonuçlar ortaya koymakta hem de mekân-psikoloji ilişkisine dair yeni bir gözlem alanı açmaktadır. Fakat araştırma tasarımı göz önüne alındığında, elde edilen bulguların nedensel bir ilişkiyi ortaya koymaktan ziyade değişkenler arasındaki örüntüsel ilişkileri yansıttığı dikkate alınmalıdır. Bu nedenle sonuçlar, mekânsal özelliklerin bireysel davranışları doğrudan belirlediği şeklinde değil, belirli psikolojik eğilimlerle birlikte ilişkili olduğu yönünde yorumlanmalıdır.

Authors' Contributions

The 1st author contributed 40 %, and the second author contributed % 40 and the third author contributed % 20.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

This research was approved by the Mimar Sinan Fine Arts University Science and Engineering Scientific Research and Publication Ethics Committee with the decision dated 07 May 2025 and numbered E-15207191-050.04-218832 (Ethics Committee Approval Number: 218881).

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Research Article

AI-augmented learning in design education: A structural model of critical thinking and creative engagement

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Abstract
This study investigates how AI integration and students' perception of AI influence critical thinking and creativity among undergraduate design students in Ghanaian technical universities. A cross-sectional survey was conducted among 394 students from three institutions. Partial Least Squares Structural Equation Modelling (PLS-SEM) was employed to examine the interrelationships among the variables of this study, with results indicating that AI engagement plays a significant role in fostering both critical thinking and creative performance among students. Likewise, students' perception and perceived challenges with AI had a notable positive effect on these outcomes. However, the moderating effects of gender and age on the relationship between AI variables and learning outcomes were not supported. These results contribute empirical clarity to an ongoing pedagogical debate: whether AI is a cognitive amplifier or undermines independent reasoning. In the Ghanaian context, where structured AI integration in design curricula remains limited, the findings suggest a compelling need to guide students in leveraging AI responsibly. The study confirms the role of generative AI in augmenting design cognition and calls for curricular frameworks that promote critical reflection alongside technological fluency. The findings have implications for curriculum developers, educators and policymakers aiming to future-proof design education in sub-Saharan Africa and beyond.

Keywords: Artificial intelligence, Creativity, Critical thinking, Design education, Higher education

Extended Abstract

Introduction: This study addresses a pressing pedagogical question: how does the informal and emerging integration of generative artificial intelligence (AI) shape higher-order cognition in undergraduate design education? While AI tools are increasingly present in design workflows, empirical evidence about their net effect on students' critical thinking and creative performance remains incomplete, particularly within sub-Saharan African technical universities where formal curricular guidance is nascent. Drawing on contemporary work that treats AI both as an enabling "object-to-think-with" and a potential vehicle for cognitive off-loading, the research positions AI interaction and student perceptions of AI as central drivers of design cognition. The literature review synthesizes recent empirical and theoretical findings that suggest AI can scaffold reflective reasoning and broaden ideational search spaces, but that benefits are contingent on how students interpret, interrogate and integrate machine outputs into reflective design practices.

Purpose and scope: The study's primary aim is to empirically determine the relationships among (a) students' AI interaction and usage, (b) students' perceptions of and perceived challenges with AI, and (c) two outcome constructs, critical thinking and creativity, within undergraduate design programs in Ghanaian technical universities. Secondary aims examine whether age and gender moderate the effects of AI engagement on these outcomes. The research focuses specifically on routinely enrolled design undergraduates across three public technical universities in Ghana, thereby situating findings within a context characterized by rising AI exposure but limited institutional scaffolding. The study further seeks to explain variance in cognitive and creative outcomes attributed to AI-related predictors rather than to produce descriptive ethnographies.

Method: This study adopted a quantitative, cross-sectional, descriptive-correlational design to examine the relationships between AI engagement variables and cognitive outcomes among undergraduate design students. This design was appropriate because it allowed for the simultaneous analysis of multiple latent constructs and the testing of predictive relationships without experimental manipulation. Data were collected via an online, self-administered questionnaire distributed through official class communication channels using a stratified random sampling procedure to ensure proportional representation across program levels. The sample comprised 394 valid responses, adequate for Partial Least Squares Structural Equation Modelling (PLS-SEM) per established guidelines. Data were analyzed using PLS-SEM in SmartPLS 3.2.9. This approach was selected for its suitability in predictive modelling with latent variables and small-to-medium samples. Measurement instruments employed multi-item 5-point Likert scales and were vetted by an expert panel for content validity. Reliability and validity of constructs were assessed using Cronbach's alpha, composite reliability and average variance extracted (AVE). Discriminant validity was confirmed through the Fornell-Larcker criterion. Structural paths were tested via bootstrapping (5,000 resamples) to determine significance, effect sizes and explained variance (R2). Psychometric evaluation indicated high internal consistency (Cronbach's α and composite reliability > 0.85), acceptable convergent validity (AVE > 0.50), and discriminant validity (Fornell-Larcker criterion met). Analytical procedures followed a two-stage PLS-SEM protocol: measurement model assessment followed by structural model testing. Bootstrapping with 5,000 resamples produced robust estimates of path significance, effect sizes (β), and explained variance (R2). Ethical clearance was obtained in accordance with Helsinki principles with (Ethics ID: RE #122-2025-DRIPPT).

Findings and conclusion: The structural model accounted for substantive proportions of variance in both endogenous outcomes (R2= 0.531) for critical thinking, R2 = 0.582 for creativity). Four direct paths were positive and highly significant ($p < 0.001$). AI interaction and usage positively predicted critical thinking ($\beta = 0.529$) and. Creativity ($\beta = 0.375$), indicating that meaningful, frequent engagement with AI tools correlates with stronger reflective reasoning and richer ideation among design students. Students' perceptions of AI and perceived challenges also exhibited strong positive effects on both outcomes ($\beta = 0.391$) for critical thinking, $\beta - 0.547$ for creativity), suggesting that interpretive awareness of appropriation of AI outputs. By contrast, hypothesized moderating effects of age and gender were not supported, implying that within the study context demographic differences did not significantly alter the cognitive benefits associated with AI engagement. These results reconcile two competing narratives: AI can operate as a cognitive amplifier when integrated reflectively, yet students' interpretive stance toward AI is decisive. For practical implications, educators should not treat AI as a prescriptive shortcut, rather, curricula must frame AI use within reflective, ethically informed pedagogies that cultivate critical interrogation, source verification, and creative re-appropriation. Consequently, to policymakers, institutional guidance and targeted AI-literacy training can convert casual, unguided use into disciplined pedagogical practice. The study contributes empirical clarity to debates about AI in creative education, and offers evidence-based direction for curriculum developers, instructors and policymakers seeking to future-proof design programs in contexts similar to Ghana's technical universities.

Keywords: Artificial intelligence, Creativity, Critical thinking, Design education, Higher education

INTRODUCTION

AI is quickly reshaping how people educate around the world, bringing new potential to improve learning, particularly in subjects that have long depended on creativity and problem-solving. In the world of design education, AI tools like ChatGPT, DALL·E, Midjourney and Canva's Magic Studio are well on their way to being part of the normal creative process for students. These tools help in conception, prototyping, and iteration of ideas or content production, as well as reconfiguring the role of the design student in a project (Zawacki-Richter et al., 2019: 5). Educators across the world are currently struggling to understand the ways in which AI will empower or disempower the development of critical skills like critical thinking and creativity, skills that are largely the domain of design disciplines. Although AI has been praised for its ability to speed up the process of experimentation and increase the range of references and inspiration available to students, there is the fear that it may also water down independent thinking, the originality of the process and the depth of the analysis (Omran Zailuddin et al., 2024: 282).

In Ghana, the adoption of AI in higher education is at an early stage. Technical universities that offer programs in graphic design, industrial art and visual communication are beginning to feel the impact of these AI tools through casual learning. Many design undergraduate students are exploring generative AI platforms idiosyncratically without formal curriculum guidance or critical reflection on their socio-technical implications (Tadimalla & Maher, 2024: 2). With all of this new exposure, one fact remains clear: very little is understood about the impact of such tools on students' abilities as critical thinkers or as design originators. There is a fear here that students may become overly dependent on AI as a source of perspective, which could inhibit problem-framing competence and weaken professional engagement with central elements of the design thinking process (Butrimė & Zuzevičiūtė, 2025: 190).

Considering the proliferation of AI in design education, the effectiveness of AI in developing students' intellect and creativity should be concretely measured. This research aims to determine the manner of interaction of AI tools by undergraduate students in technical universities in Ghana and whether this interaction promotes or reduces the creative and critical thinking of the students. In particular, the study explores the use of AI, including its limitations; student attitudes toward AI as a creativity aid; and the impact of AI on students' reflective and problem-solving strategies. By focusing on the intersection of AI, critical thinking and creativity, it adds to the emergent literature on the pedagogical challenges of AI in the creative education context. Also, the research provides timely evidence that can help instructors, curriculum developers, and decision-makers in the Ghanaian technical university context make evidence-based decisions regarding the ethical and productive incorporation of AI within design education. As the global context moves towards conversation on AI-enhanced learning, understanding its actual role in the design cognition and student outcomes in the local context gains significance (Bayaga, 2025: 1046; Jose et al., 2025: 2).

HYPOTHESES DEVELOPMENT/LITERATURE REVIEW

AI Integration and Usage in Critical Thinking

Recent years have witnessed growing interest in how interaction with AI tools impacts critical thinking, particularly within disciplines emphasizing creative problem-solving, such as design. Recent studies have highlighted the significant impact of AI on critical thinking, especially in academia. A study by Saritepeci & Yildiz Durak (2024: 25175) reported statistically significant gains in critical reflection among students who integrated AI tools into digital storytelling exercises compared to standard methods. This suggests that AI can support metacognitive practices by students comparing their own ideas to AI-generated alternatives, prompting deeper justification and reasoning.

Research in STEM and cross-disciplinary contexts indicates that conversational AI can act as "object-to-think-with," supporting hypothesis testing and problem redefinition. For example, Vasconcelos & dos Santos, 2023: 4 observed that ChatGPT and Bing Chat interactions fostered reflective problem-solving behaviors in STEM tasks. Similar processes can benefit critical thinking by enabling iterations driven by dialogue and critique when applied to design education. In design education, AI assists cognitive learning processes, including visualization, spatial reasoning and decision-making while emphasizing the need to balance AI use with

students' intrinsic creative abilities (Wang et al., 2022: 623). Comprehensive reviews highlight both opportunities and caution. AI offers tailored feedback and scaffolding conducive to critical thought, but excessive reliance may promote cognitive off-loading habits in which students bypass analysis, particularly in open-ended design tasks. To avoid this, scholars argue for embedding AI use within pedagogical frameworks that encourage questioning, justification and reflection (Gerlich, 2025: 4). Given the foregoing discussions, the following directional relationship is suggested.

H1: *AI interaction and usage significantly influence undergraduate students' critical thinking in design education*

AI Integration and Usage on Creativity

Recent experimental research demonstrates that AI integration can significantly enhance creative cognition among design students. A large-scale survey and structural equation modeling study involving 385 design majors found a string direct effect of AI use on creative cognition ($\beta - 0.610$, $p < 0.001$), with mediators including increased self-efficacy and reduced anxiety (Hwang & Wu, 2025: 3). These findings indicate that AI tools not only provide technical support but also psychologically empower students to generate more creative outcomes. Similarly, an experimental study in digital storytelling education reported significant post-intervention gains in creative self-efficacy and reflective thinking after students used ChatGPT and Midjourney across four weeks (Saritepeci & Yildiz Durak, 2024: 25716). Importantly, the positive effect was observed in the AI group and the non-AI control, suggesting that carefully structured AI use can parallel traditional creative pedagogies in enhancing creative confidence. AI's influence emerges most strongly in ideation processes.

A study in architectural design found that text-to-image generators (Midjourney, Stable Diffusion, DALL.E) supported serendipitous discovery and imaginative exploration during early-stage concept development (Paananen et al., 2024: 458). This indicates AI's utility for enhancing divergent thinking by prompting unexpected visual stimuli. Further, a recent theoretical and empirical evaluation argues that AI can act as a digital facilitator in ideation, guiding design students through methods like Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, Reverse (SCAMPER) and reverse brainstorming, offering non-judgmental feedback, and thus reducing creative inhibition (Melker et al., 2025: 4). Such facilitation fosters more varied and richer ideational output than unguided human-only sessions. Based on the foregoing discussions, the following directional relationship is suggested.

H2: *AI interaction and usage significantly influence undergraduate students' creativity in design education*

Perception of and Challenges with AI on Critical Thinking and Creativity

Surveys recently show that student perceptions, that is, how they view AI's usefulness, accuracy, and appropriateness, play a central role in shaping their cognitive engagement. A global study of university students found that while many appreciated tools like ChatGPT for summarizing and brainstorming, they were less confident in AI's reliability and less likely to view it as enhancing their critical thinking (Ibeh et al., 2025: 14; Zhumagaliyeva et al., 2025: 15). This hesitation indicates that merely having access to AI doesn't guarantee improved analytical rigor; positive perception must align with deeper evaluative trust.

Similarly, a 2025 report by Jisc (UK) highlighted that students expressed concerns that AI could diminish critical skills, especially when they relied on it without verifying its output (Sue, 2025). Students emphasized the need for clearer guidance and AI literacy training, suggesting that perceptions of risks and challenges may undermine critical engagement unless institutional structures are in place. Students commonly cite concerns over AI hallucinations, data privacy and algorithmic bias. In the Jisc study, misinformation and deepfakes were top worries, along with ethical and privacy implications. These concerns can foster skepticism, prompting critical questioning or paralysis, leading to disengagement depending on a learner's propensity to cope with ambiguity. Focus-group research with secondary students who attended AI-creativity training showed that higher AI understanding correlated with more positive views about its impact on creativity. In contrast, low familiarity led to fear and skepticism. Crucially, nearly all participants insisted that AI "could never match human creativity," highlighting the influence of perception on creative confidence (Marrone et al., 2022: 69).

Frontiers in Psychology research warns that overreliance on AI may lead to cognitive off-loading, reducing students' initiative in questioning and analyzing information unless counterbalanced by active reflection and interaction (Jose et al., 2025: 2). Students' overall attitudes towards AI act as a mediator between tool usage and critical cognition. For instance, positive perception (e.g., recognizing AI's personalized feedback) can embower engagement, while negatives (e.g., mistrust in accuracy or fear of surveillance) may discourage reflective evaluation. In Ghanaian contexts, perceptions and access challenges shape adoption: a study reported widespread awareness of ChatGPT, but limited usage due to a lack of guidelines and concerns over dependency and academic dishonesty (Baidoo-Anu et al., 2024). Therefore, it is proposed that,

H3: *Students' perception of and challenges with AI significantly influence their critical thinking in design education*

H4: *Students' perception of and challenges with AI significantly influence their creativity in design education*

Moderating Roles of Age and Gender on Creativity and Critical Thinking

Empirical research highlights developmental differences in how learners process and integrate AI assistance. A mixed-method study analyzing AI use across age cohorts (13-65+ years) reported that younger participants displayed greater reliance on AI and correspondingly lower critical thinking scores; effects not observed in older participants (Gerlich, 2025: 4). This suggests that age influences cognitive outcomes associated with AI; younger undergraduates may offload critical evaluation to AI more readily, undermining their analytical engagement.

Gender differences have also been observed in AI engagement and its creative outcomes. A study employing the UTAUT model found that performance expectancy influences ChatGPT usage more in male students than females, suggesting that AI may bolster creativity differently across genders (Elshaer et al., 2024: 1992). A MDPI study on AI-chatbot adoption reported that female users expressed more ethical concerns and lower reliance on AI, which may reduce the creative benefits or interacting with generative models in design tasks. In context, male users often approached AI with fewer reservations, allowing for freer experimentation and potentially higher creative output (Møgelvang et al., 2024: 1363). In design education, females tend to adopt experiential rather than systematic cognitive approaches, which may influence their use of AI during creative problem-solving. This could mean that men derive greater creative gains from AI's ideation prompts unless pedagogical supports address motivational and affective concerns among female students Chellappa & Luximon, 2024: 100281). The study, therefore, hypothesizes that:

H5: *Age moderates the relationship between AI interaction and usage and critical thinking.*

H6: *Gender moderates the relationship between AI interaction, usage and creativity*

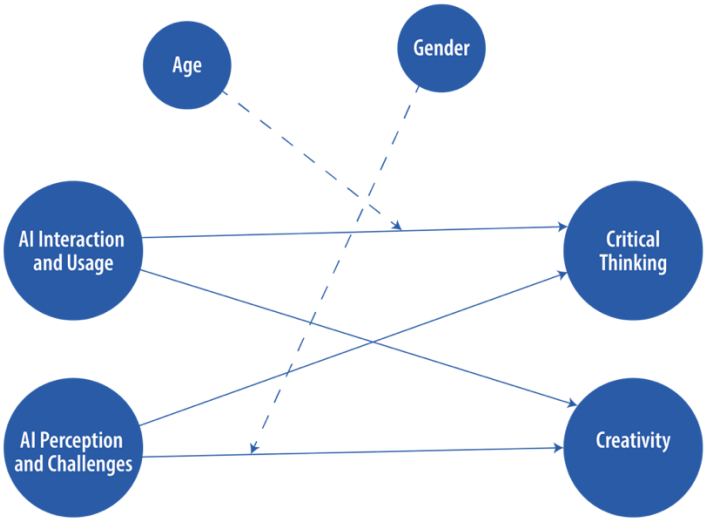

Figure 1. Research model

METHOD

The study adopted a cross-sectional, descriptive-correlational design to investigate relationships between AI engagement and cognitive outcomes. It employed a quantitative approach to analyze structured data from design undergraduates. The target population comprised undergraduate design students across three public technical universities in Ghana. A stratified random sampling technique ensured proportional representation of program levels. Over 400 online self-administered questionnaires were distributed, resulting in 394 valid responses, meeting the minimum sample size recommended for structural equation modelling (Hair et al., 2019: 24) and Krejcie & Morgan (1970: 607) sample size determination. Ethical approval was secured in consonance with the Helsinki 1964 declaration with Ethics ID: RE #122-2025-DRIPPT. The survey link was shared via official class communication channels, reinforcing voluntary participation and confidentiality. The average response time was approximately 12 minutes. All constructs used 5-point Likert scales (1= Strongly Disagree to 5 = Strongly Agree). An expert review panel (3 faculties in design education) confirmed relevance and clarity, supporting the instrument's content validity. The instrument showed strong psychometric properties; Cronbach's alpha and composite reliability exceeded 0.85, AVE surpassed 0.50 and discriminant validity was upheld via Fornell-Larcker (Hair & Alamer, 2022: 4). Data were analyzed using Smart PLS 3.2.9 software. The evaluation proceeded in two stages: testing the measurement model and assessing the structural model. Bootstrapping with 5,000 subsamples was employed to determine the significance of all hypothesized relationships.

FINDINGS AND RESULTS

The PLS-SEM tool was used to analyze data for the current study. According to Hair et al. (2019: 6), two major steps are identified in the literature: the measurement and structural models. While the measurement model estimates construct validity and reliability, the structural model assesses the nature of the relationships, or the paths, between the key constructs of the study, thereby serving as the test for the hypotheses developed for the study.

Demographics

Demographic data on participants' age and gender were collected to contextualize the study and describe the population surveyed. The final dataset comprised 394 valid responses from undergraduate design students in Ghana's technical universities. Participants ranged in age from 16 to over 32 years, categorized into five distinct groups to reflect the typical educational and developmental stages of university students. The largest proportion of respondents (45.4%) fell within the 20-23 age group, followed by 22.1% in the 24-27 range. The remaining participants were distributed among the 16-19 group (15.9%), the 28-31 range (13.4%), and those aged 32 and above (3.3%). This distribution suggests that the sample predominantly comprises students in the early to mid-stages of undergraduate studies, an observation consistent with enrolment trends in creative and design-based tertiary programs in West Africa (Azaglo et al., 2021: 7; Granić, 2022: 9730). With respect to gender, the data revealed a slightly higher representation of females (56.1%) compared to males (43.9%). This finding reflects evolving gender participation patterns in applied arts and design education, where female enrolment in visual communication, fashion design and industrial art disciplines has been steadily rising in Ghanaian technical institutions (Adams & Baddianaah, 2023: 201). Tables 1 and 2 summarize the demographic characteristics of the participants.

Table 1. Frequency distribution of respondents by age and gender

Characteristic	Age	n	% of Total	Cumulative %
Age Group	16-19	63	15.9%	15.9%
	20-23	179	45.3%	61.3%
	24-27	87	22.0%	83.3%
	28-31	53	13.4%	96.7%
	32 years and above	13	3.3%	100.0%
Gender	Male	173	43.9%	43.9%
	Female	221	56.1%	100.0%

Measurement Model Assessment

The assessment of the measurement model was guided by the standard criteria for evaluating reliability and validity within the Partial Least Squares Structural Equation Modelling (PLS-SEM) framework (Hair et al., 2019: 6). Reliability was evaluated using Cronbach's Alpha, Composite Reliability (CR) and rho_A. Convergent validity was assessed via the Average Variance Extracted (AVE), while discriminant validity was examined using the Fornell-Larcker criterion and cross-loadings. Table 2 presents the internal consistency measures for the latent constructs. All construct exceeds the minimum acceptable thresholds of 0.70 for Cronbach's Alpha and Composite Reliability (CR), indicating high internal consistency (Hair et al., 2019: 24; Henseler et al., 2015: 1) The AVE values for all constructs also surpassed the recommended 0.50 level, affirming convergent validity (Fornell & Larcker, 1981: 42). According to Fornell & Larcker (1981: 42), the square root of the AVE for each construct should exceed its highest correlation with any other construct. As shown in Table 3, this criterion is met for all constructs, confirming the discriminant validity of the measurement model. Cross loadings were used to confirm that indicators load higher on their associated constructs than on others, which is another key condition for establishing discriminant validity. As shown in Table 4, all indicators exhibited higher loadings on their respective constructs than others, thus supporting discriminant validity.

Table 2. Construct reliability and validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
AI Interaction and Usage	0.880	0.896	0.907	0.585
Creativity	0.906	0.907	0.930	0.726
Critical Thinking	0.887	0.891	0.918	0.690
Overall Perceptions and Challenges	0.621	0.719	0.795	0.579

Table 3. Discriminant validity (Fornell-Larcker criterion)

	AI Interaction and Usage	Creativity	Critical Thinking	Overall Perceptions and Challenges
AI Interaction and Usage	**0.765**			
Creativity	0.712	**0.852**		
Critical Thinking	0.775	0.800	**0.831**	
Overall Perceptions and Challenges	0.630	0.777	0.724	**0.761**

Table 4. Cross Loadings

	AI Interaction and Usage	Creativity	Critical Thinking	Overall Perceptions and Challenges
CR1	0.622	0.849	0.665	0.639
CR2	0.621	0.818	0.660	0.633
CR3	0.543	0.857	0.684	0.657
CR4	0.639	0.882	0.720	0.696
CR5	0.606	0.855	0.679	0.684
CT1	0.682	0.658	0.872	0.608
CT2	0.665	0.689	0.838	0.579
CT3	0.668	0.711	0.860	0.636
CT4	0.554	0.601	0.765	0.532
CT5	0.642	0.661	0.816	0.646
IU1	0.736	0.473	0.508	0.415
IU2	0.770	0.511	0.565	0.477
IU3	0.575	0.318	0.387	0.290
IU4	0.829	0.587	0.642	0.480
IU5	0.813	0.639	0.672	0.561
IU6	0.762	0.560	0.604	0.505
IU7	0.837	0.642	0.699	0.578
OP1	0.525	0.707	0.627	0.869
OP3	0.303	0.334	0.303	0.483
OP4	0.569	0.660	0.651	0.865

Structural Model Assessment

Path Analysis

Following confirmation of construct validity, the next step was to assess the overall model fit to determine its suitability for further structural analysis. Model fit indicators, including the Standardized Root Mean Square Residual (SRMR) and the Normed Fit Index (NFI), were examined to evaluate the degree of fit between the observed data and the hypothesized structural model. As presented in Table 5, the SRMR values for both the saturated model (0.056) and the estimated model (0.063) fall well below the commonly accepted threshold of 0.08, indicating an acceptable level of model fit (Bentler & Bonett, 1980: 590; Henseler et al., 2015: 117). Similarly, the NFI values of 0.883 for the saturated model and 0.875 for the estimated model suggest a reasonably good model-to-data correspondence, considering that NFI values closer to 1 indicate a stronger model fit (Henseler et al., 2015: 117). These indicators collectively suggest that the structural model approximates the empirical data well and meets recommended goodness-of-fit benchmarks for PLS-SEM. In addition to absolute fit indices, the chi-square statistic was also considered. While chi-square values are known to be sensitive to sample size (Hair et al., 2019: 24), the consistency between the chi-square values of the saturated (611.859) and estimated (652.207) models further reinforce the model's adequacy. To further assess the model's explanatory power, R2 values were examined for the two endogenous variables. Constructs: critical thinking and creativity. The R2 coefficient for critical thinking was found to be 0.531, indicating that approximately 53.1% of the variance in this construct can be explained by the exogenous variables (AI interaction and usage; AI perception and challenge). Likewise, the R2 for creativity was 0.582, suggesting that 58.2% of the variance in creativity is attributable to the same set of exogenous predictors. Following the interpretive thresholds proposed by Giao & Vuong (2019: 15), where R2 values obtained in this study reflect substantial explanatory power. These findings imply that the structural model has empirical predictive strength, reinforcing its relevance for explaining cognitive and creative dimensions within AI-enhanced learning contexts.

Table 5. Model fit indices

	Saturated Model	Estimated Model
SRMR	0.056	0.063
d_ULS	0.652	0.830
d_G	0.273	0.299
Chi-Square	611.859	652.207
NFI	0.883	0.875

Having verified the measurement of reliability and validity, the structural model was analyzed to assess the strength and significance of hypothesized relationships among the study constructs. In line with recommendations by Tortosa et al., (2009: 1437), the path coefficients were evaluated using the bootstrapping technique with 5,000 resamples to determine the significance levels of the direct and moderating effects. In addition to the path significance, the model's explanatory adequacy was substantiated by the coefficient of determination (R2), as previously discussed. As reported in Table 6, all four hypothesized direct paths were found to be positive and statistically significant at the $p < 0.001$ level. The relationship between AI integration and usage and critical thinking was significant ($\beta = 0.529$, $p < 0.001$), as was its effect on creativity ($\beta = 0.375$, $p < 0.001$), These results confirm that frequent and meaningful interaction with AI tools is positively associated with higher-order cognitive and creative abilities in design education contexts. Accordingly, H1 and H2 were supported. Similarly, the impact of students' perception of and challenges with AI was also statistically significant for both outcome variables. A strong positive effect was found on creativity ($\beta = 0.547$, $p < 0.001$) and critical thinking ($\beta = 0.391$, $p < 0.001$), thereby confirming H3 and H4. These results strengthen the view that how students interpret AI's role as a support or threat to their intellectual autonomy significantly shapes their engagement with academic tasks requiring creativity and critical reasoning.

Moderation Analysis

The study involved a moderation analysis of students' age and gender in the nexus between AI interaction and usage, critical thinking; AI perception, challenges, and creativity. The study reports non-significant findings. Specifically, age did not significantly moderate the relationships between AI usage and critical thinking ($\beta =$

0.010, p < 0.698), nor did gender moderate the effect of AI perception on creativity (β = 0.017, p < 0.761). These findings suggest that the influence of AI on student cognition and creative performance is relatively consistent across demographic categories within the sample. Thus, H5 and H6 were not supported. Figure 2 presents the structural model showing path coefficient values.

Table 6. Results of structural model assessment

Hypothesis	Path	Path Coefficient (β)	p value	Result
H1	UI -> CT	0.529	< 0.001	Supported
H2	UI -> CR	0.375	< 0.001	Supported
H3	OP -> CT	0.391	< 0.001	Supported
H4	OP -> CR	0.547	< 0.001	Supported
H5	Age* UI -> CT	-0.010	0.698	Not Supported
H6	Gender* UI -> CR	-0.017	0.761	Not Supported

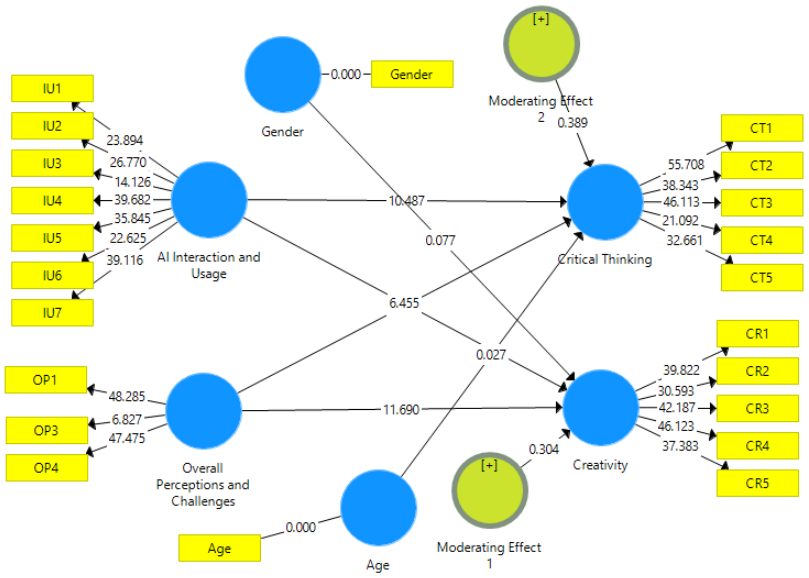

Figure 2. Structural model showing path coefficient values

Note: Standardized path coefficients estimated with 5000 bootstrap samples, R^2 values shown inside endogenous constructs, bootstrapped *t*-statistics shown on measurement paths reflect indicator significance ($t > 1.96 = p < 0.05$).

DISCUSSION

This study examined the influence of artificial intelligence (AI) interaction and perceptions on undergraduate students' cognitive and creative development in design education while also exploring the moderating roles of age and gender. Six hypotheses were tested using structural equation modelling based on partial least square (PLS-SEM). Four hypotheses were supported, while two were not. The implications of each are discussed below.

The first hypothesis proposed a direct relationship between AI interaction and critical thinking. The analysis confirmed this, suggesting that students who frequently and meaningfully engage with AI tools exhibit a more substantial capacity for reflective reasoning and logical judgement. The result aligns with previous studies that indicate AI systems, when used beyond passive consumption, could serve as cognitive catalysts that provoke questioning, comparison, and hypothesis generation. For instance, Vasconcelos & dos Santos (2023: 2296) reported that structured AI dialogues promoted analytical depth in complex STEM problem-solving. This validates the view that AI can serve not merely as an automation tool, but as a framework for developing higher-order thinking when students are guided to reflect on and interrogate its outputs.

The second hypothesis examined whether AI interaction significantly influences student creativity. This relationship was also supported. The creative disciplines, particularly design, thrive on exploration, variation and ideation. The findings imply that students who integrated AI platforms into their iterative design processes were more likely to demonstrate originality in problem-solving. This finding aligns with Shaber et al., (2025: 464), who found that AI-augmented ideation enhanced fluency and novelty in concept development among design students. This implies that AI may act as lateral input, offering divergent examples, triggering associative thinking and expanding the solution space. However, this benefit hinges on active engagement where students do not passively accept AI outputs but adapt, remix, and challenge them.

The third hypothesis tested the influence of students' perceptions and AI-related challenges on their critical thinking. The results strongly support this relationship, indicating that how students interpret AI's role, limits, and potential significantly shapes their analytical behavior. Participants who acknowledged AI's capabilities and shortcomings were more likely to scrutinize its outputs and reflect critically on their design decisions. This confirms the findings of Ibeh et al., (2025: 14) and Zhumagaliyeva et al. (2025:15) who argue that awareness of algorithmic fallibility fosters metacognitive strategies among learners. Students who internalize that AI is fallible and context-sensitive are more likely to evaluate information rigorously, compare alternative viewpoints, and rely on evidence-based reasoning rather than surface-level automation.

The fourth hypothesis focused on whether students' perceptions and challenges regarding AI significantly affect their creativity. This was the strongest supported path in the model, confirming that critical awareness of AI's role can enhance rather than inhibit innovation. Students who approached AI with a balance of curiosity and skepticism appeared better positioned to generate unique ideas. This resonates with Guzik et al. (2023: 100068), who demonstrated that users with greater interpretive awareness of AI-generated suggestions exhibited higher levels of originality.

The fifth hypothesis tested the moderating role of age in the relationship between AI interaction and critical thinking. Contrary to theoretical expectations drawn from prior research, this hypothesis was not supported. Although younger users have often been described as more digitally fluent and more likely to adopt AI tools, our data suggest that in the structured educational setting of Ghanaian technical universities, age difference becomes less predictive of learning outcomes. Kim et al. (2025): 530 noted that in unguided settings, younger users tend to engage more heavily with AI-driven platforms; however, when AI use is framed within pedagogical norms and scaffolding, such generational divides appear to diminish. These results signal that institutional strategies and learning design may play a stronger role in shaping students' AI engagement than age-related preferences alone.

The sixth hypothesis posited that gender would moderate the relationship between AI perceptions and creativity. This hypothesis was also not supported. Previous research, including that of (Asiksoy, 2024: 153; Đerić et al., 2025: 36; Møgelvang et al., 2024: 1363) suggested that female students tend to express more ethical reservations and risk-awareness when engaging with AI tools, which could hypothetically limit their experimental engagement in creative contexts. However, our findings suggest that these differences become statistically irrelevant in environments where both genders are given equitable access, exposure, and instructional guidance. In other words, when AI use is framed within inclusive pedagogical structures, both male and female students appear equally capable of leveraging AI to enhance creativity.

CONCLUSION

The findings from the study provides timely insights and empirical evidence that AI interaction and usage significantly enhance both cortical thinking and creativity among undergraduate design students, reinforcing the view of AI as a cognitive amplifier when engaged reflectively rather than passively. The findings align with prior research demonstrating that AI-mediated learning environments can stimulated reflective reasoning, metacognition and ideational expansion when students actively interrogate and adapt AI-generated outputs (Saritepeci & Yildiz Durak, 2024; Vasconcelos & dos Santos, 2023).

Moreover, the strong influence of students' perceptions and awareness of AI challenges underscores the critical role of AI literacy, supporting evidence that informed skepticism and understanding of AI limitations foster

deeper analytical engagement and creative originality (Ibeh et al., 2025; Jose et al., 2025). Importantly, the absence of moderating effects of age and gender suggest that, within structured educational contexts, the cognitive benefits of AI are broadly accessible, echoing arguments that pedagogical design and scaffolding outweigh demographic differences in shaping AI-enabled learning outcomes (Kim et al., 2025). These findings contribute to the ongoing discourse on the cognitive paradox of AI by empirically supporting the position that its educational value depends on guided, reflective integration rather that uncritical reliance (Gerlich, 2025; Jose et al., 2025).

From a practical standpoint, the study highlights the necessity of embedding AI within pedagogical frameworks that promote critical inquiry, ethical awareness and creative reinterpretation. In emerging contexts such as Ghanaian technical universities, where AI adoption remains largely informal, structure curriculum interventions and institutional policies are essential to transform adhoc usage into meaningful cognitive development. Future research should extend this model across disciplines and longitudinal designs to further validate causal mechanisms and long-term impacts of AI-assisted learning.

Authors' Contributions

The authors contributed equally to the study.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

The Ethics Committee of Accra Technical University reviewed and approved this study on 23rd July, 2025 (Ethics ID RE. #122-2025-DRIPTT). All procedures involving human participants were executed in compliance with the ethical standards established by the institutional research committee and the 1964 Helsinki Declaration, along with its subsequent amendments. All participants provided informed consent prior to the collection of data.

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Christopher Oppong is a Ghanaian Sculptor, Researcher, and Senior Lecturer at Bolgatanga Technical University. He holds a master of Fine Art Degree in Sculpture and is currently pursuing a PhD in Sculpture at Kwame Nkrumah University of Science and Technology (KNUST), where his research explores the cultural, spatial, and philosophical dimensions of basketry as a sculptural practice. His work integrates indigenous materials and weaving techniques to investigate themes of memory, migration, ecology, and transformation. Oppong is actively engaged in community art projects that promote sustainability and cultural heritage.

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Research Article

Reimaging indigenous art and craftsmanship through sustainable capsule wardrobe clothing design: A culturally grounded design framework

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Abstract
With the rapid growth and globalization, indigenous knowledge is under mounting pressure to continue its social visibility and economic appropriateness. This paper discusses how Bidayuh cultural identity in Malaysia could be perpetuated by creating a model of a culturally based, sustainable capsule wardrobe as a preservation and adaptive continuity model. A mixed-methods approach was adopted, incorporating cultural documentation, studio-based experimentation, and consumer evaluation. In three stages; cultural grounding, sustainable experimental translation and social validation, the traditional Bidayuh motifs, the meaning of the symbolic colors and principles of craft were systematically rethought into capsule wardrobe clothes by the means of the sustainable techniques. To determine consumer perception and acceptance, a survey of 116 Gen Z respondents was conducted. The findings reveal that indigenous conservation is enhanced when cultural aspects are reinterpreted through wearable, integrated, and sustainability-based systems. The paper presents a framework of Culturally Grounded Sustainable Capsule Design, which places the concept of adaptive reinterpretation and not mere replication at the heart of cultural sustainability in Borneo. The framework provides a transferable framework on how to incorporate the indigenous knowledge in modern sustainable fashion based on ethical underpinning, balanced translation and empirical validation.

Keywords: Indigenous knowledge, Cultural sustainability, Capsule wardrobe design, Design framework, Traditional craftsmanship

Extended Abstract

Introduction: The Bidayuh community of Sarawak possesses a rich cultural heritage, expressed through traditional art, textiles, motifs, colors, and craftsmanship, which remain central to its cultural identity. However, modernization, urban migration, and changing lifestyles have contributed to declining engagement with traditional attire, particularly among younger generations, leading to the underrepresentation of Indigenous heritage in contemporary fashion. At the same time, the global fashion industry is increasingly shaped by sustainability-oriented frameworks such as slow fashion, circular design, and the capsule wardrobe concept, which promote a curated collection of versatile, high-quality garments designed for longevity and mix-and-match functionality, generating multiple outfit combinations and reducing excessive consumption. While existing studies have explored sustainable fashion and the adaptation of traditional elements in contemporary design, limited research has systematically integrated indigenous cultural identity into sustainable capsule wardrobe frameworks. This gap highlights the need for a culturally grounded design framework that positions indigenous identity as an integral component of sustainable fashion practice rather than as purely aesthetic references.

Purpose and scope: This study explores how Bidayuh cultural identity, traditional art, and craftsmanship can be ethically and meaningfully integrated into a contemporary capsule wardrobe through a sustainable fashion design framework. This study seeks to identify the essential characteristics of Bidayuh textiles, motifs, color symbolism, and craftsmanship suitable for design translation while maintaining cultural integrity and sustainability principles. The scope of the research is limited to the design, development, and conceptualization of an ethnic-based capsule wardrobe, focusing on motif adaptation, material and technique selection, and design strategies that support longevity and versatility. It does not address large-scale production or commercialization. Instead, it contributes to a culturally grounded and sustainable

design framework to help designers, educators, and researchers in integrating indigenous heritage into contemporary fashion practice.

Method: This study adopted a mixed-methods approach combining qualitative and quantitative techniques across three phases: a secondary data analysis and experimental design phase, followed by a quantitative survey. The approach was chosen to enable an objective evaluation of user acceptance, perceived functionality, cultural relevance, and alignment with the sustainability of the proposed designs. guided by a culturally grounded sustainable fashion design framework to systematically examine the integration of Bidayuh cultural elements into a contemporary capsule wardrobe. The research was structured into three interconnected phases: cultural understanding and its preservation, experimental design translation, and evaluative validation. These approaches enable the assessment of cultural knowledge, design experimentation, and user feedback within a coherent framework. Secondary data from a prior study were used to ensure cultural accuracy and ethical continuity during conceptual development. An experimental design process involving digital motif translation, material testing, and prototyping was conducted to develop a 10-piece capsule wardrobe that embedded sustainability principles such as longevity, modularity, and versatility. The finalized designs were evaluated through an open survey, with data analyzed using SPSS, enabling empirical validation of the design outcomes and supporting the suitability of the capsule wardrobe as a culturally grounded, sustainability-oriented fashion system.

Findings and conclusion: The experimental phase evaluated the adaptation of Bidayuh cultural and meaningful motifs, and the craftsmanship techniques using four key criteria: motif legibility, cultural recognizability, suitability for repeated wear, and material compatibility for everyday garments. A range of sustainable strategies, including lino printing, applique, patchwork, embroidery, beadwork, cut-out, and cyanotype, were tested on comfort-oriented fabrics such as cotton, linen, cotton-linen blends, and felt to assess their functional and visual performance within a capsule wardrobe. The findings demonstrate that practical cultural preservation in contemporary fashion relies on selective and respectful translation rather than direct replication. Technique suitability was strongly influenced by motif complexity, garment function, and fabric behavior, with lino printing proving most effective for intricate motifs, and applique, patchwork, and embroidery better suited for bold forms. High contrast color application was essential for maintaining symbolic clarity, and these insights directly informed subsequent prototype development, ensuring that cultural identity was preserved through wearable, durable, and sustainable design solutions. Guided by experimental findings, a 10-piece Bidayuh-inspired capsule wardrobe was developed through selective motif adaptation, cohesive color strategies, and sustainable material choices to promote versatility and reduce consumption. Digital visualizations were employed throughout the design process to refine motif placement and silhouette interactions while minimizing material waste. The capsule wardrobe yielded 28 mix-and-match styles over four weeks, demonstrating functional versatility and everyday wearability. Market evaluation involving 116 respondents revealed strong acceptance of the Bidayuh-inspired capsule wardrobe among Gen Z, with particularly high interest. Statistical analysis confirmed a significant relationship between gender, ethnic background, sustainability values, and interest in a capsule wardrobe, indicating broad cross-cultural appeal beyond the Bidayuh community. Reliability analysis demonstrated strong internal consistency of the acceptance scale, supporting the robustness of the findings. Multiple regression analysis showed that belief in successful modern adaptation of the Bidayuh motif was the strongest predictor of acceptance, followed by sustainability-oriented perception and artistic interest, with the model explaining 58% of the variance in acceptance. These results confirm that cultural relevance must be translated into a contemporary, wearable design language to achieve market acceptance, reinforcing the study's theoretical framework, which positions design adaptation as the mediator between cultural identity, sustainability, and consumer uptake. In conclusion, this study validates a culturally grounded sustainable fashion design framework that integrates indigenous identity into capsule wardrobe design. It extends sustainable fashion scholarship by positioning cultural sustainability alongside environmental and functional dimensions. For designers, the findings suggest prioritizing the reinterpretation of contemporary motifs, functional versatility, and clear sustainability narratives when developing indigenous-inspired capsule wardrobes. For educators and industry practitioners, the framework offers a structured approach for embedding cultural adaptation strategies into sustainable fashion education and practice, supporting both cultural continuity and responsible consumption within the contemporary fashion landscape.

Keywords: Indigenous knowledge, Cultural sustainability, Capsule wardrobe design, Design framework, Traditional craftsmanship

INTRODUCTION

One of the most significant native communities of Sarawak is the Bidayuh community, which has a rich cultural heritage manifested in language, craftsmanship, and traditional clothing. Bidayuh art is studied as being rich in material culture with beadwork and patterned weaving being employed as the carriers of the cultural meaning, the representations of nature, spirituality, and identity of the community (Jalil & Alison,

2026). Migration to cities, the change in lifestyle, and the growing generational values and cultures are some of the factors that lead to the gradual separation of younger Bidayuh people with the traditional attire and crafts (Santhar, 2023). The secret of the successful translation of this heritage to modern fashion is that a person must not restrain themselves to aesthetic motivation and further transform it to the moral one. This underrepresentation restricts its potential to contribute to cultural preservation, creative innovation, and community pride. Meanwhile, the minimalistic way of life, slowness in fashion, and sustainable consumption trends are becoming the primary influences of global fashion trends. As one of the fashion styles that promote sustainability values, the capsule wardrobe, with its focus on versatility, durability, and conscious fabric selection, has become a defining trend (Jalil & Shaharuddin, 2019: 1226-1231). Considering the similarity of the value of cultural preservation and sustainable design, there is an urgent need to consider how Bidayuh cultural identity can be strategically incorporated into sustainable design principles. Nonetheless, the research that brings together indigenous identity and sustainability is insufficient, mainly because there are no sustainable fashion design systems that are based on culture. Whether indigenous motifs can be modernized or not is not a question, but how they can be systematically applied to sustainable fashion systems without being diluted culturally or rejected by the market. Thus, the study will examine how cultural identity and sustainability can inform new contemporary capsule wardrobe design that is one of the trendy sustainable practices. In particular, the research is aimed at determining the key attributes of Bidayuh art and craftsmanship that can be best applied to a costume based on ethnicity and at discussing viable ways of incorporating the traditional Bidayuh motifs into modern clothes design. The results of this study will be advantageous to the designers as they provide ethical and systematic method of integrating native aspects in modern fashion design, local communities by promoting cultural images and conservation, and teachers with a cultural reference point of embedded culturally responsive and sustainable fashion design.

LITERATURE REVIEW

Sustainable Capsule Wardrobe Concepts

The fashion industry is among the most wastage and polluting industries in the world that contributes greatly to the environmental degradation with the likes of over production, wastage of textile, carbon emissions. The linear model of fashion, take-make-dispose, of fast fashion makes these problems worse, as clothes are usually used a few times before they are disposed of (Niinimaki et al., 2020: 198). Sustainable fashion is a paradigm developed in opposition to these dilemmas focusing on the environmental responsibility, social ethics, and the creation of long-term value (Jalil, 2022). A number of related theoretical constructs can be used to explain sustainable fashion, and all of them revolve around the challenge of fast fashion. Slow fashion is one of the most influential ones, and the first approach to it is offered by Fletcher (2014), who suggests slowing down the process of production and consumption, focusing on quality, craftsmanship, and emotional longevity, rather than on the trends of quantity. It is true that slow fashion supports physically and aesthetically durable garments, enhancing stronger user-connections and minimizing wastes (Castro-Lopez et al., 2021: 7-9; Fletcher, 2010: 262-265). To supplement slow fashion, the system of circular design and the circular economy that conceptualize fashion systems as a closed loop based on natural cycles is in place. It is determined to remove waste by means of reuse, repair, recycling, and regeneration (Niinimaki et al., 2020: 196-197). The capsule wardrobe has become a clear and feasible approach in this wider sustainable fashion rhetoric that both instantiates these values at both the design and consumption level (Jalil & Shaharuddin, 2019: 1230-1231). Capsule wardrobe is a select set of high-quality clothing, which is versatile and has a long lifespan, as well as providing the flexibility of various can combinations and limits the requirement of excessive consumption (Hsiao & Grauman, 2018: 7166-7168; Bardey et al., 2022: 114; Magano et al., 2025: 2). It encourages conscious, low consumption through the adoption of the practice of maximizing the utility of the existing clothes and thus minimizing the need to make new purchases impulsively (Horn et al., 2025: 7-14). Design innovation is essential to the realization of the circular potential of capsule wardrobes. Jalil and Shaharuddin (2019: 1226-1229) used the Cradle-to-Cradle Apparel Design model when developing an eco-capsule wardrobe with the concept of incorporation of multifunctional and convertible garments. There are also social and psychological advantages of building a capsule wardrobe that are revealed through empirical research. The exploratory qualitative study from Bardey et al. (2022: 118-125) that involved participants in a three-week

capsule wardrobe challenge identified that participants felt less stressed and less connected to the changing fashion trends, more aware of conscious consumption, and that the participants found greater self-expression through restrictions. Bang and DeLong (2022: 6-19) investigated everyday creativity in the form of an eight-week capsule wardrobe project that included seven participants. Their results showed that it might result in more creative outfit building, less impulsive buying and better sustainability, including clothes repair and reuse. Such creative products were created out of intrinsic motivation, which supports the values of slow fashion of quality, mindfulness, and voluntary simplicity. The most recent research was conducted by Magano et al. (2025: 8-24) who surveyed 776 consumers and discovered that positive perceptions toward a capsule wardrobe had a strong relationship with socially responsible behavior. The authors emphasize that more systematic interventions, such as designer-led strategies, should be used to enhance the capsule wardrobe strategies. In reaction, modern fashion designers are becoming less and less interested in the production of standalone pieces and more focused on creating systems of compatibility (Jalil, 2022). Although it has been demonstrated that the capsule wardrobe can be viewed as a sustainability approach that is promoted by consumers, there is a relative lack of literature discussing the potential of the capsule wardrobe as a design approach to implementing cultural identity and craftsmanship into the sustainability fashion system.

Integration of Traditional Elements in Contemporary Design

The integration of the traditional ethnic motifs, colors and patterns into modern fashion may be referred to as the altering discourse between the cultural preservation and the innovative thought (Jalil et al., 2024a). Designers are removing and repackaging the traditional elements in the globalized markets to produce globally familiar but culturally specific designs due to globalization, identity formation, conscious consumerism, and differentiation (Skaskiv & Chuprina, 2025; Yao & Inchan, 2024). Rather than imitating the past artefacts, the modern practice is a deconstructive analysis and reinterpretation, combining indigenous craftsmanship with modern materials, updated production processes and modernistic sensibilities (Le et al., 2024; Jalil et al., 2024b). Traditional culture, in this case, serves not as background reference but as the source of design logic and symbolic meaning (Hwui & Jalil, 2025). More recent scholarships focus on adaptive transformation as an important part of continuity in cultures. According to Jalil et al. (2024a; 2024b), preservation is expressed through symbolic meaning, principles of narrative structure, and design rather than the duplication of materials (Jalil, 2024), specifically in SME and contemporary craft. Building on this argument, Jalil (2025: 3-7) and Jalil et al. (2025) show how intangible heritage could be converted into other forms of visual languages using digital and AI-mediated tools without cultural loss. These studies favor a model of culturally based adaptations where the technological mediation and design innovation is concomitant to the preservation of identity in systems that are sustainability oriented. The investigation of Chinese Han cultural aspects proves that simplification, abstraction and re-scaling allow converting the sophisticated traditional motifs into modern-day products without losing symbolic meaning (Yao & Inchan, 2024: 645-648; Jalil et al., 2024b). This is made possible by the use of similar techniques of abstraction and visual condensation to make culturally representative symbols conform to minimalist aesthetics without losing cultural meaning (Han, 2025: 270-271). The process of deformation of the motifs (Kaya & Romanescu, 2022: 198), change of structure and silhouette (Hu, 2022: 28-31), and color recalibration, be it in the direct use of the meaningful traditional palette or using tonal harmonization, are examples of controlled translation, not aesthetic replacement. Ying and Yaacob (2025: 334-337) showed that incorporating Suzhou double-sided embroidery into modern casual clothes not only preserves tradition but also makes it appear more luxurious. These researches prove the fact that traditional elements are adaptive cultural systems, but not fixed artefacts (Jalil & Alison, 2026). Nevertheless, despite a record of fruitful motif reinterpretation across different cultural settings, there are two essential constraints. To start with, a significant portion of the research to date views ethnic integration as an aesthetic intervention rather than as cultural identity incorporated into a formal sustainability framework. Whereas sustainable fashion studies focus on material efficiency, circular systems and consumer behavior (Fletcher, 2010: 262-265; Niinimaki et al., 2020: 195-198), they mainly focus on environmental and functional aspects, with cultural sustainability relatively under-theorized. Indigenous people in Borneo, especially Bidayuh community, are still underrepresented in empirically validated research. As a result, integrative models that can bring together cultural grounding, sustainable material strategies, calibrated design translation, and consumer validation into a cohesive framework are severely lacking.

This study formulates the concept of cultural sustainability as a dynamic process where the indigenous identity is maintained due to structural reinterpretation and not replication. Figure 1 shows the proposed Culturally Grounded Sustainable Capsule Design Framework, which combines 3 connected areas: cultural grounding which is supported by previous research (Skaskiv & Chuprina, 2025; Han, 2025; Yao & Inchan, 2024; Le et al., 2024; Jalil et al., 2024b), sustainable design translation, and market validation. It is based on cultural grounding, which involves symbolic motifs, color meanings and artisan craft traditions based on Bidayuh heritage. These aspects inform the second area, sustainable design translation, in which conventional knowledge is experimentally redefined through environmentally efficient methods and capsule wardrobe values (Bang & DeLong, 2022; Jalil & Shaharuddin, 2019). This structure revolves around the degree of design translation, as an idea that is conceptualized as a moderating element that balances the stress between cultural authenticity and wearability of the time. Market validation determines the perception and acceptability of the consumer (Magano et al., 2025) to make adaptive reinterpretation an economic and social concept. The framework that forms cultural identity within a sustainability-based system of design establishes a paradigm in which indigenous knowledge is implemented as cultural memory and current design capital.

Figure 1. Culturally Grounded Sustainable Capsule Design Framework (CGSCD Framework)

METHOD

This study adopted a mixed-methods approach. This work can be applied to a proposed culturally-based sustainable fashion design system, where the study is organized into three interdependent stages, i.e., cultural knowledge or identification adjustment, experimental transfer of sustainable clothing design, and the acceptance/evaluative validation of the market. This study adopted a mixed-methods approach combining qualitative and quantitative techniques across three phases: a secondary data analysis and experimental design phase, followed by a quantitative survey. This study received ethical approval from the Ethics Committee of the Faculty of Applied and Creative Arts, Universiti Malaysia Sarawak. The research procedures were conducted in accordance with the ethical guidelines and regulations of Universiti Malaysia Sarawak and followed internationally accepted standards for research involving human participants. Ethics approval for this study was obtained from the UNIMAS Human Research Ethics Committee (Non-Medical) during Meeting No. 04/2025, held on 19 May 2025.

Cultural Grounding and Preservation

To begin with, at the first stage, which is the step of developing and imagining the cultural identity, and a level of cultural preservation, this research paper relies on the secondary data by referring to the previously published and peer-reviewed results as a means of informing its conceptual formation to avoid misrepresentation and commodification of the motifs, symbols, and meanings. In addition, the idea of transferring of traditional elements to modern forms without corrupting culture is paramount in cultural studies as well as being instrumental in the intergenerational transmission of indigenous knowledge. In this study, the cultural meanings, identity adaptations, and known classifications of the important Bidayuh motifs were systematically laid out and confirmed by Jalil and Alison (2026). The authors began with the collection of secondary data that included semi-structured interviews with Bidayuh artisans and the community leaders, which they published in a report (Jalil & Eleen, 2026). This ethnographic data was supported by a visual analysis of Bidayuh artifacts in order to identify and codify the symbolic value of the most significant biomorphic motifs and patterns. Since these cultural data points have already been validated by the essential means of ethnographic research and

academic analysis, the current research does not aim to repeat or redefine the same cultural records. Rather, the authenticated quantitative secondary data are strategically used as a credible source of knowledge to help build a sustainable framework of a culturally based design of a capsule wardrobe. Such methodological approach helps to increase the rigor of research, prevents the repetitions of the same information, provides the continuity of an ethical character, and permits contemporary study to make the recent theoretical and design-oriented developments beyond the area of the initial documentation.

Sustainable Experimental Translation

There was an experimental procedure in the desire to integrate the Bidayuh cultural aspects into a modern concept of the capsule wardrobe. This stage aims at taking Bidayuh patterns into the modern capsule wardrobe products that can be worn on a daily basis. During observation, photographs of motifs were made of material culture of Bidayuh (Jalil & Alison, 2026). The creation of timeless objects, aimed at the reduction of excessive consumption, the experimentation with the old patterns, in accordance with the environmentally friendly procedures, the materials that do not have negative effects or cause harm, or that are made locally are of great importance within this stage. Motifs that were ritual related and cultural taboos were left out. This contributed to the fact that the process of the translation is culturally respectful and suitable in the context of modern fashion. These motifs were then translated into wearable applications by the experiment phase using the vectorized motifs to facilitate motif translation which allowed translation of the motifs to different surface designs and translation methods. To create a baseline of the silhouettes and measure the accuracy of construction, prototypes of 10 pieces of a capsule wardrobe were developed. The principles of sustainability were introduced at the design phase, which included the adoption of timeless silhouettes, modular and mix-and-match styling, and experimenting with limited materials in accordance with the capsule wardrobe principles that put more emphasis on longevity and less on consumption.

Social and Market Validation

At the last phase, the user assessment was performed as a part of the entire design set-up. The purpose of this evaluation was to confirm the design in question as effective with respect to user acceptance, perceived functionality, cultural relevance and sustainability alignment. This step enabled the capsule wardrobe to remain only a conceptual or aesthetic result, but a design system created by the user, which promoted sustainability. An open survey sampling methodology (non-probability) was used, and anyone (not gender-specific) could participate in the study. This open voice strategy allowed gathering a variety of opinions about the suggested capsule wardrobe designs and, at the same time, it remained topical with the fashion customers of the time. In spite of the fact that the capsule wardrobe was initially designed with Gen Z users in mind, there was no specific age limitation in terms of responses, which allowed expanding the perception of the wearability, cultural relevance, and sustainability values. But among 189 respondents, 116 were found to measure validity between Gen Z, who are aged between 19 and 27 years. The information was collected using Google Forms in December 2025 to capture the user feedback of the respondents in Malaysia. The data were gathered and analyzed with the help of SPSS to measure the acceptance of users, perceived functionality, cultural relevance, and compatibility with sustainability of the Bidayuh-inspired capsule wardrobe.

FINDINGS AND RESULTS

Cultural Identity Adaptation and Motif Documentation

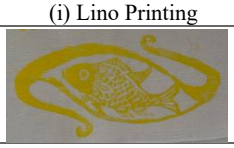
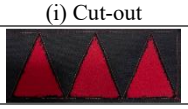
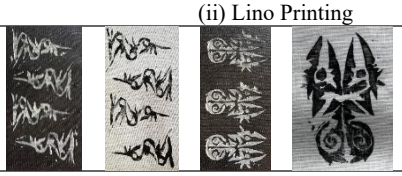
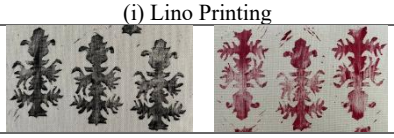
The experimental procedures were tested in terms of motif legibility, cultural recognizability, the ability to repeat the wear, and material compatibility to daily garments. Table 1 captures the experimentation of the motif that was completed in this stage, material experimentation, modification of the motif, silhouette experimentation, and color experimentation which has been captured in a sequence of experimental photographs created by the researchers. This experimental procedure allowed choosing the best method of motif development through the comparison of the advantages and weaknesses of each method, which is consistent with the objectives of producing culturally-based but useful pieces of the capsule wardrobe. Table 1 has shown that lino printing was the most effective method in the intricate and multi-element motif, whereas applique, patchwork and embroidery was the best method in bold and structurally defined motives. In all the

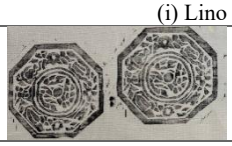
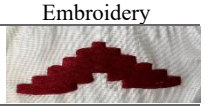
experiments of lino printing, the pairings of colors of high contrast were necessary to maintain the legibility of the motifs and the symbolic power. The results of these findings were the direct input to the methods of selection and the material used in the next stage of the development of the prototype of the capsule wardrobe design. In addition to technical optimization, these experimental results operationalize the principle of calibrated design translation in that they show that the complexity of motifs, color contrast and material behavior can have a direct effect on symbolic clarity. This step guarantees that cultural recognizability remains intact but, at the same time, the motifs are adjusted to suit modern-day wear by performing a systematic test of technique-motif compatibility. The results, consequently, form the structural base of culturally based sustainability to avoid ornamental excavation and strengthen symbolic autonomy in the capsule system.

Sustainable capsule wardrobe, material experimentation, and design trials

Based on the experimental results on the motif translation of Bidayuh (Table 1), a 10-piece capsule wardrobe was created through the selective incorporation of culturally relevant motifs confirmed by Jalil and Alison (2026), sustainable materials, and unified color schemes. As shown in Figure 2, each item represents contextual communication between the Bidayuh cultural symbolism, modern wearability and eco-friendly design practice.

Table 1. Translation of selected Bidayuh motifs into contemporary designs using sustainable techniques

Original Bidayuh Motif (Jalil & Alison, 2026)	**Translated Design - Applied Technique(s)**		
	(i) Applique	(ii) Patchwork	(iii) Beadworks
(a) *Boton Manuk Puni* (Pigeon's Eye) 			
(b) Tiger Head 	(i) Hand Embroidery (Button form)		(ii) Lino Printing
			
(c) *Ikan Koi* 	(i) Lino Printing		
			
(d) *Pucuk rebung* (Bamboo Shoot) 	(i) Cut-out	(ii) Hand Embroidery	(iii) Lino Printing
			
(e) *Paku-pakis* (Fern) 	(i) Hand Embroidery		(ii) Lino Printing
			
(f) Bamboo Leaf 	(i) Machine Embroidery		(ii) Lino Printing
			
(g) Paddy 	(i) Lino Printing		
			
(h) *Daun sireh* (Piper betel) 	(i) Lino Printing		
			

(i) Floral	(i) Lino Printing			
				
(j) *Rojak dien* (Durian Thorn)	(i) Beadworks (Mapped)	(ii) Beadworks (Hanging)	(iii) Patchwork	(iv) Hand Embroidery
				
(k) Dragon + *Paku-pakis* (Fern)	(i) Lino Printing			
				
(l) *Bidayuh ring ladies*	(i) Cyanotype			
				

Notes:

- Original motifs are adapted from Jalil & Alison (2026), excluding culturally sensitive or ritual-related motifs.
- Sustainable techniques include low-waste and craft-based approaches such as appliqué, embroidery, lino printing, and cyanotype.
- "Translated Design" refers to the prototype application within contemporary capsule wardrobe development.

Figure 2. A ten-piece Bidayuh-inspired capsule wardrobe collection

Boton manuk puni (Table 1-a): The motif was experimented with using applique, patchwork, and beadwork techniques. The use of applique, patchwork, and beadwork consistently produced positive results. Applique (Table 1-a-i) and patchwork (Table 1-a-ii) made with felt consistently yielded positive results due to their non-fraying edges, which allowed the motifs to retain a clean, well-defined form. These techniques demonstrated a strong structural stability and visual appeal, making them suitable for repeated wear in daily garments. Beadwork enhanced the motif's tactile quality, reinforcing its cultural prominence and decorative emphasis.

Tiger head motif (Table 1-b): The motif was explored through hand embroidery and lino printing. Hand embroidery (Table 1-b-i) produced a detailed and dimensional outcome, particularly when shaped into button forms, highlighting the motif's expressive qualities. Lino printing (Table 1-b-ii) revealed that color contrast played a critical role in motif visibility. The black-on-white linen produced the strongest visual contrast. The red-on-white also achieved acceptable clarity. In comparison, yellow-on-red linen resulted in reduced visual impact, suggesting limitations in color pairing. A more successful outcome was observed with a yellow-on-black and black-on-red, which provided stronger visual separation between motif and background, allowing the form to remain prominent.

Ikan koi (Table 1-c): Due to the intricacy of the motif, lino printing (Table 1-c-i) was the only technique tested. Linen fabric was used during the experimentation. Yellow-on-black printing maintained acceptable clarity despite its complexity. In contrast, yellow-on-white and yellow-on-red combinations reduced contrast, leading to a loss of definition in finer details and a decrease in visual impact.

Pucuk rebung (Table 1-d): The motif was tested using cut-out, hand embroidery, and lino printing techniques. Cut-out technique (Table 1-d-i) employing black cotton-linen paired with red felt produced a strong visual contrast and sharp motif definition. Hand embroidery (Table 1-d-ii) using red DMC thread on cotton fabric yielded refined results, reinforcing the motif's geometric clarity. Lino printing in black on white cotton further confirmed the technique's effectiveness for this motif.

Paku-pakis (Table 1-e): The motif showed excellent adaptability across techniques. Hand embroidery (Table 1-e-i) produced highly refined results, enhancing the motif's organic curves. Lino printing (Table 1-e-ii) was also effective, particularly in white-on-black and black-on-white linen combinations. However, the black-on-red combination reduced contrast, making the motif appear less distinct and therefore less suitable for precise representation.

Bamboo leaf (Table 1-f): This motif was explored through machine embroidery and lino printing, both of which were effective. The machine embroidery (Table 1-f-i) process, using interfacing cut to motif shape and ironed onto organza before outlining, created a lightweight yet defined appearance, suitable for layering and semi-transparent garments. Lino printing (Table 1-f-ii) further reinforced motif clarity, with both white-on-black and black-on-white on linen fabric applications yielding strong visual results.

Paddy motif (Table 1-g): The motif was tested exclusively through lino cutting (Table 1-g-i). Black-on-white linen produced the most evident contrast and the most legible outcome. In comparison, black-on-red and yellow-on-black combinations resulted in reduced visual impact, while yellow-on-red produced only moderate clarity due to minimal tonal contrast.

Daun sireh motif (Table 1-h): Given its complexity, the motif was explored solely through lino cutting (Table 1-g-i). Black-on-white and red-on-white combinations effectively captured the motif's intricate forms without visual clutter. Black-on-white and red-on-white effectively captured the motif's intricate forms without visual clutter, producing a clear, contrasting outcome. Yellow-on-black and yellow-on-red yielded an acceptable, but slightly subdued, outcome. However, the red-on-black combination failed to achieve sufficient visibility, underscoring the importance of high-contrast color pairings.

Floral motif (Table 1-i): The motif was developed using linocut printing (Table 1-i-i). Both black-on-white and red-on-white linen produced a clear, visually balanced result that enhanced the motif's elegance.

Rojak dien (Table 1-j): This motif was explored through patchwork, beadwork, and embroidery. Patchwork (Table 1-j-i) applications using black linen as the base, paired with felt, yielded structurally strong, visually coherent results. Beadworks experiment produced varied results. Bead mapping (Table 1-j-ii) directly onto fabric yielded excellent clarity and stability, whereas hanging-bead (Table 1-j-iii) applications were visually acceptable but less controlled. Hand embroidery (Table 1-j-iv) using red DMC thread on white cotton fabric further demonstrated the motif adaptability and suitability for garment surfaces.

Dragon and paku-pakis (Table 1-k): The combined motif was successfully translated using lino printing (Table 1-k-i). White-on-black and black-on-white combinations on linen yielded strong contrast and visual clarity, indicating that lino printing is particularly well-suited to these complex, multi-element compositions.

Bidayuh art (Table 1-l): The artwork was explored using the cyanotype technique. When applied to cotton fabric, the process produced a clear and stable image with strong visual definition. However, results on linen were less successful, suggesting that cotton is a more suitable substrate for cyanotype applications. These experimental outcomes confirm that technique selection must be guided by motif complexity, intended garment function, and material behavior. Lino printing emerged as the most versatile technique for complex motifs, while appliqué, patchwork, and embroidery were better suited for bold, structurally defined motifs. Overall, the results indicate that high-contrast color pairings are crucial in lino printing to preserve clarity and symbolic strength when translating Bidayuh visual elements into contemporary textile applications. These findings directly informed the selection of techniques and materials for subsequent prototype development in the capsule wardrobe design phase.

The experimental outcomes indicate that technique selection must be guided by motif complexity, intended garment function, and material behavior. Lino printing emerged as the most versatile technique for intricate and multi-element motifs, while applique, patchwork, and embroidery were most suitable for bold, structurally defined motifs. Across all lino printing experiments, high-contrast color pairings were essential for preserving motif legibility and symbolic strength. These findings directly informed the selection techniques and materials for the subsequent prototype development of the capsule wardrobe design phase.

Building on the experimental findings on Bidayuh motif translation (Table 1), a 10-piece capsule wardrobe was developed by selectively integrating culturally significant motifs, sustainable materials, and cohesive color strategies. The final designs (Figure 2) comprise a top, vest, jacket, blouse, two pairs of wide-leg pants, a wrap skirt, two dresses, and a bag, enabling multiple styling configurations while maintaining a coherent Bidayuh-inspired visual identity. Not all experimentally explored motifs were applied in the outcomes; selective adaptation was intentionally employed to prevent visual saturation and to preserve balance, cultural clarity, and garment versatility within the capsule system. All design developments were digitally visualized before physical execution, enabling iterative refinement of motif placement, proportion, and composition while minimizing material waste, thereby supporting sustainability objectives. Each garment reflects a contextual dialogue between Bidayuh cultural symbolism, contemporary wearability, and responsible design practice. The tank top uses white cotton in a neutral ground to receive the *Bidayuh ring ladies* motif of the cyanotype (Table 1-k-vi), which foregrounds the artistic expression in a daily figure. Based on the male Bidayuh clothing, a sleeveless denim vest incorporates the *pucuk rebung* (Table 1-d-i) and paku-pakis (Table 1-e-iv) patterns with white embroidery, which strengthens the cultural theme through the use of organized layering. Further examples of selective positioning of motifs are in outerwear and top garments. One of them is a black linen jacket with r*ojak dien* (Table 1-i-ii), which is red patchwork on the cuffs, referring to its historical position in the functional form. The sleeved blouse uses Bidayuh color symbolism, red, white, and black, as the cuffs and the paddy motif (Table 1-g-v) on the white central stripe is done in black lino print. Two wide-leg trousers take the motif experimentation to a next level with patchwork and cut-out designs, with *boton manuk puni* (Table 1-a-i) and *pucuk rebung* (Table 1-d-i), respectively, balancing between durability and visual differentiation. The skirts and dresses are more based on the traditional Bidayuh costume sensibilities. The midi wrap is a wrap skirt that is vertically striped, red and white (on the wrap edge), and *pucuk rebung* (Table 1-d-v) is placed using lino printing. The strapless red linen dress in a similar manner makes *pucuk rebung* (Table 1-d-iv) to be placed at the bottom part to give cultural emphasis and a detachable two-part dress outfit to incorporate paddy motifs (Table 1-g-v) and *rojak dien* beadwork (Table 1-i-iii). Finally, a red canvas belt bag is completed with the capsule, *paku-pakis* (Table 1-e-iv) performed in white embroidery, and with the help of which the motifs continue to unite the accessories. As shown in Figure 3, a total of 28 different styles were developed through the combination of outfits proposed during Weeks 1 to 4. Such combinations used in Figure 3 indicate how versatile and mix-and-match the capsule wardrobe can be. These glances show how the culturally inspired patterns enable the visual identity of the clothes without concealing their contemporary functionalism.

The development of the 10-piece capsule wardrobe demonstrates how selected motifs and experimental techniques can be systematically translated into contemporary garments while maintaining cultural coherence and functional versatility. The selective application of motifs, combined with consistent color strategies and adaptable silhouette, supports the capsule wardrobe's role as a sustainability-driven design system. Following

the design development in Figure 2, a total of 28 unique styles were created by combining outfits suggested across Weeks 1 to 4. These combinations, shown in Figure 3, demonstrate the versatility and mix-and-match potential of the capsule wardrobe. These looks illustrate how culturally inspired motifs enhance the garments' visual identity without overpowering their modern functionality. This styling exploration also serves to validate the practicality of incorporating traditional Bidayuh elements into casual everyday wear for younger audiences. The capsule wardrobe will be further evaluated to assess user perception, acceptance, and overall wearability.

Evaluation and market acceptance

116 respondents were used to carry out the survey. The majority of respondents as indicated in Table 2 fell within the 22-24 years age. The target population was mainly female (69.00%), as it is within the aim of this research. The target of the study is not to address Bidayuh Gen Z; it is the issue of cultural maintenance in the younger generation. This distribution will offer a good foundation in the analysis of how the Bidayuh-inspired clothing is perceived by the target culture as well as other ethnic groups. In terms of the preference of styling, the most preferred style was subtle and minimalistic followed by modernized. This implies that modernizing the designs is preferable to traditional designs. The concept of a particular product has a positive reception to the point of being overwhelming. When questioned whether they would be interested in clothing that is inspired by the Bidayuh art and cultural aspects 79.3% of the respondents responded in the affirmative, with only 3.4% responding in the negative. This means that there is good market viability. This establishes the fact that capsule wardrobes cease to be viewed as abstract ideas of sustainability but as practical lifestyle strategies that may be associated with use-oriented models of sustainable fashion.

Figure 3. Styling combinations – Bidayuh capsule clothing wardrobe

A Chi-Square ($\chi 2$) test was conducted to find out whether gender has any effect on the interest in having a capsule wardrobe which was is a big relationship ($\chi 2 = 17.49$, $p = 0.002$). Connection between ethnic and interest towards Bidayuh-inspired clothing was very much significant ($\chi 2 = 82.16$, $p < 0.001$). As anticipated, 100 percent of Bidayuh respondents showed interest, but other ethnic groups were also found to have a high interest indicating that the appeal is not limited to certain ethnic groups. The importance attached to

sustainability by the user and the desire to pay a premium price on sustainability were found to have a significant relationship ($\chi 2 = 12.93$, $p = 0.044$).

Table 2. Demographic profile of respondents (N=116)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Age	19-21	32	27.6
	22-24	56	48.3
	25-27	22	19.0
	28 and above	6	5.2
Gender	Female	80	69.0
	Male	28	24.1
	Prefer not to say	8	6.9
Ethnicity	Bidayuh	28	24.1
	Chinese	24	20.7
	Malay	16	13.8
	Iban	14	12.1
	Melanau	10	8.6
	Others (Bajau, Indian, etc.)	24	20.7

The average points in Table 3 demonstrate a positive rating of the concept of the capsule wardrobe and adaptation of the Bidayuh cultural elements to modern fashion. Preference towards fewer, versatile garments ($M = 4.21$) has the highest mean score, which demonstrates the strong adherence of the respondents to the principles of minimalist and sustainable fashion. The Reliability Analysis (Cronbach's $\alpha = 0.86$) shows a good internal consistency, which means that the items are useful in measuring a single construct associated with acceptance of a Bidayuh-inspired capsule wardrobe.

Table 3. Descriptive statistics of key constructs (N = 116)

No.	Variable	Mean	SD
V1	A capsule wardrobe improves daily outfit planning	3.86	0.82
V2	Preference for owning fewer mix-and-match clothes	4.21	0.89
V3	Interest in wearing Bidayuh-inspired clothing	3.78	0.86
V4	Belief that cultural motifs can be adapted into modern clothing	4.13	0.74
V5	Suitability of Bidayuh-inspired capsule wardrobe for daily lifestyle	3.64	0.78

Further, the key variables were all positively and significantly related to each other, which suggests that the sustainability-oriented clothing behavior is strongly interrelated with the cultural interest and perceived suitability of the lifestyle (Table 4). Hence, the ideation of successfully adapting Bidayuh to the modern world was associated with cultural interest ($r = 0.66$) and lifestyle suitability ($r = 0.61$).

Table 4. Pearson correlation matrix ($p < 0.01$)

Variables	V1	V2	V3	V4	V5
V1 Capsule wardrobe improves planning	1				
V2 Preference for fewer clothes	0.48**	1			
V3 Interest in Bidayuh-inspired clothing	0.41**	0.39**	1		
V4 Belief in the modern adaptation of motifs	0.44**	0.36**	0.66**	1	
V5 Lifestyle suitability	0.52**	0.43**	0.55**	0.61**	1

To test the concept, a Multiple Regression Analysis was done as demonstrated in Table 5. The regression explains 58% of the variation in acceptance of Bidayuh-inspired capsule wardrobe. Belief in the successful modern adaptation of cultural motifs was the most significant predictor ($\beta = 0.41$), then there were the perceptions connected to sustainability and artistic interest. This implies that culture relevancy has to be reduced into the modern design language to guarantee daily wearability. The findings validate the mediation effect of the degree of design translation as the mediating variables between consumer acceptance and cultural identity in the context of sustainable systems. Results obtained from experimental calibration, capsule system development and consumer validation give empirical evidence to the proposed Framework. The cultural grounds created symbolic clarity; sustainable translation meant functional and material sustainability, and

market validation consumer acceptance in the case where the perception of successful adaptive reinterpretation was made.

Table 5. Multiple regression analysis predicting acceptance of Bidayuh-inspired capsule wardrobe ($p < 0.001$)

Predictor	β	t	Sig.
Sustainability-oriented capsule wardrobe perception (V1)	0.29	3.21	0.002
Preference for fewer clothes (V2)	0.18	2.07	0.041
Interest in Bidayuh-inspired clothing (V3)	0.24	2.88	0.005
Belief in modern adaptation of cultural motifs (V4)	0.41	4.96	< 0.001

DISCUSSION

As a subset of the greater sustainability discursive of Borneo, in which the processes of speedy development, the climate pressures, and the globalization processes are all the more violent in terms of the indigenous visibility, the research makes it a design-oriented strategy to preserve the traditional knowledge. The paradigm does not introduce indigenous craftsmanship as a flexible resource that can adapt to the economic and lifestyle systems of modernity, instead of portraying the act of preservation as one of resistance to modernity. The study contributes to the paradigm of regional resilience in which cultural knowledge is not yet out of sight in the social, economic and ecological domains. It directly addresses the calls to preserve traditional knowledge in Borneo by showing how design innovation can serve as one way of preserving cultural continuity through change.

Grounding and Adaptation of Ethics and Culture

The research provided a cultural background through the systematic identification of Bidayuh motifs, symbolic color meanings, material traditions, and contextual meanings. The design process did not think of motifs as decorative resources but rather placed them as identity bearers as part of the environmental and social storylines. This strengthens the idea that the indigenous motif must undergo an ethical consultation and contextual sensitivity before adaptation. The results also indicate that the preservation in modern design should be dynamic. The fact that most of the respondents were sure that the modern adaptation of Bidayuh motifs is successful points to the fact that heritage can be viewed as a living system and not a fixed object. The framework helps ensure the continuity of culture outside the ceremony by integrating motifs into everyday garments, enhancing the intergenerational presence and applicability of indigenous identity in Borneo.

Experimental Translation Sustainability

The idea of the level of design translation became a very important tool of connecting the authenticity of cultural to wearability and sustainability. The results of experiments showed that the complexity of motifs, fabric behavior, and color contrast have a significant impact on translation results. Lino printing was most successful with intricate patterns, embroidery and patchwork with structurally demarcated shapes. Notably, translation quality is a mediator of the correlation between culture grounded and consumer acceptance. The integrity of culture did not provide usability, but instead selective re-interpretation provided comfort, longevity and repeated use. The maintainability viewpoint implied that halting heavy embellishment in favor of lightweight, all-purpose methods decreased and promoted the principles of the capsule wardrobes of durability, mixability, and consumption minimalism. Hence, it was not an aesthetic change, but the measured change that created a balance between recognizability and functional efficiency.

Social Justification and Market Acceptance

The quantitative results are empirical confirmation of the third pillar of the framework. The sustainability-oriented perception was positively correlated with the lifestyle suitability, moderately and significantly predicted the acceptance. Minimalist ownership preferences also played a positive, albeit smaller, role in the same. The most interesting finding was that belief in the successful modern adaptation of Bidayuh motifs was the most significant predictor of acceptance. This implies that sustainability and cultural interest can only be adopted as a consumer when incorporated into modern and wearable design solutions. The importance of this variable means that design implementation mediates two values, cultural and sustainability, and turns them into functionality compatibility with lifestyle. These results support the theory of slow fashion but apply it in

the case of indigenous regions, where sustainability acts not as an environmental responsibility but as a justification mechanism to justify the fact of everyday incorporation of traditional knowledge.

Theoretical, Practical and Methodological Contribution

The research develops a sustainable theory by making cultural sustainability a structural aspect as opposed to a fringe aesthetic one. The study contributes to the research design-based inquiry through the incorporation of the cultural documentation, experimental garment development, and quantitative consumer validation in the same empirical framework. However, in extending this framework for broader commercial application, it is essential to ensure the protection of the Bidayuh community's intellectual and cultural rights. Future implementation should prioritize ethical collaboration, proper acknowledgment, and equitable benefit-sharing mechanisms to support the community's socio-cultural and economic well-being. This triangulated method overcomes the conceptual arguments of heritage integration by affixing to a statistically confirmed methodology. The suggested capsule wardrobe system is a feasible structure in terms of turning Bidayuh indigenous knowledge to a sustainable economic resource to directly meet the dual issues of cultural erosion and economic insecurity. The strategy is part of the Malaysian creative economy by enabling native women entrepreneurs and using a cultural resource, which is not fully exploited, to develop sustainably. With Bidayuh culture identity centered on sustainable capsule system, the research paper can also be seen as a part of an emerging sustainability discourse on Borneo, as it illustrates how indigenous knowledge could be turned into an adaptive commodity, as part of a modern design economy, and not merely a static preservation discourse.

CONCLUSION

This paper has illustrated how Bidayuh cultural identity can be instituted into modern sustainable fashion using a capsule wardrobe strategy leading to formulating and approving a Culturally Grounded Sustainable Capsule Design Framework. The research is carried out through systematic three-process research method, i.e. cultural backgrounding, experiment translation and user validation of the research, and this validates that native integration in fashion entails more than aesthetic referencing. It demands moral cultural consultation, re-interpretation in moderation as well as consistency with sustainable consumption regimes. The results define the preservation within the modern environment as a dynamic interpretation, which does not imply the stagnation of the reproduction of the heritage forms but promotes the preservation of recognizability and improvement of functionality, durability, and practicality. The study fills the gap between preservation, innovation, and responsible consumption by framing the idea of a capsule wardrobe as a means of maintaining a culture. Although confined to one indigenous setting, as well as pilot-scale research, the framework provides a conceptual framework transferable to designers, educators and industry practitioners interested in integrating indigenous knowledge into the system of sustainable fashion.

Authors' Contributions

The authors contributed equally to the study. Marzie Hatef Jalil is responsible for conceptualization, methodology, data curation, validation, resources, formal analysis, writing-original draft, writing-review & editing. Jane Eleen Alison is responsible for Conceptualization, methodology, investigation, visualization, resources, writing-original draft.

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Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

Ethics committee approval dated 21/05/2025 and numbered UNIMAS/NC-20.02/06-04/01 (54) was obtained by University Malaysia Sarawak Human Research Ethics Committee (Non-Medical).

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Research Article

Art Nouveau in contemporary children's picturebooks: Ornament, typography and page design

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Abstract
This article examines how Art Nouveau operates in two contemporary children's picturebooks, Lisa Perrin's *After Alice* (2015) and Júlia Sardà's *The Queen in the Cave* (2021). It argues that in these books Art Nouveau works not merely as a historical decorative reference, but as a page-organizing system that shapes visual composition, directs the reader's attention, and reinforces narrative atmosphere. The study focuses on the cover and interior-page illustrations of these two case studies. Methodologically, it employs qualitative comparative visual analysis, with particular attention to page architecture, line rhythm, color strategy, ornamental density, and typographic integration. The findings show that curvilinear motifs, botanical framing, borders, and serif typography do more than quote a historical style; they function as structural elements that support readability, visual continuity, and atmospheric coherence across the book. This is significant in the context of contemporary picturebooks because it suggests that historical ornament can remain active as a functional visual language rather than survive only as nostalgic decoration. In this sense, Art Nouveau continues to offer an adaptable design logic for contemporary illustration.

Keywords: Art Nouveau, Children's picturebooks, Digital illustration, Page design, Ornamental framing

Extended Abstract

Introduction: Art Nouveau is usually recognized through its flowing lines, plant-based motifs, decorative framing, and the close relationship it establishes between image and lettering. What is less obvious is how these qualities continue to appear in contemporary children's picturebooks. In such books, the page is not simply a surface for illustration. It is a designed space in which image, text, rhythm, and readability must work together. This makes the picturebook a useful place to examine how a historical visual language can remain active in contemporary illustration. In this study, Art Nouveau is approached not as a style brought back unchanged, but as a set of formal strategies that still shape attention, atmosphere, and visual coherence on the page.

Purpose and scope: This study focuses on two contemporary children's picturebooks, Lisa Perrin's *After Alice* (2015) and Júlia Sardà's *The Queen in the Cave* (2021). It examines how ornament, typography, and page design operate in these books and how Art Nouveau-related features continue to shape the reading surface under digital production conditions. The scope is limited to covers and selected interior pages published between 2012 and 2022.

Method: The research uses qualitative comparative visual analysis. The books were chosen through purposive sampling. The analysis was carried out through five main areas: page architecture and composition; line rhythm and drawing technique; color strategy; ornamental density and motif selection; and typographic integration. These categories enabled reading both books through the same set of visual concerns while preserving their differences. The analytical process moved in two stages. First, each book was examined separately through close reading of the cover and selected interior pages. At this stage, attention was given to framing, visual hierarchy, the movement of the line, the placement of lettering, the handling of decorative elements, and the balance between richness and readability. Second, the observations drawn from the two books were considered alongside selected historical Art Nouveau references. These references were not used as fixed models or one-to-one sources. They were used to clarify broader principles such as flowing line, surface unity, decorative framing, and the close relation between text and image. Additional works by Lisa Perrin and Júlia Sardà were considered only where they made recurring tendencies in the two main case studies easier to see. The analysis also

considered how crafted visual qualities survive under digital production conditions, especially through line quality, surface texture, and controlled detail.

Findings and conclusion: The analysis shows that Art Nouveau is most visible in these books when ornament carries a structural role. In *After Alice*, curving botanical forms frame the central figure and title, while the serif lettering follows the same visual rhythm. The cover reads as a single designed surface. The title does not feel added after the image. It belongs to the same compositional structure. The interior pages maintain this quality through controlled detail, careful emphasis, and a consistent relation between decoration and narrative atmosphere. Art Nouveau appears here in the pacing of the line, in the framing of the page, and in the steady relation between typography and image. In *The Queen in the Cave*, the visual tone is different. The palette is warmer, the decorative treatment is denser, and the atmosphere is more enclosed. Even so, the page remains clear and readable. Borders, empty space, and ornamental elements work together to guide attention without crowding the composition. Sardà's hand-drawn sensibility remains visible in the finished illustrations. This point is especially important for the study. The work retains a crafted surface quality while still belonging to contemporary digital production. Art Nouveau appears here through rhythm, framing, and the use of decoration as part of the reading surface. Read together, the two books suggest that Art Nouveau is best understood through what it does on the page. Curving forms, vegetal motifs, borders, and integrated typography all contribute to emphasis, continuity, and mood. Their importance lies in their function. They help shape how the page is read. The study shows that Art Nouveau remains active in contemporary children's picturebooks through formal habits that still carry visual force. Its continuing value lies in the organization of the page, the handling of rhythm, the relation between ornament and readability, and the integration of typography with image. This becomes clear in both *After Alice* and *The Queen in the Cave*, even though the two books differ in palette, atmosphere, and surface density. The study is limited to two books, so its conclusions should be read with caution. Even so, the findings point toward a useful direction for further research. A broader group of picturebooks could show how widely these visual strategies circulate in recent illustration. Interviews with illustrators and reader-response studies could also deepen the discussion by showing how such strategies are planned, perceived, and adapted. The study therefore, offers a focused starting point for future work on ornament, typography, and page design in contemporary children's picturebooks.

Keywords: Art Nouveau, Children's picturebooks, Digital illustration, Page design, Ornamental framing

INTRODUCTION

Art movements do not remain fixed within the period in which they first emerge. Their visual principles often continue in later forms of design, illustration, typography, and graphic communication, as noted by Hodge (2021) and Lahor (2007). Children's picturebooks make this continuity especially visible. In these books, illustration does more than accompany the text; it shapes how form, rhythm, color, and composition are first encountered by young readers. For that reason, picturebook illustration is one of the areas in which broader aesthetic ideas enter everyday visual experience and become part of early visual learning. Children's books also carry cultural values, visual habits, and shared ways of seeing. Chung (2024) draws attention to their role in transmitting social and cultural perspectives, while Sipe (2000) emphasizes the importance of the picturebook as an aesthetic object. In practical terms, this means that illustrations help children become familiar with visual organization, compositional balance, and stylistic expression at an early stage. Scholastic (2015) and Reading Partners (2018) similarly underline the role of picturebooks in the development of visual literacy, which helps explain why illustration deserves to be examined with the same seriousness as text.

The present study focuses on the years 2012-2022, a period in which digital tools became deeply embedded in children's book illustration. Here, digital production conditions are considered through three connected concerns: contemporary surface design, materiality, and post-digital craft. The issue is not only that illustrations were produced digitally. More important is how line, texture, detail, and surface are handled within digital or hybrid workflows. Rather than being considered only in technical terms, digital production is examined here as a visual condition in which line control, surface texture, and crafted detail remain active within digitally finished illustration. This makes it possible to ask how crafted visual qualities continue to survive in recent picturebooks, even when the final work is digitally finished, and why that persistence matters for visual analysis.

Art Nouveau is especially useful for this discussion because of its flowing lines, plant-derived forms, decorative detail, and refined treatment of typography. Art Nouveau is recognized for its organic forms derived from nature, flowing lines, decorative details, and refined typographic sensibility (Beksaç, 2015). Its influence

extended across architecture, fashion, interior design, book design, and posters, bringing aesthetic experience into everyday life. In contemporary picturebooks, its continuing relevance lies in the way ornament, lettering, and framing still shape the page. The question is therefore not whether recent illustrators simply borrow Art Nouveau motifs, but how they use its formal principles to organize visual attention, support readability, and build atmosphere.

This article examines two contemporary picturebooks: Lisa Perrin's *After Alice (*2015) and Júlia Sardà's *The Queen in the Cave* (2021). These books were selected because Art Nouveau-related features appear across both cover and interior-page design, and because typography in both works functions as part of the overall visual structure. The central question of the study is how Art Nouveau operates in these books under digital production conditions. More specifically, the article asks through which formal strategies ornament, typography, line, color, and framing continue to shape the page. The findings discussed in the following sections address this question directly and show how Art Nouveau remains active in contemporary picturebook illustration through page organization, visual rhythm, and the close relationship between text and image.

The Historical Process of the Art Nouveau Movement

The term Art Nouveau, first used in the 1884 issue of the Belgian journal L'Art Moderne, emerged in the nineteenth century (Martinez, 2019). Art Nouveau is an art movement that denotes a fifteen-year period beginning in 1890 and ending shortly after the start of the new century (Lahor, 2007: 6). As a movement that influenced many artists across numerous countries, Art Nouveau both influenced and was influenced by many fields of art and design, including music, sculpture, poetry, and literature (Amaya, 1971). According to Rheims (1966: 10), Art Nouveau stood out particularly for its determination to break away from academicism and to create a new world. Consciously initiated in the 1890s as a concrete expression of the "social conscience," Art Nouveau opposed the romantic tradition that existed in the nineteenth century and aimed, on the eve of the twentieth century, to reflect across all branches of art a new "realist" stance toward the individual and the individual's relationship with society (Lenning, 1951: 3).

According to Howard (1996: 4), Art Nouveau encompassed nearly all of the abundant innovations of the period; although it contained a reaction against empirical knowledge and the signs of materialist progress, it nevertheless shared, through new worldviews, a sense of discovery, a new identity for the self, and a kind of love of movement. Defined in various ways by many, Art Nouveau is, at its core, an aesthetic understanding that is compatible with cultural diversity, rejects the old world order, embraces a progressive outlook, adopts a realist stance, draws inspiration from nature, and employs orderly, uninterrupted lines. In the context of the floral motifs and asymmetrical and linear planes, it also draws on Japanese art. According to Hodge (2021:16), Art Nouveau artists depicted form through organic themes and asymmetrical Japanese-style compositions. In the 1888-designed cover of the Japanese Art Journal shown in Figure 1, curvilinear lines are likewise prominent.

Figure 1. Cover design of a *Japanese Art Magazine*

The time period in which this movement, revealing the transformations brought about by the Industrial Revolution on art, took place was one in which art moved beyond museums and art galleries and began to assume a function that addressed everyone and served the public.

Figure 2 presents an advertising design produced by Henry van de Velde (1863-1957) for the *Tropon* egg brand. Bearing the slogan "Tropon, the most concentrated nourishment," the work can be seen as an early example of aestheticized advertising addressed to a broader public. In the late nineteenth century, the food sector, like many other industrial fields, underwent a significant transformation as food preservation, processing, and distribution practices changed across Europe. At the same time, the wider circulation of prepared and packaged products expanded the conditions of commercial promotion (Oddy & Drouard, 2013). Within this setting, Art Nouveau posters combined commercial promotion with aesthetic refinement and became increasingly visible in urban public spaces (Petre, 2008).

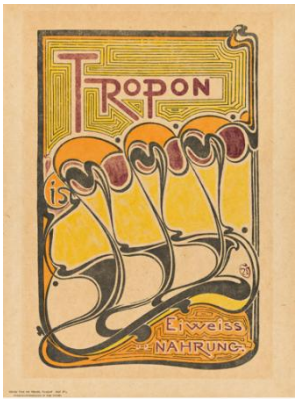

Figure 2. Poster design for the *Tropon* brand

Many Art Nouveau artists and designers advocated for the decorative arts to attain the status of fine art (Hodge, 2023: 92). The movement, which placed strong emphasis on craftsmanship, was characterized by organic and curvilinear forms, as well as the frequent use of plant motifs and female figures. Flowers, leaves, branches, and shoots were often incorporated into these compositions, while feminine figures contributed to the symbolic and visual coherence of the overall design.

Nature was one of the central sources of Art Nouveau visual language, often represented through interwoven patterns, curvilinear forms, and ornamental density. A clear example of this approach can be seen in the work of Alphonse Mucha (1860-1939). As shown in Figure 3, Mucha's 1896 calendar design includes a striking female figure, a halo-like form above her head referring to the twelve zodiac signs, and abundant ornamentation.

Figure 3. Calendar design created for *La Plume Magazine*

Characterized by ornate motifs and curvilinear structures, Art Nouveau extended across a wide range of applied arts, including household objects, jewelry, book design, graphic work, and illustration (Sembach, 2007). In the late nineteenth century, the expansion of print culture and poster production made these visual principles increasingly visible in everyday life. As Petre (2008) argues, Art Nouveau posters played an important role in bringing art into public space through advertising and mass visibility. Within this broader context, Art Nouveau also shaped book and magazine design through flowing lines, decorative surfaces, and the integration of image and typography. As shown in Figure 4, the poster produced for the "Job" brand reflects this visual language

through its ornamental framing, flowing lines, and the close relationship between figure, typography, and decorative surface.

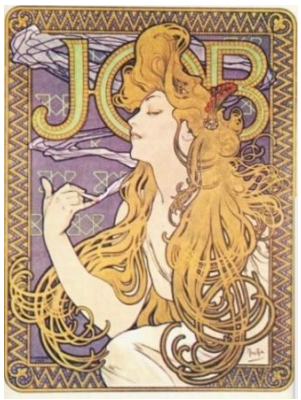

Figure 4. Poster design produced for the *Job* brand

Art Nouveau was visible not only in commercial advertising but also in the visual promotion of exhibitions and cultural venues. As shown in Figure 5, the poster for a permanent Art Nouveau exhibition in Paris reflects characteristic features of the movement through its stylized plant forms, decorative framing, muted color palette, and the close integration of text and image. The typography is not treated as a separate informational layer; rather, it becomes part of the overall composition. In this respect, the poster demonstrates how Art Nouveau functioned as a unified visual language across different fields of design.

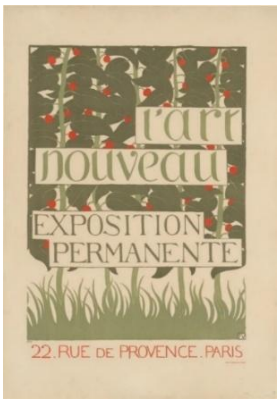

Figure 5. Poster for a permanent *Art Nouveau* exhibition in Paris

Art Nouveau and Typography

Typography, the visual organization of written language, is a fundamental element of book design. Through typography, words and ideas acquire visual form, reach the reader, and become accessible through different modes of presentation (Sarıkavak, 2017: 2). Moreover, typography has an influence not merely by offering readability to the reader, but also by shaping the reader's or viewer's purchasing behavior and enabling the emotion of the text to be grasped more effectively. A typeface can create a neutral effect on the reader, or it can also generate an effect that activates passions (Ambrose & Harris, 2014: 6). For example, while the roundness of a typeface can be regarded as a visual metaphor for qualities such as organicity, naturalness, and femininity, a bold typeface may connote meanings such as assertiveness and solidity (Van Leeuwen, 2005: 140). In the Art Nouveau period as well, artists and designers, aware of this, used typefaces consistent with the movement's general style. In the typographic elements employed, curvatures, ornamentations, and calligraphic elements can be observed. This situation can be regarded as the counterpart in the art of lettering to Art Nouveau's reaction against industrialization. They sought to convey the sense that the typefaces were produced originally for the work or design in question. Figure 6 presents the "Eckmann" typeface designed in 1896, and Figure 7 presents the "Auriol" typeface designed in 1901. The harmonious curves used in Art Nouveau visuals are also evident in these typefaces.

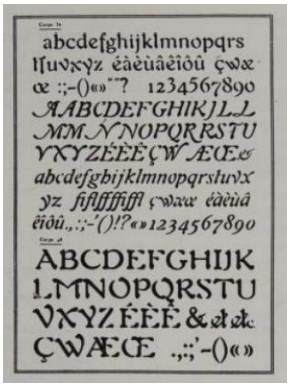

Figure 6. *Eckmann* Font **Figure 7.** *Auriol* Font

The typeface in Siegfried Bing's work, shown in Figure 8, created for the L'Art Nouveau exhibition held at the Grafton Galleries in London in 1899, reflects characteristic features of the period. Although the lettering shows a relative simplicity in its nature-inspired curvilinear structure, its serif forms still retain an ornamental quality associated with Art Nouveau. The contrast between thin and thick strokes gives the text a sense of movement, while the overall arrangement echoes the asymmetrical rhythms often found in the visual language of the period. This concern with typography did not remain limited to letterform alone; it also extended to the organization of the page as a whole.

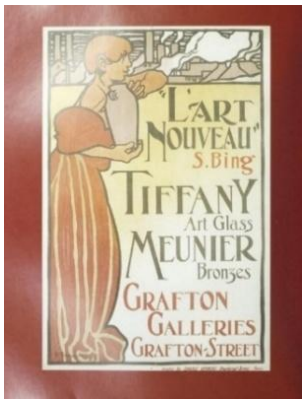

Figure 8. A poster designed for the *L'Art Nouveau* exhibition

Art Nouveau's lasting contribution to graphic design lies in its tendency to treat text and illustration as parts of a single visual system. Rather than composing the page by first producing text and image separately and then bringing them together, Art Nouveau designers often organized the page as a unified surface (Clara, 2021). As shown in Figure 9, the interior page from Étude de la plante exemplifies this approach through the close integration of decorative framing, title lettering, illustration, drop cap, and body text. A comparable concern for visual unity can also be seen in the interior page design presented in Figure 10.

Figure 9. Interior page from *Étude de la Plante* **Figure 10.** Book interior page design

This understanding of the page as a unified visual field can also be related to the work of William Morris (1834-1896). Although Morris is more closely associated with the Arts and Crafts movement, he also produced significant works in printed book design, in addition to the furniture, wallpaper, and household objects he created throughout his career. Arguing that the books of his time were as poor in quality and badly designed as the furniture of thirty years earlier, and that printing had fallen far behind, the designer focused on this issue and, by 1891, published his first book bearing his imprint (Selz & Constantine, 1972: 24-25). Through the books printed at the "Kelmscott Press" he founded, he demonstrated that a book could be transformed into a work of art by having the designer attend to every element of the book, including the typeface (Selz & Constantine, 1972: 25). He helped elevate book design and typography as central concerns of artistic production and also supported the idea of art for the public benefit. Figure 11 presents a design created by William Morris for the Kelmscott Press. The curvilinear structures inspired by nature, characteristic of the Art Nouveau movement, are also striking here.

Figure 11. *Kelmscott Press* emblem

As shown in Figure 12, the cover of *The Valley of Vision*, written by Henry Van Dyke and illustrated by Margaret Neilson Armstrong, reflects several features associated with Art Nouveau book design. The deep blue ground is animated by an ornate floral composition rendered in gold and warm orange tones, which gives the surface a decorative richness while preserving clarity. Stylized botanical motifs spread across the cover in a symmetrical arrangement, and the title is integrated into this ornamental structure rather than placed as a separate element. The spine also carries a vertically organized decorative panel, reinforcing the sense of unity across the whole cover. Through its floral stylization, framed lettering, and carefully balanced surface design, the cover presents a strong example of Art Nouveau influence in book design.

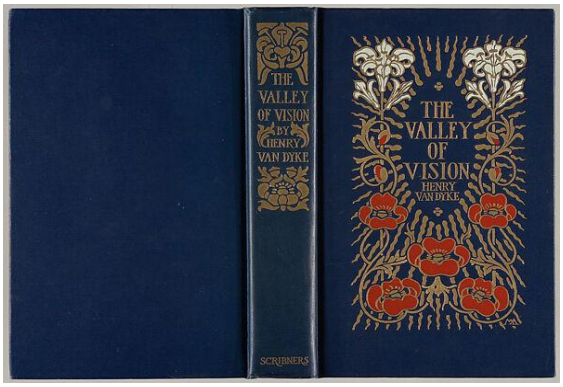

Figure 12. Cover design of *The Valley of Vision*

Figures 13, 14, and 15 show that characteristic features of Art Nouveau -such as refined lines, floral motifs, borders, and decorative surface treatment- also played an influential role in book cover design. Book covers are among the most important means through which a book first addresses its reader. The first connection between author and reader is often established through the cover. Incorporating elements such as typography, color, and pattern, book covers may also influence the reader's purchasing behavior. When a cover visually refers to the content of the story, it can also familiarize the reader with the narrative world before reading begins. As a paratextual element, the book cover functions as a mediating surface between the text and the reader, while its visual design may also shape the reader's first impression and perceived value of the book (Genette, 1997; Park et al., 2023).

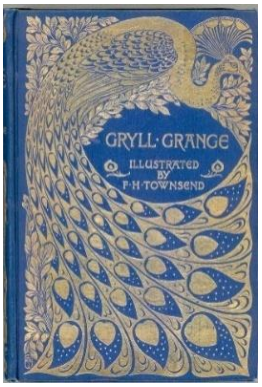

Figure 13. Cover design of the book *Gryll Grange*

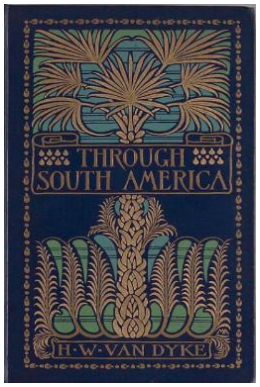

Figure 14. Cover design of the book *Through South America*

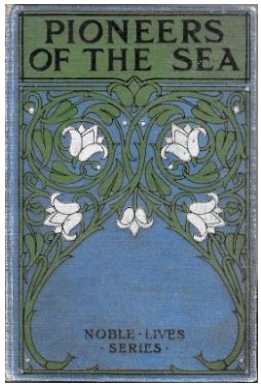

Figure 15. Cover design of the book *Pioneers of the Sea*

These examples show that Art Nouveau shaped book cover design through more than ornament alone. They also highlight the importance of framing, typography, and visual unity, which provide a basis for the contemporary case studies discussed in the following section.

METHOD

This study employs qualitative comparative visual analysis to examine how Art Nouveau-related features appear in contemporary children's picturebooks published between 2012 and 2022 under digital production conditions. The research is based on two main case studies selected through purposive sampling: Lisa Perrin's *After Alice* (2015) and Júlia Sardà's *The Queen in the Cave* (2021). These books were chosen because Art Nouveau-related features appear consistently across both cover and interior-page design rather than as isolated details. In both books, typography also functions as part of the overall visual composition. The analysis was carried out through five main categories: page architecture and composition, line rhythm and drawing technique, color strategy, ornamental density and motif selection, and typographic integration. Each book was first examined individually through close visual reading of selected covers and interior pages. The observations were then compared in order to identify recurring formal principles such as flowing line, decorative framing, vegetal motifs, and the integration of text and image.

Historical Art Nouveau examples were used as comparative reference points to clarify these formal principles. The aim of this comparison was not to establish direct influence, but to determine whether similar visual strategies continued to operate in contemporary picturebook design. Additional works by Lisa Perrin and Júlia Sardà were considered only when they helped make recurring tendencies in the main case studies more visible. The digital dimension of the study was approached not simply as a matter of production technique, but as part of the visual logic of the works. For this reason, the analysis also considered how line quality, surface texture, and controlled detail were handled in digitally produced or digitally finished illustrations.

FINDINGS

An Analysis of Lisa Perrin's After Alice

Published by Headline Publishing in the United Kingdom on 20 October 2015, *After Alice* reimagines the world of Lewis Carroll's *Alice's Adventures in Wonderland* (1865). Carroll's novel is structured around Alice's descent into a fantastical world populated by figures such as the White Rabbit, the Cheshire Cat, and the Queen of Hearts. In *After Alice,* this familiar narrative universe is revisited through Ada, Alice's friend, who sets out to follow her and falls down a rabbit hole in turn (Deitz, 2019). As shown in Figure 16, the cover already signals this connection through visual references to the White Rabbit, the Cheshire Cat, the Queen of Hearts, and the tea-party world associated with the original story. Because both the cover and the interior illustrations were designed by the same artist, the book also achieves a strong sense of visual unity.

One of the first elements that stands out in the cover is the use of cool pastel tones, which recall a color sensibility often associated with Art Nouveau. The curvilinear forms are equally notable. The vegetal elements with flowing branches evoke the stylized plant motifs frequently used by Art Nouveau artists, while the female figure with wavy hair, refined hands, and a flexible body posture also recalls the movement's visual language. The selection of objects further reinforces the narrative dimension of the design. Details such as the magician's hat, the Queen of Hearts playing card, the clock, and the teacup refer directly to the story world. The relationship between figure and ground, together with the grouping of text and image within a unified frame, strengthens this sense of visual unity. The curvilinear structures in the typeface are also compatible with the branch forms in the illustration. In addition, the black ground enhances the sense of mystery, while variation in typeface and scale helps guide the viewer's attention across the surface.

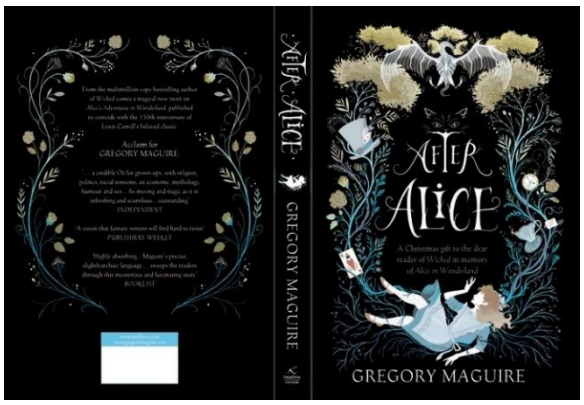

Figure 16. Cover design of *After Alice*

This narrative connection is reinforced through the treatment of the title and the surrounding decorative elements. The title After Alice is written in large letters and immediately draws the viewer's attention. Directly below it, the phrase "a Christmas gift for the dear Wicked reader in memory of Alice's Adventures in Wonderland" appears in small lowercase letters in green tones, set in a serif italic typeface. This choice improves readability while remaining consistent with the overall design in terms of color and form. The visual forms are highly curvilinear and flexible, and their rectangular arrangement creates a natural frame for the text. The posture of the girl figure conveys a sense of falling appropriate to the story's content. Her elegant stance, the use of feminine features, and the vegetal forms all recall the visual language of Art Nouveau. Similar qualities can also be seen in the Art Nouveau examples shown in Figures 17 and 18, particularly in the subdued facial expressions, refined hand gestures, and the flowing treatment of drapery.

Figure 17. Poster design by Manuel Orazi

Figure 18. Poster design by Paul Berthon

Selected additional works by Lisa Perrin are included here only to clarify recurring formal tendencies already visible in *After Alice*. As shown in Figure 19, similar features can also be seen in Perrin's *The Dollmaker of Krakow*, particularly in the subdued facial expression, the plant forms that spread across the surface, the serif and asymmetrical lettering, the reserved text area, and the use of borders.

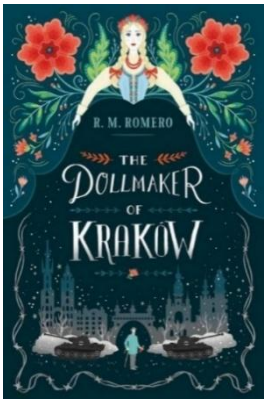

Figure 19. Lisa Perrin, cover design for *The Dollmaker of Krakow*

When the artist's other works are examined, the effects of the Art Nouveau movement are likewise noticeable. Figure 20 presents an illustration by Lisa Perrin, while Figure 21 presents a lithograph by the French Art Nouveau artist Paul Berthon. In both, an elegant female figure stands out, and the overall spirit of the works appears similar. Positioned at the very center of the composition, one of these figures is shown in right profile and the other in left profile, and both hold flowers with curvilinear, refined hands. Their wavy hair and the flowers surrounding them evoke the Art Nouveau movement.

Figure 20. Lisa Perrin, illustration featuring a female figure with flowers

Figure 21. Magazine cover design created by Paul Berthon for *L'Ermitage*

Figure 22 presents a design created by the illustrator and academic Lisa Perrin for a fashion-themed group exhibition, while Figure 23 presents a work by the painter and graphic artist Otto Eckmann (1865-1902) for the cover design of Jugend, a magazine whose title means "youth" in German. In both works, the plant motifs covering the background and the strong yet elegant female figures placed at the focal point of the composition reflect Art Nouveau's nature-inspired, feminine aesthetic.

Figure 22. Lisa Perrin, illustration for a fashion-themed group exhibition

Figure 23. Issue of *Jugend Magazine*

Taken together, these features show that Art Nouveau in *After Alice* does not function merely as decorative quotation. Rather, it operates as a page-organizing system in which framing, curvilinear rhythm, and typographic integration work together to guide attention and sustain visual unity. In this respect, the cover

demonstrates how Art Nouveau-related strategies remain active as structural devices in contemporary picturebook design. A different version of this page-organizing logic appears in Júlia Sardà's *The Queen in the Cave*, where similar concerns are developed through a different palette and compositional atmosphere. Figures 20-23 are used not as separate case studies but as supporting examples that make recurring Art Nouveau-related tendencies in Perrin's visual language easier to recognize.

An Analysis of Júlia Sardà's The Queen in the Cave

Júlia Sardà's *The Queen in the Cave*, first published by Walker Books in the United Kingdom in 2021, also reveals clear Art Nouveau influences. As both writer and illustrator of the book, Sardà constructs a visually dense yet controlled narrative world shaped around the story of three sisters who set out on an excursion to a cave. The book's mysterious atmosphere, ornamental surface treatment, and integration of text and image make it especially relevant to the present study (Shelf Edition, 2021).

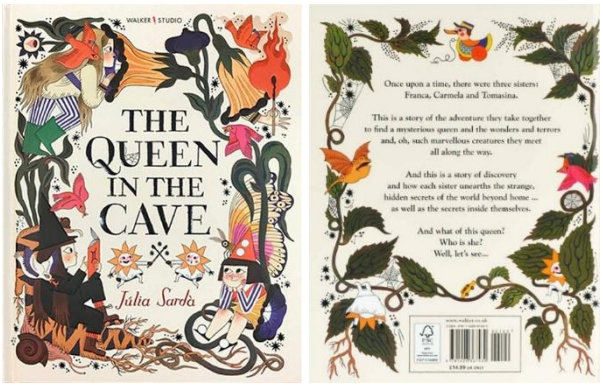

Figure 24. Front and back cover design of *The Queen in the Cave*

Figure 24 is included not only as a record of the book's cover design but also as evidence of how framing, color contrast, and ornamental integration establish narrative atmosphere and visual hierarchy from the outset. The cover is organized as a two-dimensional composition shaped by warm color relations, controlled contrast, and ornamental framing. The color relations are handled to preserve the clarity of the forms. Warm colors dominate the overall design. The text and background were selected in contrasting colors, enhancing legibility. The spider web in the cover lettering serves as a reference to the story's eerie and adventurous aspects. The drawings introduce the main characters and the story's setting. The characters' curious identities can be inferred from how they look into the flower and from their attitude while reading a book. In the author's name, an italic serif typeface commonly used in the Art Nouveau movement was employed. Typefaces similar to the one used are shown on the right. In the book title, the conjunction was written smaller than the other words, making it easier to draw attention to the main emphasis. The visuals have highly curvilinear, flexible forms. The shapes form a natural rectangular frame. The design was first hand-drawn by the artist with pencil and paper, and this approach aligns with Art Nouveau's exaltation of craftsmanship and rejection of mechanization. Figure 25 is especially important because it makes the production process visible and shows how digital finishing can preserve, rather than erase, hand-drawn structure, line rhythm, and crafted surface quality.

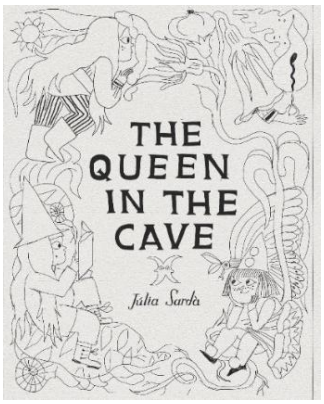

Figure 25. The designer's hand drawn sketch for *The Queen in the Cave*

Selected additional works by Júlia Sardà are included here only to clarify recurring visual tendencies already visible in *The Queen in the Cave*. In Figure 26, a page from another book design illustrated by the artist is presented. In this design from the book *Leina* and *the Lord of the Toadstools*, the rooster's curvilinear and flexible feathers, the serif typeface, the reservation of a dedicated area for the text, and the framing of this text with motifs evoke the Art Nouveau movement. In the image from the book Bradley in Figure 27, the peacock likewise features sharp lines and colors as well as curvilinear feathers. The bold use of white space, the creation of a rectangular blank area for the text, the serif typeface, and the rectangular frame composed of motifs display similar characteristics.

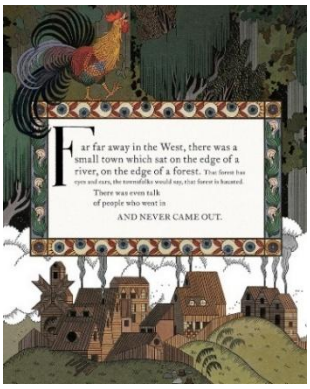

Figure 26. An excerpt from the interior pages of *Leina and the Lord of the Toadstools*

Figure 27. Cover design of the *Magazine Bradley, His Book*

In Figure 28, taken from an interior page of Júlia Sardà's *The Liszts*, the decorative border surrounding the text is especially noteworthy. A similar curved border structure can also be seen in Figure 29. In both designs, the focal point is the human figure, creating a contrast to the overall structure of the design. The emphasis on drawings rather than colors is also consistent with the spirit of Art Nouveau. The simpler approach compared to the other designs examined can also be attributed to the style of artists like Charles Rennie Mackintosh, a representative of the movement, who introduced a more minimalist look to Art Nouveau.

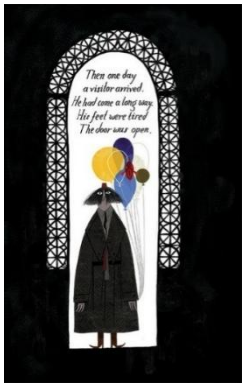

Figure 28. Júlia Sardà, interior page from *The Liszts*

Figure 29. A poster design by Alfons Mucha

In *The Queen in the Cave*, Art Nouveau is reinterpreted through a warmer palette, controlled negative space, and a flexible ornamental structure that supports mood without reducing readability. The case also makes the digital dimension more visible, since the transition from hand-drawn sketch to finished illustration shows how crafted qualities can be retained within digital production. Figures 26-29 serve as comparative reference points that help situate Sardà's use of borders, page framing, and decorative rhythm within a broader Art Nouveau-oriented visual logic.

CONCLUSION

This article has examined Art Nouveau in contemporary children's picturebooks as a visual logic that continues to help organize the page. A close reading of *After Alice* (2015) and *The Queen in the Cave* (2021) shows that

the strongest continuity lies not in a single motif or icon, but in a method: curves that keep the eye moving, ornament that behaves like structure, and typography that is treated as part of the image rather than as a separate label.

In Perrin's *After Alice*, the cover does much of this work immediately. Branch-like forms and stylized plants do not merely decorate the surface; they build a frame that holds the figure and the title together, so the page reads as one designed field. The serif forms and curving letter shapes echo the surrounding lines, creating a unified visual field on the page. Sardà's *The Queen in the Cave* arrives at a similar unity through a different route. Here, the palette is warmer, and the detailing is denser, but the composition remains readable because the illustrator controls contrast and spacing carefully; ornament becomes a way of directing attention rather than a way of crowding the page. The presence of hand drawing -visible in preparatory sketches and carried into the final rendering- also matters, because it keeps the images from looking clinically perfect even when the final stage is digital. Together, the two books suggest that Art Nouveau is best identified by what it does rather than what it quotes. Curved borders and plant-like motifs repeatedly serve as reading aids: they set a mood, create a visual rhythm, and make the transition between text and image feel continuous rather than abrupt. In this respect, the study suggests that Art Nouveau in contemporary picturebooks should be understood as a functional page-organizing system.

The contribution of the study lies in the way it reads ornament in contemporary children's picturebook illustration. Rather than treating Art Nouveau only as a stylistic echo, the article shows how ornament, typography, and framing continue to work as structural elements within the page. In this way, it adds to scholarship on children's book illustration by shifting attention from what ornament looks like to what ornament does. It also brings together art history, illustration studies, and digital production by showing how a historical visual language remains active in recent picturebooks through formal and compositional strategies. Taken together, these findings support the argument that Art Nouveau in contemporary picturebooks should be understood not as decoration alone but as a functional page-organizing system.

The analysis is limited to two titles and does not claim to represent the entire 2012-2022 field; however, it does point toward a productive way to study the topic: Art Nouveau as a practical page system for atmosphere and unity. Future research could extend this framework to a broader range of picturebooks, compare additional illustrators, or examine how such strategies operate across different publishing contexts. The study may also contribute to design-oriented discussions of contemporary picturebooks, especially in relation to how ornament, typography, and framing help organize a coherent reading surface.

Author's Contribution

The author contributed 100% to the study.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

This study does not require ethics committee approval.

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Research Article

Simulation-supported energy retrofit in historic educational buildings: Ziya Gökalp Elementary School

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Abstract
Energy retrofitting of historic buildings is important for sustainability. However, this is a difficult task due to regulations aimed at preserving historical values. This study aims to develop energy retrofit strategies for the 20th-century Ziya Gökalp Elementary School built as a type of project during Ottoman educational reforms. The method is predicated on a comparative analysis of the model created using DesignBuilder simulations, examining both the current state and retrofit scenarios. Energy performance retrofit scenarios have been developed with consideration for national and international guidelines, local climate conditions, and the building's cultural heritage value. Energy retrofit recommendations were made for the walls, attic floor, and window components. Energy, carbon emission and thermal comfort analyses were conducted for the current state of the building and proposed scenarios. As a result of the proposed scenarios, it was determined that energy conservation was achieved at a rate of 72.43%, the number of comfortable days increased by 31%, and operational carbon emissions decreased by 10.39%. It has been determined that the increase in embodied carbon can be offset by a decrease in operational carbon within two years. These results show that energy retrofits can be conducted without damaging historic educational buildings.

Keywords: Historic building, Energy retrofit, Building simulation, Thermal comfort, Carbon emission

Extended Abstract

Introduction: The building sector is responsible for approximately 40% of total energy consumption and 36% of CO^2 emissions, and its impact on climate change is significant. Furthermore, it is estimated that approximately 85% of buildings in use in 2050 will be existing structures. This underscores the efficacy of energy retrofitting as a pivotal strategy for promoting sustainability within the building sector. Given that historic buildings constitute 30-40% of the building stock in the European Union, the implementation of energy retrofitting in such structures is of paramount importance. It is evident that a significant number of European Union countries have recognized the pivotal role of energy retrofitting historic buildings in achieving the 2050 sustainability targets. In this context, a guide for energy retrofitting of historic buildings was published in 2017, and energy retrofitting of these buildings was encouraged.

Purpose and scope: A paucity of research has been conducted about energy efficiency in historic educational buildings. The objective of this research is to develop an approach that will reduce energy consumption in historical educational buildings constructed in the 20th century. The Ziya Gökalp Primary School in Diyarbakır, which is in Türkiye's hot and arid climate zone and continues to operate as an educational institution, was selected as the application area for the study. This study represents the inaugural research to be conducted specifically on historical educational buildings in Türkiye's hot and arid climate zone. It is hypothesized that the findings will contribute to the resolution of a significant lacuna in the extant literature on the energy retrofitting of historical educational buildings.

Method: The research is founded upon a comprehensive approach that combines quantitative and qualitative methods. In accordance with this approach, a comprehensive program of research was conducted in stages, encompassing literature reviews, archival research, field observations, on-site measurements, and energy analyses using a dedicated energy analysis program. A comprehensive literature review was conducted using the Web of Science and Scopus databases. A thorough evaluation of the extant literature identified the subject's strengths and weaknesses. The primary objective of ascertaining the strengths was to determine the most efficacious strategies for the renovation of historic buildings, while the primary objective of identifying the weaknesses was to contribute to the ongoing discourse. Ten studies were identified in searches conducted in the Web of Science database using the specified keywords. Seventy-eight studies were identified

in searches conducted in the Scopus database using the same keywords. Twenty of these studies were excluded as they were in different disciplines. When both databases are evaluated together, it is evident that most studies focus on thermal comfort analysis in historic school buildings or on energy retrofitting of non-historic educational buildings. It has been determined that the number of studies on the energy retrofitting of historic educational buildings is quite limited. It is understood that most of the existing studies focus on buildings constructed in the 20th century and that the research is generally conducted in cold or hot-humid climate regions. These studies frequently include recommendations for improving energy efficiency by enhancing the performance of exterior walls, basement walls, roof and attic insulation, and windows. In this scope: improvements to the interior walls, roof, and windows of the historic building, which is the subject of the current study, have been proposed. DesignBuilder Software Version 7 was utilized for energy analysis. On-site measurements were taken to calibrate the software. The calibration process involved the utilization of a Micro Lite USB Data Logger 5016 temperature sensor. The Root Mean Square Error Coefficient of Variation (CV(RMSE)) and Mean Error (MBE) were utilized in conjunctions to ensure calibration. Furthermore, the requisite information was collected on site through the utilization of observation techniques, photographic documentation, and direct interviews. Improvements to the interior walls, roof, and windows of the historic building, which is the subject of the current study, have been proposed.

Findings and conclusion: The implementation of the proposed scenarios resulted in a 72.43% reduction in energy consumption, a 31% increase in the number of comfortable days, and a 10.39% decrease in operational carbon emissions. It has been calculated that the increase in concrete carbon resulting from the applications can be balanced by a reduction in operational carbon within approximately two years. The findings demonstrate that energy renovation interventions are possible without damaging the original values of historic educational structures.

Keywords: Historic building, Energy retrofit, Building simulation, Thermal comfort, Carbon emission

INTRODUCTION

The energy crisis that emerged in the late 1970s has led countries to reduce their energy consumption. The building sector accounts for 40% of total energy consumption and 36% of carbon emissions (IEA, 2021; UNEP, 2020). Energy retrofitting of constructed buildings is important for reducing energy consumption and carbon emissions. It is estimated that existing buildings will account for approximately 80-90% of the building stock in 2050 (Angrisano et al., 2021: 4). This shows that a significant portion of the energy consumed and to be consumed already comes from existing buildings (Power, 2008: 4487). However, only 1-3% of existing buildings are retrofitted for energy each year. This shows that the energy retrofitting of existing buildings is insufficient (Ali & Hashlamun, 2019: 1). The European Commission has published various regulations aimed at increasing the energy efficiency of existing buildings. However, the first three of these regulations state that historic buildings may be exempt from energy retrofitting due to their special architectural value or their status as part of a specific environment (Directive 2002/91/EC, n.d.; Directive 2010/31/EU, n.d.; Directive 2012/27/EU, 2012). In addition, many building energy efficiency regulations have ignored the energy retrofit of historic buildings (Martínez-Molina et al., 2016). Approximately 30-40% of the building stock in Europe consists of historic buildings. This shows that energy retrofitting of historic buildings is crucial for achieving the European Green Deal 2050 (Buda et al., 2022; European Commission, 2016; Ruggeri et al., 2020). Many European countries have also recognized that energy retrofitting historic buildings is important. (Martínez-Molina et al., 2016: 82).

In response to this situation, the European Committee for Standardization (CEN) published a guide in 2017 (EN 16883, 2017). EN 16883 aims to assist in making the best decisions to improve the energy performance of historic buildings without compromising their value, through interdisciplinary planning (Leijonhufvud, 2021). The lack of insulation in exterior walls, the use of non-standard materials, and the complexity of physical characteristics due to traditional construction methods, as well as the necessity of interventions to comply with conservation principles, are the main challenges in the energy retrofitting of historic buildings (Webb, 2017: 749). The European Commission states that reference buildings can be selected for the national building stock in the energy upgrading of historic buildings. It has been specified that criteria such as building age, building size, construction material, user type, and climate zone should be considered in selecting reference buildings (European Commission, 2012). Studies can be conducted by selecting one or more reference buildings for the building stock (Ruggeri et al., 2020; Timur et al., 2022) Ruggeri et al. (2020) selected a building representing the building stock of War Wounded Houses in Italy) and conducted analyses

within the scope of this building (Ruggeri et al., 2020). Timur et al. (2022) analyzed one reference building each from rural and urban areas of Muğla in their study on the traditional Turkish house with an outer hall (Timur et al., 2022). The building to be retrofitted does not have to be representative of stock. Energy retrofitting can also be carried out on a single building (Kyritsi et al., 2025; Šekularac et al., 2020; Ziozas et al., 2024). It can be said that studies on energy retrofitting of historic buildings are generally specific to individual buildings (Lidelöw et al., 2019: 239). It can be said that passive measures are primarily taken in studies related to the energy retrofitting of historic buildings (Burattini et al., 2015). In this context, recommendations were made for the building envelopes, such as wall and roof, reinforcing window openings, and window shutters (Ali & Hashlamun, 2019; Cho et al., 2020; Kolokotsa et al., 2009; Kyritsi et al., 2025; Loukaidou et al., 2017; Ziozas et al., 2024). Insulation recommendations for historic buildings are focused on the inner surface of the external wall and roofs. The main reason for this is that the outer surface of exterior walls often has special details (Webb, 2017). The fact that the visual loss in the historic building cannot be compared to energy savings explains this situation (Šekularac et al., 2020: 3). It can be said that different materials are used in wall insulation. In this context, it can be said that insulation materials such as XPS, EPS, calcium silicate boards, rock wool, aerogel, cork lime, and hemp lime timber boards are used (Ali & Hashlamun, 2019; Etxepare et al., 2020; Walker & Pavía, 2015). Recommendations for window openings generally focus on energy-efficient glass choice, double glazing or window film installation (Burattini et al., 2015; Moghaddam et al., 2021; Timur et al., 2022). In addition, there are various studies recommending window replacement or window frame reinforcement on building facades. These studies generally recommend window materials that will not change the external appearance of the building (Ziozas et al., 2024). In addition to the building envelope, the effect of fuel change on energy conservation was also investigated. Şahin et al. (2015) analyzed the impact of energy sources such as fuel oil and electricity on the energy retrofitting of historic buildings (Şahin et al., 2015).

Literature reviews suggest that buildings recommended for energy retrofitting were generally constructed in the 20th century. The fact that most of these are still in active use makes it possible for the recommended strategies to achieve effective results in the short term in terms of energy savings and thermal comfort. This situation can be considered the main reason for offering recommendations specifically for buildings constructed in the 20th century (Lidelöw et al., 2019; Martínez-Molina et al., 2016). Martinez-Moline et al. (2016) noted that research on energy retrofits in historic buildings has focused on building types such as residential buildings, religious structures, museums, and theatres (Martínez-Molina et al., 2016: 74). It has been noted that academic buildings and palaces are among the least studied building types in the field of energy retrofitting of historic buildings (Butera et al., 1985; Sauchelli et al., 2014). Ten studies were identified in searches using the Web of Science database with the codes ((TS= (“energy retrofit” OR “energy efficiency” OR “energy rehabilitation” OR “energy intervention” OR “energy restoration” OR “energy refurbishment” OR “energy saving”)) AND TS= (“historic” OR “traditional”) AND TS= (“education building” OR “school building”). The same keywords were searched in the Scopus database using the “Article title, abstract, keyword” filter. Within this scope, seventy-eight studies were identified. Twenty of the studies identified in the Scopus database were excluded because they were in fields such as “Mathematics,” “Computer Science,” and “Chemical Engineering.” A significant part of the studies identified in the Web of Science and Scopus databases are aimed at determining the thermal comfort analyses of historic school buildings or the energy retrofitting of non-historic educational buildings (Carlos, 2016; De Santoli et al., 2014; Salvalai et al., 2017; Yang et al., 2016) A few studies have been identified that focus on the energy retrofitting of historic educational buildings (Baggio et al., 2017; Buvik et al., 2014, 2015; Jerominko & Cichowicz, 2025; Park et al., 2025; Run et al., 2023). It can be said that these studies generally focus on buildings constructed in the 20th century. The climate zones where the studies were conducted are cold or hot and humid climates. It can be said that these studies generally propose recommendations for wall, roof and attic insulation, and window glass reinforcement (Table 1).

Table 1. Summary of literature on energy retrofit in historic educational buildings

(Butera et al., 1985)	Case study: twenty-nine historic school buildings found in the Palermo region of Italy
	Retrofitting recommendation: Smart indoor temperature control systems + insulation inner surface of the external wall
	Case study: High school building constructed in the Varese region of Italy in the 1960s

(Sauchelli et al., 2014)	Retrofitting recommendation: Hypotesis 1: Use of added external glazing facade + Use of double glazing with the addition of internal glazing+ Replacement of all windows with highly insulated and high-performance windows, Hypotesis 2: external wall insulation, Hypotesis 3: Roof insulation + Mechanical ventilation + replacement window
(Buvik et al., 2014, 2015)	Case study: 1914 Brandengen Primary School in Norway
	(Buvik, 2014) Retrofitting recommendation: Passive house window (they were not the original windows in the building- replaced in 1965) + Attic floor insulation + Waterproofing and thermal insulation of the basement wall + Ground source heat pump + Building energy management system
	(Buvik, 2015) Retrofitting recommendation: Mineral woll insulation on the floor and walls of the attic floor + Drainage of the basement floor wall + Replacement of non-original windows with passive house windows + Replacement of original windows with E-glasses + Addition of a heat pump to the external environment
(Run et al., 2023)	Case study: University of Technology buildings built in France in the late 1960s
	Retrofitting recommendation: External wall insulation + argon 16mm filled double glazing + Rock wool insulation (120mm) + Mechanical ventilation+ district heating+ radiator and thermostat-controlled heating
(Park et al., 2025)	Case study: An educational building built in 1930 in Jinju, South Korea
	Retrofitting recommendation: New roofing instead of Asphalt Shingle + Replacement of aluminum window and door frames with wooden frames + Replacement of 3 mm single glazing with 24 mm low-emissivity double glazing + Adding PF insulation board to the walls.
(Jerominko & Cichowicz, 2025)	Case study: An insulated educational building built in Poland in the 1970s
	Retrofit recommendation: replacing the old coal boiler (the current heat source) with gas absorption heat pumps and a condensing boiler + Adding an independent ventilation system according to the usage programs of the classrooms and the number of users + Adding PV on the roof of the building + Replacing the lighting elements with LED lighting systems

Within the scope of the literature review, it can be said that there are very few studies on energy retrofitting of historical educational buildings. The aim of this study is to present an approach to energy retrofitting of historic educational buildings built in the 20th century. In the study, Ziya Gökalp Primary School building in Diyarbakır, which is in the hot and arid climate zone of Türkiye and continues its educational function, was selected as the reference building. This is the first study on historical educational buildings in Türkiye and in a hot and arid climate zone. It is thought that this study will partially fill an important gap in the literature on energy retrofitting of historic educational buildings. The materials section of the study examines the typical characteristics of educational buildings constructed as type projects during the Ottoman period, the climatic and geographical conditions of Diyarbakır, and the architectural features and structural components of the Ziya Gökalp Primary School. The methods section includes the literature review methodology, the procedures and durations of on-site measurements, descriptive information regarding the DesignBuilder software, the model calibration process and the formulas used, as well as explanations about thermal comfort and carbon emission analyses. “Findings” section encompasses the calibration process, in addition to the analysis results and evaluations concerning building components, energy consumption, CO2 emissions, and thermal comfort.

MATERIAL

In the post-Tanzimat period, the Ottoman Empire strategically emphasized the development of physical learning environments to modernize educational infrastructure as part of its Westernization reforms (Kodaman, 1991). In this context, school projects from various parts of Europe, particularly France, were compiled. These projects were built as type projects for various levels of education in the Ottoman Empire in many places such as Diyarbakır, Kayseri, İstanbul, Mardin, Kırşehir, etc (Türkmen, 2022). The educational buildings constructed are similar in terms of plan typology, thick walls, geometry, symmetrical design, facade arrangement and building construction materials. Interior designs are generally in a linear classroom arrangement around a singular corridor. Window and door openings are usually symmetrically arranged and arched (Ergün & Halifeoğlu, 2023; Parlak, 2018). Ziya Gökalp Primary School in Diyarbakır is one of the educational buildings built as a type of project in the post-Tanzimat period (Ergün, 2024; Ergün & Halifeoğlu, 2023).

Diyarbakır

It (37°55’ N, 40°12’ E) is in the Southeastern Anatolia region of Türkiye, between Karacadağ mountain and the Tigris River, within the Al Jazeera region. The historical settlement, including the Ziya Gökalp Primary School, is bounded by the Diyarbakır Fortress. “Diyarbakır Fortress and Hevsel Gardens Cultural Landscape”

was registered in the UNESCO World Heritage Convention in 2015 (UNESCO World Heritage Convention, 2015). June, July, August, and September are the hottest months of the year, and the city is in a hot and dry climate zone (Figure 1) (Meteoroloji Genel Müdürlüğü, 2026).

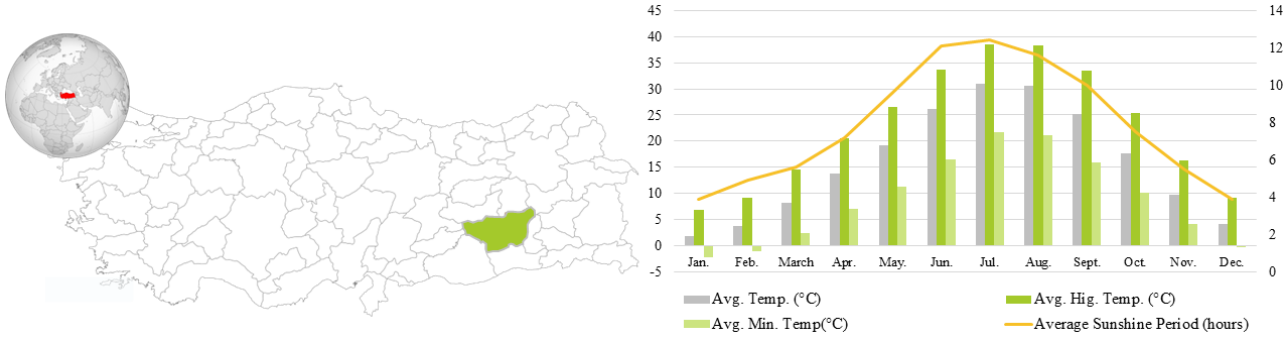

Figure 1. Diyarbakır's location and climate data

Ziya Gökalp Primary School

It is thought to have been built in the 1910s during the post-Tanzimat period (Baydaş, 2007). The building is an educational building registered in 1980 (Diyarbakır Regional Board of Cultural Heritage Conservation, 1980). The building continues to function for educational purposes. The total area of the building actively used is 740m². The total building area is 1153m² with a basement floor + 2 floors. The basement floor is not actively used and is closed. The school measures 2420*1670. The building extends in the north-south direction, making an angle of about 5° with the north (Figure 2). The school originally had two doors, a garden and the main entrance. As a result of the interventions, a window on the east façade was changed into a garden door. The main entrance of the building is on the west façade, and the original garden door is on the south facade (Figure 2). The building's survey, restitution and restoration projects and detailed information are given in ref (Ergün, 2024).

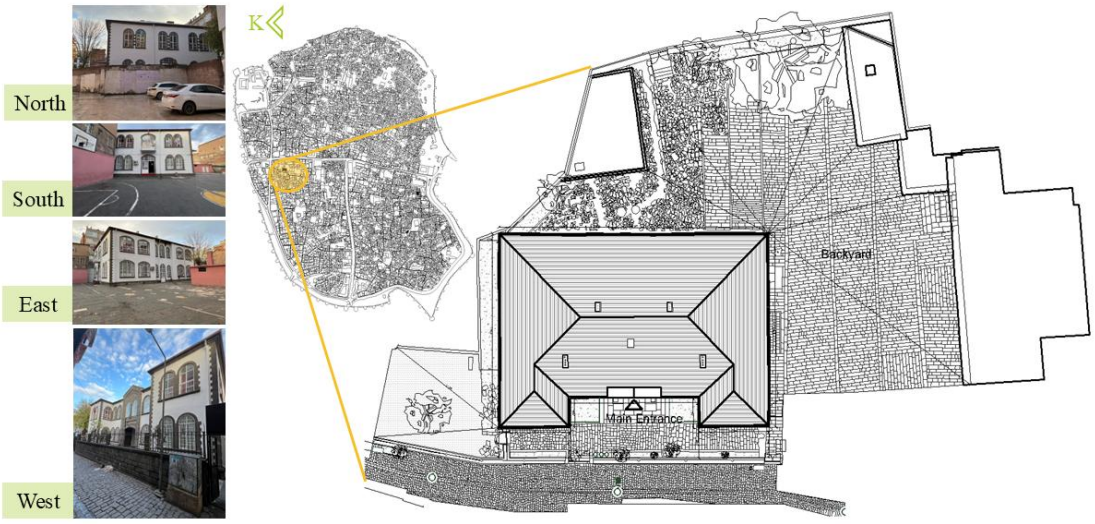

Figure 2. Ziya Gökalp Primary School

There are six classrooms in the school. The classrooms are located on the ground (2 classrooms) and first floor (4 classrooms). Classrooms have a total area of approximately 265m². The floor height of the classrooms is 4m. The average density of the classrooms is 1.2 people/m². At least two walls of all classrooms are designed as exterior walls. The total number of windows in 6 classrooms is 29. There is also one balcony in classroom 1-05. The window-to-wall ratio (WWR) in the classrooms is approximately 25% (Figure 3).

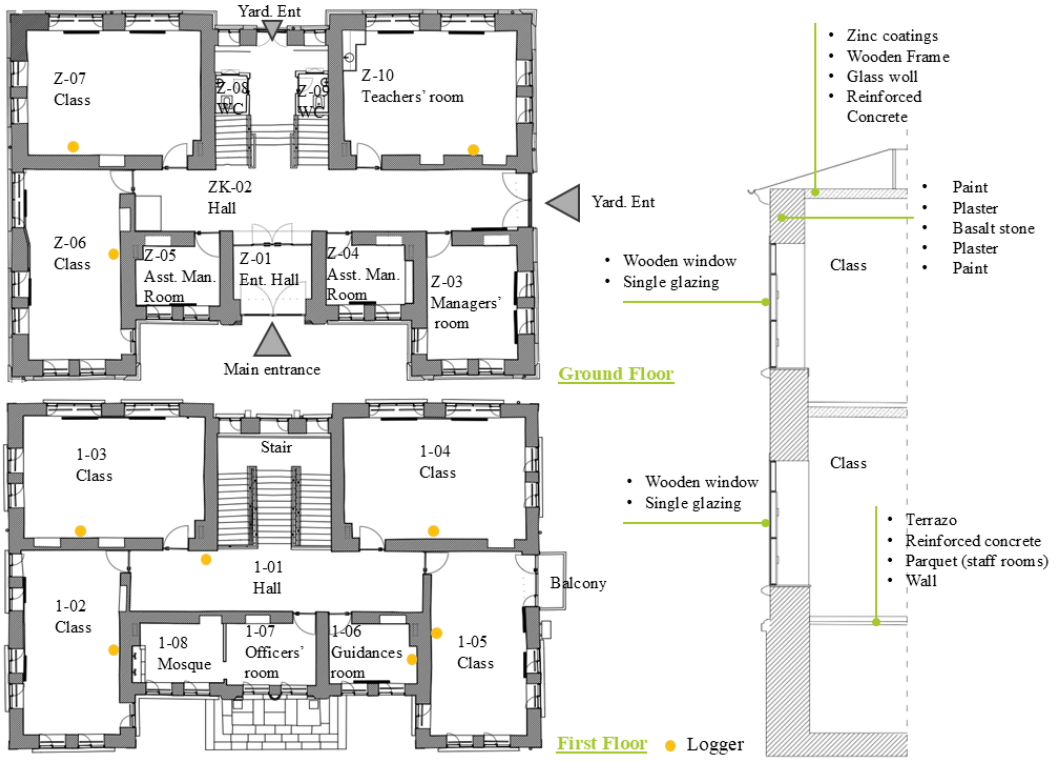

Figure 3. Floor plans and building components.

The school is used for educational purposes from 07.00 to 18.00. The school has approximately 550 students and 46 teachers. Approximately 220 students and twenty-two teachers use the building between 07.00-12.30, while the rest of the students and teachers use the building between 12.40-18.00. The school is closed for summer vacation each year from June 15 to September 15.

Building components

The building was restored in 1962 (Baydaş, 2007: 131). The original building components of the building before the restoration and the current building components were obtained from the measured drawing project The Prime Ministry Republican Archives (1933), project drawings of the period architecture for the 20th century educational buildings and field studies (Table 2).

Table 2. Original and existing building components

Component	Original (1912-1962)	Existing (1962-)
Exterior wall		Paint + plaster + masonry + plaster*+paint*
Roof	Wooden frame + Roof tiles	Wooden frame* + Membrane* + Galvanized sheet metal*
Attic floor	20cm wooden beam +2cm wooden covering	Concrete slab (20cm) * + glass wool*
Floor	20cm wooden beam +2cm wooden covering	Concrete slab (20cm) * + terrazo*
Window	8-division wooden framed window+ Clr single glazing	6-division wooden framed window+ Clr single glazing
Window jamb	2 cm thick basalt stone	2 cm thick basalt stone
Main entrance door	Wooden	Wooden *
Interior doors	Wooden	Wooden *

* Refers to modified components. Note: Administrative rooms also have parquet flooring.

In the existing building, the walls are not insulated. The attic of the building is not used (cold roof). The roof is galvanized sheet coating. No heat insulation material is used under the galvanized sheet coating. Attic floor is covered with glass wool on reinforced concrete. The flooring of the spaces is reinforced concrete slab and

terrazzo coating. The floor in the manager's room, assistant manager's room, teachers' room, guidance room and masjid is covered with parquet (Figure 4).

Figure 4. Classroom, Masjid, Manager room, Building entrance, Classroom window, Manager room door

All the windows are single glazed with wooden frames. There are no shading elements other than 2cm jambs. All interior doors are made of wooden material. The original main entrance door has been conserved. Windows are used for natural ventilation in classrooms (Figure 4). Electricity and coal are used as energy sources in the building. Coal is used for heating, and electricity is used for lighting. A coal boiler is used for heating. The water heated by the boiler is distributed to 60x150cm radiators to provide heating.

METHOD

The aim of the study was to propose energy efficiency improvements without causing damage to the original components of the historic building. The identification of the original components of the historic building was achieved through archival research and fieldwork. A comprehensive review of the relevant literature was conducted to ensure the correct implementation of the proposed improvements to the building. Calibration analyses were performed to ensure consistency between the simulation model and the actual characteristics of the building. The DesignBuilder Software was used for the purposes of energy analysis, thermal comfort analysis, and CO2 emission analysis. Within this scope, the study is based on a multi-dimensional method using a combination of quantitative and qualitative methods. In this context, literature reviews, archival research, field studies, on-site measurements, DesignBuilder software (Figure 5).

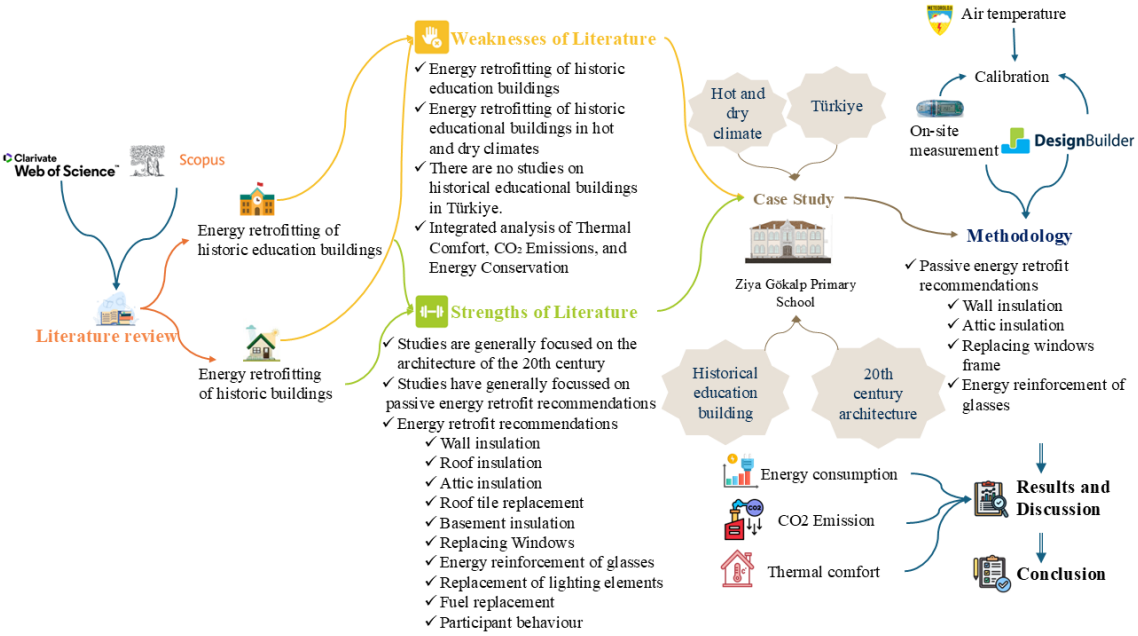

Figure 5. Research process

Literature Review Procedure

In the first stage, the literature was reviewed. Web of Science and Scopus databases and archival research were used in the literature review. In this context, energy retrofits of historic buildings and historic educational

buildings were investigated. Based on the data obtained, the strengths and weaknesses of the literature were identified. Given the weaknesses in literature, this study aims to contribute to it. In this context, historical educational buildings in Türkiye, energy retrofitting of historical buildings in hot and dry climates, carbon emissions, and gaps in thermal comfort integration were identified. In this context, the aim was to contribute to the literature through integrated analyses. By identifying the strengths of the literature, the right strategies for energy retrofitting of historic buildings can be determined, as well as the historic building to be selected. In this context:

- Selecting a 20th-century educational building in a hot and dry climate as a field study,
- Adding insulation to the inner surface of the external wall
- Adding insulation to the attic floor,
- Replacement of windows

All proposals are within the scope of passive strategies, and no mechanical systems are proposed (Figure 3). The recommendations are directly linked to literature reviews, Türkiye-Thermal Insulation Requirements in Buildings (TS 825) project guidelines, EN 16883:2017, field study, international heritage conservation charter and building requirements. TS 825 is prepared according to European standards and specifies the minimum thermal insulation values of buildings in Türkiye. According to these rules, the energy efficiency of buildings in Türkiye is close to the energy efficiency of buildings in European countries (Diz, 2024). It is a legal obligation to be applied in various buildings such as education and training buildings (Republic of Türkiye Ministry of Environment Urbanization and Climate Change, 2025; Turkish Standards Institute, 2008, 2024). The main reason for using TS 825 standards is to ensure the functional sustainability of the existing building.

On-Site Measurement

As part of the on-site measurements, the indoor air temperature was measured with a Micro Lite USB Data Logger 5016 temperature logger. The temperature recording range of the logger is between -40°C and 80°C (Fourtec, n.d.). A total of 9 loggers, one in each classroom, guidance room, teachers' room and first floor corridor. The loggers were placed at a height of 1.1 meters as recommended in American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc (ASHRAE) Standard 55-2013. Measurements were taken between 27.05.2025 hours: 18.00- 30.05.2025 hours: 16.00 every 15 minutes for 70 hours. In addition to physical measurements, observation, photography and face-to-face interview techniques were also utilized in field study. Field studies played an important role in determining the criteria such as the active usage periods of the school, the duration of the open windows, the average density of the classrooms, and the general clothing combinations of the users for determining the clothing insulation (clo) values. The main purpose of the holistic study of the building is to ensure the calibration between simulation and real building data.

Designbuilder Software Analysis

Designbuilder software with Energy Plus engine was used for the analysis. Designbuilder is a validated program according to ANSI/ASHRAE Standard 140-2023 Building Thermal Envelope and Fabric Load Tests using the BESTEST procedure for validation of building energy simulation programs (Designbuilder Sofware, 2025). This simulation software can calculate energy consumption for heating and cooling, carbon emissions, thermal comfort-PMV values, and lighting. DesignBuilder software was used in four stages in the study. In the first stage, it was used in the calibration process of the real building and the modeled building. In the second stage, it was used to determine the heat transmittance coefficient (U Value) of the existing building components. In the third stage, it was used to calculate the U values of the proposed building components. In the fourth and final stage, it was used for energy consumption analysis, thermal comfort analysis (PMV value) and carbon emission analysis of the building according to the existing and proposed building components.

Calibration

Calibration is performed to test the accuracy of energy models. The most used strategies for calibrating energy simulations of buildings are Dry Bulb Temperature of indoor spaces, air temperature, electricity bills and energy consumed for heating (Chong et al., 2021: 17). For calibration, first the real data of the building is obtained. The same data is then analyzed in a simulation program. In many studies, Coefficient of Variation of the Root Mean Square Error [CV(RMSE)], Mean Bias Error (MBE) or a combination of both is used (Chong

et al., 2021; Royapoor & Roskilly, 2015; Şahin et al., 2015). If the results of these data are in accordance with ASHRAE Guideline-14 "Measurement of Energy Demand Savings", the calibration is considered successful. According to ASHRAE Guideline 14, if the calibration is calculated according to monthly criteria, the MBE value is expected to be within ±5% and the CV(RMSE) value is expected not to exceed 15%. If calculated according to hourly data criteria, the MBE value is expected to be within ±10% and the CV(RMSE) value is expected not to exceed 30%. (ASHRAE, 2002). If calibration is not achieved, the parameter causing the error is determined and necessary adjustments are made. This process continues until calibration is achieved.

$$CV(RMSE)=\frac{\sqrt{\sum_{i=1}^{ni}\frac{(Mi-Si)^2}{Ni}}}{\frac{1}{Ni}\sum_{i=1}^{Ni}Mi} \qquad \text{Eqs 1.}$$

$$MBE=\frac{\sum_{i=1}^{Ni}(Mi-Si)}{\sum_{i=1}^{Ni}Mi} \qquad \text{Eqs 2.}$$

Mi and Si are measured in hourly values and simulated hourly values, respectively. Ni, the number of adjustable model parameters (Royapoor & Roskilly, 2015: 113). In this study, indoor dry bulb temperature and outdoor air temperature data were used for calibration purposes. Data recorded with Micro Lite USB Data Logger 5016 was used for the calibration of dry bulb temperature. Hourly averages of measurements taken every 15 minutes were used. The outside air temperature data to be used for calibration was obtained from the closest station to the study area, Turkish State Meteorological Service 15th Regional Directorate, Yenişehir/Eşref Bitlis Heliport/18166. CV(RMSE) and MBE values were determined and evaluated depending on the hourly criteria for the calibration of the measured real data and simulation data.

Thermal Comfort

In the Organisation for Economic Co-operation and Development (OECD) countries, students spend an average of 7634 hours in schools (Organisation for Economic Co-operation and Development, 2023). Inappropriate thermal comfort of school interiors directly affects the level of learning (Pies et al., 2020). Energy retrofitting of educational buildings directly affects indoor thermal comfort (Jerominko & Cichowicz, 2025). Thermal comfort refers to users' satisfaction with the thermal environment (Zhang et al., 2020). Thermal comfort limitations help to determine the air conditioning of buildings (Taleghani et al., 2013). In this study, Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) indices were used as thermal comfort limitations (Park et al., 2025). PMV within the ±3 range represents how people perceive the thermal environment. PPD, on the other hand, indicates the percentage of people dissatisfied with the thermal comfort of the environment (ASHRAE, 2017; Wei et al., 2024). Air temperature, mean radiant temperature, air velocity, relative humidity, metabolic rate and clo values are used to calculate PMV values. PPD value is calculated with the formula based on the PMV value (Eqs 3) (ASHRAE, 2017; Zhang et al., 2020).

$$PPD=100- 95e^{(-0.03353PMV4 -0.2179PMV2)} \qquad \text{Eqs 3.}$$

According to ASHRAE Standard 55, the PMV value should be ±0.5 and the PPD index should be below 10% in a comfortable environment. The further away from this value range, the lower the level of satisfaction and thermal comfort (ASHRAE, 2017; Park et al., 2025). In this study, PMV values were simulated daily through DesignBuilder software-Fanger (PMV) output. PPD values were calculated by processing PMV values in Excel program (Eq 3).

Carbon Emissions

In the study, carbon emissions are defined as operational carbon and embodied carbon. CO2 emissions were simulated in DesignBuilder software using Life Cycle Assessment (LCA) data. LCA is a tool that can assess CO2 and other greenhouse gas emissions over the lifetime of a building (Angrisano et al., 2021; Jaemoon et al., 2023). Operational Carbon emissions are usually directly related to fuel type and fuel quantity. Operational carbon emissions are usually directly related to fuel type and fuel quantity. It is the amount of carbon emissions resulting from the energy expended to provide heating, cooling and lighting, etc. Embodied carbon emission is the expression in kg of the amount of carbon emitted during the production, transportation, construction, etc. of building materials (Ibn-Mohammed et al., 2013: 234).

FINDINGS

Analyses and evaluations were completed in three stages. In the first stage, calibration was performed. In the second stage, the U values of the existing building components and the proposed building components were determined. Scenarios were created according to the proposed building components. In this context, Package 1: Original wall + 9cm rock wool + paint + plaster, Package 2: Window replacement: 6mm + 13mm argon + 6mm, Package 3: Attic floor insulation: 13cm rock wool. In the third stage, the effects of the proposed packages on energy consumption, carbon emission and thermal comfort have been analyzed.

Calibration

In the first stage of calibration, simulations and field measurements were conducted for indoor dry-bulb temperature data from 27.05.2025 at 18.00 to 30.05.2025 at 16.00. It was determined that the temperature measurements and simulations for nine different locations were generally parallel (Figure 6).

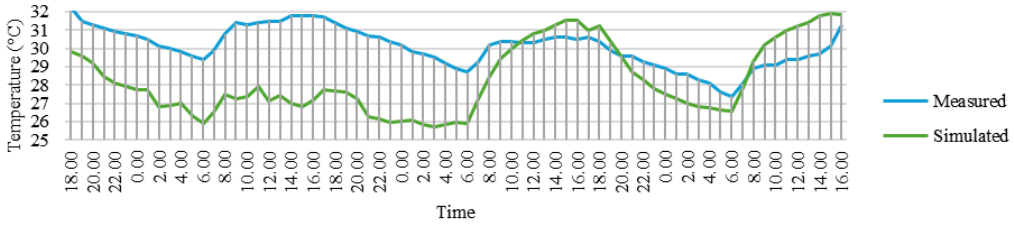

Figure 6. Comparison of temperature data in simulations and measurements (Class 1-04)

MBE and CV(RMSE) values were determined for the calibration evaluations of nine spaces. It was determined that the MBE and CV values in all nine spaces were in accordance with ASHRAE-Guideline 14 (Table 3).

Table 3. Errors for calibration of the model for each space

Metrics	Space									ASHRAE Guideline -14 Limit
	Z-06	Z-07	Z-10	1-01	1-02	1-03	1-04	1-05	1-06	
CV(RMSE) (%)	9.39	7.45	7.5	10.86	9.14	7,97	9.10	9.12	5.62	30
MBE (%)	6.52	0.48	2.28	9.16	5.80	3.58	6.06	8.36	-1.10	±10

In the second stage of the calibration, real outside air temperature data and simulated outside air temperature data were calibrated. In this context, the CV(RMSE) value was determined to be 21.34% and the MBE value to be 9.47% according to the hourly data criteria. The results of the two-stage analysis show that the simulation is calibrated.

Building components

U-values for wall, attic floor, and window (frame + glass) components were determined using DesignBuilder software for both existing and proposed materials. The existing and proposed building components were evaluated by comparing them with the minimum U-values specified for the 4th climate zone in TS 825. Diyarbakır Central district, where the study area is located, is in the 4th climate zone according to TS:825 standards (Turkish Standards Institute, 2024).

Wall: The interior and exterior surfaces of the school walls are basalt stone walls covered with plaster and paint. The walls consist of three layers, stone filling in the middle and basalt stone blocks on the inner and outer surfaces. The U-value of the existing wall is 0.983 W/m²K (Table 4).

Table 4. U-values of base case and proposed wall

Component detail		U value (W/m²K)
Base Case	*Out*-Plaster + paint (1cm) + basalt masonry block (20cm) +gravel (20cm) + basalt masonry block (20cm) +plaster + paint (1cm)-*In*	0.983
Proposed	*Out*-Original wall + rock woll (9cm) +plaster + paint (1cm)-*In*	0.266
TS 285 U value (W/m²K): 0.35		

In Package 1, 9cm thick rock wool insulation material and plaster + paint was added to the inner surface of the original external wall. Rock wool is preferred because it is a natural and recyclable material with low

conductivity (λh=0,033), resistant to moisture and fire (Danaci & Akin, 2022). No intervention was made to the outer surface of the external walls of the building. In this context, the U value of the proposed wall was determined as 0.266W/m²K. This value is in accordance with TS 825 4th climate zone wall components U value.

Window: The existing building uses 6 mm transparent single glazed windows with wooden frames with 6 divisions, 1 sash of which can be opened. The U-value of the existing window glasses was determined as 5,778 W/m²K. This value is well above TS 825 standards (Table 6).

Table 6. U-values of base case and proposed window

Component detail		U value (W/m²K)
Base Case	Painted wooden frame + 6mm Clr single glass	4.5
Proposed	Painted wooden frame + Argon-filled Low-E coated double glazing (6mm+13mm+6mm)	1.698
TS 285 U value (W/m²K): 1.8		

The window frames were renewed with the same material and number of divisions. It was proposed to replace the glass with 13mm argon filled Low e (e=2) coated glass (Package 2). In this context, it was determined that the glasses with a U value of 1,698 W/m²K follow TS 825 standards.

Cold roof-Attic floor: The attic of the existing building is not used. In this context, no intervention has been made to the sloping roof. The roof insulation is 8 cm thick glass wool and is laid on the attic floor. The cold roof U value of the existing building is determined as 0.43 W/m²K (Table 5).

Table 5. U-values of base case and proposed attic floor

Component detail		U value (W/m²K)
Base Case	Plaster+paint (2cm) +Reinforced concrete (15cm) + glass woll (8cm)	0.43
Proposed	Plaster+paint (2cm) +Reinforced concrete (15cm) + rock woll (13cm)	0.234
TS 285 U value (W/m²K): 0.25		

To reduce the U value of the attic floor, 13cm thick rock wool is recommended to be laid on the attic floor. Insulation thickness complies with TS 825 standards. No intervention other than insulation material is recommended. In this context, it can be said that the Cold roof U value of 0,23W/m²K is in accordance with TS 825 standards.

Impact of Envelope Retrofitting Strategies on Annual Energy Savings

In the first stage, the heating energy consumption of the existing building was analyzed. In this context, it was determined that the total annual energy consumption was 23252kWh (Figure 7).

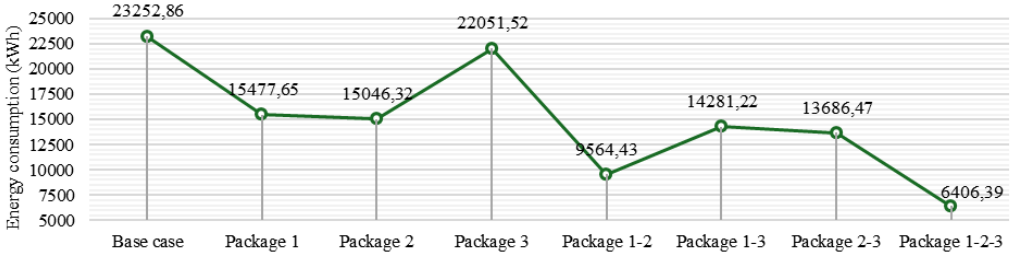

Figure 7. Impact of scenarios on energy consumption

In the second stage, the effect of the proposed scenarios on the energy requirement for heating purposes was analyzed. Package 1, the annual energy demand for heating is found to be 15477 kWh. This shows that the energy demand for heating purposes decreased by 33.43%. When the recommendations within the scope of Package 2 are analyzed, it is determined that the annual energy demand for heating purposes is 15046 kWh. In this context, it can be said that the use of argon-filled low-e double glazing can reduce energy demand by 35.29%. In Package 3, it is determined that the energy demand for heating purposes is 22051 kWh because of the proposal to replace the attic insulation. This shows that only by changing the type and thickness of the attic insulation, can the energy demand be reduced by 1201kWh per year. The combination of packages 1 and 2

resulted in a reduction of the annual energy demand to 9564 kWh. This result shows that the energy demand is reduced by 58.95%. As a result of the combination of Package 1 and 3, the energy demand was 14281 kWh. This shows that the annual heating energy demand will decrease by 38.56%. It is determined that the combination of Packages 2 and 3 will result in an energy demand of 13686 kWh. In this context, it can be said that the energy demand for heating purposes will decrease by 41.13%. In the package 1-2-3 combination proposal, energy demand for heating purposes is determined as 6406 kWh. It shows that 72.43% energy conservation will be achieved because of the implementation of Package 1-2-3 combination. It is also clear that this combination is the most effective method. These results show that a total of 160150kWh energy savings will be achieved in 25 years within the scope of the European Green Deal 2050.

Impact of Envelope Retrofitting Strategies on Thermal Comfort

The analysis revealed that, in the building's current state, thermal comfort conditions (with PMV values within ±0.5 and PPD values below 10%) were maintained for 157 days per year, accounting for 43.01% of the annual period (Figure 8).

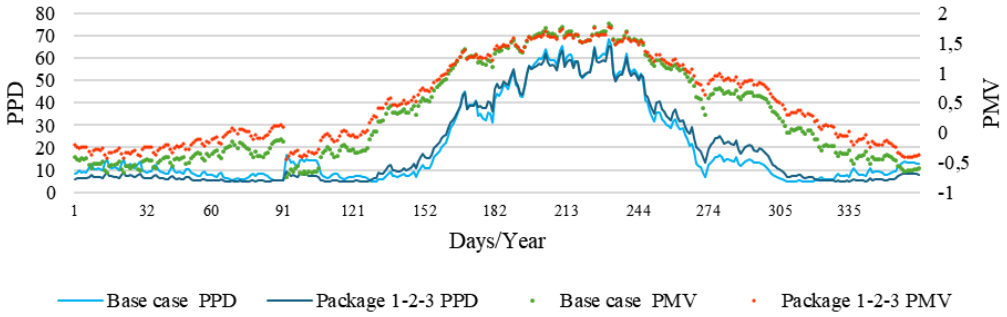

Figure 8. Annual Variation of PMV and PPD Values

In the Package 1-2-3 combination, it was determined that the PMV value remained within the ±0.5 range and the PPD value stayed below 10% for 206 days (56.43% of the year). This indicates an approximate 31% increase in the number of days with thermal comfort because of the implemented recommendations. The days when PMV values are in the ±2 range are usually when school is closed for summer vacation.

Impact of Envelope Retrofitting Strategies on Carbon Emission

It is determined that the annual operational carbon emission of the existing building is 70510kg, while the Package 1-2-3 combination is 63183kg. It can be said that the implementation of Package 1-2-3 will reduce the annual operational carbon emission by 7327 kg. This shows that the operational carbon emission of the building can be reduced by ~10.39% per year (Figure 9).

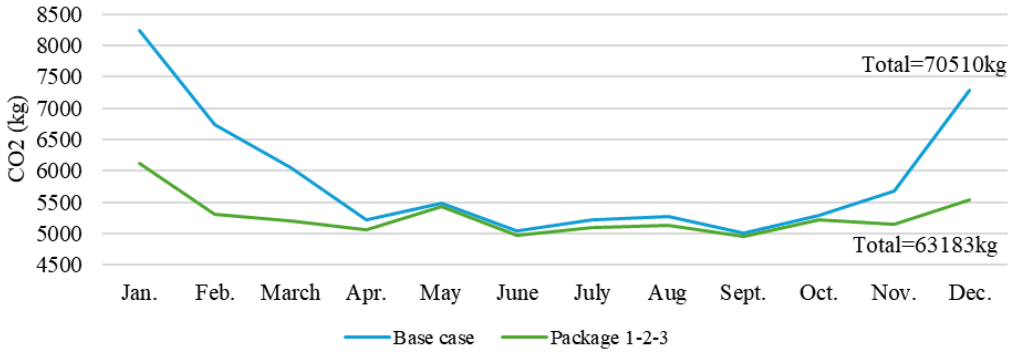

Figure 9. Carbon emission (kg/month)

In the baseline scenario, the embodied carbon emissions of the building is ~431097kg. Under the combination of Package 1-2-3, the embodied carbon emissions of the building is ~445184kg. The difference in embodied carbon between Package 1-2-3 and base case is ~14087 kg. The biggest reason for this increase is the addition of rock wool used in attic floor insulation (Figure 10).

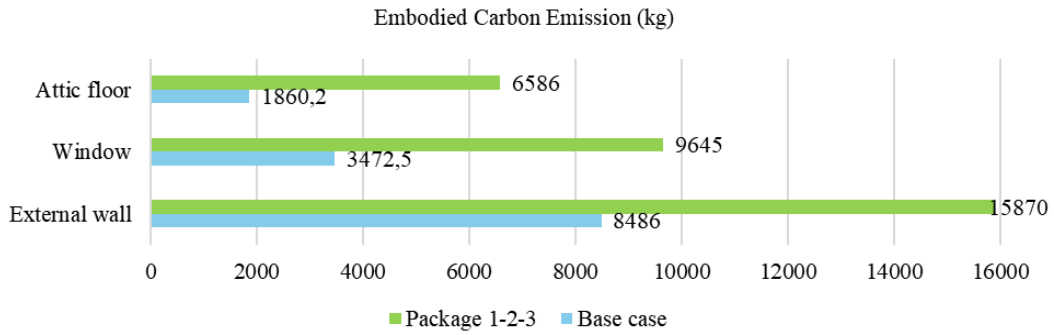

Figure 10. Embodied carbon emission amount of building components

Considering the total life cycle emissions, where operational carbon emissions and total embodied carbon emissions are calculated together, it can be said that the carbon footprint of the building will reach an equivalent level to the base case in about 2 years under the proposed scenario. After 2 years shows that building will become advantageous in terms of carbon emission. Within the scope of the European Green Deal 2050, it can be said that the building will emit 183175kg less carbon emissions in 25 years. This shows that there will be a serious improvement in the carbon footprint of the building (Figure 10).

CONCLUSION

It is very difficult to achieve sustainability only by developing design criteria for new buildings without considering existing buildings. Existing buildings are among the major drivers of energy consumption and carbon emissions. It can be defined as an important solution for sustainability with the right energy retrofits to existing buildings. In recent years, CEN has published encouraging guidelines for energy retrofitting of historic buildings due to their energy consumption, carbon emissions, and inappropriate indoor thermal comfort conditions.

This study focuses on the energy retrofitting of Ziya Gökalp Primary School, which was built as part of a project in Diyarbakır, Türkiye, within the scope of educational reform in the post-Tanzimat period of the Ottoman Empire. Based on real data, the building was simulated using DesignBuilder. First, calibration was performed to ensure accurate data. Then, the proposed scenarios for wall, attic floor and window replacements were compared with the existing condition. All recommendations are in accordance with the EN 16883:2017 guidelines for energy retrofitting of historic buildings, existing literature and national and international laws and regulations for the conservation of historic buildings. Within the scope of these recommendations, it was determined that the most helpful scenario for energy consumption is the Package 1-2-3 combination. It was determined that the Package 1-2-3 combination provides significant advantages in terms of carbon emissions and thermal comfort as well as energy consumption. In this context, it was determined that energy demand decreased by 72.43% and the number of comfortable days increased by 31%. Although there was an increase in embodied carbon emissions, this increase was balanced within two years by a 10.39% reduction in operational carbon emissions. As a result, it can be said that it will provide a significant advantage for carbon emissions. It is thought that the building will provide a significant advantage within the scope of the European Green Deal 2050 by reducing energy consumption by 160150kWh and carbon emissions by 183175kg by 2050. The fact that the existing building was built as a project type suggests that the analyses will yield greater sustainability benefits. Given that the existing building is a type of project, various recommendations for educational buildings in hot, dry climates in the post-Tanzimat period are summarized in Table 7.

Table 7. Evaluation in terms of carbon emissions, energy consumption and thermal comfort

External wall	External wall insulation is a key factor in reducing the heating energy demand. The outer surface of the external wall should not be interfered with as there are decorations. The U-value and carbon emission of the insulation material to be added to the inner surface of the outer wall should be low. Rock wool can be considered as a material suitable for these recommendations. The thickness of the insulation material should be determined by calculating the U-values according to TS 825 and the materials used in the original wall. For the existing building with a U-value of 0.98 W/m²K, a 9 cm thick layer of rock wool, which has a thermal conductivity of $\lambda = 0.033$ W/mK, is sufficient.

Window frame	When replacing window frames, it is advisable to choose materials, divisions, and operable sashes that match the building's original or existing condition. In the present study, the material, sash and number of divisions suitable for the existing window frame were preferred.
Window glass replacement	If possible, replacement of a single glass with a low insulation level can be recommended. In case of window glass replacement, DbL Low e(e2=1) Clr 6mm/13mm argon glass can be recommended. Although the embodied carbon emissions are high, the advantage in terms of produced carbon emissions will close this gap in a brief time.
Attic floor	If the attic is not used and there is no insulation material available or if the existing insulation has reached the end of its useful life, it is recommended to use new insulation material. In the existing building, the application of 13cm thick rock wool provided a significant effect as the 8cm thick glass wool, which was worn out in the attic, did not have sufficient U level.

These recommendations for the energy retrofit of historic educational buildings under similar conditions can be considered. However, although their original conditions are like the building within the scope of this study, variables such as differences in material use, location, climatic data, user profiles, and renovations undergone by the buildings should be considered, as they may prevent the proposed scenario from having a similar effect on the existing building.

Author's Contribution

The author contributed 100% to the study.

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Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

This study does not require ethics committee approval.

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Figure References

Figure 2-3: Ergün, Ş. (2024). Diyarbakır Ziya Gökalp Primary School conservation project [Master of Science, Dicle University].

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Research Article

Modüler logotype tasarımında üretim yöntemleri ve farklı ortamlarda uygulanabilirliği

Production methods and applicability in different platform in modular logotype design

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Özet
Dijital çağda seçenek çeşitliliğinin arttığı bir ortamda markalar, fark edilebilir olma ve güncelliğini sürdürme gerekliliğiyle karşı karşıyadır. Bunun paralelinde marka kimliği anlayışında statik kimlik yapılarının yerine esnek, uyarlanabilir ve etkileşimli sistemler ortaya çıkmaktadır. Geleneksel yaklaşımlara alternatif olan bu sistemler, bağlamsal koşullara göre biçimlenebilen, kullanıcı etkileşimine açık ve algoritmalarla yönlendirilebilen yaklaşımları içermektedir. Çalışmada modüler logotype kavramının kuramsal ve uygulamalı yönleri ele alınarak, grafik tasarım disiplinine çağdaş bir tasarım yaklaşımı olarak katkı sunması amaçlanmaktadır. Araştırma kapsamında, modüler logotype sistemlerinin üretim yöntemleri ve farklı medya ortamlarına uyarlanabilirliği incelenerek bu sistemlerin kurumsal iletişim üzerindeki rolü ortaya incelenmektedir. Nitel araştırma yöntemiyle yürütülen çalışmada betimsel analiz ve örnek olay incelemesi tekniklerinden yararlanılmakta; uluslararası tasarımlardan örneklerle görsel ve içerik analizi yapılmaktadır. İncelemeler neticesinde, modüler yapıya sahip dinamik logotypeların dijital çağın değişken iletişim ortamlarına etkili biçimde uyum sağlayabilen yenilikçi marka kimliği aracı olarak yalnızca estetik bir yenilik değil, aynı zamanda stratejik bir iletişime sahip olması ile hem profesyonel tasarımcılar hem de marka yöneticileri için yönlendirici bir kaynak niteliği taşıması ön görülen sonuçlar arasındadır.

Anahtar Kelimeler: Modüler logotype, Dinamik logotype, Değişken görsel kimlik, Algoritmik logotype

Abstract
In the digital age, where the variety of options is increasing, brands face the need to be noticeable and to remain relevant. In parallel, flexible, adaptable, and interactive systems are emerging in the understanding of brand identity, replacing static identity structures. These systems, which offer alternatives to traditional approaches, include approaches that can be shaped according to contextual conditions, are open to user interaction, and can be guided by algorithms. This study aims to contribute to the graphic design discipline as a contemporary design approach by addressing the theoretical and practical aspects of the modular logotype concept. Within the scope of the research, the production methods of modular logotype systems and their adaptability to different media environments are examined, revealing the role of these systems in corporate communication. The study, conducted using a qualitative research method, utilizes descriptive analysis and case study techniques; visual and content analysis is performed with examples from international designs. As a result of the examinations, it is predicted that dynamic logotypes with a modular structure, as an innovative brand identity tool that can effectively adapt to the changing communication environments of the digital age, are not only an aesthetic innovation but also possess strategic communication, serving as a guiding resource for both professional designers and brand managers.

Keywords: Modular logotype, Dynamic logotype, Variable visual identity, Algorithmic logotype

Extended Abstract

Introduction: In the contemporary communication environment shaped by rapid technological evolution, brand identity has undergone a significant transformation. Traditional static visual identity structures are no longer sufficient to meet the demands of increasingly fragmented and interactive digital platforms. As the volume of visual stimuli and information multiplies in the

digital age, brands face the critical challenge of remaining relevant, distinguishable, and emotionally engaging. Consequently, the need for adaptable and responsive identity systems has grown, giving rise to alternative approaches in logotype design. Among these, the concept of modular logotypes stands out as a key innovation, offering both flexibility and coherence across various media environments. The theoretical basis of this study is rooted in contemporary literature on dynamic branding, visual identity systems, and algorithmic design. Generative design, which enables the creation of visual outputs through predefined rules, algorithms, or AI-driven systems with minimal human intervention, has emerged as a vital tool for designers aiming to craft sustainable and innovative identity solutions. This study addresses the relationship between generative design principles and modular logotype structures and evaluates their capacity to respond to contemporary branding challenges.

Purpose and scope: This research aims to examine the conceptual and practical dimensions of modular logotype systems within the context of generative design approaches. The study seeks to answer the following questions: How do modular and generative systems contribute to brand recognition and adaptability in multi-platform communication environments? What are the design principles behind modular logotypes that allow them to meet the demands of flexible, data-responsive identity structures? The scope of the study encompasses the analysis of internationally recognized modular logotype systems developed through generative methods. Case studies from prominent global branding projects have been included to illustrate how visual identity can be dynamically adapted across physical and digital touchpoints. Furthermore, the study investigates the design logic behind these systems, including the use of grid structures, parametric variations, and algorithmic patterns that allow modular elements to function both independently and cohesively.

Method: The study employs a qualitative research methodology, combining descriptive analysis with case study techniques. Primary visual materials and branding documents were evaluated through visual and content-based analysis. Selected logotype systems were analyzed according to their structural principles, adaptability to various media platforms, and consistency in brand communication. Descriptive analysis was used to interpret visual strategies and systematization methods, while the case study approach enabled in-depth exploration of modular logotype applications in real-world scenarios. The cases included dynamic identity systems that incorporate repeated modules (e.g., geometric forms), grid-based structures, and parameter-driven variation rules that align with generative design philosophies. This methodological approach was chosen to facilitate a comprehensive understanding of how generative systems can be designed and implemented in branding projects.

Findings and conclusion: The findings suggest that modular logotype systems designed through generative principles offer considerable advantages in terms of brand visibility, personalization, and cross-platform adaptability. Grid-based structures and algorithmically generated modules enable consistent variation, maintaining brand coherence while introducing freshness in visual communication. The capacity of such systems to respond to environmental and contextual data increases the relevance of the brand experience and enhances user engagement. One of the key contributions of the study is the identification of a design paradigm where the logotype is not a fixed image but a dynamic system that evolves in interaction with users, contexts, or data streams. This redefinition aligns with the broader shift in branding philosophy -from monolithic identity to responsive identity. The integration of generative design into branding processes contributes to a richer, more personalized, and emotionally resonant brand experience. It also offers practical advantages in the production process: automated design generation, reduced development time, and seamless integration across platforms. The study concludes that modular logotypes grounded in generative principles are not merely aesthetic innovations but strategic tools for navigating the complexities of contemporary brand communication. They offer design professionals and brand managers a scalable and future-proof method of creating identities that evolve alongside their audience and context.

Keywords: Modular logotype, Dynamic logotype, Variable visual identity, Algorithmic logotype

GİRİŞ

Çalışmada modüler sistemlerin sunduğu yeniden kombinasyon ve kişiselleştirme olanaklarının, marka kimliğini kapsayıcı, katılımcı ve sürdürülebilir bir yapıya nasıl dönüştürdüğü araştırılmaktadır. Araştırmada yer alan logotype terimi Türkçe alan yazını taramalarında logotype ve logotayp olarak iki şekilde yer almaktadır. Türkçe yayınlarda logotayp olarak tercih edildiği gibi tıpkı logo kelimesinde olduğu gibi Türkçeleştirmeden kullanımı da mevcuttur. Erkmen (1986), Ergüven (2012), Pektaş (2021), logotayp terimini tercih ederken, Karçığa (2016), Engizek (2017), Kavasoğlu (2018), Uğur (2019), Aktaş (2019), Baltacı (2019), Kuran (2022), Çınar (2023) ve Grafik Tasarımcılar Meslek Kuruluşu Derneği (GMK) (Admin, 2016) yayınlanan bir yazıda logotype terimine yer vermiştir. Bu çalışmada da logotype teriminin kullanılması tercih edilmiştir. Grafik tasarım alanında logotype tasarımı konusunda yapılan açıklamalarda çoğu zaman belirli bir sonuca ulaşan nihai ifadelerden ziyade, çok sayıda "ama" ve "duruma bağlı" sözcüklerinin bulunduğu yoruma açık olasılıklara rastlanmaktadır. Bu tartışmalar genellikle logotypeların farklı platformlarda işlevselliğini koruması, kolay algılanabilir ve hatırlanabilir olması amaçlarıyla temel tasarım ilkeleri çerçevesinde şekillenmektedir. Netlik, sadelik, sınırlı renk kullanımı gibi ilkelerle logotype tasarımında sıkça

karşılaşılmaktadır. Ancak tasarımın öznel ve bağlama bağlı doğası gereği, bu ilkelerin her projeye birebir uygulanması her zaman mümkün olmayabilmektedir.

Markanın hedef kitlesi, iletişim dili, kullanım bağlamı ya da teknolojik platformlar, tasarımın biçimini etkilemektedir. Tasarımcılar, bir yandan söz konusu ilkeleri dikkate alırken diğer yandan projeye özgü ihtiyaçları ve yaratıcı yorumları da tasarıma entegre etmeye çalışmaktadır. Dolayısıyla iyi bir logo; teknik olarak işlevsel, estetik açıdan etkileyici, bağlamsal olarak anlamlı ve stratejik olarak özgün bir yapıya ihtiyaç duymaktadır. Bu durum, logo tasarımında yalnızca yerleşik kurallara değil aynı zamanda tasarımcının bağlamsal sezgilerine ve yaratıcı çözüm üretme becerisine dayanan bir süreci doğurmaktadır. Frascara (2004: xii-xiii) *Communication design: Principles, methods, and practice* kitabının giriş bölümünde tasarımın salt teknik ya da estetik kurallara bağlı bir süreç olmadığını, bağlamsal bilgi, insan odaklı sezgi ve profesyonel muhakeme gerektiren dinamik bir insan iletişimi problemi olduğunu savunmaktadır. Bu bakış açısı, grafik tasarım sürecinin dijital olanaklarla birlikte daha esnek bir yapıya kavuştuğunu göstermektedir. Armstrong'un kitabında (2009: 102), Lupton, ele aldığı bölümde dijital mecralarda tasarımın statik baskıya kıyasla daha özgür, değişken ve yeniden biçimlendirilebilir hale geldiğini savunmaktadır. Dolayısıyla logotypeların üretim sonrası sayısız fiziksel materyale (kartvizit, antetli kâğıt, broşür gibi) sabitlenmesi zorunluluğu ortadan kalkmaktadır. Logotypeların zamanla değiştirilebilmesi, dönüştürülebilmesi ya da tamamen yeniden tasarlanabilmesi artık çok daha düşük maliyetli ve pratik bir hale gelmiştir. Dijital platformların sunduğu esneklik, logotypeların sabit ve değiştirilemez bir görsel öge olmak zorunda olmadığını; aksine değişebilen, duruma göre farklı biçimlere evrilebilen ve kullanıcısıyla etkileşime geçebilen bir yapı olabileceğini ortaya koymaktadır. Bu bakış açısı, modern marka kimliklerinin sadece tutarlılığı değil, aynı zamanda adaptasyonu ve yenilenebilirliği de temel alması gerektiğini göstermektedir. Adaptasyon ve yenilenebilirlik söz konusu olduğunda belirli değişkenlere (zaman, hava durumu, kullanıcı verisi, müzik, sosyal medya etkileşimleri vb.) bağlı olarak kendini sürekli güncelleyebilen ve bağlamsal olarak yeniden şekillenebilen dinamik logotypelara rastlanmaktadır. Dinamik logotypelar kapsamında farklı platformlarda, farklı hedef kitlelerle etkileşim kurarken ortama uygun şekilde yeniden yorumlanabilmesini ve hem bütünsel hem de bireysel temsiliyeti mümkün kılan modüler yapıdaki logotypelar bu çalışmanın temel konusunu oluşturmaktadır.

Grafik tasarımda modüler ve sistematik yaklaşımın temelleri, ızgara (grid) sistemleri ve geometrik yapı prensiplerine dayanmaktadır. Bir metni olabildiğince farklı biçimlerde düzenlemek için modüler ızgara sistemi önemlidir. Modüler yapıda ızgara sistemini Ellen Lupton şöyle açıklamıştır: Modüler bir ızgara, soldan sağa uzanan dikey bölümlere ek olarak yukarıdan aşağıya tutarlı yatay bölümlere sahiptir. Bu modüller hem görsellerin hem de metnin yerleştirilmesini ve kırpılmasını belirler. 1950'ler ve 1960'larda Karl Gerstner, Emil Ruder ve Josef Müller-Brockmann gibi İsviçreli grafik tasarımcılar, burada gösterilen türde modüler ızgara sistemleri geliştirmiştir (Lupton, 2004: 151). Müller-Brockmann'ın ortaya koyduğu ızgara sistemi anlayışı, tasarım elemanlarının belirli oranlar ve hizalama ilkeleri doğrultusunda organize edilmesini sağlayarak görsel düzenin rasyonel bir temele oturtulmasını sağlamaktadır. Bu yaklaşımın kökenleri, harf biçimlerinin kare, daire ve üçgen gibi temel geometrik formlar üzerinden inşa edildiği erken tipografik sistemlere kadar uzanmaktadır (Müller-Brockmann, 1981: 161). Tarihsel süreçte harflerin belirli ölçü birimleri ve modüler parçalar aracılığıyla oluşturulması, günümüzdeki modüler tasarım anlayışının öncül örnekleri olarak değerlendirilebilir. Nitekim, farklı boyutlardaki geometrik formların bölünmesi, çoğaltılması ve yeniden birleştirilmesi yoluyla oluşturulan işaret sistemleri hem yapısal tutarlılığı hem de biçimsel çeşitliliği mümkün kılan bir tasarım mantığı ortaya koymaktadır. Bu sistematik yaklaşım, yalnızca görsel düzen sağlamanın ötesinde, karmaşık tasarım problemlerinin çözümünde etkin bir araç olarak işlev görmekte ve tasarımcıya kontrollü bir yaratıcılık alanı sunmaktadır. Dolayısıyla, modüler logotype tasarımlarında gözlemlenen parametrik çeşitlilik, tekrar eden modüller ve değişken yapı mantığı, ızgara temelli organizasyon ilkeleriyle doğrudan ilişkilidir ve çağdaş tasarım pratiklerinde algoritmik üretim süreçleriyle birlikte daha da gelişmiş bir form kazanmaktadır (Müller-Brockmann, 1981: 160-165).

Dijital medya kuramı bağlamında Lev Manovich (2001), yeni medyayı yalnızca teknolojik araçların çeşitlenmesiyle açıklamak yerine, üretim mantığındaki dönüşüm üzerinden tanımlamaktadır. Manovich'e göre (2001: 19-26) yeni medya, bilgisayar temelli sistemler aracılığıyla üretilen ve işlenen bir yapı olup, geleneksel medyadan temel olarak sayısal temsil, modülerlik, otomasyon ve değişkenlik gibi özellikleriyle ayrılmaktadır. Bu çerçevede tüm görsel ve işitsel içerikler sayısal verilere dönüştürülmekte; böylece tasarım, matematiksel

olarak tanımlanabilir ve algoritmalar aracılığıyla yeniden üretilebilir bir niteliğe kavuşmaktadır. Manovich'in (2001: 30-31) ortaya koyduğu modülerlik ilkesi, dijital tasarımın birbirinden bağımsız ancak birlikte çalışan parçalardan oluştuğunu ifade etmektedir. Bu yapı, tasarım bileşenlerinin ayrı ayrı düzenlenebilmesine ve farklı kombinasyonlarla yeniden oluşturulabilmesine olanak tanımaktadır. Buna paralel olarak otomasyon, tasarım süreçlerinin belirli kurallar ve algoritmalar aracılığıyla insan müdahalesi olmaksızın üretilebilmesini mümkün kılarken; değişkenlik *(variability)* ilkesi, tek bir tasarımın sabit bir form yerine çok sayıda farklı versiyonunun üretilebileceğini ortaya koymaktadır (Manovich, 2001: 36). Bu durum, dijital tasarımın durağan bir nesne olmaktan çıkıp, dinamik ve sürekli dönüşebilen bir sistem haline gelmesini sağlamaktadır. Bu bağlamda, modüler logotype tasarımları Manovich'in tanımladığı yeni medya ilkeleriyle doğrudan örtüşmektedir. Logotypeların modüler bileşenler üzerinden kurgulanması, parametrik değişkenler aracılığıyla farklı varyasyonlar üretebilmesi ve dijital ortamlara uyum sağlayabilmesi, tasarımın algoritmik bir sistem olarak ele alındığını göstermektedir. Dolayısıyla, çağdaş logotype tasarımlarında gözlemlenen bu esnek ve üretken yapı, yeni medyanın sunduğu olanaklar doğrultusunda gelişen bir tasarım paradigması olarak değerlendirilebilir.

Araştırmanın temel amacı, dijitalleşmenin etkisiyle grafik tasarım alanında ortaya çıkan esnek, çok biçimli ve değişken kimlik yapılarının kurumsal iletişimde nasıl bir rol oynadığını ortaya koymaktır. Bu bağlamda yapılan araştırmalar incelendiğinde genellikle dinamik marka sistemlerine rastlanmaktadır. Hsu (2013: 41), yaptığı araştırmada dinamik marka kimliği örneklerini etkileşimli tasarım estetiği bağlamında inceleyerek bu kimlikler arasında tanıma, işlevsellik ve estetik/duygusal deneyim açısından bir sınıflandırma yapmıştır. Guida (2014: 121), görsel kimlik tasarımlarda algoritma ve kod tabanlı sistemleri incelemiştir. Cunha ve diğerleri (2021: 91), dinamik görsel kimliklerin geleneksel (statik) kimliklerden nasıl ayrıştığını ve özellikle esnekliğin (flexibility) bu kimliklerde hangi varyasyon mekanizmalarıyla üretilebileceğini incelemektedir. Fekete (2022: 43), pazarlama ve tasarım alanlarının kesişimindeki bu sınır bölgede disiplinlerarası tartışmayı ve bilimsel incelemeyi teşvik etmek amacıyla, betimsel yöntemle üretken *(generative)* türde dijital dinamik görsel kimliklerin özelliklerini ele almıştır. Dinamik görsel kimlik tasarımlarıyla ilgili yapılmış bu araştırmalarda modüler yönün incelenmediğine rastlanmıştır. Bunlardan farklı olarak Rebelo ve diğerleri (2022), hesaplamalı ve üretken tasarım yaklaşımlarının dinamik görsel kimlik tasarımında kullanımı üzerine odaklanarak otomatik ve yarı otomatik üretim yöntemleriyle harf formları üretebilen, görsel tutarlılığı koruyan bir üretken tasarım sisteminin geliştirilmesini ve bu sistemin tasarım sürecine katkılarını incelemiştir. Bu araştırma modüler özellik taşımaktadır. Ancak sadece harf formlarında modüler yapının üretken sistemleriyle üretilmesine odaklanmıştır. Tümüyle logotype sistemini ya da birden fazla örnek analizini içermemektedir. Bu araştırmalar içerisinde çalışmaya ışık tutan çalışma Faria ve Fernandes'e aittir. Faria ve Fernandes (2019: 23) modüler kimlik sistemi üzerine bir tasarım önerisi geliştirmiş, anketler ve görüşlerle tasarımı desteklemiştir. Literatür tarama verisi kavram ve örnek analizi katkı sağlayıcı olmamasına rağmen geliştirdiği örnekle modüler kimliğin yapısının çözümünde yarar sağlamaktadır.

Araştırmada yer alan örnekler kapsamında dinamik logotypelar ana başlığı altında modüler olma özelliği gözetilmiştir. Görsel örnekler üzerinden yapılan analizlerde logoların biçimsel yapıları, varyasyon üretme düzeyleri, bağlamsal esneklikleri ve kullanıcıyla kurdukları etkileşim incelenecektir. Ayrıca seçilen örneklerde kullanılan tasarım sistemlerinin teknik altyapısı, üretim süreçleri ve medya uyarlanabilirliği gibi parametreler de değerlendirme sürecine dahil edilmektedir. Çalışmanın sonucunda, modüler yapıya sahip dinamik logotypeların, görsel kimliğin günümüz dijital ortamına nasıl adapte edilebileceğine dair kuramsal bir çerçeve sunulmakta; ayrıca bu yaklaşımın markalar için yenilikçi, esnek ve etkileşimli bir kimlik stratejisi geliştirmede etkili bir araç olabileceği ortaya konulmaktadır. Esnek yapıları sayesinde farklı mecralara ve hedef kitlelere kolaylıkla uyum sağlayabilen bu sistemlerin, marka farkındalığı ve etkileşimini artırmada etkili olduğu görülmektedir. Ayrıca algoritmik süreçlerle desteklenen üretken tasarım yaklaşımlarının, markaların dinamik yapısını yansıtmakla kalmayıp aynı zamanda yaratıcı üretim süreçlerini daha verimli ve sürdürülebilir kıldığı saptanmıştır. Elde edilen bulgular doğrultusunda, gelecekte modüler ve üretken sistemlerin grafik tasarım eğitimi, marka yönetimi ve dijital iletişim stratejilerinde daha yaygın olarak yer alacağı öngörülmektedir. Bu araştırmanın tasarımcılar, markalar ve akademisyenler için dinamik kimlik sistemlerinin potansiyelini ortaya koyan uygulanabilir ve yönlendirici nitelikte bir kaynak olması beklenmektedir.

YÖNTEM

Bu çalışma, modüler logotype tasarımlarının tarihsel gelişimi, tasarım parametreleri ve çağdaş grafik tasarım uygulamaları içerisindeki yerini incelemek amacıyla nitel araştırma yöntemi çerçevesinde yürütülmüştür. Gözlem, görüşme ve doküman analizi gibi nitel veri toplama yöntemlerinden yararlanan nitel araştırma, daha önce fark edilmemiş ya da tanımlanmamış problemlerin kavranmasına olanak tanırken, bu problemlere ilişkin doğal olguların gerçekçi bir biçimde ele alınmasına yönelik öznel ve yorumlayıcı bir süreci ifade etmektedir (Seale, 1999'den aktaran Baltacı, 2019: 367-369). Araştırma sürecinde betimsel analiz ve örnek olay incelemesi tekniklerinden yararlanılmıştır.

Bu çalışma, nitel araştırma yaklaşımları çerçevesinde betimleyici tarama modeline dayanmaktadır. Tarama modeli, mevcut bir olgunun geçmişteki ya da güncel durumunu ortaya koymayı amaçlayan bir yöntemdir (Karasar, 2007: 77). Çalışmada, alan yazını taraması yapılarak modüler tasarım sistemlerinin kuramsal temelleri, grafik tasarım tarihindeki yeri ve üretken tasarım yaklaşımları ile olan ilişkisi ortaya konmuştur. Ayrıca nitel araştırma yöntemlerinden, araştırılması hedeflenen olgular hakkında bilgi veren belge ve dokümanların çözümlenmesini içeren doküman analizi (Yıldırım & Şimşek, 2021: 187) kullanılarak konuya ilişkin yazılı ve görsel kaynaklar sistematik biçimde değerlendirilmiştir. Örneklem seçimi, amaçlı örneklem yöntemi doğrultusunda gerçekleştirilmiştir. Bu kapsamda, ulusal ve uluslararası düzeyde öne çıkan, modüler ve/veya üretken tasarım özellikleri taşıyan logotype örnekleri çalışma kapsamına dahil edilmiştir. Seçilen örnekler; dijital ortamlarda uygulanabilirlik, varyasyon üretme kapasitesi ve tasarım sistemi açısından temsil gücü yüksek çalışmalar arasından belirlenmiştir.

Analiz birimi, her bir logotype tasarımının yapısal ve kavramsal özellikleri olarak tanımlanmıştır. Bu doğrultuda logotypelar; ızgara sistemi, modüler yapı, parametrik/algoritmik değişkenlik, medya uyarlanabilirliği ve tasarım yaklaşımı gibi ölçütler çerçevesinde incelenmiştir. Bu ölçütler, grafik tasarım kuramı ve dijital tasarım yaklaşımlarına dayalı olarak belirlenmiştir. Görsel analiz sürecinde, logotypeların biçimsel özellikleri kadar üretim mantıkları ve bağlamsal kullanımları da dikkate alınmıştır. Tasarımcıya ait açıklamalar, proje metinleri ve varsa röportaj içerikleri analiz sürecine dahil edilerek değerlendirme derinleştirilmiştir. Sınırlılıklar açısından çalışma, seçilen örneklemle sınırlıdır ve genellenebilirlik iddiası taşımamaktadır. Ayrıca analizler, araştırmacının yorumlayıcı yaklaşımı çerçevesinde gerçekleştirilmiş olup, farklı kuramsal perspektiflerle farklı değerlendirmeler yapılabilir. Bu metodolojik yaklaşım doğrultusunda, modüler logotype sistemlerinin günümüz dijital iletişim ortamlarına entegre oluş şekli, tasarım süreçlerinde dönüşüm yaratma usulü ve markalaşma stratejilerine sağladığı katkı ortaya konmuştur.

BULGULAR

Bu çalışma kapsamında seçilen modüler logotype örnekleri; tasarım sistemi, yapı mantığı, uygulama alanı ve dijital medya uyumluluğu gibi ayırt edici kriterler doğrultusunda incelenmiştir. Örneklem olarak belirlenen logotype tasarımları, görsel dokümantasyon, literatürdeki kuramsal açıklamalar ve varsa tasarımcılara ait beyanlar veya röportaj içerikleri temelinde karşılaştırmalı biçimde analiz edilmiştir. İnceleme sürecinde, her bir logotype ızgara yapısı, modül tekrarı, parametrik çeşitlilik ve algoritmik yapı gibi formel bileşenler açısından değerlendirilmiş; ayrıca dijital estetik unsurlar ve çağdaş grafik tasarım pratikleriyle kurduğu ilişkiler yorumlanmıştır. Tüm bu analizler, modüler logotype sistemlerinin çağdaş iletişim tasarımı içinde nasıl konumlandığını ve markalaşma süreçlerine nasıl katkı sağladığını ortaya koymak amacıyla yürütülmüştür.

Tablo 1. Modüler logotype örneklerinin karşılaştırmalı analizi

Örnek Çalışma	Izgara (Grid) Sistemi	Modüler Yapı	Parametrik / Algoritmik Yapı	Uyarlanabilirlik	Tasarım Yaklaşımı
IDTV	Belirgin ızgara	Piksel modüller	Parametrik varyasyon	Yüksek	Dijital estetik
TV Asahi	Serbest sistem	Blok modüller	Veri tepkili (reaktif)	Çok yüksek	Etkileşimli kimlik
Casa da Música	Geometrik yapı	Çokgen modüller	Yazılım tabanlı üretim	Yüksek	Kişiselleştirilebilir
Tess Management	Izgara tabanlı	Kare ızgara üzerine yerleştirilen farklı şekiller	Kombinasyon	Yüksek	Sistematik varyasyon
Nordkyn	Özel ızgara	Çokyüzlü form	Gerçek zamanlı veri	Çok yüksek	Veri odaklı tasarım

	(Örümcek ağı şeklinde)				
MIT Media Lab (2011)	Geometrik yapı	Geometrik modüller ve Renk geçişleri	Algoritmik üretim ve kontrollü raslantısallık	Çok yüksek	Üretken tasarım
MIT Media Lab (2014)	7x7 Izgara	Glif modüller	Algoritmik üretim	Çok yüksek	Sistematik/ parametrik
Bordeaux	Izgara tabanlı	Nokta + çizgi	Parametrik bağlantı	Yüksek	Ağ temelli yapı
Móra	Özel ızgara (Kurallar ile şekillenen)	Üçgen modüller	Sınırlı varyasyon	Yüksek	Oyun temelli
DDW 2023	Izgara tabanlı	Çeyrek daire ve dikdörtgen modüller	Üretken tipografi	Çok yüksek	Deneysel sistem
Muse Group	Geometrik yapı	Geometrik modüller	Üretken sistem	Çok yüksek	Ritmik/algoritmik

Tablo 1'de bulgular karşılaştırmalı analizin sistematik bir çerçevede yürütülebilmesi amacıyla belirli ölçütler doğrultusunda değerlendirilmiştir. Analiz sürecinde öncelikle logotypeların yapısal organizasyonunu ortaya koymak amacıyla ızgara sistemi incelenmiş; bu doğrultuda tasarımların belirli bir düzen ve hizalama sistemi içerip içermediği değerlendirilmiştir. İkinci olarak, logotype tasarım bileşenlerinin parçalanabilirliği ve yeniden kombinasyon oluşturabilmesi bağlamında modüler yapı ele alınmıştır. Üçüncü ölçüt olarak, tasarımların önceden tanımlanmış kurallar, parametreler veya veri girdileri doğrultusunda varyasyon üretme kapasitesini ifade eden parametrik/algoritmik yapı değerlendirilmiştir. Dördüncü olarak, logotypeların farklı iletişim ortamlarına uyum sağlayabilme düzeyini belirlemek amacıyla medya uyarlanabilirliği ölçütü kullanılmıştır. Bu ölçüt; tasarımın farklı mecralarda kullanılabilirliği, ölçeklenebilirliği dikkate alınarak değerlendirilmiştir. Son olarak, her bir logotypeların kavramsal ve biçimsel üretim mantığını ortaya koymak amacıyla tasarım yaklaşımı ölçütü ele alınmıştır. Bu ölçüt kapsamında, tasarımların üretken *(generative)*, parametrik, etkileşimli, veri odaklı ya da deneysel gibi farklı tasarım paradigmaları içerisinde nasıl konumlandığı analiz edilmiştir.

Dinamik Logotype

Günümüz görsel iletişim ortamında, imgelerin sürekli tekrarlandığı ve bilgi akışının yüksek hızda gerçekleştiği bir bağlamda, markaların ayırt edici bir kimlik oluşturması giderek zorlaşmaktadır. Gerçekliğin çok katmanlı bir yapıya büründüğü bu süreçte tasarım, yalnızca görsel unsurları düzenleyen bir araç olmanın ötesine geçerek; anlam üretme, anlatı kurma ve kullanıcıyla duygusal bağ geliştirme gibi işlevler üstlenmektedir. Bu doğrultuda, markaların sıradanlaşan görsel ifadenin dışına çıkarak özgün, tutarlı ve bağlamsal olarak güçlü bir iletişim dili geliştirmesi, çağdaş tasarım araştırmalarının ve uygulamalarının temel sorun alanlarından biri hâline gelmiştir. Böylece markaların özgün ve etkileyici yüzü olan görsel kimlik tasarımları, hedef kitleyle kurulan duygusal ve görsel bağın en güçlü temsilcisi olarak teknolojik ve kültürel dönüşümler doğrultusunda yeniden yapılandırılmaktadır. Nitekim duygusal markalama, tüketiciler ile markalar arasında bir bağ kurar, duygusal ihtiyaçları karşılar ve kimlik ile aidiyet duygusu sağlar (Saeidi & Tabrizi, 2020: 4). Bu doğrultuda, modüler logotypelar; bireylerin çoklu duyularına hitap edebilen yapıları sayesinde yalnızca görsel değil, aynı zamanda psikolojik ihtiyaçlara da yanıt verebilecek biçimde tasarlanabilme potansiyeline sahiptir. Böylelikle tasarım disiplininde hem biçimsel açıdan zenginlik hem de içeriksel çeşitlilik görülmektedir.

İnsan ihtiyaçlarının giderek çeşitlenmesi ve bireylerin estetik algılarındaki artış, logo tasarımında yalnızca işlevselliği değil, aynı zamanda insan merkezli tasarım anlayışını da kaçınılmaz bir gereklilik hâline getirmiştir. Neticede, çağdaş tasarım anlayışının daha çeşitli, yenilikçi ve özgün biçimlere yönelmesi doğru olacaktır.

Schaefer (2014), değişken yapılarla karakterize edilen logotype tasarımlarını literatürde *dinamik logolar (dynamic logos)* olarak tanımlamakla birlikte; bu tür kimlik yapılarının *değişken logolar (mutable logos), esnek logolar (flexible logos), logo serileri (logo series)* veya *logo aileleri (logo families)* gibi farklı kavramlarla da adlandırıldığını belirtmektedir. Bu bağlamda, Bruce Mau da günümüz tüketicisinin her gün binlerce simgesel uyarana maruz kaldığını vurgulayarak sabit ve durağan görsellerin bu kalabalık içerisinde dikkat çekiciliğini yitirdiğini savunmaktadır. Mau'ya göre, "hareket etmeyen bir imge yok olur"; bu nedenle yalnızca değişime açık, yenilenebilir ve bağlama göre çeşitlenebilen görsel kimlikler izleyicinin zihninde kalıcılık elde edebilmektedir (Rawsthorn, 2007). Bu noktada, dinamik logolar; daha değişken, esnek ve çok boyutlu görsel formlar aracılığıyla, bireysel beklentilere yanıt verme konusunda geleneksel logolara kıyasla çok daha etkili

bir alternatif sunmaktadır. Dolayısıyla, insan odaklı tasarım anlayışının gelişimi, dinamik logoların da biçimsel ve kavramsal olarak evrilmesine katkı sunan temel faktörlerden biri olarak değerlendirilmektedir (Duhan, 2017: 64; Wang, 2020: 13; Jing, 2019: 21; Zhou, 2018: 7-11).

Dinamik bir logo tasarımı oluşturmanın ilk adımı, kendi başına anlam taşıyabilen, güçlü bir temel logoyu oluşturmaktır. Bu temel yapı, markanın kimliğini net bir şekilde yansıtmalı ve tüm varyasyonların dayandığı sabit referans noktası olmalıdır. Ardından, bu yapı üzerine farklı görsel çeşitlilikler ve dönüşebilir unsurlar eklenerek dinamik tasarım ögeleri geliştirilebilir. Bu kapsamda; zamanla değişen veya gradyanlarla zenginleştirilen renk paletleri, logonun farklı görsel stillerde (örneğin gerçekçi, çizgi film tarzı veya eskiz olarak) sunulması gibi biçimsel değişiklikler kullanılabilir. Ayrıca, hareketli unsurlar (örneğin logonun merkezinin dönmesi), mevsimsel ya da kültürel temalara göre şekillenen versiyonlar ve ışık-gölge geçişleri gibi animatif dokunuşlar da dinamik yapıyı güçlendiren diğer seçenekler arasında yer almaktadır. Tüm bu varyasyonlar, markanın hedef kitleyle farklı platformlarda ve bağlamlarda daha esnek bir iletişim kurmasını sağlar. Ancak burada dikkat edilmesi gereken en önemli unsur, logonun bu değişken yapısına rağmen markanın temel değerleriyle olan bağını koparmamasıdır. Dinamik bir logo, dönüşüm ve çeşitlenmeye açık bir sistem olmasına rağmen tanınırlığını ve marka kimliğiyle olan ilişkisini kaybetmemelidir. Dolayısıyla, değişkenlik ile tutarlılık arasındaki dengeyi kurmak, başarılı bir dinamik logo tasarımının temelini oluşturmaktadır (Dodhia, 2024). Hsu (2013: 42), Wang'ın (2005) sembollerin değiştirilebilirliğine ilişkin görüşlerini şu şekilde aktarmaktadır: "Sembollerin değiştirilebilirliği açısından bakıldığında, bir kimlik sisteminde sembolik ifadenin her bir ögesi yüksek derecede sabit olabileceği gibi rastlantısal olarak da değiştirilebilir. Ancak dinamik bir stil, çoğu zaman yaratıcı bir estetik oluşturur ve özgün bir çekicilik sunar" (Wang, 2005'ten aktaran Hsu, 2013: 42).

"Dinamik logolar, çok yönlülük, kişiselleştirme ve geleceğe uyum gibi avantajlar sunarak markaların hem görsel açıdan dikkat çekici kalmasını hem de farklı bağlamlara uyum sağlamasını mümkün kılar" (Rao, 2024). Örneğin, Google'ın özel günlerde değiştirdiği Doodle logoları, yerelleştirme ve kültürel bağlamlara uyum konusunda etkili bir örnek teşkil ederken; Coca-Cola ve Disney gibi markalar ise dinamik logolar aracılığıyla duygu aktarımı ve kullanıcı bağlılığı yaratmaktadır. Yalur'a göre (2020: 2797) dinamik logolar, renk, görsel unsur ve sembollerin anlamlı değişimleri aracılığıyla markanın tüketici karşısında beklenmedik ve dikkat çekici biçimde konumlanmasını sağlarken, bu hareket temelli yapı markanın akılda kalıcılığını artırmaktadır. Dinamik logotype tasarımları, geleneksel grafik tasarımın sınırlarını aşarak, teknolojik olanakların sunduğu araçlarla yeniden tanımlanmaktadır. Bu bağlamda, yazılım tabanlı sistemler, algoritmalar, görsel, video ve metin verilerinin işlenmesi, parametrik tasarım yaklaşımları ve veri odaklı etkileşim mekanizmaları, dinamik logoların teknik altyapısını oluşturan temel bileşenlerdir. Bu altyapılar sayesinde bir logonun biçimi, rengi, hareketi veya bileşenleri; zaman, kullanıcı etkileşimi, konum, tarih, sosyal medya verisi ya da diğer dışsal parametrelere bağlı olarak otomatik biçimde değiştirilebilir hale gelmektedir. Böylece logolar, yalnızca temsil ettikleri markanın sabit bir sembolü olmakla kalmayıp aynı zamanda canlı, değişken ve bağlamsal olarak duyarlı birer iletişim aracına dönüşürler. Dinamik logotype sistemlerinde sıklıkla kullanılan üretken tasarım algoritmaları, görsel çeşitliliği ve kişiselleştirmeyi mümkün kılarak markaların dijital çağda daha esnek ve çok katmanlı bir kimlik sunmasına olanak tanımaktadır.

Modüler Logotype

Günümüzde marka tasarımı, değişen toplumsal, teknolojik ve kültürel dinamiklere uyum sağlayabilen esnek ve çok katmanlı stratejiler gerektirmektedir. Bu bağlamda çağdaş marka kimliği yaklaşımları; esneklik, etkileşim, algoritmik çeşitlilik ve bağlamsal temsil gibi çok boyutlu tasarım anlayışlarının bir araya gelmesiyle şekillenmektedir. Özellikle dinamik logotype sistemleri, bağlama göre biçim, renk ve animasyon gibi unsurlarının değiştirilebilmesi yoluyla esnek bir kimlik yapısı sunmaktadır. Bunun yanı sıra üretken tasarım yaklaşımları, yapay zekâ, algoritmalar ve veri odaklı girdiler aracılığıyla çok sayıda varyasyonun üretilmesine olanak tanımaktadır. Kişiselleştirilmiş kimlik sistemleri, kullanıcıya ya da kurumsal birimlere göre farklılaşan görsel çıktılar üretirken; hareketli logotype uygulamaları, görsel kimliğin animasyonlu biçimlerde sunulmasını mümkün kılmaktadır. Değişken tipografi sistemleri, yazı karakterlerinin bağlamsal olarak uyarlanabilir olmasını sağlarken; zaman tabanlı kimlik sistemleri ise kimlik unsurlarının mevsimsel, zamansal ya da gündem odaklı biçimde dönüşmesine imkân tanımaktadır. Son olarak, sesli ve etkileşimli kimlik ögeleri, sesli asistanlar, dijital uygulamalar ve sosyal medya entegrasyonları aracılığıyla çok duyulu ve etkileşim temelli

marka deneyimlerinin geliştirilmesini desteklemektedir. Tremayne ve Dunwoody (2001: 115), etkileşimi iki yönlü mesaj alışverişine dayalı bir iletişim süreci olarak tanımlamakta ve bu süreçte en az iki tarafın hem gönderici hem de alıcı rolünü üstlenmesi gerektiğini vurgulamaktadır. Araştırmacılara göre, yalnızca tek yönlü ya da sınırlı tepkisel geri bildirim içeren iletişim biçimleri tam anlamıyla etkileşimli olarak değerlendirilemez. Etkileşimin temel koşulu, taraflar arasında değiş tokuş edilen mesajların birbiriyle ilişkili olması ve karşılıklı olarak birbirine yanıt vermesidir. Ayrıca mesaj alışverişinin eşzamanlı ya da eşzamansız olması, etkileşimin varlığını ortadan kaldırmamakta; bu durum daha çok kullanılan medya kanalının bir özelliği olarak ele alınmaktadır. İnsan müdahalesi olmadan ya da minimum müdahaleyle, önceden tanımlanmış kurallar, algoritmalar ya da yapay zekâ destekli sistemler aracılığıyla tasarımın kendi kendine üretilmesini sağlayan üretken tasarım *(generative design)* olarak adlandırılan tasarım yaklaşımları hem sürdürülebilir hem de yenilikçi kimlik sistemlerini ortaya çıkarmaktadır. Çağdaş tasarım ve iletişim çözümleri arasında modüler logotype tasarımları, markalaşmanın hızla değişen dinamiklerine uyum sağlayan çözümlerden biridir.

Öncelikle modüler kelimesinin anlamı incelendiğinde modülerliğin karmaşık sistemlerin tasarımı ve yönetiminde etkili bir yaklaşım olduğu görülmektedir. Diğer bir deyişle, modüller terimi daha büyük bir sistem içinde yapısal olarak birbirinden bağımsız ancak birlikte çalışan birimleri temsil etmektedir (Baldwin & Clark, 2000: 63). Modular kelimesinin bilinen en erken kullanımı 1810'lara kadar dayanmaktadır. Oxford English Dictionary (OED) tarafından belgelenen en erken örnek, 1815 yılına ait, matematikçi Charles Hutton'ın bir sözlüğünde yer almaktadır (Oxford English Dictionary, 2002). Sözlük tanımına bakıldığında "parçalı, belli bir ölçüye dayanarak oluşturulan (tasarım, yapı)" olarak ifade edilmektedir (Güncel Türkçe Sözlük, t.y.). Tanımlar incelendiğinde modülerliğin bir sistemin bileşenlerinin ayrıştırılabilir ve yeniden birleştirilebilir olma derecesini ifade ettiği görülmektedir. Sahip olduğu yapı sayesinde sistem, esneklik kazanarak farklı kullanım senaryolarına kolayca uyum sağlayabildiği anlaşılmaktadır. Modülerlik, yalnızca mühendislik alanlarında değil; grafik tasarım, yazılım geliştirme, mimarlık ve organizasyonel sistemler gibi birçok farklı disiplinde esneklik, yeniden kullanım ve ölçeklenebilirlik gibi avantajlar sunan temel bir tasarım ilkesi olarak değerlendirilmektedir. Özellikle tasarım ve marka kimliği bağlamında, modülerlik; görsel ögelerin sabit bir düzenden ziyade, belirli kurallar dâhilinde çeşitlendirilebilmesine imkân tanımaktadır. Böylece hem tutarlılık hem de yaratıcılık aynı anda sürdürülebilir hale gelmektedir.

Modüler logotype hem dinamik hem de kimi zaman algoritmik/üretken logolarla kesişen ama kendi içinde daha sistematik ve yapısal bir yere sahiptir. İncelenen örneklerde güncel yaklaşım olarak üretken tasarım örnekleri hakimdir. Patrik Hübner, markaları için yaptığı işlerde geleneksel tasarımdan üretken tasarıma ilk geçiş yapanlardandır. Veriler tarafından yönlendirilen ve algoritmalar ile programlar tarafından biçimlendirilen üretken tasarım sistemleri, tasarıma alışılmadık bir anlayış getirerek tasarımcıları artık tasarım sürecinin uygulayıcıları olmaktan çıkararak, sistemin fikir üreten unsurları haline getirmiştir. Hübner bir röportajında üretken tasarımı "tıpkı yaşam gibi, anlamlı etkileşimler üzerine kurulu" bir sistem olduğundan bahsetmektedir. Böylelikle, üretken tasarım sistemlerinin sabit ve tekil çıktılar üretmekten ziyade, çevresel verilerle etkileşime girerek her seferinde farklı ve bağlama duyarlı sonuçlar ortaya koyan, dinamik ve evrimsel bir yapıya sahip olduğunu vurgulamaktadır (Pham & Lenze, 2023). Üretken tasarımda, tasarımcı fikirlerini kurallara dönüştürerek otomatik ve tekrar üretilebilir tasarımlar oluşturan programlar geliştirir. Bu sistemler, gerçek dünya verilerini kullanarak tasarım sürecini dışsal etkilerle dinamik hale getirir. Veri, sadece bir araç değil, aynı zamanda tasarımı yönlendiren anlamlı bir unsur haline gelir ve markanın hikâyesinin merkezinde yer alabilir (Borg, 2023).

Modüler logo; belirli parçalardan (modüllerden) oluşan ve bu parçaların farklı kombinasyonlarla bir araya getirilerek oluşturduğu, değiştirilebilir ama tanınabilir kimlik sistemini içermektedir. Genellikle aynı temel ızgara ya da yapı içinde, çeşitli versiyonlar oluşturmaktadır. Salem ve Abouelnage (2022: 177), "logo tasarımında parametre sisteminin kullanımı, logoya yönelik çekici ve çeşitli bir tasarım patlamasına yol açtı; bu da kurumların ve kuruluşların bu tür tasarımlara olan talebinin artmasına neden oldu. Çeşitlilik yolları ve parametrik modülasyon, dinamik logo tasarımında birçok tasarım çözümüne ve yeniliğe yol açtı" ifadesiyle parametrik sistemlerin grafik tasarımda, özellikle logotype tasarımı bağlamında sağladığı olanaklara dikkat çekmektedir. Parametre tabanlı yaklaşımlar sayesinde logolar artık sabit bir görsel öge olmaktan çıkmakta; değişken, uyarlanabilir ve çoğaltılabilir yapılara dönüşmektedir. "Tasarım patlaması" ifadesiyle, bu tekniklerin sunduğu biçimsel çeşitliliğin ve estetik zenginliğin, tasarım dünyasında geniş bir yaratıcı alan açtığı

vurgulanmaktadır. Bu da kurumların sadece kimliklerini temsil etmekle kalmayan aynı zamanda çağın gerektirdiği esnekliği ve güncelliği de taşıyan logotype tasarımlarını talep etmelerine neden olmuştur. Ayrıca, parametrik modülasyon ile oluşturulan dinamik sistemler, logonun farklı varyasyonlarla yeniden üretilebilmesini sağlamaktadır.

Modüler logotypeların, farklı mecralarda ve iletişim bağlamlarında esnek bir yapıda yeniden kurgulanabilir olması büyük önem taşımaktadır. Bu tür sistemlerde logo, sabit bir form yerine, modüller aracılığıyla farklılaştırılabilen bir yapı ortaya koymaktadır. Dolayısıyla, bir modüler logo hem basılı materyallerde (örneğin kartvizit, afiş, ambalaj) hem de dijital platformlarda (web sitesi, mobil uygulama, sosyal medya) tutarlılığını koruyarak yeniden üretilebilmelidir. Bu çok yönlü kullanım olanakları, logonun tek renkli bir versiyonla küçük ölçekte (örneğin bir kalem ya da e-posta imzasında) ya da detaylı bir yapıyla büyük formatlarda (örneğin billboard, video jeneriği) etkili bir şekilde görünür olmasına olanak sağlamaktadır. Modüler logotype tasarımı, her bir bileşenin kendi içinde tanımlı kurallara bağlı olarak çeşitlenmesine imkân tanıdığı için marka kimliğinin hem bütüncül hem de kişiselleştirilebilir biçimde temsil edilmesini sağlamaktadır. Bu da markanın farklı temas noktalarında hem tanınabilirliğini hem de bağlamsal uyarlanabilirliğini artırarak görsel iletişimde sürdürülebilir bir etki ortaya koymaktadır. Rebelo ve diğerleri (2022: 6), modüler logotype tasarımı kuramsal bir tanım üzerinden değil, görsel kimliğin önceden tanımlanmış modüller, ızgara yapısı ve üretken süreçler aracılığıyla otomatik olarak bir araya getirildiği hesaplamalı bir sistem üzerinden ele almaktadır. Faria ve Fernandes'in (Bone, 2017'den aktaran 2019: 24) aktardığı bilgilere göre, modüler kimlikler, bir grafik kimliği oluşturan bazı ögelerin ayrıştırılarak yeniden bir araya getirilmesine dayanan sistemlerdir. Bu tür kimliklerde sabit ögeler korunmakta, bu ögelerin kullanımına ilişkin farklı kombinasyon ve uygulama seçenekleri sunulmaktadır. Ancak modüler kimlik sistemlerinde, mevcut görsel dil çerçevesi korunur ve kimlik sistemine yeni unsurlar eklenmez. Aynı bağlamda Faria ve Fernandes (van Nes, 2014'ten aktaran 2019: 24), dinamik kimliklerin ise sabit ve esnek ögelerin birlikte çalıştığı yapılar olduğunu belirtmektedir. Sabit ögeler markanın tanınabilirliğini desteklerken, esnek ögeler kimliğin daha canlı, uyarlanabilir ve bağlamsal olarak değişken olmasını sağlamaktadır. Bu esnek yapı, dış girdilerin kimlik sistemine dâhil edilmesine olanak tanıyarak markanın mesajlarını hedef kitleye göre yeniden şekillendirmesine ve zaman içinde gelişmesine imkân tanır. Bununla birlikte, artan esneklik, kimliğin istenilen yönde evrilmesini sağlamak adına daha yüksek düzeyde dikkat ve kontrol gerektirmektedir.

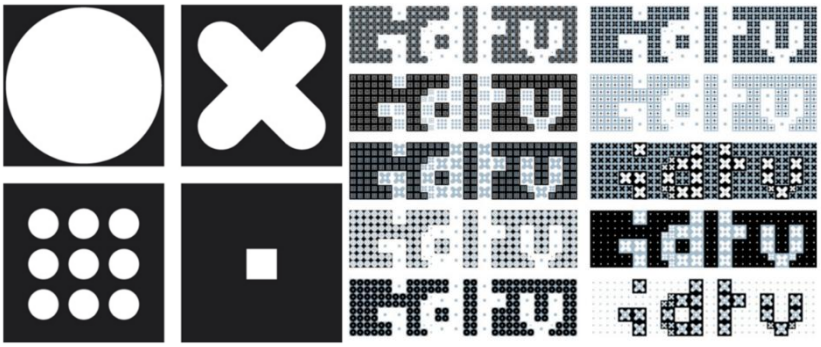
Tablo 1. Modüler logotype ve uyarlanabilir *(adaptive)* logotype arasındaki temel farklılıklar

Modüler Logotype	**Uyarlanabilir (Adaptive) Logotype**
Modüllerden oluşur.	Kullanım yerine göre değişir.
Platforma göre uyarlanabilmesi için bütünü oluşturan parçaları yer ve renk değişebilir.	Platforma göre uyarlanabilmesi için şekil değişikliğine sahiptir.
Görsel varyasyonlarda estetik temel amacıdır.	Dijital ve farklı medya platformlarında işlevsel olmak temel amacıdır.

Modüler logotype tasarımları**,** dinamik sistemler içerisinde yer almakla birlikte sıklıkla uyarlanabilir logolarla karıştırılmaktadır. Her iki yaklaşım, esnek ve bağlamsal temsile açık yapılar sunsa da teknik altyapıları ve işlevsel amaçları bakımından ayrışmaktadır. Modüler logolar, önceden tanımlı modüller aracılığıyla estetik çeşitlilik sunarken marka bütünlüğünü korumayı hedefler. Buna karşın uyarlanabilir logolar, farklı dijital platformlara işlevsel uyum sağlamayı amaçlayarak dönüşümünü daha çok bağlamsal ihtiyaçlara göre gerçekleştirir. Dolayısıyla modüler sistemler içsel yapısal esneklik üzerine kurulu iken, uyarlanabilir sistemler dışsal koşullara tepki veren bir yapı sergiler. Bu ayrım, tasarım sürecinde yaklaşım tercihini belirlemede belirleyici olmaktadır.

IDTV'nin piksel tabanlı modüler görsel kimlik tasarımı, modüler logotype sistemlerinin erken ve öncü örneklerinden biri olarak kabul edilmektedir. 2001 yılında Hollandalı Lava Design stüdyosu tarafından geliştirilen bu tasarım, hem dinamik medya üretim süreçlerini yansıtmakta hem de dijital iletişim araçlarına uyum sağlamaktadır. Çalışma, 2007 yılında Dutch Design Awards'ın iletişim kategorisine aday gösterilmiştir (Görsel 1) (Dutch Design Awards, 2007). Tasarımda tüm karakterler belirli bir ızgara sistemi üzerinde konumlandırılmış, bu da parametrik ve algoritmik tasarım süreçlerinin karakteristik bir özelliği olarak öne çıkmıştır. "X", daire ve kare gibi temel geometrik formlar modüller olarak tekrar edilerek sistemin yapı taşlarını oluşturmuştur. Her satır ve sütundaki görsel farklılıklar, önceden tanımlanmış kurallar çerçevesinde

üretilmiş programatik varyasyonlara işaret etmektedir. Boyut, doluluk ve yoğunluk gibi parametrelerin kontrollü değişimi ise tasarımın parametre tabanlı bir yapıyla üretildiğini göstermektedir. Bu yaklaşım, logotypeların hem sabit hem de değişken olabilen bir kimlik taşımasını mümkün kılmakta; tanınabilirliği korurken farklı bağlamlara uyarlanabilir bir esneklik sağlamaktadır. Pikseller, ekran temelli görselliğin yapıtaşı olarak markanın dijital kültürle olan ilişkisini vurgulayan bir görsel DNA işlevi görmektedir. Dört temel piksel formunun çeşitli kombinasyon ve ölçeklendirmelerle bir araya getirilmesi sayesinde, sistem sınırsız sayıda varyasyon üretimine olanak tanımaktadır. Böylece logotype, farklı çözünürlük ve medya ortamlarında etkisini sürdürebilecek dijital estetik bir yapıya kavuşmaktadır.



Görsel 1. Lava Design, *IDTV logotype tasarımı,* 2001

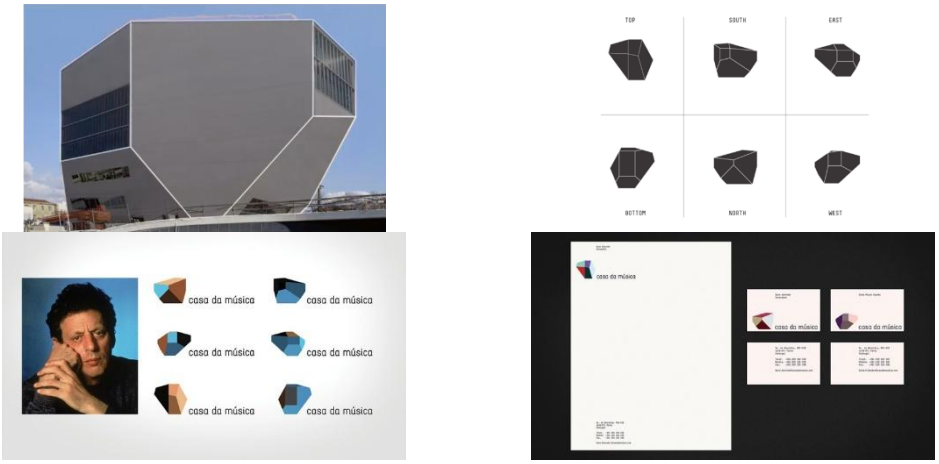
TV Asahi'nin 2002'de yenilenen marka kimliği, çağdaş dinamik kimlik tasarımına öncülük eden bir örnektir. Tomato Stüdyosu tarafından geliştirilen bu sistem, "reaktif kimlik" yaklaşımıyla, ses girdilerine tepki veren üç boyutlu içerik blokları üzerinden yapılandırılmıştır. Yayın sırasında sesle tetiklenen bu sistem, logonun renk ve hareketlerini anlık olarak değiştirerek çevresiyle etkileşim kurar. Böylece TV Asahi'nin logosu, sabit bir görselden çıkarak dinamik ve yaşayan bir forma dönüşür. %300 oranında artan kanal farkındalığı bu dönüşümün stratejik etkisini ortaya koyarken; açık hava reklamlarından dijital ekranlara kadar çok çeşitli uygulama alanlarında başarıyla kullanılması, sistemin işlevsel gücünü göstermektedir. Ayrıca Victoria & Albert Museum tarafından "tüm zamanların en önemli 100 ticari sanat eseri" arasında gösterilmesi, bu kimliğin yalnızca görsel değil, kültürel bir değer de taşıdığını kanıtlamaktadır (Dirkvandooren, 2002) (Görsel 2). Tasarımda yer alan renkli, yarı saydam çubuklar konum, uzunluk, kalınlık ve renk gibi değişkenler üzerinden yeni düzenlemelerle farklı kompozisyonlar akışkan**,** açık sistemli bir logotype anlayışına işaret etmektedir. Bu da onu bir parametrik tasarım sistemi hâline getirmektedir. Her yeni uygulama, sistemin içinde kalarak benzersiz ama tanınabilir bir varyasyon üretmektedir. Örneğin; TV programlarında mavi tonlar kullanılırken, kamuya açık alanlarda sıcak renkler tercih edilmiştir. Nitekim, farklı izleyici deneyimlerine uyum sağlayan duyusal çeşitlilik yaratılması muhtemel amacı olarak görülmektedir.

Görsel 2. Londra Tomato Tasarım Stüdyosu, *TV Asahi logotype tasarımı*, 2002

Modüler logotype tasarımlarının ilk örnekleri arasında yer alan konser içerikli kültür merkezi olarak işlev gören Casa da Musica'nın logotype tasarımı 2007 gibi eski bir tarihe dayanmaktadır. Casa da Musica'nın görsel kimliği, Stefan Sagmeister tarafından tasarlanan ve logoyu yönetmeye olanak tanıyan bir logo generator yazılımına dayanmaktadır. Bu sistem, binanın altı farklı tarafından ilham alarak logonun şeklinin ve renginin

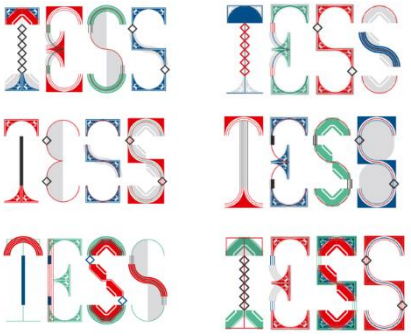
değişmesine olanak tanımaktadır. Böylece, sistem farklı etkinlikler için özel temalara dayalı olarak özelleştirilebilir renk paletleri sunmakta, kurum kimliğini yöneten profesyonellere ve son kullanıcıya kişiselleştirilmiş çözümler sağlamaktadır (Salem & Abouelnaga, 2022: 162).

Casa da Música'nın görsel kimliği, modüler logotype tasarımı açısından değerlendirildiğinde, günümüzün dinamik iletişim ortamlarına uyum sağlayan örnek bir kurumsal kimlik yaklaşımı sunmaktadır. Logonun temelinde, kurum binasının çokgen geometrisine dayanan sabit bir yapı yer almakta; bu yapı, farklı içerik ve bağlamlara göre çeşitli modüller aracılığıyla esnek biçimde yeniden düzenlenebilmektedir. Söz konusu esneklik, logonun hem farklı medya ortamlarında kullanılmasını kolaylaştırmakta hem de görsel çeşitliliği artırmaktadır. Bu modüler sistem, algoritmik temelli bir yazılım tarafından yönetilmekte; böylece her yeni versiyon yapısal tutarlılığını korurken özgünleşebilmektedir. Renk ve biçim varyasyonları üzerinden yapılan bu uyarlamalar sayesinde her etkinliğe veya kullanıcıya özgü grafik çıktılar elde edilebilmektedir. Kişiselleştirilmiş kartvizitler ya da etkinliğe özel afişler, sistemin kullanıcıya açık, katılımcı doğasını ortaya koymaktadır. Tüm varyasyonlar, belirli tasarım ilkeleri ve yazılımsal sınırlar içinde üretildiğinden, görsel çeşitlilik kurumsal bütünlüğü zedelemeden sürdürülebilmektedir. Casa da Música'nın bu yapısı, yalnızca genel kimliği temsil etmekle kalmaz; aynı zamanda sahne alan sanatçıların görsel estetiklerine uyarlanabilir biçimde özelleştirilebilir. Örneğin, Philip Glass ve Lou Reed'in portreleri, logotype renk paletinin oluşturulmasında referans alınmış; sanatçıların sahne atmosferi ve genel görsel karakteristiklerine uygun özgün kombinasyonlar yaratılmıştır. Bu yaklaşım, her sanatçıya özel alt kimlik üretimini mümkün kılarak, kurum kimliğinin dinamik ve bağlamsal olarak özelleştirilebilir doğasını öne çıkarmaktadır. Böylece Casa da Música'nın modüler logotype sistemi, kişiselleştirme olanakları ve içerik çeşitliliğine uyum kapasitesiyle çağdaş tasarımın gereksinimlerini etkili biçimde karşılayan güçlü bir örnek sunmaktadır (Görsel 3).



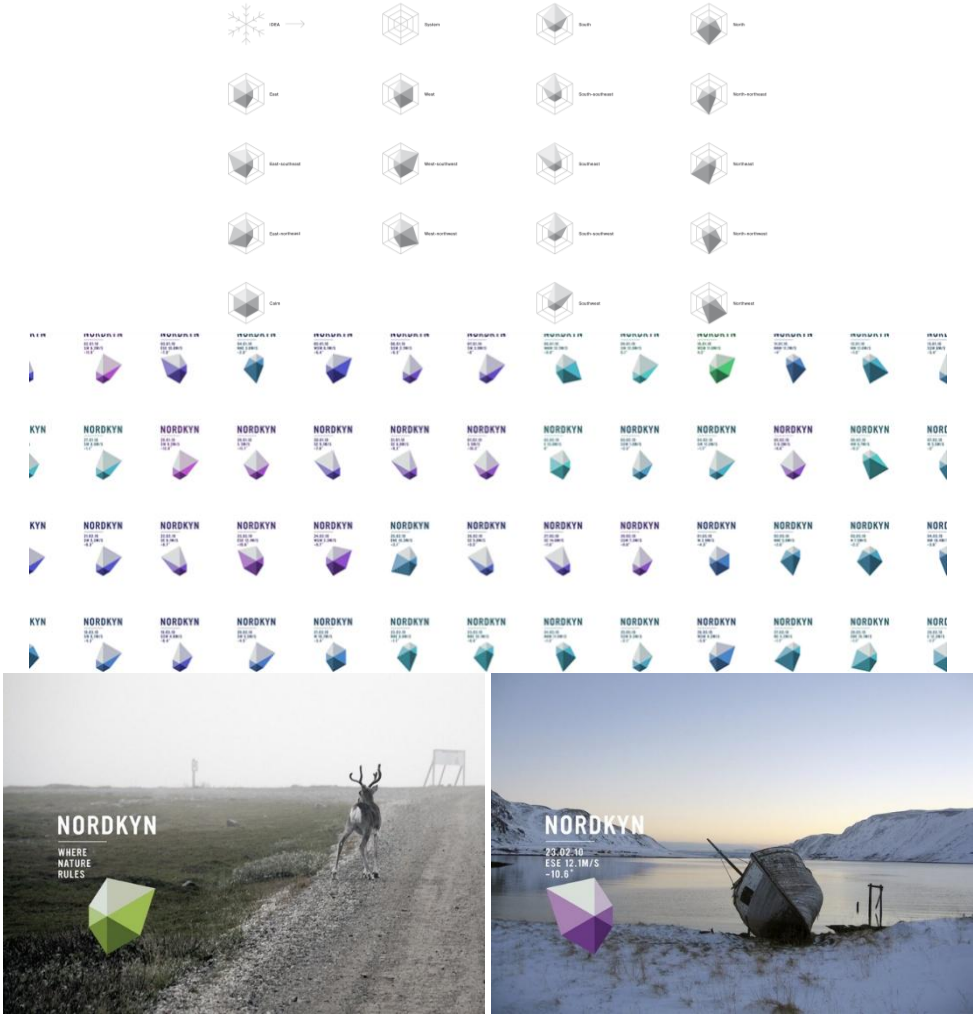
Görsel 3. Stefan Sagmeister, *Casa da Música logotype tasarımı,* 2007

Mind Design tarafından geliştirilen Tess Management görsel kimliği, modüler tasarım anlayışını kuramsal bir tanım üzerinden değil, modüller ve ızgara temelli bir sistem aracılığıyla, uygulama üzerinden ortaya koymaktadır (Mind Design, 2011: 60-63; Rebelo vd., 2022: 5). Söz konusu çalışmada modüler tasarım, küçük görsel birimlerin belirli bir ızgara sistemi üzerinde farklı kombinasyonlarla bir araya getirilmesi ve bu sayede tekil bir logo yerine çok sayıda tutarlı kimlik varyasyonu üreten bir sistem olarak ele alınmaktadır (Görsel 4).



Görsel 4. Mind Design, *Tess Management logotype tasarımı,* 2011

2010 yılına gelindiğinde ise modüler logotype örneği olarak Norveç'in en kuzeydeki bölgesi olan Finnmark'ta yer alan bir Nordkyn yarımadasının logotype tasarımı dikkat çekmektedir (Görsel 5). Visit Nordkyn'in dinamik görsel kimlik sistemi, 2010 yılında Norveç merkezli Neue Design Studio tarafından tasarlanmıştır. Bu tasarım, Nordkyn Yarımadası'ndaki Lebesby ve Gamvik belediyelerinin turizm potansiyelini artırmak amacıyla başlatılan bir girişimin parçasıdır. Proje, bölgenin sert iklim koşullarını ve doğayla iç içe yaşamını yansıtan, gerçek zamanlı meteorolojik verilere dayalı olarak sürekli değişen bir logo sistemi oluşturmayı hedeflemiştir. Logo, Norveç Meteoroloji Enstitüsü'nden alınan anlık hava durumu verileriyle entegre çalışarak, rüzgar yönü ve sıcaklık gibi faktörlere bağlı olarak şekil ve renk değişiklikleri göstermektedir. Bu dinamik yapı, bölgenin doğasının sürekli değişkenliğini ve "doğanın hüküm sürdüğü yer" temasını görsel olarak ifade etmektedir. Ayrıca, Visit Nordkyn platformu, her anın güncel hava verilerine uyarlanmış logoyu özel bir jeneratör aracılığıyla indirip kullanabilmektedir. Bu yenilikçi yaklaşım, 2011 yılında D&AD tarafından "Branding Schemes/Small Business" kategorisinde Wood Pencil ödülüne layık görülerek uluslararası alanda da takdir edilmiştir (Dandad, 2011).

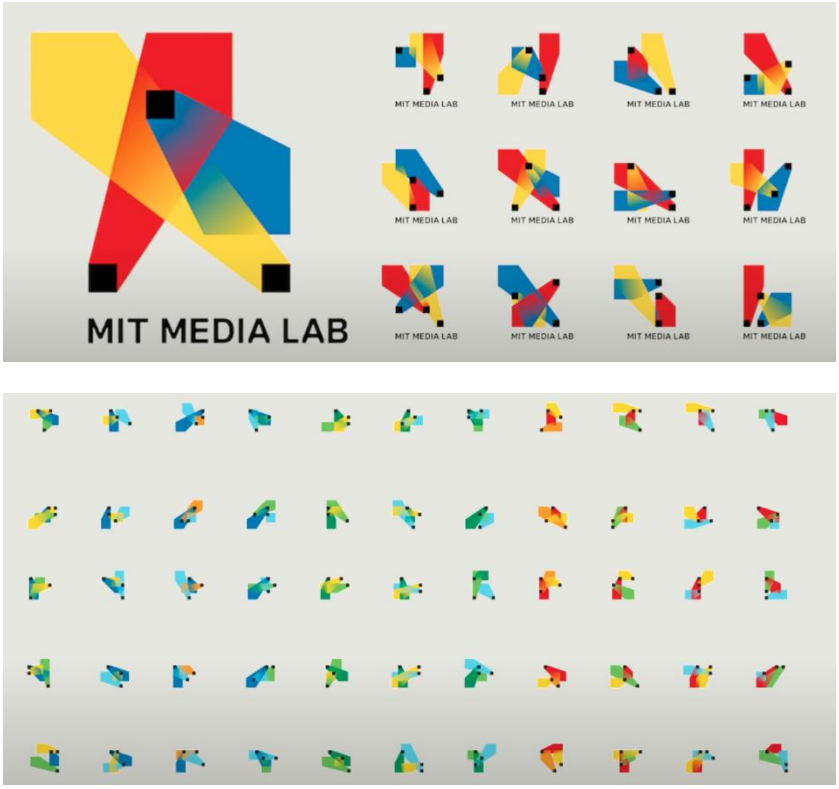


Görsel 5. Neue Design Studio, *Visit Nordkyn logotype tasarımı,* 2011

Bölgenin iklimsel karakteristiğine dayalı olarak inşa edilen logotype sistemi Görsel 4'ün üst kısmında gösterildiği gibi temel yapı, bir kar tanesinden yola çıkılarak geliştirilen, rüzgâr yönü ve sıcaklık verisi gibi gerçek zamanlı meteorolojik değişkenlere bağlı olarak şekil ve yön değiştiren çokyüzlü, geometrik formları kapsamaktadır. Logonun formu ve renk geçişleri; rüzgârın yönüne göre dönmekte, sıcaklığa göre renk skalasında değişmektedir. Bu durum, tasarımın parametrik bir yapı üzerine kurulu olduğunu göstermektedir. Bu sistemde, logotype semiyotik açıdan yalnızca bir görsel temsil değil, aynı zamanda bilgi taşıyan bir gösterge hâline gelmektedir. Bu durum ziyaretçilere hem Nordkyn bölgesinin nerede olduğu hem de anlık olarak nasıl bir iklim sunduğu hakkında sezgisel bilgi vermektedir. Böylece logonun görsel yönü, işlevsel bir veri

arayüzüne dönüşmektedir. Ziyaretçilerin konumuna göre, logotype web sitesi üzerinde o anki hava durumu bilgisine bağlı olarak canlı biçimde değişmektedir**.** Bu interaktif ve adaptif yapı, geleneksel logonun sabit doğasına karşıt olarak jeneratif kimlik anlayışını temsil etmektedir. Bu yaklaşım, destinasyon markalaşmasında veriye dayalı anlatı tasarımı açısından güçlü bir örnektir.

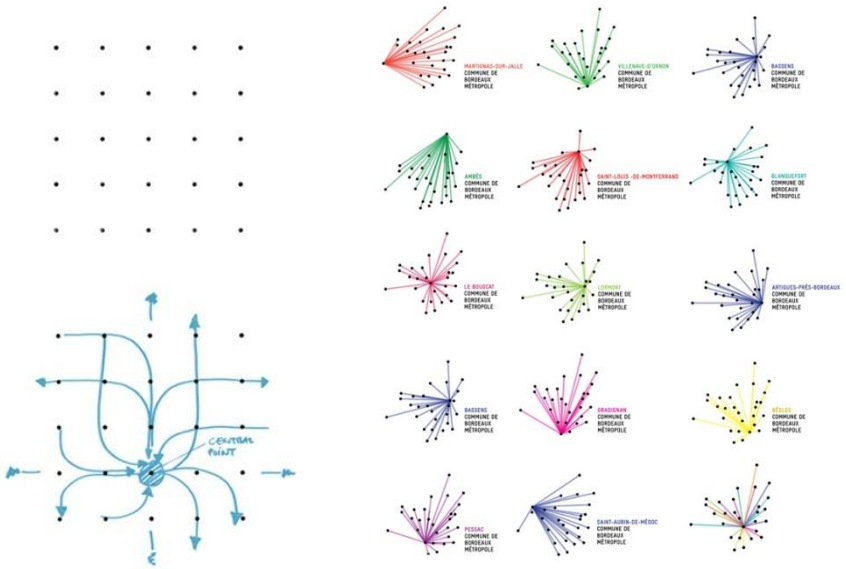
MIT Media Lab'in görsel kimliği, modüler logotype tasarımlarının çağdaş örneklerinden biri olarak öne çıkmaktadır (Görsel 6). Disiplinlerarası ve kolektif yapısını yansıtmak amacıyla geliştirilen bu sistem hem bireysel özgünlüğü hem de kurumsal bütünlüğü aynı anda temsil etmektedir. İlk olarak 2011 yılında Richard The ve Roon Kang tarafından geliştirilen algoritmik yapı, 25. yıl kutlamaları kapsamında tanıtılmıştır. Bu sistem, rastlantısal olarak tanımlanan ışın yolları üzerinden 40.000'i aşkın varyasyon üretme kapasitesine sahiptir. Görsel bütünlük, önceden belirlenmiş kısıtlamalar ve Media Lab binasındaki Kenneth Noland duvar resmine referansla oluşturulan renk paletiyle sağlanmıştır. 2014 yılında ise Michael Bierut liderliğinde daha tanımlı ve sabit bir yapıya geçilmiştir. 7x7'lik ızgara sistemi üzerine inşa edilen ML monogramı, her araştırma grubuna özgü gliflerle genişletilmiş; Helvetica tipiyle desteklenerek sade ve işlevsel bir kurumsal dil oluşturulmuştur. Glifler sabit görünüme sahip olsa da algoritmik olarak yeniden düzenlenebilecek biçimde tasarlanmıştır. Bu yapı, merkezi bir sistem etrafında çeşitlenebilen ama bütünlüğünü kaybetmeyen bir modülerlik örneği sunar. Aynı zamanda, animasyonlar ve kartvizitlerden dijital arayüzlere kadar tüm kurumsal kimliğe yayılan bir görsel iletişim altyapısı oluşturulmuştur. MIT Media Lab'in bu iki dönemli kimlik sistemi, modüler tasarımın esneklik, kişiselleştirme ve birlik arasında nasıl bir denge kurabileceğini başarıyla göstermektedir (Görsel 7) (Stinson, 2014; Labarre, 2011; Design, 2011; TheGreenEyl, 2011). Media Lab logotype sistemi, parametrik tasarım ilkeleri doğrultusunda her varyasyonu aynı geometrik temele dayandırmakta; pozisyon, yönelim ve çakışma düzenleriyle farklılaşma sağlamaktadır. Algoritmik olarak üretilen bu varyasyonlar, dönüş açısı, konum, renk yoğunluğu ve çakışma gibi parametrelerle tanımlanır. Böylece her alt birim özgün bir kimliğe sahip olurken genel bütünlük korunur. Kontrollü rastlantısallık ilkesinin uygulandığı sistem, laboratuvarın disiplinlerarası, deneysel ve kolektif yapısını da semiyotik düzeyde yansıtmaktadır. Saydamlık ve çakışan renkler ise etkileşim ve iş birliği metaforlarını güçlendirir (Görsel 7).



Görsel 6. Richard The ve Roon Kang, *MIT Media Lab logotype tasarımı,* 2011

Görsel 7. Michael Bierut, *MIT Media Lab logotype tasarımı,* 2014

Bordeaux Métropole logosu, 2015 yılında tasarlanmıştır. Görsel 8'de gösterilen logo, Fransız-İsviçreli tasarımcı Ruedi Baur ve ekibi tarafından geliştirilmiştir. Her biri bölgedeki 28 belediyeyi temsil eden siyah noktaların, farklı renklerdeki çizgilerle birbirine bağlanmasıyla oluşturulan bu tasarım, her belediyenin kendi merkezinde olacak şekilde uyarlanabilmesi sayesinde toplamda 28 farklı dinamik logo varyasyonu sunmaktadır (German Design Council, 2016). Bu durum, tasarımın parametrik çeşitliliğe açık olduğunu göstermektedir. Her bir konumdan çıkan çizgilerin yönü, uzunluğu ve yoğunluğu değişmekle birlikte; modüler ızgara ve nokta sistemi sayesinde tüm versiyonlar bütüncül bir dilin parçaları hâlinde kalmaktadır. Görselin ilk satırında yer alan boş ızgara sistemi, tüm tasarım varyasyonlarının temel yapısını oluşturmaktadır. Bu ızgara, modüler bir referans alanı sunarak her logotype bileşeninin mekânsal ilişkilerinin belirlenmesine olanak tanımaktadır. İkinci görselde, bu ızgaraya yönlenen oklarla farklı merkezlerden çıkan çizgilerin hareket yönü ve yoğunluğu görselleştirilmiştir. Bu yapı, coğrafi/topolojik referanslara dayalı parametrik bir sistemi göstermektedir. Semiyotik katman bağlamında her bir logotype varyasyonu, bir hareket ve bağlantı metaforu sunmaktadır. Siyah noktalardan çıkan çizgiler, kentlerin birbirine bağlanma biçimini, iletişim yollarını ya da sosyo-kültürel etkileşimleri simgelediği düşünülebilir. Bu semiyotik yapı, sadece grafiksel değil aynı zamanda anlamsal bir sistemi de yansıtmaktadır. Tasarımın dinamik yönleri, markanın merkeziyetçi olmayan, çoğulcu ve ağ yapılı doğasını temsil etmektedir. Dijital estetik ve medya uyumluluğu hakkında farklı dijital mecralarda (web, mobil, navigasyon sistemleri) kullanılmak üzere optimize edilmiştir. Varyasyonel yapının renk farklılıkları, her alt birime kimlik kazandırırken, sistemin genel tutarlılığı korunmuştur. Sahip olduğu renk skalasının muhtemel amacı, bilginin ayrıştırılmasını kolaylaştırmak ve kullanıcıya sezgisel bir yön bulma imkanı sunmaktır.

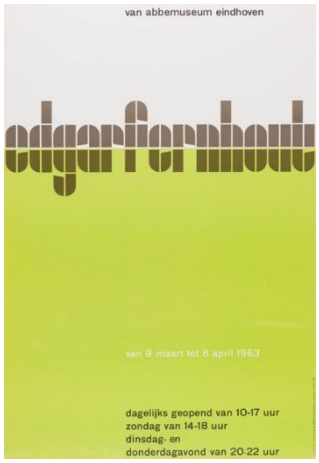


Görsel 8. Ruedi Baur ve Ekibi, *Bordeaux Métropole logotype tasarımı,* 2015

Móra Ferenc Gençlik Yayınları, 2015 yılında yenilediği kurumsal kimliğiyle modüler logotype anlayışına dayalı etkili bir örnek sunmuştur. Artan sektörel rekabet ve yeni yayınevlerinin yükselişi, Móra'nın pazar payında kayıplar yaşamasına ve kurumsal aidiyeti güçlendirecek bütüncül bir kimlik sistemine ihtiyaç duyulmasına neden olmuştur. Bu bağlamda geliştirilen yeni tasarım, "M" harfinin iki üçgensel modül aracılığıyla temsil edilmesine dayanmakta; modüllerin boyut ve konumları değişse de bu varyasyonlar önceden tanımlanmış sınırlı bir ızgara sistemi içinde kurgulanmaktadır. Böylece logotype, kitap kapakları, dijital platformlar ve kurumsal materyallerde her defasında farklı bir versiyonla yer almakta; bu çeşitlilik, markanın dinamik ve yenilikçi karakterini pekiştirirken, tüm varyasyonların ortak bir görsel ilkeye dayanması sayesinde kurumsal bütünlük korunmaktadır (Zwoelf, 2012). Dik üçgen, dikdörtgen ve kareden oluşan tasarım sistemi oyun temelli bir yapı mantığı içerir. Bu yaklaşım çocuk yayıncılığına uygun, eğlenceli ve esnek bir görsel dil ortaya konduğunu düşündürmektedir. Görsel 9'de her biri farklı kompozisyonlara sahip ama aynı yapı taşlarını içeren logotype versiyonları parametrik varyasyon ilkesiyle tutarlıdır: tasarım bir yandan oyun alanı yaratırken bir yandan da sistemin sınırlarını korumaktadır. Modüler yapının oyun çağrışımlı olması, markanın yayın yaptığı hedef kitleyle doğrudan duygusal bir bağ kurma amacı muhtemel düşüncedir. Bu yönüyle logotype yalnızca işlevsel bir kurumsal kimlik unsuru değil, aynı zamanda marka hikâyesini taşıyan semiyotik bir yapı olarak değerlendirilebilir. Seçilen sade, düz renklerin (ilk renkler: sarı, kırmızı, mavi) her varyasyonun net ve kontrastlı oluşu, dijital uygulamalarda (web, mobil, e-kitaplar) okunabilirliği ve tanınırlığı desteklemektedir.

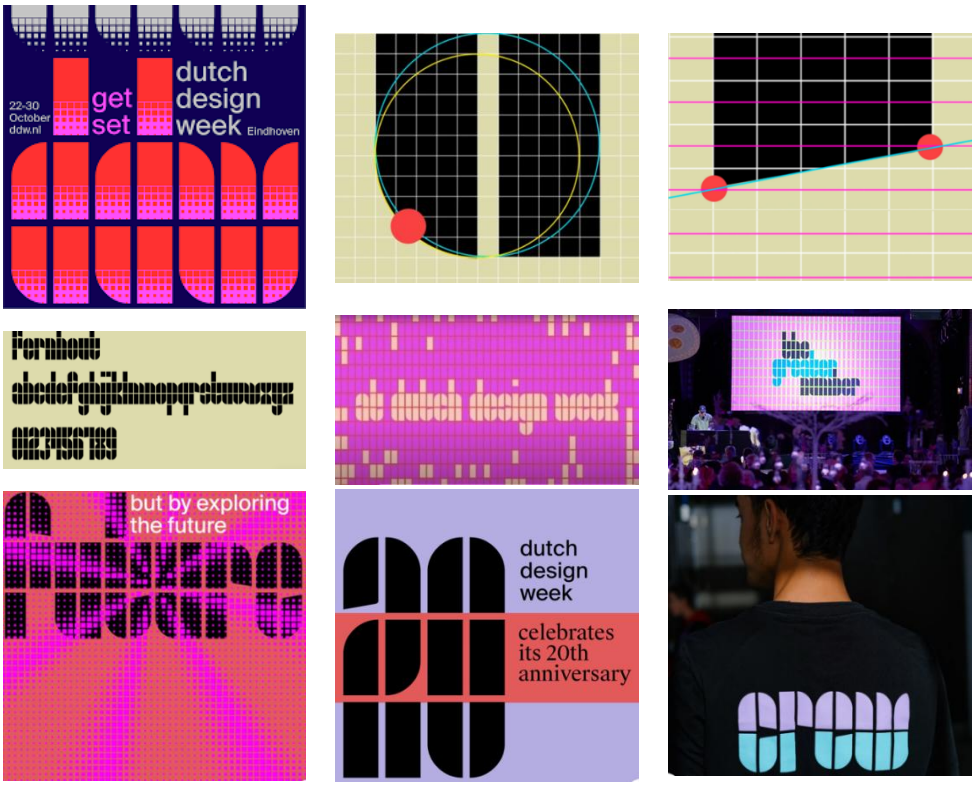
Görsel 9. Zwoelf, *Móra Ferenc Ifjúsági Könyvkiadó (Móra Ferenc Gençlik Yayınları) logotype tasarımı,* 2015

Modüler yapı yalnızca amblem tasarımlarında değil, aynı zamanda logotypelardaki harf biçimlerinde de günümüz grafik tasarım anlayışının öne çıkan bir yaklaşımı hâline gelmiştir. Bu bağlamda, Dutch Design Week (DDW) görsel kimliği 2023 yılında yenilenmiştir. Her yıl Eindhoven'da düzenlenen DDW, uluslararası çağdaş tasarımın önemli etkinliklerindendir. Festival, profesyonel tasarımcılarla genç yetenekleri bir araya getirerek Hollanda tasarım kültürünün yenilikçi yönünü vurgulamaktadır. Etkinliğin simgesi hâline gelen lale sembolü, DDW'nin görsel kimliğiyle uyumsuz görülmüştür. Bu nedenle markalaşma sürecinde kurumsal kimliğin tarihsel bağlamla yeniden ilişkilendirilmesini amaçlayan stratejik değişime gidilmiştir. Sistemin temelini, Wim Crouwel'in 1963'te Edgar Fernhout sergisi için tasarladığı postere dayanan ve onun tasarım anlayışını referans alan yeni bir yazı karakteri oluşturmaktadır. İlham alınan afiş, sade kompozisyonu, modüler ızgara düzeni ve Helvetica'dan türetilmiş geometrik tipografisiyle Crouwel'in sistematik ve işlevsel tasarım anlayışını yansıtır (Görsel 10). DDW'in yenilenen görsel kimliği için Foundry Types iş birliğiyle geliştirilen yazı karakteri ailesiyle hem Hollanda grafik tasarım geleneğini hem de geleceğe yönelik esnek ve yenilikçi bir tasarım dili yansıtılmıştır. Küçük harf kullanımı ve karakterler arası boşluk kurgusu sayesinde okunabilirlik artmış; tasarıma daha insani, sıcak bir yaklaşım kazandırılmıştır. Bu yönüyle Crouwel'in yalınlık ve işlevselliğe dayalı tasarım ilkeleri, günümüz iletişim gereksinimleriyle bütünleştirilmiştir. Söz konusu yazı karakteri, DDW logotype tasarımının modüler bir sisteme dönüşmesini sağlamış; web siteleri, basılı materyaller, yönlendirme sistemleri ve animasyonlar gibi çok çeşitli mecralarda tutarlı ama esnek bir yapı oluşturmuştur. Harflerin yer değişimi ve/veya rotasyon ile yeni ifadelerin oluşması, sistemin üretkenliğini ve uygulama çeşitliliğini göstermektedir. Kullanıcıların kendi görsellerini özelleştirmelerine olanak tanıyarak kişisel uyarlama imkânı sunmuştur. Bu özelleştirilebilir yapı, bireysel temsiliyetin yanı sıra katılımcı ve dinamik bir kurumsal kimlik anlayışını yansıtmaktadır (Studio Thonik, ty).



Görsel 10. Van Abbemuseum, Eindhoven Poster, *Wim Crouwel, Edgar Fernhout Exhibition,* 1963

Görsel 11'deki ilk görsel tasarım sisteminin matematiksel altyapısı olan dairesel, eğimli ve ızgara tabanlı çizgiler, yazı formunun oluşturulma mantığını görselleştirir. Bu yapı, tipografik formun sadece okunurluğa değil, aynı zamanda hareket, dönüşüm ve ritim yaratımına hizmet ettiğini göstermektedir. Harflerin içindeki boşluklar, çizgi kalınlıkları ve kavis noktaları parametrik olarak tanımlanmıştır. Böylece her uygulama bağlamında farklı varyasyonlar oluşturulabilir. Görseldeki farklı afiş ve baskı örneklerinde, "future", "crowd", "DDW" gibi ifadelerin her defasında farklı tipografik yüzeyler ve ızgara yapılarıyla üretildiği görülmektedir. Bu durum tasarımın jeneratif doğasını ortaya koymaktadır. Harflerin iç içe geçmesi, optik illüzyonlar yaratması ve pikselleşen görsel alanlara dönüşmesi, geleceğe yönelik spekülatif bir estetik üretmektedir. DDW'nin teması olan *geleceği keşfetmek (exploring the future)* bu deneysel ve değişken tipografik sistemle bütünleşen bir görsel dile dönüşmüştür.



Görsel 11. Studio Thonik, *Dutch Design Week (DDW) 2023 logotype tasarımı,*

Muse Group, Audacity, Ultimate Guitar, MuseClass, MuseScore ve MuseHub gibi müzik üretiminin tüm aşamalarını kapsayan dijital ürünlerden oluşan bir ekosistemdir; ancak bu ürünler uzun süre ortak bir görsel dil ve bütüncül bir marka kimliği altında birleşmemiştir. Bu doğrultuda, 2025 yılında Collins tasarım stüdyosu

tarafından Muse Group için, tüm ürünleri tek bir çatı altında toplayan ve markayı "Creative Fluency Company" olarak konumlandıran yeni bir görsel kimlik sistemi geliştirilmiştir (Görsel 12). Tasarlanan kimlik, müziğin temel yapı taşlarından olan ritim, motif, tekrar ve doğaçlama kavramlarını referans almakta; bu kavramlar modüler ve üretken bir tasarım sistemi aracılığıyla görsel dile dönüştürülmektedir (Baird, 2025). Özellikle Muse Display adlı özel yazı karakteri ailesi, ortak oranlara sahip modüler geometrik formların soyutlanmasıyla oluşturulmuş; bu sayede tipografi, sabit bir biçimden ziyade farklı bağlamlara uyarlanabilen, ölçeklenebilen ve hareketli uygulamalara açık bir yapı kazanmıştır. Tipografik modüller, tekrar eden desenler, semboller ve animasyonlu formlar aracılığıyla hem logolarda hem de dijital arayüzlerde, sosyal medya uygulamalarında ve kurumsal iletişim materyallerinde kullanılmakta; böylece marka, farklı temas noktalarında tutarlı ancak değişken bir görsel davranış sergilemektedir. Bu modüler yapı, Muse Group'un çok sayıda dijital ürünü arasında görsel süreklilik sağlamakta ve dinamik görsel kimlik anlayışı doğrultusunda esnek, ölçeklenebilir ve kullanıcı etkileşimine açık bir marka sistemi oluşturmayı mümkün kılmaktadır.

Görsel 12. Collins, *Muse Group 2025 Logotype Tasarımı,*

Sonuç olarak, modüler logotype tasarımları, günümüzün hızlı değişen iletişim ortamında hem tutarlılıklarını korumalarına hem de ortama göre uyum sağlamalarına olanak tanımaktadır. Bu yaklaşım; görsel kimliğin durağan ve tek biçimli yapısından uzaklaşarak, yeniden düzenlenebilir, özelleştirilebilir ve kişiselleştirilebilir olmasını mümkün kılmaktadır. Dijital adaptasyonu ve kullanıcı katılımını da tasarım süreçlerine entegre eden, çok sayıda alternatif üretmeyi mümkün kılan parametrik düşünce biçimiyle harmanlanan modüler yapı anlayışı hem teknolojik hem kültürel gereksinimlere cevap veren sürdürülebilir ve çağdaş bir marka dili oluşturmaktadır.

SONUÇ

Bu çalışma, modüler logotype tasarımlarının hem görsel kimlik sistemleri içindeki rolünü hem de çağdaş iletişim ortamlarına entegrasyon biçimlerini analiz etmeyi amaçlamıştır. Nitel araştırma yöntemi kapsamında ele alınan örnekler, modüler yapının yalnızca estetik bir tercih değil, aynı zamanda stratejik, işlevsel ve teknolojik bir tasarım yaklaşımı olduğunu göstermektedir. Görsel kimlikler, günümüzde yalnızca markayı tanımlayan görsel unsurlar olarak değil, marka ile hedef kitle arasında çok katmanlı ilişkiler kuran iletişim sistemleri olarak ele alınmaktadır. Özellikle dijital dinamik görsel kimliklerin özelleştirilebilir ve esnek yapıları, kullanıcıyla etkileşimi güçlendiren deneyimlerin tasarlanmasına yönelik yeni olanaklar sunmaktadır (Fekete, 2022: 50). Bu bağlamda, dinamik yapıya sahip modüler logotypelar, söz konusu dönüşümün görsel kimlik tasarımındaki en belirgin yansımalarından biri olarak öne çıkmaktadır. Modüler logotypelar, logonun temel yapısal ögelerini korurken, bu ögelerin farklı kombinasyonlar, ölçekler ve bağlamlar içerisinde yeniden düzenlenmesine olanak tanıyarak hem tutarlılık hem de esneklik arasında dengeli bir yapı sunmaktadır. Böylece marka kimliği, farklı mecra ve kullanım senaryolarında sürekliliğini korurken, değişen iletişim ihtiyaçlarına uyum sağlayabilen dinamik bir sistem hâline gelmektedir.

Modüler logotype sistemleri, özellikle dijital çağın ihtiyaçlarına yanıt verebilen uyarlanabilir**,** çoğalabilir ve kişiselleştirilebilir yapılarıyla öne çıkmaktadır. Kolay kişiselleştirme olanakları sayesinde, kitlesel özelleştirme tamamen otomatik bir biçim de alabilmektedir (Fekete, 2022: 50). Bu durum, modüler logotypelar açısından değerlendirildiğinde, görsel kimliğin manuel müdahaleye ihtiyaç duymaksızın, önceden tanımlanmış kurallar ve sistemler doğrultusunda çoğaltılabilen ve varyasyon üretebilen bir yapıya dönüşmesini mümkün kılmaktadır. Modüler logotypelar, algoritmik ya da kural temelli sistemler aracılığıyla farklı kullanıcılar, alt birimler veya bağlamlar için otomatik olarak yeni varyasyonlar üretebilmekte; böylece marka kimliği, kitlesel ölçekte kişiselleştirilmiş ancak bütüncül ve tutarlı bir görsel dil içerisinde sunulabilmektedir. Bu yaklaşım hem üretim süreçlerini hızlandırmakta hem de dijital ortamlarda marka–kullanıcı etkileşimini güçlendiren sürdürülebilir bir kimlik yapısı oluşturmaktadır. Ayrıca, farklı ekran boyutlarına ve platformlara (web siteleri, mobil uygulamalar, sosyal medya, dijital ekranlar vb.) kolayca adapte olabilmeleri sayesinde bu sistemler çok kanallı marka iletişimi için vazgeçilmez olmaktadır. IDTV, MIT Media Lab, Casa da Música ve Dutch Design Week gibi örneklerde olduğu gibi; logotypeların her defasında farklı bir versiyonla yeniden üretilmesi, markaların hem tanınabilirliğini korumasına hem de bağlama özel varyasyonlar geliştirmesine olanak tanımaktadır. Ayrıca modüler yapılar yalnızca görsel çeşitlilik sağlamakla kalmamakta aynı zamanda markaya anlatısal bir derinlik de kazandırmaktadır. Modüller aracılığıyla kültürel çeşitlilik, ürün tanıtımı, sosyal sorumluluk projeleri veya etkinlikler gibi temalar kolaylıkla temsil edilebilmektedir. Böylece marka, hedef kitlesiyle daha özgün, daha katmanlı ve bağlamsal bir iletişim kurabilmektedir.

Bu sistemlerin en dikkat çekici yönlerinden biri de algoritmik ve parametrik altyapılar ile desteklenmeleri, yani yalnızca grafiksel değil aynı zamanda veriye ve yazılıma dayalı sistemsel düşünme biçimleri ile kurgulanmalarıdır. Özellikle MIT Media Lab ve Visit Nordkyn örnekleri, algoritmalar aracılığıyla sonsuz varyasyonlar üretilebileceğini ve bu sayede markaların yaşayan, dönüşebilen yapılara kavuşabileceğini ortaya koymaktadır. Dahası modüler logotype sistemleri kullanıcıyla etkileşim kurabilen kimlik yapıları sunmaktadır. Tıklanabilir modüller, hareketli geçişler veya kullanıcı tarafından özelleştirilebilen logolar, markayla hedef kitlesi arasında interaktif bir bağ kurulmasına katkı sağlamaktadır. Özellikle Dutch Design Week ve TV Asahi gibi örneklerde, görsel kimliğin sadece sabit bir gösterge değil, aynı zamanda katılımcı bir deneyim aracı hâline geldiği görülmektedir. Bu durum, grafik tasarım disiplininin kodlama, veri görselleştirme ve kullanıcı etkileşimi gibi alanlarla daha da iç içe geçmesini zorunlu kılmaktadır.

Sonuç olarak; modüler logotype tasarımları, kurumsal kimlik oluşturma sürecinde Bugünün ihtiyaçlarına cevap veren modüler sistemin aynı zamanda geleceğin tasarım eğilimlerine de uyum sağlayacağı düşünülmektedir. Bu yönüyle modüler sistemler, yalnızca bir logo tasarımı yaklaşımı değil; çağdaş tasarım düşüncesinin bütüncül bir yansıması olarak değerlendirilmektedir.

Author's Contribution

This is a single-authored study. The author contributed 100% to the study.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

Ethics committee approval is not required.

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Research Article

Visual identity of urban space: Principles of forming the image of cities in Shandong Province, China

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Abstract
Urban visual identity constitutes a vital component in the contemporary dissemination of a city's image. Whilst numerous cities incorporate diverse design approaches within their artistic practices, certain issues invariably arise, thereby undermining the unique value of the city. By examining the application of design practices in the visual identity of cities within Shandong Province of China, this study aims to establish a principled framework for local urban visual identity. The core of the research lies in the analysis of visual elements in the city through a mixed research methodology, in particular using a combination of questionnaires, comparative analysis and visual case studies. The questionnaire contained within the article comprises three sections, designed to present the public's perception, judgement and expectations regarding visual elements. An analysis of urban case studies was also conducted to distill, summarize and corroborate the key principles of urban visual identity. Research indicates that elements such as city logos, iconic buildings, guide signs and public artworks are indispensable components of a city's visual identity. This demonstrates the vital importance of establishing a framework comprising four principles of visual identity: uniqueness, identifiability, sustainability, and regionalism. Research has shown that urban visual identity is not only a means of visual beautification, but can also participate in the formation of urban spatial perception and local identity. This study can provide a reference for the optimization of urban visual image and related research in Shandong Province.

Keywords: City image, Visual communications design, Urban visual identity, Cities of Shandong Province of China

Extended Abstract

Introduction: In the contemporary shaping and dissemination of urban image, the city's visual identity plays an irreplaceable role. Although many cities and regions typically employ diverse approaches to artistic design practices, this often gives rise to certain issues that undermine the cultivation of a city's unique value and diminish its overall distinctiveness. This situation requires transformation through a systematic approach that treats the city as a holistic structure encompassing multiple layers of meaning and sensory experience, thereby enabling the construction of a more refined and enriched urban visual image. In this regard, cities in Shandong Province stand as exemplars, having been shaped by the profound influence of their time-honored cultural heritage while simultaneously bearing the mission of renewing visual landscapes spurred by China's urban modernization drive. This study systematically evaluated the visual identity elements of six cities in Shandong Province-Jinan, Qingdao, Jining, Rizhao, Liaocheng and Yantai-identifying key factors influencing urban visual identity through a public perspective. It explores the equilibrium between cultural heritage and contemporary communication to reveal the value of urban visual identity in fostering regional identity and shaping modern city image.

Purpose and scope: By analyzing the role of visual elements in shaping urban image and conveying regional characteristics, this article aims to explore the defining characteristics of urban visual identity within the contemporary design context. The study also examined how visual design influences the public's perception and experience of cities, revealing the equilibrium between aesthetic culture and regional characteristics within urban visual systems. In terms of research scope, the article examines four categories of visual elements: city logos, iconic buildings, guide signs, and public artworks. Analyze their performance in terms of formal organization, linguistic expression, compatibility with the urban environment, and aesthetic experience value. The study covered six representative cities in Shandong Province of China, and invited 100 young people aged 18 to 26 who were permanent residents within the province to complete a questionnaire.

Method: This study employs a mixed research methodology through questionnaire survey, comparative analysis and visual case study to examine the visual identity elements of six representative cities in Shandong Province: Jinan, Qingdao, Jining, Rizhao, Liaocheng and Yantai. The questionnaire section takes public perception as the clue, and there are three parts to understand the respondents' perception and attitudes towards four types of visual elements: the city logos, iconic buildings, guide signs, and public artworks. Part one clarifies the public's base perception of these urban visual elements by means of a comprehensive evaluation through five-level Likert scale matrix questions; part two presents respondents' attitudes towards visual identity in the form of single-choice questions on a five-point Likert scale; part three uses multiple-choice questions to capture people's overall value orientations and areas of focus. These contents provide the basis for the distillation of the four principles. Questionnaire data were used to analyze the relationship between visual phenomena and public experience to reveal general tendencies. Comparative analysis is used to identify the differences between the four types of visual elements in terms of visual morphology and cultural symbols, and to explore their roles in the expression of regional culture and the formation of urban identity. During the visual case study phase, the article employs four principles as an analytical framework, placing both distinct cities and visual elements within each narrative for elaboration. It offers a multidimensional interpretation of urban identity systems to explore how these design principles manifest across different visual media and their distinctive characteristics.

Findings and conclusion: The study also that visual elements such as city logos, iconic buildings, guide signs and public artworks are influenced by the distinct environments of different cities, enabling them to respond in their own ways to the demands of local culture and the modernization process. Based on the results of the questionnaire survey, it can be assumed that people's understanding of the city's visual identity is also more concerned with its integrated role in the communication of the city's image and the perception of place. Building upon this foundation, the present study has distilled a framework comprising four core design principles: uniqueness, identifiability, sustainability, and regionalism. Differentiating characteristics are the cornerstone of the principle of uniqueness; the principle of the identifiability emphasizes the effective connection between visual identity and spatial context; the principle of sustainability allows visual elements to have a stable cultural expression; and the principle of regionalism perpetuates the expression of local culture within visual communication. This framework not only reveals the synergistic relationship between urban image and modern visual language, but also clarifies the intrinsic structure of visual identity design for cities in Shandong Province. The results of the study also show that the formation of the urban visual identity system is the result of a variety of visual elements working together and in the long-term urban development and cultural accumulation. In summary, the formulation of these four principles provides evidence for understanding the hierarchical relationships within urban visual systems, and also indicates that visual identity has established a stable connection between urban communication and public cognition. The study and its framework of principles could also be applied to other cities and regions, taking into account the local context, and consideration could be given to expanding the scope and size of the sample.

Keywords: City image, Visual communications design, Urban visual identity, Cities of Shandong Province of China

INTRODUCTION

In the context of contemporary urban globalization, the visual identity of a city carries the expression of the city's characteristics and becomes an important means of cultural dissemination and social identity construction. Visual identity constructs the core expression of the city's image in the form of static non-verbal symbols, enabling cross-cultural communication of the city's message without the need to use language and text to break through geographical boundaries (Xu, 2013). This is a systematic visual communication design phenomenon by which the area of communication between people and the environment is formed (Vorobchuk & Skliarenko, 2022). However, many cities tend to use internationalized design language in shaping their image, often using standardized and highly reproducible visual symbols as the main form of expression, in order to quickly increase the competitiveness of the city. This is often based on the abstraction of the city's

cultural texture, social history and local identity, resulting in the visual image of the city appearing as "homogenization" (Grêt-Regamey & Galleguillos-Torres, 2022).

Cities situated in different locations often exhibit distinct characteristics in their respective visual identity development processes, shaped by local history, culture, economic conditions, and social structures. The character of the city generally includes monumental architectural, geographical, cultural and other historical features and determines the generation of the city's image (Mohamad et al., 2022). Urban development in Shandong Province has been influenced by a combination of historical and cultural heritage, the geographical advantage of being both inland and open to the coast, and convenient transportation. Shandong Province remains a significant cradle of Chinese civilization, possessing profound roots in the "Qilu culture" (Pan et al., 2024), this includes diverse and distinctive regional cultural resources such as seashores, springs, canals, Confucian culture, etc., which have led to the formation of a diverse type of urban image within the province. This also provides a rich source of material for visual elements such as city logos, iconic buildings, guide signs and public artworks. This has also enabled different cities to develop their own different visual expressions in urban regeneration and the shaping of public space, thus ensuring that the visual identity of the city can be carried out effectively. The demand for communicating the image of cities is constantly increasing. Existing research on visual identity can serve as a point of entry, as it not only bridges urban culture and spatial environments but also enables multifaceted exploration of the functionalities and values inherent in these elements.

Certain scholars have examined the role of graphic design within urban visual identity systems (Adamus-Matuszyńska & Dzik, 2017; Adamus-Matuszyńska & Dzik, 2020; Zhou, 2024). In particular, this article by Zhou (2024) looks at Jinan's urban visual identity as a systematic structure and creates an urban identity manual that includes a core logo, IP image, supporting graphics, and web posters in multiple design categories. Wardani and Wahyurini (2014), on the other hand, emphasize the role played by logo design in city branding, arguing that logos enable cities to develop a clearer brand identity.

Urban identity in contemporary scientific research constitutes a composite phenomenon that intersects multiple disciplines such as spatial studies, cultural studies, sociology, and communication processes. In the works of Ökesli and Gürçınar (2012), Oktay (2002), and Umar et al. (2024), identity is first characterized by both tangible and intangible aspects. These encompass architectural forms, landscapes, historical symbols, spatial usage patterns, cultural codes, and the everyday practices of residents. This view matches that of Melnychuk and Gnatiuk (2019), who emphasized that urban identity is determined both by socio-cultural transformations that shape public perceptions of the city and by the actual characteristics present in the contemporary environment.

In the shaping of identity, both visual and graphic elements, alongside urban communication, play a role and determine the aesthetic value of the chosen themes. Köylü (2025) and Torbati (2018) contend that it is precisely the small-scale environmental graphic design elements—such as navigation systems, information signage, and even the often-overlooked manhole covers—that ensure the stability of the urban environment, enhance cultural legibility, and forge a sense of identity and emotional connection between people and their surroundings.

From a semiotic point of view, urban visual identity can be understood as the process by which the elements of a city shift from material form to cultural connotation. Using Morris's model of semiotics, Zhuang and Yusoff (2025) point out that urban visual identity is actually composed of multiple visual elements through the three dimensions of syntactics, semantics, and pragmatics. Its role is also not only to convey the cultural significance of the city through symbols, but also to influence the public's perception of the city's image. Similar to this is the article by Muktiono (2024), it points out that cities are not just a collection of buildings and infrastructure, but that each element of the urban environment has a unique meaning. The character and identity of the city can be more effectively recognized through the interpretation of symbols in streets, buildings and public spaces.

Urban visual identity not only relies on the generation of symbolic meaning, but also relates to the way visual images are presented and viewed in public space. In his book (2014: 2), Debord points out that landscapes are not just a simple collection of images, but a social relationship in which the public participates through the

mediatization of images. This idea suggests that urban visual elements influence the public's understanding of the city when they are repeatedly viewed, communicated and encountered by people in public spaces.

In general, although existing studies have discussed urban visual identity from the perspectives of visual communication, city branding, urban identity and spatial symbols, these results have focused more on a certain type of visual elements in the lack of attention to the perception of the joint role of multiple elements in urban image. How visual identity elements will affect the public's understanding of the city's image can be kept in view.

METHOD

This study adopts a mixed research method combining questionnaire survey, comparative analysis and visual case study to examine the characteristics of urban visual identity alongside public experience within a unified design framework. The research also focuses on the composition and perception of city's visual identity in Shandong Province, examining four categories of visual elements: city logos, iconic buildings, guide signs, and public artworks:

- City Logos: Utilizes the official version for prefecture-level cities, serving as the most intuitive visual symbol;
- Iconic Buildings: Three historical and three modern structures selected;
- Guide Signs: Frequently employed within urban public spaces;
- Public Artworks: The sculptural art of which was chosen to be analyzed is incorporated holistically.

The study selected six representative cities in Shandong Province, Jinan, Qingdao, Jining, Rizhao, Liaocheng and Yantai, as the object of research and analysis:

- Jinan: The capital city of the province, with the image of a spring city culture and administrative center;
- Qingdao and Yantai: Reflecting the visual characteristics of coastal open cities;
- Jining and Liaocheng: Associated with Confucian culture and canal culture respectively;
- Rizhao: Presenting coastal ecology and emerging city image.

These cities were chosen mainly because of the uniqueness and clarity of their local images and the ability of these images to form comparable research objects through visual elements. The research analysis conducted in this paper is also not concerned with the actual overall rankings of these cities, but mainly examines the respondents' evaluations of the visual elements of different cities and uses them as a basis to illustrate the role and characteristics of these visual identity contents in public perception.

It is also necessary to define the scope of the research group: (1) Residents of Shandong Province in China; (2) Those aged between 18 and 26 years. The sample included both students and those already employed, who also had some differences in their perceptions of the city: Students are more exposed to the city's image through campus life and strolling and traveling around the city, and their evaluations are more likely to be influenced by the scope of campus life and urban public cultural space; while employed people form their awareness of the urban environment more in their work commute and daily life, and are more likely to pay attention to the effect of using urban visual information. This group was also chosen because they are more active in the daily use of urban public space, the frequency of social media communication, and their demand for and acceptance of visual elements in the city is higher than that of other age groups. Due to the limitations of the sample size and age range, the findings in this paper are mainly used to reflect the perceived tendencies of young respondents in Shandong Province, and are not intended as generalized conclusions applicable to all public groups.

By extrapolating and estimating the relevant demographic data of Shandong Province, the number of young people aged 18-26 in Shandong Province can be estimated to be about 12 million, and the Cochran formula was used to calculate the sample size as follows:

$$n = \frac{Z^2 \times p \times (1-p)}{E^2}$$

Choose a confidence level of 95% and a Z-value of about 1.96; allowable error is 10%, i.e. E = 0.1; the predicted value of the overall proportion, p = 0.5,

$$\text{I.e., for: } n_0 = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.1^2} = 96.04.$$

Rounded up, the minimum sample size was 97. Considering also the completeness of the questionnaire recovery and the operationalization of the study, 100 valid questionnaires were finally used for the analysis of this paper. Table 1 presents the general demographic data for these respondents. The questions in the questionnaire are pre-set to obtain standardized and low-bias feedback. The questionnaire also received the support and understanding of the respondents. At the same time, this study is part of the design discipline and does not involve minors, vulnerable groups or the private information of any individual. It has also been approved by the Ethics Committee of the School of Art and Design at Shaanxi University of Science and Technology, with the approval number of Shaan Ke Da She Yi [2025] No. 0902, and the date of approval is 2 September 2025.

Table 1. Statistics on respondents' data

Project	Classification	Value
Gender Count	Male	49
	Female	51
Age Distribution	18 - 20 years	34
	21 - 23 years	38
	24 - 26 years	28
Educational Background Composition	High school and below	9
	Post-secondary students	63
	Postgraduate	28
Occupational Distribution	Student	81
	Employed	19
Length of Residence in the Province	Less than 1 year	24
	1 - 3 years	36
	3 - 5 years	26
	More than 5 years	14

The purpose of designing this questionnaire is to establish a framework of principles for determining the city's visual identity, which will be distilled from the results of the survey:

(a) Questionnaire Survey: An online questionnaire was designed via the Chinese professional survey platform "Wenjuanxing" (www.wjx.cn) and distributed through WeChat, China's largest and most widely used social media application. The questionnaire asked all respondents to rate four categories of visual elements in six cities in Shandong Province, thus ensuring the translation of comparable data from the respondents. Part 1 of the questionnaire consisted of five-level Likert scale matrix questions, which were tested for internal consistency using Cronbach's alpha coefficients, followed by descriptive statistics to elaborate on the distribution of the responses and the percentage of positive ratings; part 2 was all single-choice questions on a five-point Likert scale, and only descriptive statistics were used to present the distribution of responses and the proportion of positive ratings for each question; part 3 of the questionnaire was multiple choice and multiple response analysis was used to count the frequency and percentage of choices for each option.

(b) Comparative analysis: It is used to examine the differences in the representation of the four types of visual elements in six cities in Shandong Province, focusing on comparing the visual representations of different cities and the different roles of these four types of visual elements in the shaping of the city's visual identity.

(c) Visual case Study: Conducting a descriptive analysis of representative visual elements within urban public spaces in Shandong Province.

It is also necessary to explain the structure and purpose of the three parts of the questionnaire. Part one focuses on public perceptions regarding the evaluation of city logos, iconic buildings, guide signs and public artworks, guiding respondents to assess the visual presentation of these elements holistically. For each type of visual element question, six different multiple-choice questions were set up, which could present the relative advantages of the four types of visual elements under a unified standard.

Unlike the part one, the part two focuses on the role of visual elements in communication, experience and memory, comprising eight multiple-choice questions. Respondents are required to evaluate and select based on the following criteria: the impact of visual elements, international expression, frequency of exposure, cultural alignment, recognition and appeal, compatibility with regional culture, emotional experience, and overall satisfaction with the image. This enables them to articulate their perceptions and attitudes towards the city's visual identity elements within a broad contextual perspective.

The part three comprises three multiple-response questions centered on value prioritization, existing shortcomings in visual recognition, and enhancing attention levels. These questions aim to clarify individuals' understanding, evaluation, and expectations regarding these visual elements. The findings of this part supplement the specific assessments of urban visual elements conducted in the preceding two parts.

It should also be noted that by combing the literature and analyzing the results of the questionnaire, it was possible to clarify the way in which the four principles of uniqueness, identifiability, sustainability and regionalism were formed: the literature study provided a conceptual basis for these four principles, and the questionnaire results reflected respondents' perceptions and evaluations of these elements. The discussion section will corroborate the way the four principles are expressed in the city's visual identity with specific visual examples.

FINDINGS

Visual Identity Elements in Urban Space in Shandong Province

This article re-examines the orientation of shaping the visual image of urban spaces in Shandong Province based on a pre-designed questionnaire. This study focuses on four categories of visual elements: city logos, iconic buildings, guide signs, and public artworks. These elements play a fundamental role in the perceived evaluations of respondents. The results of the reliability and validity test for the first part of the questionnaire are shown in table2; parts 2 and 3 are not tabulated here, and their results are described directly in the body of the text to avoid repetition with subsequent textual content.

Table 2. Results of the reliability test for the first part of the questionnaire

Visual Element	Number of Questions	Reliability Coefficient
City Logo	6	0.885
Iconic Building	6	0.922
Guide Sign	6	0.887
Public Artwork	6	0.874

City Logo

The most widespread and frequent primary content and visual communication element of the city's visual identity and image is the city logo (Xu, 2013); it is a central symbol in the communication of the city's brand, crosses cultural and spatial boundaries, and emerges as a powerful tangible asset for the city (Wardani & Wahyurini, 2014). According to the questionnaire survey, respondents generally held positive overall evaluations of the logos for the six cities of Jinan, Qingdao, Jining, Rizhao, Liaocheng and Yantai (Figures 1 and 2). Among the six options, the proportions of "agree" and "strongly agree" exceeded half. Among them, the positive evaluations of aesthetic harmony and ease of memory accounted for 55% and 53% respectively, showing relatively outstanding performance; positive ratings on clarity of color and form, embodiment of cultural identity, suitability of the medium, and potential for long-term use and promotion were all 51%. City logo also showed relative strength in the two comparison questions, with the frequency of selection topping all four categories of visual elements: positive ratings were 53% for "influence in shaping the overall image of the city" (Figure 9a) and 32% for "representativeness in international communication" (Figure 9b). This underscores logo pivotal role in both local image recognition and external international communication.

These logos chosen for this paper uses the officially released version in the six cities, which is widely used in public activities such as cultural and tourism promotion in these cities, and was shown to the respondents during the distribution of the questionnaire with the corresponding multiple-choice questions.

a b c d e f

Figure 1. Shandong provincial city logos: a) Jinan, b) Qingdao, c) Jining, d) Rizhao, e) Liaocheng, f) Yantai

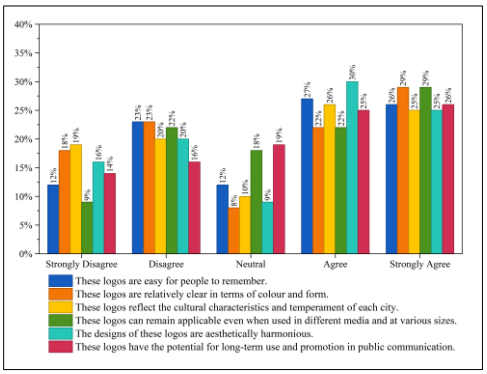
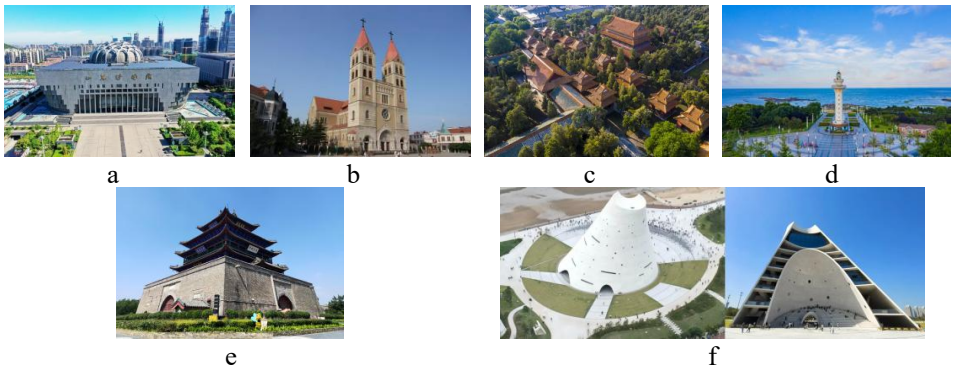


Figure 2. Overall visual assessment of the city logos

Iconic Building

Iconic buildings have an important value in the urban built environment, shaping people's unique perceptions of the city, and have a symbolic value in the city's identity (Zamparini et al., 2023); iconic buildings is also a constant influence on the standard of living and the quality of the environment in urban spaces (Riza et al., 2012). The construction of iconic buildings can also quickly attract people's attention to the city's construction, in order to obtain more recognition and enhance the city's reputation (Elhagla et al. 2020). Respondents also expressed positive overall assessments of the iconic buildings in these six cities (Figures 3 and 4). Of the six options, easy to recognize and remember received the highest positive rating, with a total of 59% choosing "agree" and "strongly agree"; the positive ratings of reflecting cultural characteristics and the spirit of the times, and possessing visual harmonization and aesthetics were both 57%; positive ratings for both distinctive stylistic features and use value for long-term preservation were 51%; the positive evaluation of modern communication and multi-scenario application adaptability is 48%, which is relatively low, and there is still room for improvement in communication adaptability. On the question of frequency of daily contact, 56% of the respondents chose "often" and "very often" together, slightly higher than public artwork, guide sign, and city logo, suggesting that they are highly visible in the daily spatial experience of the city (Figure 9c). The six iconic buildings selected in this paper are mainly from the preliminary data collation and urban case screening, with randomness; and these buildings also have clear identification characteristics and high visibility in their respective cities, and frequently appear in the public visual image, with a good typical role. Special questions have also been set up in the questionnaire and these images have been shown to the respondents at the time of distribution.



a b c d e f

Figure 3. Iconic buildings in Shandong province: a) Jinan, b) Qingdao, c) Jining, d) Rizhao, e) Liaocheng, f) Yantai

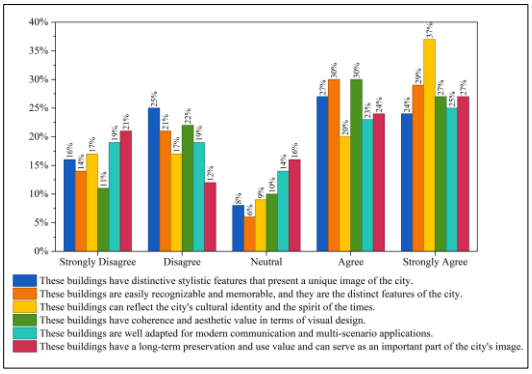


Figure 4. Overall visual assessment of urban iconic buildings

Guide Sign

Guide signs are actually a set of information systems that depend on the space with the area (McCarthy, 2006). In ordinary roads, street corners and other public spaces we commonly see guide signs that generally follow universal design, inclusive design, accessible design and other methods (Persson et al., 2015).

Survey findings indicate that people hold a generally neutral to positive attitude towards guide signs in the six cities (Figures 5 and 6). Long-term usability and adaptability to urban development had the highest positive rating of 56% for this question; the choices of directional guidance and information communication, incorporation of regional characteristics, and visual expressiveness in different environmental conditions were all 52%, indicating that these cases have gained a certain degree of recognition in terms of functional identification and regional expression; the positive evaluation of functional needs and the value of the cultural viewing experience was 50%, which is in a more balanced state. Meanwhile, the positive rating for the coordination of guide signs in the surrounding environment is 47%, which indicates that these respondents believe that guide signs need to be optimized in terms of environmental adaptation. Guide signs in urban spaces in Shandong Province are generally characterized by modern design in terms of Harmonization of materials with the environment, Integration of regional characteristics and aesthetics, and Dynamics and emotional interaction (Li and Skliarenko, 2025). It should also be noted that the regional characteristics of cities in Shandong Province and the modern urban development situation are taken into account in the selection of cases in this paper, and except for Fig. 5d, the pictures of the cases are taken from the results of the published paper. Pictures of these cases had also been provided to the respondents at the beginning of the questionnaire distribution with special multiple-choice questions.

a b c d e f

Figure 5. Guide signs of Shandong province: a) Jinan, b) Rizhao, c) Qingdao, d) Liaocheng, e) Jining, f) Yantai

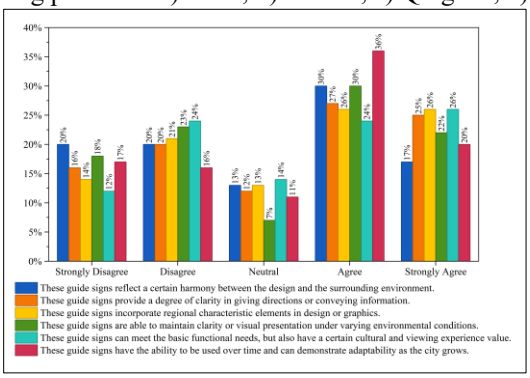


Figure 6. Overall visual assessment of urban guide signs

Public Artwork

Public art influences people's perceptions with the uniqueness of its own composition, encompasses people's attitudes to life, and reflects cultural phenomena in the city through artistic means (China Architecture and Culture Center, 2018: 17). It encompasses a wide variety of forms, such as urban sculptures, monuments, arches, street furniture, murals, details of public buildings, digital displays, and even graffiti and street art (Jasmi & Mohamad, 2018).

The survey findings indicate that respondents' evaluations of public artworks in these six cities varied considerably (Figures 7 and 8): Visual coherence and aesthetics had the highest positive rating in this question at 60%, indicating that public art is better recognized on an aesthetic level; the positive ratings of 51% for being a city landmark symbol and easy to remember, and 50% for creativity and visual appeal, and expressiveness and adaptability in different scenarios indicate that these public artworks have a role to play in visual appeal and spatial communication. It is worth mentioning that the positive rating of 49% for long-term value and 47% for reflecting the city's cultural connotations, historical memory and contemporary spirit are relatively low, indicating that there is still room for improvement in the ability of these artworks to symbolize adaptation, cultural expression and sustained dissemination. The selected cases of urban public art in Shandong Province in this paper take urban sculpture as the main object, and these works, through the combination of urban landscape and regional spatial characteristics, present a more distinctive regional cultural imprint in the modern urban development. After organizing the visual material of the six cities, works with a high degree of local orientation and more famous were selected to be included in the questionnaire. Images of these sculptures were also shown to the respondents when the questionnaire was distributed.

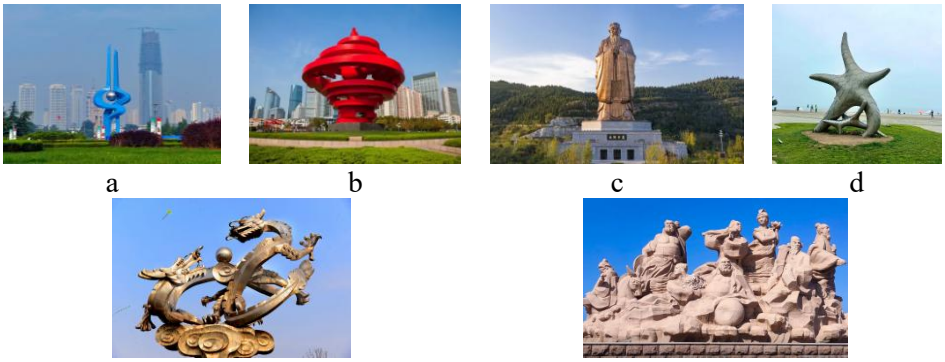


Figure 7. Iconic buildings of Shandong province: a) Jinan, b) Qingdao, c) Jining, d) Rizhao, e) Liaocheng, f) Yantai

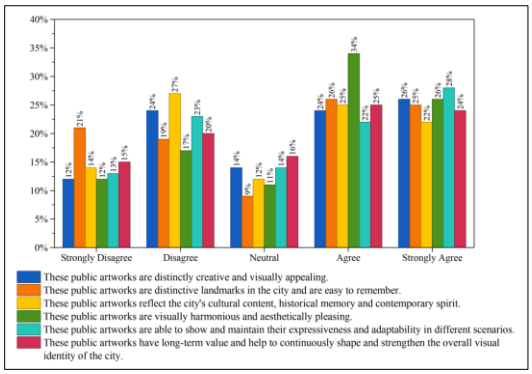


Figure 8. Overall visual assessment of urban public artworks

Features of Visualizing Emotional Perception of a City

The public's perception of a city's image is gradually formed through daily use and experience. A clear, stable and positive city image can enhance the city's visual appeal and strengthen people's emotional attachment to it. The findings further demonstrate that these visual elements continue to exert an influence over prolonged use and memory retention. The part two of the questionnaire further investigated respondents' subjective assessments of these four categories of visual elements. The results show that 52% of the respondents

recognized the important value of visual design in conveying local cultural and historical identity (Figure 9d). With 56% of respondents believing that these visual elements have a positive role to play in shaping the city's visibility and attractiveness, this option has the highest percentage of choices among these five questions (Figure 9e). The positive rating of 51% in terms of regional cultural fit and the city's competitive advantage shows that respondents tend to understand the city's visual identity in relation to its regional character (Figure 9f). Overall, 55% of respondents recognized the ability of these elements to influence their experiences and memories, and to enhance the sense of belonging to some extent (Figure 9g); and in the evaluation of overall satisfaction, 53% of people have a positive attitude towards these cities and their visual elements, which shows that the visual image of the six cities has gained relatively stable recognition (Figure 9h).

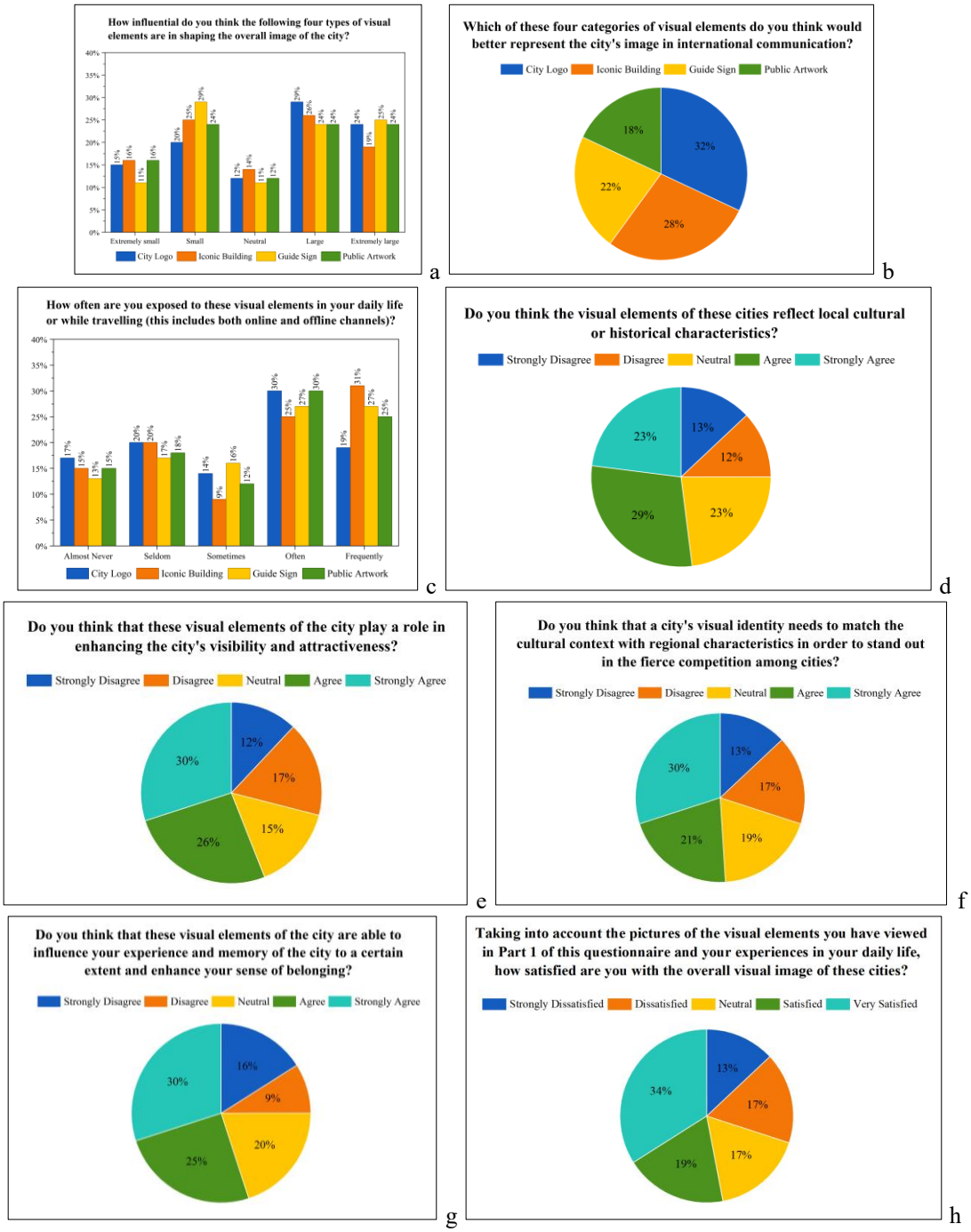


Figure 9. Emotional perception of the city (Questionnaire results): a) Visual impact, b) The international communication of city image, c) Frequency of contact, d) The historical and cultural characteristics of the locality, e) The city's reputation and appeal, f) Cultural background, g) Experience, Memory and Belonging, h) Overall satisfaction

The part three clarifies respondents' overall expectations regarding the city's visual identity. The results show that when asked about the values that should be most prominent in the city's visual identity (Figure 10a), the highest percentage of respondents chose the option of the heritage of the local culture, at 57%; the percentage of choices for functional identification, long-term maintenance and multi-scene adaptation, and differentiated presentation are 47%, 44% and 43% respectively, which shows that the respondents' judgment of the value of urban visual identity is not limited to visual aesthetics, but pays more attention to its cultural expression and practical application value. Feedback on deficiencies centered on insufficient exploration of regional culture, insufficient attention to artistic aesthetics, lack of environmental adaptation, and too much similarity between elements, with 75%, 59%, 52%, and 52% of choices, respectively, suggesting that people would like to see a more prominent and distinctive image of the city (Figure 10b). Regarding the reasons for the growing interest in the city's visual identity (Figure 10c), efficient identification and communication, and improvement and maintenance of the visual identity system were both selected by 56%, and the development of the city's brand by 55%; and the percentage of choices for the concept of sustainable urban development was 45%, which is lower than the previous three, but still close to half, indicating that respondents are also beginning to understand the value of visual identity from the perspective of long-term urban development. It is also clear from the question that respondents are beginning to understand urban visual identity as an important aspect in the communication and spatial renewal of the city's image.

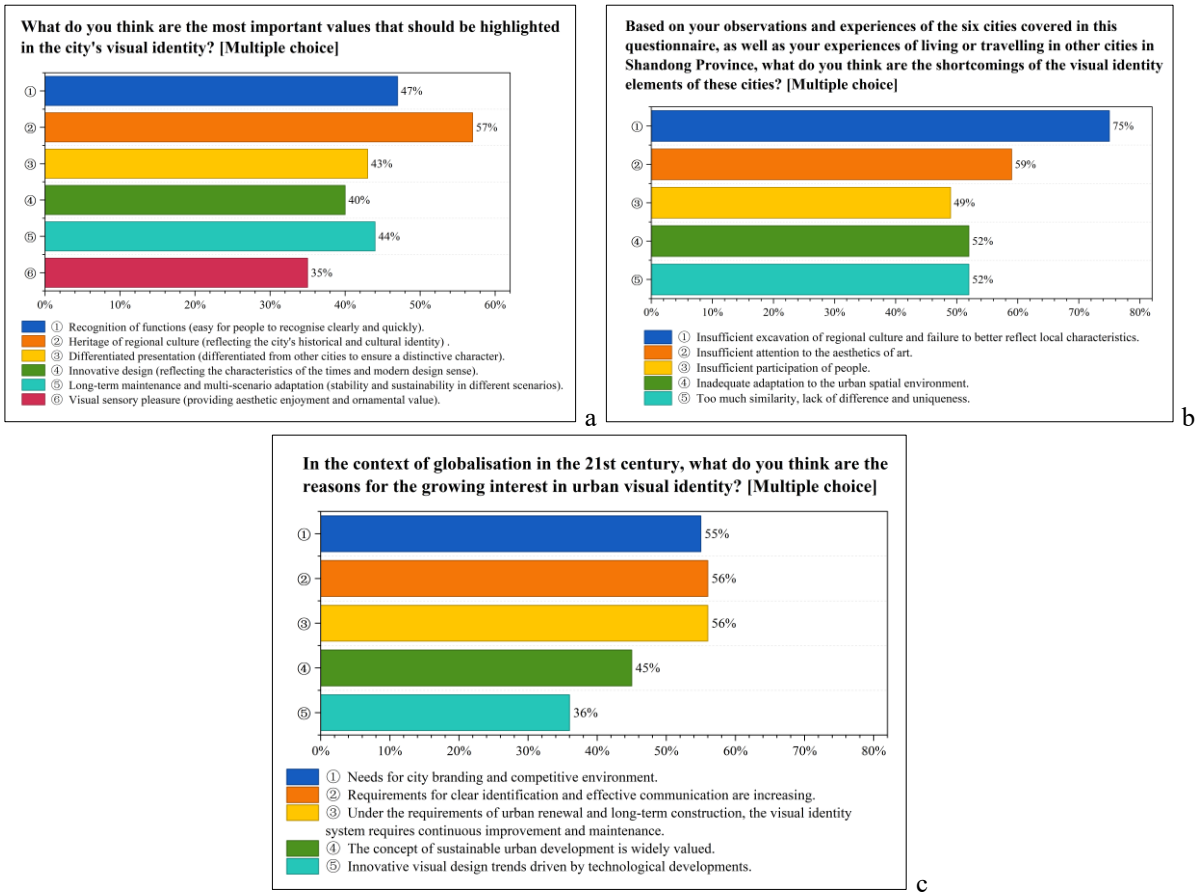


Figure 10. The overall value orientation and focus of the urban visual image: a) The distinctive value of urban visual identity, b) Shortcomings in urban visual identity elements, c) Emerging trends in urban visual identity

The city logos, iconic buildings, guide signs and public artworks collectively form a legible and perceptible visual system. The results of the questionnaire show that urban visual identity plays a significant role in shaping the public's spatial cognition and emotional attachment. Respondents demonstrated a greater propensity to identify with visual elements that possess cultural symbolism, exhibit clear form, and harmonize with the urban environment. Therefore, to enhance a city's competitiveness and identity, it is essential to establish systematic principles for urban visual identity design.

DISCUSSION

The Principle of Uniqueness

Distinguishing between cities and their regions requires an exploration of the notion of distinctive identity (Ginting & Wahid, 2017), and the uniqueness of cities is made manifest by the combination of material and immaterial elements (Musiaka et al., 2021).

Guided by the principle of uniqueness, multiple representative elements of Shandong's cities have been integrated through historical and cultural synthesis to construct distinctive visual imagery. Based on the findings of the previous questionnaire, it is evident that respondents' interest in the city's image is influenced by the visual appearance of its elements and the experiential impact within the urban space.

The principle of uniqueness holds that possessing distinctive expressiveness and recognizability is fundamental to a city's visual identity. The combination of these elements' form, material and color can give a city a visual character distinct from other cities. Whether static logo graphics or spatial elements such as architecture, signage and sculpture, these components resonate across multiple dimensions, ensuring the distinctive character of the locality is consistently conveyed through diverse media and settings. This motif appears in the Jinan city logo (Figure 1a), the Qingdao city logo (Figure 1b), Saint Michael's Church (Figure 3b), beer cap-shaped signage (Figure 5c), and the "May Wind" (五月的风) sculpture (Figure 7b).

The Principle of Identifiability

Similar to identifiability is the scientific definition of legibility, which was first proposed by Lynch in his monograph 'The Image of the City' (Lynch, 1964: 2-6). According to him, it can be assumed that a clear city attracts people's attention quickly, creates a stable image of the city in their minds and brings them a sense of security. Unlike legibility, identifiability emphasizes how visual elements can be distinguished and highlighted, focusing on whether visual symbols can be recognized by different groups in diverse circumstances within complex urban environments. In the survey results, the majority of respondents favored elements within the urban environment that enable them to quickly recognize and retain vivid memories.

Among cities in Shandong Province, the principle of identifiability manifests across multiple visual media. The Confucian Temple complex in Jining (Figure 3c) embodies the solemn and dignified character of traditional Chinese architecture through its majestic ritual order, enabling visitors to swiftly form an impression of the regional culture upon entering the space; its tourist orientation map (Figure 5e) employs concise graphics and judicious color schemes to enable visitors to swiftly ascertain key location information. The "Spring Mark" (泉标) sculpture in Jinan (Figure 7a), with its fluid, dynamic form, serves as both the visual focal point and defining symbol of the space, while also functioning as a significant daily gathering place for people. The "Eight Immortals Crossing the Sea" (八仙过海) sculpture in Yantai (Figure 7f) features mythological figures as its central image, creating a profound visual impression and similarly possessing a high degree of locational recognition.

The Principle of Sustainability

Sustainable development is often addressed in urban and design research in topics such as ecology and social development, emphasizing the protection of environmental resources and the coordination of human-nature relations (Ge, 2024; Skliarenko et al., 2022). One of these studies also points out that sustainable development also involves multiple dimensions such as cultural, spatial and social (Ragheb et al., 2022). The term sustainability in this paper is closer to "visual sustainability", which emphasizes the stability of recognition and cultural expression of visual elements in long-term use. Hanachi and Moghimi (2017) argue that physical and visual elements can influence the sustainability of cities and regions over time and intervene in cultural sustainability. This perspective offers help in understanding sustainability in terms of visual identity and urban identity maintenance.

The visual elements of multiple cities in Shandong Province demonstrate design objectives capable of enduring dissemination under this principle. The city logos of Rizhao and Yantai (Figures 1d and 1f) feature a distinct color structure and stable graphic form, enabling them to adapt and harmonize across various visual media.

Yantai's "Time Tower" (Figure 3f) stands along the coastline, its architectural form possessing strong modern characteristics and enduring symbolic value; the Shandong Museum (Figure 3a), an iconic building in the inland city of Jinan, presents an image that combines the orderly and rational qualities of modern design with the steadfastness and solemnity inherent in Qi-Lu culture. The guide signs in Jinan and Rizhao (Figure 5a and 5b) make use of the context of streets and lanes and the landscape features of greenways to extend the coordinated cultural expression of the visual messages in daily use and urban renewal. Yantai's coordinate check-in frames (Figure 5f) maintain landscape appeal by employing a visual language that is both robust and gravitas-imbued, while permitting repeated updates. The starfish sculpture in Rizhao (Figure 7d) uses an exaggerated image of the sea creature to demonstrate its ability to maintain a stable expression of its image under different lighting and landscape conditions.

The Principle of Regionalism

Regionalism is regarded as possessing authentic attributes, its essential characteristics lying in the shaping of a spirit of place, the enhancement of cultural belonging, and the achievement of contextual adaptation between the built environment and the regional ecology (Anderson & Al-Bader, 2006). This principle also advocates drawing design elements from local languages, skillfully integrating cultural achievements specific to a region into visual design.

Visual expression must maintain a close connection with the local cultural context, thereby ensuring the city's image achieves a harmonious and stable balance between cultural continuity and regional distinctiveness. Within this principle, Jining's city logo (Figure 1c) and Liaocheng's city logo (Figure 1e) respectively employ calligraphic and pictorial graphic compositions to address the visual expression requirements of their respective urban cultural characteristics within the flat graphic identity system. It is worth noting that Liaocheng, renowned as the "Jiangbei Water City" (江北水城), draws inspiration for its logo design from the iconic Guangyue Tower (Figure 3e). Here, the city's character and its geographical memory converge and resonate. Viewed from afar, the lighthouse structure at Rizhao Coastal Plaza (Figure 3d) merges its transparent spatial interface with the distant azure sky and sea, embodying the modern openness characteristic of a coastal city. Localized written expressions appear on Liaocheng's dialect culture wall (Figure 5d), where such regional vocabulary frequently garners attention and affection in everyday life. The bronze statue of Confucius in Jining (Figure 7c) and the "Two Dragons Playing with a Pearl" (二龙戏珠) sculpture at Tenglong Square in Liaocheng (Figure 7e) become the focal point of public recognition through their grand, stable shapes, ensuring that they can be clearly identified from a distance.

CONCLUSION

The dissemination of contemporary urban image increasingly relies upon the diverse expressions of visual media, and the role played by the urban visual identity in this process cannot be overlooked. Multi-faceted design interventions not only effectively elevate the standard of artistic development within cities but also address issues arising from the fast-paced social context, thereby enhancing the unique value of urban environments. Based on a structured questionnaire, this study identifies how four categories of visual elements -city logos, iconic buildings, guide signs, and public artworks- influence people's visual perception. The reason why visual image can play a role in shaping urban perception is inseparable from the fact that people constantly come into contact with these visual elements in their daily spatial and media experiences, and form an understanding of urban image and its characteristics through their visual judgments. Visual content with stable identification characteristics and regional cultural orientation can enhance people's regional memory and association of the city, and transform the material city image into imaginative environmental experience.

In addition, the four key principles for constructing a city's visual identity: uniqueness, identifiability, sustainability and regionalism also come together to form a complete content of the city's visual identity, providing a basis for categorizing the visual composition: the principles of uniqueness and identifiability can regulate and optimize the convergence of urban visual expression and the lack of image recognition, so that its visual elements can be more easily recognized and remembered, and can be applied to the visual image design of most cities; the principle of sustainability applies to cities where visual elements have been used for a long

time or are undergoing urban renewal and image integration, and is concerned with the continuity of expression and stabilization of recognition of visual elements over a long period of time; the principle of regionalism can be used in cities with deep historical and cultural resources or rich natural and geographic landscape elements, so that the visual language can fit the regional characteristics, and the problem of homogenization of urban image expression can be improved.

This study still has some limitations: the sample size of the questionnaire is 100 people, the age of the respondents is limited to 18-26 years old, and the results of the survey mainly reflect the tendency of the youth group in Shandong Province to perceive the visual identity elements of the city, which does not directly represent the entire age group. At the same time, the framework of visual identity principles proposed in this paper is mainly based on the six specific cities of Jinan, Qingdao, Jining, Yantai, Liaocheng and Rizhao in Shandong Province; for other provinces, regions and cities, although the framework can provide reference ideas and bases for understanding the formation process of the city's visual identity, it cannot be regarded as an established design form, and still needs to be adjusted according to the status quo of the respective regions and cities in the actual application.

Authors' Contributions

The authors contributed equally to the study.

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Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

Ethics committee approval dated 02/09/2025 and numbered 0902 was obtained by Ethics Committee of School of Art and Design at Shaanxi University of Science and Technology.

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Figure 7b: Baidu Baike. (n.d.). ***五月的风 [May Wind***]. Baidu Baike. https://baike.baidu.com/item/%E4%BA%94%E6%9C%88%E7%9A%84%E9%A3%8E/5900119 [in Chinese] (12.01.2026).

Figure 7c: Shandian News. (2025). *山东友城故事多丨文明为基 礼仪为道 济宁用文化"钥匙"打开国际友好之门 [Shandong has many friendship city stories | Civilization as Foundation, Etiquette as Principle: Jining Opens the Door to International Friendship with Cultural "Keys"]*. Sohu. https://www.sohu.com/a/896151697_100023701 [in Chinese] (12.01.2026).

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Figure 7f: Luv. [@59368921724]. (2025). *这里是中国古代四太名楼—蓬莱阁。忽闻海上有仙山，山在虚无缥缈间，借问八仙居何处，身在蓬莱即是仙！ [Here stands the ancient Chinese tower of Penglai Pavilion, one of the Four Great Pavilions. Suddenly hearing there is a fairy mountain on the sea, the mountain is in the illusory mist. Asking where the Eight Immortals reside, being in Penglai is being an immortal!]*. #Yantai #Penglai Pavilion #The Eight Immortals Crossing the Sea #Trending on Douyin. Douyin. https://www.douyin.com/note/7498015440842951975 [in Chinese] (12.01.2026).

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Research Article

An evaluation of spatial user experience in transportation interiors: Berlin-Südkreuz Station and Wrocław Central Station

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Abstract
This study examines user experience (UX) in transportation interiors by conducting a comparative analysis of Berlin Südkreuz Station and Wrocław Central Bus Station. Stations and bus terminals, as key public transportation nodes, have increasingly evolved beyond their infrastructural role into cultural and social spaces where diverse users interact. This study aims to investigate how interior design components influence user perceptions, comfort, and satisfaction. A phenomenological approach is employed, utilizing user data obtained from open-source Google Maps reviews. User comments were transcribed, coded, and analyzed through content analysis to identify recurring themes, including accessibility and wayfinding, spatial comfort and hygiene, aesthetic value, security, additional functions, and impact on urban identity. The study findings highlight themes that stand out as critical factors determining user experience in transportation spaces. The additional amenities and integration of cultural features offered by these spaces contribute to the stations' roles as mediators of urban identity and collective memory. By framing transportation hubs as user-centered public interior spaces, the study emphasizes the importance of holistic and inclusive design strategies. The results are expected to contribute to the literature by suggesting spatial user experience (SUE) themes that can guide future transportation-functional space design.

Keywords: Transportation interior, Transportation space, Station interior, Spatial user experience, Interior design

Extended Abstract

Introduction: As indoor spaces providing access to transportation options, stations and bus terminals have evolved from being merely infrastructural components of public transport to cultural spaces with their own unique social dynamics and diverse experiences. These spaces are environments experienced by various user groups, where both individual needs are met and perceptions that shape the urban image are formed. The design quality of transportation-functional indoor spaces plays a decisive role in creating user satisfaction. Poor ergonomics, inadequate lighting, or ineffective wayfinding can negatively affect spatial perception and increase feelings of insecurity. Beyond functionality, transportation hubs contribute to urban identity and memory and often serve as the first point of contact for visitors in the city. In this respect, spatial design, with its additional functions and cultural elements, can have positive potential effects on the city image and thus support tourism. As Lynch (2010) emphasizes, while environmental image is formed through identity, structure, and meaning, Ponti (2007) emphasizes the sense of belonging created by place identity. In this context, the spatial user experience (SUE) framework offers a holistic approach that links perception, emotion, and interaction to spatial design. Despite the growing literature addressing the physical, sensory, and psychological aspects of public interiors, studies focusing on user experience in transportation spaces as public interiors remain limited. This study aims to fill this gap by analyzing user evaluations in two current interior design projects: Berlin Südkreuz Station and Wrocław Central Bus Terminal. Through content analysis of real user evaluations on Google Maps, spatial themes reflecting user perceptions are identified, providing insights for future transportation hub design.

Purpose and scope: The main objective of this study is to evaluate spatial user experience (SUE) in transportation interiors, focusing particularly on station and terminal interiors. Highlighting that transportation hubs are not only infrastructural elements but also cultural and social spaces, the study aims to identify which sensory elements influence user perceptions and responses. The scope of the study is to reveal the themes determining user experience in transportation-functional interiors through a comparative analysis of two high-user transportation hubs from Europe and content analysis of user evaluations. These are Berlin Südkreuz Station in Germany and Wrocław Central Bus Terminal

in Poland. Both stations were selected as samples of recently constructed and renovated projects serving as important transfer points in their respective regions. Google Maps reviews, an open-source user-generated data source, were used to capture real experiences and perceptions. Reviews from the past six years were transcribed and analyzed using content analysis to identify recurring themes related to user experience. This study aims to contribute to the literature by generating thematic data on spatial user experience in transportation interiors, providing guidance for future design practices and decision-making processes.

Method: This study adopts a qualitative research design to evaluate user experience in transportation interiors. A phenomenological approach is used to capture user perceptions and lived experiences in transportation-functional interiors. In the first stage of the study, visual and published documents from two sample projects were collected for comparative analysis: Berlin Südkreuz Station and Wrocław Central Bus Terminal. Both stations are examples of significant transportation-functional projects that have been built or renovated in recent years. The data collection and analysis methods chosen in the study aim to obtain themes regarding how physical and sensory design elements affect user perception. Open-source user data obtained from Google Maps reviews was used as the primary dataset. To ensure currency in the findings, reviews entered or updated within the last six years were included. A content analysis procedure was followed to obtain the findings. Transcription files were compiled, user-generated reviews were coded according to their recurring content, and systematically analyzed. The codes were then grouped under broader thematic categories. Each review was referenced with a user number to ensure traceability within the dataset while maintaining anonymity.

Findings and conclusion: Analysis of user-generated data revealed common themes shaping spatial user experience in transportation interiors. These themes include accessibility and wayfinding, spatial comfort and hygiene, aesthetic value, safety, additional functions, and impact on urban identity. Accessibility stands out as one of the most critical factors in user evaluations; users frequently emphasize the importance of elevators, ramps, and barrier-free circulation systems. Functional deficiencies in these areas negatively affect user experience. Wayfinding is one of the most frequently mentioned spatial experience themes by users. Clear signage, information systems in different languages, and consistent color coding are noted to significantly reduce cognitive load and improve spatial readability. Lighting and vertical circulation solutions (elevators) stand out as elements shaping perceptions of accessibility and safety. The role of sensory design and safety measures in fostering psychological well-being and a sense of security is highlighted. The integration of amenities such as hygiene, maintenance, and retail or cultural elements into these spaces is closely linked to user experience. Examples such as the public piano in Berlin's Südkreuz demonstrate that transportation hubs can transcend their transportation functions, offering opportunities for social interaction and cultural expression. Beyond spatial comfort, this study considers transportation interiors as gateways contributing to urban identity and memory. Consequently, it emphasizes that transportation hubs are not merely infrastructural nodal points, but also symbolic and cultural spaces that influence the urban image.

Keywords: Transportation interior, Transportation space, Station interior, Spatial user experience, Interior design

INTRODUCTION

Stations and terminals, which are places where basic actions such as waiting for public transportation take place, are not only infrastructural elements but also significant places where people spend considerable time, representing a crucial user experience. They have transformed into spaces experienced by diverse user profiles, where daily interactions occur, and which possess social dynamics. The fundamental reason for this transformation is the need for spatial quality arising from the length and variety of time users spend in these areas while waiting for public transportation. Transportation-related indoor spaces are not only functional transition areas but also environments where users directly interact with the physical environment during their waiting times, and this interaction shapes their overall experience. During the waiting process, interior design components such as the ergonomics of seating elements, lighting conditions, and the effectiveness of wayfinding and information systems directly affect the user experience. Approaching public transportation-related indoor spaces from a user-centered perspective is a vital necessity to improve the waiting experience and create safer, more comfortable, and more accessible environments. As public indoor spaces characterized by high user circulation, public transportation interiors affect the well-being of users as an important part of daily life. In this context, user experience has become increasingly important in the design of multi-layered station and terminal structures. Studies in the literature emphasize the critical role of sensory design elements, particularly acoustics and lighting quality, in enhancing passenger comfort (Aktop-Maden & Avlar, 2017: 18). Similarly, studies have shown that physical design components, such as seating arrangements and lighting conditions in station interiors, have a decisive impact on user experience, especially during long waiting times.

Such interiors require multidisciplinary design approaches at different scales; the design process is not limited to architects but also includes interior designers, graphic designers, landscape architects, lighting designers, crowd management specialists, and even industrial designers (Öztürk, 2020: 20). These findings demonstrate that sensory and physical factors such as lighting, ergonomics, accessibility, and wayfinding directly affect users' spatial perceptions and psychological states in transportation-oriented public interiors. Therefore, adopting user-centered approaches in the design of transportation-functional public spaces emerges as a requirement to ensure a positive spatial experience.

Transportation areas play a significant role in shaping urban identity (image), enhancing the daily comfort of city dwellers, and contributing to the tourism mobility. Lynch (2010: 8) states that the environmental image can be divided into three components: identity, structure, and meaning. Similarly, Ponti (2007) defines place identity as a sense of belonging arising from the intrinsic identity of a place. Both place sense and place identity, as a multi-layered process, are important components of place discourse (Carter et al., 2007: 756). Furthermore, it is emphasized that passengers' perceptions of safety are closely related to the physical and social organization of the space; inadequate maintenance, lack of navigation systems, or physical ambiguities can foster feelings of insecurity (Evans, 2009: 372). It is observed that some terminals and stations that have become city landmarks can be attractions that enhance the city's tourist value through their architectural design elements, additional functions, and artistic features. Station interiors, serving as the first point of contact with the city for both domestic and international visitors, function as the face of the city, act as intermediaries of urban identity, and contribute to the construction of collective urban memory.

The relevant literature reveals that the design of transportation areas and interior elements plays a significant role in the perception of the urban environment. A study on metro stations in Istanbul showed that the sensory and physical design of metro interiors directly affects user satisfaction, creating a positive perception of the city among both tourists and locals (Tunç, 2007: 104). While a significant number of studies examine the physical and sensory design elements of public spaces, studies focusing specifically on user experience in transportation interiors are more limited. This study aims to fill this gap by approaching transportation interiors from a user experience perspective, conducting a comparative analysis of selected sample station interiors, and revealing user-centered design themes. The objectives of the study are to comparatively evaluate station and terminal interior designs focusing on user experience through two sample spaces, and to propose spatial user experience themes suitable for transportation environments. Berlin Südkreuz Station in Germany, selected as one of the sample areas for this study, serves as a significant example with its user-friendly features added during its renovation project in 2020. This multi-functional transfer station houses both train and bus services, as well as incorporating additional functions. The second sample project, the Wroclaw Bus Terminal in Poland, opened in 2017 and stands out with its user-centered design approach, emphasizing well-organized and accessible design criteria. The findings of this study are expected to contribute to the literature by generating spatial experience themes that can shed light on the future design of public transportation environments.

THE CONCEPT OF SPATIAL USER EXPERIENCE (SUE)

In the design process of a space or product, the individuals who engage with that space or product are defined as "users." The quality of spatial design can be evaluated through the positive or negative feedback provided by users following their experiences. User experience is grounded in the perceptions, habits, and acquisitions that emerge during the use of a space. This experience reveals the extent to which the design responds to user needs. In essence, user experience represents the interactive practices between action and environment, encompassing space-oriented objects, products, and services, and, from another perspective, constitutes the final output of design (Nazlı Erap, 2022: 27). According to Norman, who first introduced the concept of user experience, it is defined as a series of interconnected and integrated experiences (Norman, 2010). The International Organization for Standardization (ISO) defines user experience as "a person's perceptions and responses resulting from the use and/or anticipated use of a product, system, or service" (ISO, 2010). User experience (UX) is a strange concept that has been readily embraced by the human-computer interaction (HCI) community, practitioners, and researchers, yet repeatedly criticized for being vague, elusive, and ephemeral (Hassenzahl & Tractinsky, 2006: 92).

User experience (UX) is defined as the holistic expression of the perceptions, emotions, and responses that emerge from an individual's interaction with a product, system, or service. In recent years, this concept has gained increasing importance, particularly in the context of public spaces and transportation systems. Perceptions related to interior atmosphere are directly linked to individuals' knowledge of the physical characteristics of a space, and this knowledge plays a decisive role in the evaluation of that space. Such evaluations made by users guide and shape their behavioral patterns within the environment. Spatial perception, in turn, is associated with the individual's short- or long-term experiences with the space or its surroundings and with the mental recall of these experiences. Based on a comprehensive review of the literature from multiple disciplines, primarily product design and human-computer interaction, a six-dimensional Spatial User Experience (SUE) model has been defined as the main factors of SUE by Juliá Nehme et al. (2020: 7). These dimensions are divided into two groups: (1) Ergonomic-Instrumental, Spatial Cognition, Physical Conformity and Environmental Conformity; and (2) Affective, Affective Response, Spatial Appreciation and Proxemic. In high-traffic environments such as metro stations, enhancing user experience has become essential to meet both physical and psychological needs. In this regard, user experience represents a holistic construct that extends beyond functionality to encompass multiple layers, including aesthetics, ergonomics, accessibility, and sensory perception (Erap et al., 2021: 341). SUE in metro stations and other transportation-oriented spaces is shaped by the interaction between individuals and the physical as well as sensory design elements. Components such as wayfinding systems, lighting, and aesthetic qualities influence the quality of experience by enhancing user satisfaction and the sense of belonging. User-centered and holistic design approaches transform station interiors from being mere transit spaces into social environments that are integrated with the city.

Accessibility, Wayfinding and Sensory Design in Transportation Interiors

An examination of approaches concerning individuals with disabilities reveals that awareness of the social exclusion and denial of rights faced by such groups began to emerge in the mid-20th century (Yelçe, 2020: 16). Addressing a societal issue such as disability from the perspective of spatial accessibility has been highlighted in the literature as essential for identifying problems and proposing solutions (Yıldırım et al., 2021: 196). In transportation hubs, accessibility design constitutes a fundamental component of the experiential relationship established between the space and its users. Physical access provisions, including elevators, ramps, and tactile floor surfaces, not only support mobility but also directly shape emotion-based perceptions of the space, such as perceivability and user safety. The perception of a terminal or station as sensorially accessible positively affects users' emotional experiences, thereby enhancing overall satisfaction levels (Vega et al., 2025: 12). Wayfinding systems directly contribute to the cognitive processes of SUE. Lynch's (1964: 101) theory of the image of the city and Passini's (1984: 163) wayfinding theory indicate that environmental cues - such as landmarks, nodes, and signage- facilitate the formation of mental maps within the space and help users understand the environment, thereby reducing cognitive load. Critical architectural determinants of spatial cognition encompass internal environmental information, layout features, and accessibility, expressed through components such as facility locations, landmarks, signage, spatial differentiation, mapping, and lighting (Wei et al., 2025: 2). For qualified wayfinding within metro station design, the legibility and visual coherence of signage must be strengthened to facilitate quick and intuitive recognition by users of varying age demographics (Wei et al., 2025: 22).

Visual environment design and sensory atmosphere are spatial parameters that significantly impact user experience. Elements such as color, texture, material, atmospheric qualities, and spatial constraints act as visual factors that influence users' stress levels, mood, and overall experience. Wu and Park (2025: 1) highlight cultural differences in spatial perception, noting that Chinese participants preferred narrower, brighter, cool-colored passages for improved orientation and focus, while Korean participants favored wider, darker, warm-colored passages for greater accessibility and stability. Sensory elements have a significant impact on user experience in interaction with a space. For instance, in transportation interiors, physical factors such as the absence of natural light due to being underground, changes in ambient temperature, and the cold sensation conveyed by concrete materials can play a decisive role in shaping users' positive or negative perceptions of the environment. An atmospheric perception also involves judgements beyond the five Aristotelian senses, such as sensations of orientation, gravity, balance, stability, motion, duration, continuity, scale and illumination

(Pallasma, 2014: 231). The sensory effects present within a space indicate not only its physical accessibility but also its accessibility in terms of psychological experience. The use of technology also emerges as a necessity for an accessible spatial experience. Technological wayfinding solutions, such as mobile navigation applications and auditory or tactile information systems, enable users to navigate spaces independently and safely (Mimra et al., 2025: 6). In addition to functionally supporting accessibility, these systems can enhance the quality of the relationship between users and the environment by promoting psychological well-being.

METHODOLOGY

Research Model and Method

This study employs a two-stage methodology. In the first stage, visual and written documents related to the selected sample station locations were classified using visual comparative analysis, and a comparison table of visual and written materials containing project design features were presented. In the second stage, user experience research was conducted using a phenomenological approach with open-source online user reviews. User experience research has become an effective approach for obtaining data to understand user behavior and develop contemporary spatial design strategies. In this study, the phenomenology design, one of the qualitative research methods, was employed to analyze user experiences in sample transportation interiors based on user feedback. The transportation interiors selected as study sample are Berlin Südkreuz Station in Germany and Wroclaw Bus Terminal in Poland. Phenomenology is a qualitative research design that gathers information about a phenomenon by consulting the perspectives of individuals who have directly experienced it (Çapar & Ceylan, 2022: 295). Within this context, the design of interior spaces in transportation hubs and associated user experiences were examined through users' online Google reviews. The phenomenological approach was selected as it provides an appropriate means to obtain in-depth, experience-based knowledge and interpret the lived experiences of users. Google Maps reviews of the selected stations were treated as written documents reflecting user perspectives. User comments directly related to user experience were extracted separately for each sample station and transcribed. These transcripts were systematically coded by the researcher using a qualitative data analysis approach, and the resulting themes were organized and presented in a comparative table. The selection criterion for the comments was that they had been posted or updated within the past five years. This approach aimed to obtain up-to-date information regarding the current conditions of both stations.

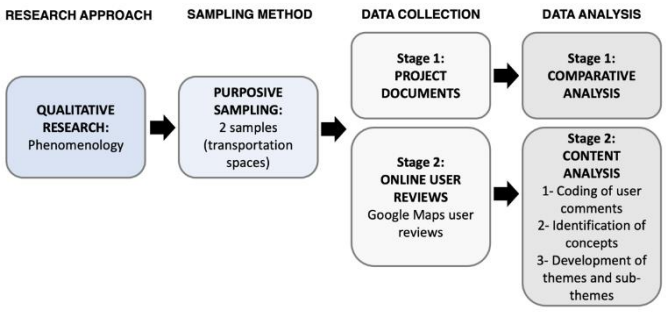


Figure 1. Graphical abstract of study

The use of online open-source user reviews as a primary data source is supported by studies that increasingly recognize digital platforms as valuable repositories of unsolicited, natural user feedback (Song et al., 2020: 1; Liu & Xiao, 2021: 1; Chen & Cheng, 2024: 1). Such reviews capture firsthand experiences expressed by users in their own language, thus providing rich qualitative data that is less affected by researcher intervention compared to traditional interviews or surveys. Additionally, studies have highlighted the effectiveness of online reviews, particularly in environmental and spatial experience research, where users freely report their perceptions of comfort, accessibility, and satisfaction within specific built environments. Google Maps, as a widely known and easily accessible platform, is frequently used. It has become the first-line platform for users seeking information about any given location. This digital mapping service provides users with a medium to post ratings and reviews about various organizations (Chen & Cheng, 2024: 4).

The aim of this study is to investigate the impact of interior design elements on user experience in two comprehensive transportation hub samples (Berlin-Südkreuz Station and Wroclaw Terminal) based on user-generated data. The key criteria for selecting these two transportation hubs in different European countries were that the design projects are recent projects constructed by professional experts within the last decade and that they are renovation projects at existing stations as part of a contemporary spatial design initiative. Additionally, their location as high-user transfer stations connecting different cities and countries in Europe was another selection criterion. Both stations function as important hubs in their respective locations. During the analysis process, themes derived from user reviews on Google Reviews were supported by station-specific visual and informational documents to provide contextual support. This approach aims to provide a user-experience-focused analytical framework for transportation hubs with different design characteristics, offering insights into how spatial functionality and interior design features influence passengers' perceptions and behaviors.

Sample Selection

This study aims to select transportation space projects incorporating contemporary design approaches as samples for evaluating the user's interior experience in transportation spaces. For this aim, two different specially designed transportation space projects were selected using a purposeful sampling method based on certain criteria. The logic and power of purposeful sampling lie in selecting information-rich cases for study in depth (Patton, 2002: 230). The process of selection of the samples was guided by the following criteria:

- To be designed by a professional architectural design office,
- Access to documented project information,
- The spatial design project should include innovative design solutions specifically regarding wayfinding and accessibility.

Within this scope, sample transportation hub projects from each of two different countries in Europe that meet these criteria were selected.

Sample Station 1: Berlin-Südkreuz Station

The station Berlin Südkreuz, which was determined as the first sample, is located south of Berlin's city center in the Schöneberg district in Germany. Long-distance trains, regional trains, the S-Bahn, and buses stop here. From Südkreuz, travel to the inner city takes about 20 minutes (The Official Website of Berlin, 2025). Berlin-Südkreuz Station is one of 16 future stations nationwide (Germany) at which DB is testing new concepts and services. Berlin-Südkreuz station was the scene of improvements in 2020 (Architonic, 2025). This station underwent a renovation project in 2020. Signaling guidance system with identity-creating spatial sculpture "The Flow". In close collaboration with the Berlin-based design agency No Pink Studio, a space-defining intervention was created at Berlin's Südkreuz railway station that combines functionality with design conciseness. The aim was to develop an identity-creating signage system that makes the complex spatial structure of the transport hub intuitively tangible (Schmidt & Pütz, 2021). The project was conceived and executed with notable dedication and a strong sense of commitment by all parties involved (Architonic, 2025). The main element is a consistent color concept that unfolds across all levels, from the S-Bahn entrances to the platforms. Visual continuity guides passengers naturally within the space (Schmidt & Pütz, 2021). This color-based design approach can be seen in Figure 2.

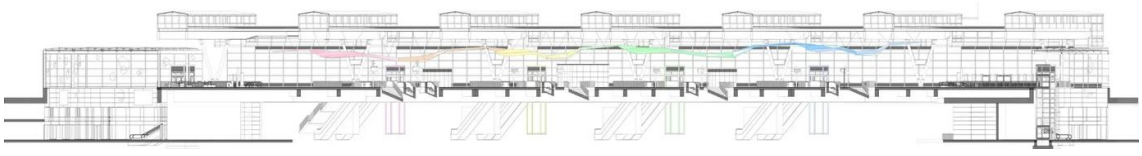


Figure 2. Elevation of the renovation project of Berlin-Südkreuz Station

According to the project information obtained, thanks to the precise interaction of the professionals involved, a solution was achieved that met both high functional requirements and design demands. The project resulted in an innovative navigation system used by more than 200,000 passengers daily. Due to its conceptual design strength and consistent implementation, the project was honored with a "Special Mention" at the 2022 German

Design Award (Schmidt & Pütz, 2021). Berlin is a city shaped by layered transport histories. Emerging as a trading center in the 13th century, the city expanded rapidly with industrialization and the development of extensive railway networks in the 19th century. In the 20th century, the city was divided following World War II, leading to the separation of transport systems in East and West Berlin. After the fall of the Berlin Wall in 1989, these infrastructures were reintegrated (Ladd, 2028).

Figure 3. Map of Berlin City

Sample Station 2: Wrocław Central Bus Station

Located in the Huby residential district of Wrocław, Poland. Wrocław Central Bus Terminal (Dworzec Wrocław) is located on the second basement floor of the Wroclavia shopping mall and is immediately adjacent to Wrocław Główny train station. Officially opened in 2017, the terminal represents the only underground PKS bus terminal built in Poland. The facility forms part of a wider urban development initiative, with the Wroclavia shopping center opening in October 2017 and the bus terminal opening shortly after. The new Wrocław bus station was built on the minus two level of the Wroclavia shopping center. It is the only PKS bus station in Poland to be built underground, with 11 departure platforms, three arrival platforms, and one reserve platform. The terminal has the capacity to accommodate 1,000 buses and serve several thousand passengers daily. It was built with the expectation that it would serve up to 5.4 million people annually (Pajączek, 2017). The Polbus bus station is a key part of the multifunctional Wroclavia building. The interiors were designed with attention to clarity and functionality of the space, as well as the durability of the materials used (ATP Asymetria, 2017).

Figure 4. Wrocław Central Bus Terminal

Wrocław, historically known as Breslau, developed as a key Central European trade and transport hub from the medieval period, shaped by its position along the Oder River. Rapid industrialization in the 19th century brought extensive rail infrastructure and station development. Following the devastation of World War II and subsequent border changes, the city underwent major reconstruction under Polish administration (University of Lodz, 2025).

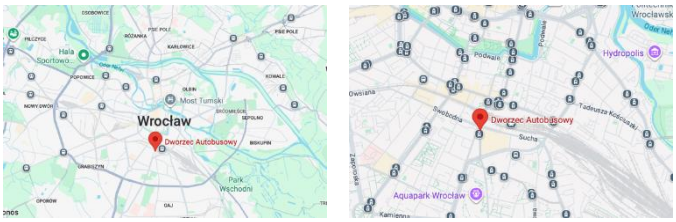


Figure 5. Map of Wrocław City

Data Collection

In the data collection process, publicly accessible user reviews from Google Maps were utilized. For both samples, comments from 2020 to date were used by accessing Google Maps in 2025 and 2026. Since the first sample underwent a renovation project in 2020 and the second sample was completed in 2017, data from the last 6 years was used for both samples. User reviews for each station available on Google Maps were gathered,

transcribed, and subjected to content analysis to extract relevant themes. Two separate sample terminal users were coded internally as P1, P2, and so on. Following the transcription of the reviews, thematic coding was conducted, resulting in the identification of key themes related to the sampled transportation hubs, including design, accessibility, wayfinding, safety, and functional comfort etc. These themes were subsequently evaluated as factors directly influencing user experience within transportation facilities.

Data Analysis

In the first stage of the study, visual and written data were collected and used to create comparative analysis tables. The tables were organized according to the content of the information. In the second stage of the findings, online user comments were selected according to specific criteria and subjected to content analysis. Content analysis is defined as a research method used to make replicable and valid inferences from data to the context of their use (Hansen, 2003: 55). Content analysis can be used with a wide variety of data sources, including textual data, visual stimuli (e.g., photographs/videos), and audio data (Stemler, 2015: 1). The collected user reviews were transcribed and analyzed using the content analysis method defined by Krippendorff (2018: 411), a systematic qualitative approach aimed at identifying patterns and drawing valid, replicable inferences from textual data within its context. The data were first coded inductively to extract recurring themes directly related to user experience in the sampled stations. Based on these identified themes, a comparative evaluation table was developed, enabling both station-specific and cross-case analyses. This dual approach allowed the influence of key themes such as design, accessibility, wayfinding, safety, and functional comfort on user experience to be examined individually for each station and comparatively across the selected transportation hubs. By systematically contrasting these findings, differences in spatial design and user experience between the case study stations were revealed. This comparative analysis facilitated the identification of each station's strengths and weaknesses, thereby offering insights into how interior design elements affect user satisfaction. The use of content analysis in this study aligns with its established role in environmental behavior research, where it is frequently applied to interpret unstructured, user-generated data.

FINDINGS

Sample Station 1: Berlin-Südkreuz Station

The aim of the project was to create a pleasant place for travellers and residents alike to linger. According to Deutsche Bahn management, the travellers like to use the furniture. The primary objective in this sample station was to design an inviting environment that encourages both travelers and residents to spend time in the space. Key features include a triangular seating island, an expansive flowerbed with a lawn enclosed by high-quality seating furniture, and undulating seating elements integrated with the steps. Hardwood was intentionally selected for its tactile and visual qualities, which enhance the welcoming character of the area. The project was conceived and executed with notable dedication and a strong sense of commitment by all parties involved (Architonic, 2025). The following images illustrate the general parts of Berlin Südkreuz Station, highlighting details related to accessibility, wayfinding, and lighting (Table 1).

Table 1. Berlin-Südkreuz Station interiors

Project Name	Spatial Description	Images
Berlin-Südkreuz Station	Station interiors-wayfinding and lightning	  

In the main areas shown in Table 1, an open ceiling was used to reveal the steel and glass construction details. During the daytime, natural lighting is utilized, while artificial lighting is provided by the quad spotlight

fixtures on the ceiling to create general illumination. Different color accents are applied in the wayfinding design throughout the space. In the elongated main hall, areas corresponding to different platforms can be identified through the parametrically curved ceiling element and other vertical wayfinding components, each assigned distinct color codes. For example, in the area where the ceiling form, elevator, and vertical signage are pink, Platforms 11-12 and the corresponding S-Bahn lines are located. Photographs of the interior and wayfinding elements are presented below (Table 2).

Table 2. Berlin-Südkreuz Station interiors

Project Name	Spatial Description	Images
Berlin-Südkreuz Station	Station interiors-wayfinding, lightning and waiting areas	

In Table 2, the vertical wayfinding elements (signage) indicating train lines are color-coded according to their respective areas. The third image in Table 2 depicts the interior space of the station where activities such as shopping, waiting, and social interaction occur. This waiting hall is surrounded by retail outlets, including food and beverage shops and a supermarket. In this image, a publicly accessible piano is located at the center of the space, along with a person providing piano performances for station users. This entirely spontaneous activity offers a spatial opportunity for social interaction, which has a tangible impact on station users. Below, the exterior area containing the station's bus stops is shown, along with urban furniture designed as part of the station renovation project in the surrounding environment.

Table 3. Berlin-Südkreuz Station bus perrons and exterior/environmental design

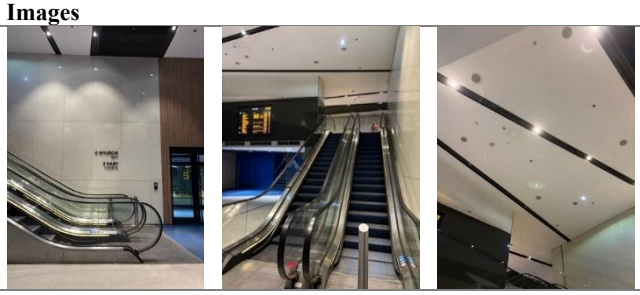
Project Name	Spatial Description	Images
Berlin-Südkreuz Station	Station exterior and environmental design	

Table 3 presents the bus platforms and the exterior spatial arrangements of the station. At this location, the bus platforms are designed as open-air spaces, reflecting a functional approach to circulation and accessibility. The urban furniture positioned in front of the station's main entrance was introduced within the scope of the renovation project, enhancing the public realm by providing areas for rest, orientation, and social interaction. These design interventions not only improve the functional use of the exterior environment but also contribute to the overall spatial quality and user experience of the station.

Sample Station 2: Wrocław Central Bus Station

Table 4 illustrates the interior spaces of the Wroclaw Central Bus Station, highlighting details related to accessibility, wayfinding, and lighting conditions. In terms of spatial accessibility, vertical circulation is facilitated through escalators, positioned to connect the street level with the bus platforms efficiently. At the lower level of the escalator, essential wayfinding signage is provided in both Polish and English, ensuring clarity and ease of navigation for international users. The lighting design primarily employs spot fixtures to create a consistent and evenly distributed illumination across the interior. The overall spatial atmosphere is reinforced with light-colored finishes on ceilings, walls, and flooring, generating a sense of spaciousness, while dark blue accents and wooden cladding serve as secondary design elements that introduce contrast and warmth into the environment.

Table 4. Wroclaw Central Bus Station interiors

Project Name	Spatial Description	Images
Wroclaw Central Bus Station	Station interiors-wayfinding and lightning	

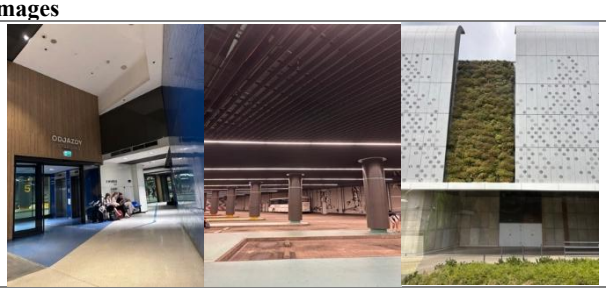
In comparison to Berlin Südkreuz Station, where spatial identity is reinforced through large-scale structural transparency and vertical spatial color coding, Wrocław Central Bus Station demonstrates a different design approach. As illustrated in Table 5, the station integrates wayfinding, lighting, and waiting areas with a more restrained yet coherent visual language. The vertical surface behind the fixed seating elements in the waiting zone employs a striking shade of blue, which is further extended to the floor wayfinding system to create visual continuity. This design strategy not only provides aesthetic integrity but also enhances users' cognitive mapping of the environment by clearly indicating pathways to key areas such as "arrivals" and "exits". Moreover, a digital board projecting real-time bus schedules significantly improves information accessibility, fostering both functional efficiency and user comfort. Thus, while Berlin Südkreuz emphasizes spatial orientation through expansive structural gestures and color-coded nodes, Wrocław Central Bus Station adopts a more enclosed, interior-focused strategy that leverages color, digital media, and compact spatial cues to achieve accessibility and user satisfaction.

Table 5. Wroclaw Central Bus Station Interiors

Project Name	Spatial Description	Images
Wroclaw Central Bus Station	Station interiors-wayfinding, lightning and waiting areas	

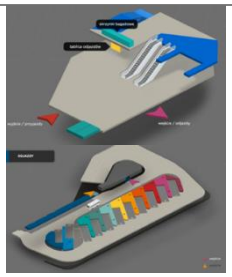
Table 6 illustrates several key spatial components of Wrocław Central Bus Station and its immediate context. The first image shows the "departures" gate, located directly opposite the escalators, which provides users with fast and convenient access to the bus platforms. The second image depicts the platform area, where artistic wall murals have been integrated as aesthetic interventions. The floor is accentuated with a light blue tone, while linear LED fixtures installed on the open-system ceiling generate general illumination across the space. The final image presents a detail of the Wroclavia Shopping Center façade, which includes the bus station. The building is characterized by a contemporary envelope design incorporating a green wall and permeable façade elements, thereby establishing a visually distinctive presence within its urban context.

Table 6. Wroclaw Central Bus Station-bus perrons and exterior/environmental design

Project Name	Spatial Description	Images
Wroclaw Central Bus Station	Bus perrons and exterior/ environmental design	

When compared with Berlin-Südkreuz Station, spatial and architectural strategies of the two hubs reveal different approaches to public identity and user experience. Berlin-Südkreuz emphasizes structural transparency through its extensive use of steel and glass construction, while relying heavily on natural daylight. By contrast, Wrocław Central Bus Station is integrated into a commercial complex, and its design highlights a hybrid identity-functioning simultaneously as a transport hub and a retail environment. The use of green walls and permeable façades reflects a contemporary emphasis on sustainability and urban integration, whereas Berlin-Südkreuz projects an infrastructural clarity rooted in mobility and efficiency. Thus, while both stations operate as major nodes within their respective urban networks, their architectural expressions represent distinct interpretations of accessibility, atmosphere, and the symbolic role of transport infrastructure in shaping urban identity. Table 7 presents the fundamental data of the sampled transport hubs, including their design and conceptual approaches, connectivity, urban context diagrams, and architectural floor plans, in a comparative format. As illustrated in the table, both stations serve as significant nodes of urban mobility within the European Union, despite being located in different countries and cities.

Table 7. Comparative analysis of sample stations

	Berlin-Südkreuz Station	**Wroclaw Central Bus Station**
Design Approaches and Concept	The aim was to create a pleasant place for travelers and residents alike to linger. A triangular seating island, a large flowerbed whose lawn is enclosed by high-quality seating furniture, and wavy seating elements that nestle against the steps. Hardwood was deliberately chosen because its feel and look make it more inviting. All those involved planned and implemented the project with commitment and heart and soul (Architonic, 2025).	The Wroclaw Central Bus Station (Polbus bus station) is a key part of the multifunctional Wroclavia building. The interiors were designed with attention to clarity and functionality of the space, as well as the durability of the materials used (ATP Asymetria, 2017).
Links	The train station Berlin Südkreuz is located south of Berlin's city center in the Schöneberg district. Long distance trains as well as regional trains and the S-Bahn stop here. From Südkreuz, travel to the inner city takes about 20 minutes (The Official Website of Berlin, 2025).	The most modern facility of its kind in this part of Europe, located right next to the main railway station and the public transport hub at the intersection of Borowska and Ślężna streets (Dworzec Wrocław, 2025).
Close Environment Map	 Südkreuz Station	 Wroclaw Central Bus Station
Plan	 Südkreuz Station Plan	 Wroclaw Central Bus Station Plan

Content Analysis Themes of User Reviews

In the scope of this study, Google Maps reviews, used as an open data source, were extracted, and compiled into transcript files. In the subsequent stage, these transcripts containing user reviews were carefully examined, and a content analysis was conducted. The table below presents the themes identified through this analysis, along with the corresponding user comments coded under each theme. The user number associated with each comment is indicated at the end of the respective entry. The comments were accessed from the Google Maps pages of the relevant sample stations in 2025 and 2026 (Google Maps Südkreuz, 2025; Google Maps Wrocław Central Bus Station, 2025).

Table 8. Content analysis themes based on Google Maps comments

Content analysis themes	Berlin-Südkreuz Station Coded Google Maps Reviews	Wroclaw Central Bus Station Coded Google Maps Reviews
Theme 1: Accessibility and Wayfinding	"…Both elevators and escalators broken." (P1) "It's a major S-Bahn regional and long-distance station." (P2) "This "future station" gets one star for its mostly dysfunctional accessibility-floor lights that blink (occupancy indicators are now off again), a rotating solar panel, and other gimmicks were sufficient." (P3) "…Südkreuz is more of a regional train station, offering good transfer options to the S-Bahn, long-distance buses, and local BVG buses." (P5) "Escalators are broken, one elevator is out of service, and the other is closed for repairs. Accessibility? None." (P8) "Excellent connections…" (P10) "As a frequent traveler, I can't get used to this station. I've found the strange architecture of the intersection of long-distance and S-Bahn trains to be unsightly for years." (P12) "Even if you are visiting the station for the first time, it is quite easy to reach." (P16) "…well-serviced and convenient train station". (P18) "It's huge and inconvenient if you don't know your way around. It's hard to find a bus." (P17)	"…A public transport hub is located nearby… It is well-marked..." (P2) "It was easy to find my Flixbus here." (P4) "Great centre, everything is nearby." (P6) "The entrance is a bit confusing. Yes, it's on the first floor of Wroclavia, on the northeast side, I think." (P7) "Easy communication." (P9) "What interested me: the toilet room and Wi-Fi. toilet: If you want to pay with a card… then you'll have to go to the ticket office :)" (P1) "Ticket offices and information desks are located at the top of the station, while platforms are located at the very bottom, well-marked…". (P12) "Public transport stops, the train station, and a taxi rank are nearby. The market square is just a few hundred meters away." (P14) "…and is well-located, right under the shopping mall and close to the train station." (P18)
Theme 2: Spatial comfort and Hygiene	"This large station is neither comfortable, safe, clean, nor inviting." (P2) "Homeless people are urinating on the wall in front of the bus stop, so everything is spilling onto the road. The station itself is completely filthy and covered in bird droppings." (P6) "…It smells like vomit, urine, and alcohol." (P9) "Unfortunately, the station hasn't been this clean and hygienic in the last two years." (P11) "I never expected to see such a dirty train station... We had a four-hour layover to catch a bus, and there wasn't even a covered, heated waiting area; we were freezing..." (P20)	"There's nowhere to sit while waiting. People are standing in the adjacent shopping mall. The restrooms are poorly ventilated." (P5) "…It is well-marked and clean." (P2) "…and clean." (P12) "…Passengers can wait for their bus in the warm basement of the Wroclavia shopping center." (P14) "…the toilet is a disgrace… it's dirty, smelly, and filthy. The toilet is generally very dilapidated and neglected." (P18)
Theme 3: Aesthetic Value	"…a First-Class station..." (P1) "Südkreuz station itself has good transport connections and is quite "new," but otherwise, it's nothing spectacular." (P4) "Beautiful train station…" (P7) "The train station is truly wonderful." (P10) "A modern station…" (P14) "Beautiful, well-serviced and convenient train station". (P18)	"The modern PKS bus station..." (P2) "The station is great…" (P3) "Cool." (P8) "New, Modern." (P11) "A perfectly designed bus station..." (P14) "Beautiful, comfortable, modern." (P15) "Beautiful, useful." (P16) "The station looks nice…" (P18)
Theme 4: Security	"Every day, drunk people hang around in front of the entrance, harassing passersby. We have to call the police almost daily." (P6) "All the seats are occupied by smelly, drunk, and bullying men… There's federal police station there, but the men and women there don't seem to do anything." (P9) "In my opinion, there's insufficient security outside the station, especially around the bus station. You'll be harassed and sometimes threatened by drunk people…" (P10) "What's also very unpleasant and disgusting is the sight of all the people smoking and drinking alcohol in the mornings." (P11) "It was filthy and very dangerous at 1 a.m." (P20)	"…but the impression is constantly spoiled by a less-than-adequate guard. He's arrogant, oversteps personal boundaries, is tall, has gray hair, and is 50+ years old. Everything else is fine." (P3)

Theme 5: Additional Functions (Art/shopping/social interaction etc.)	"The Edeka supermarket, open 7 days a week, is good." (P1) "…good shopping opportunities, and friendly staff." (P10) "You can really find everything you need there…" (P11) "…and you can also do a little shopping." (P12) "…you can go shopping and there are many options for food…" (P12)	"…located in the Wroclavia shopping center…" (P2) "There should be proper restrooms, seats, and basic amenities like tea/coffee/newspaper kiosks." (P5) "Good place, but the toilet should be free." (P13) "Ticket sales lady is rude and doesn't speak English." P17
Theme 6: Impact to Urban Identity	"It's also so neglected there, there's a huge thicket full of garbage, clothing, beer bottles, and other things. If something isn't done soon, the situation will only get worse, with nothing but useless projects and ideas that don't help the station at all…" (P6)	"…It was a transfer station on the way." (P1) "Beautiful, useful. Not like the one in Warsaw..." (P16)

The themes obtained from the analyses conducted in this study are presented collectively in Figure 6 below, in addition to Table 8.

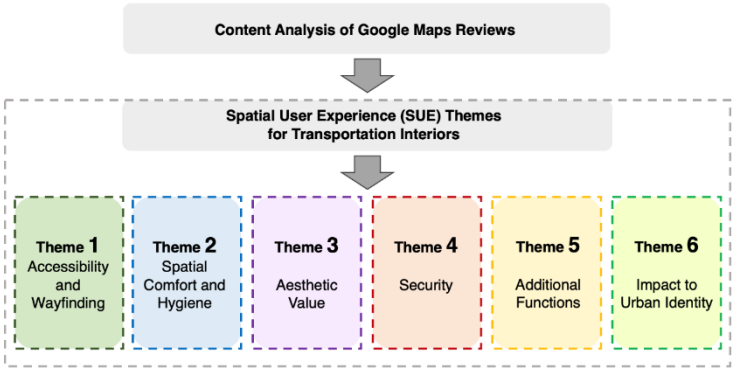


Figure 6. Graphical summary of findings of the study

"Accessibility and wayfinding" emerged as one of the most frequently mentioned themes. While some users praised the ease of transfers and well-marked routes at both Berlin Südkreuz and Wrocław Central stations, others reported serious issues such as malfunctioning elevators and escalators. "Spatial Comfort and hygiene" emerged as a critical concern. In the Berlin example, positive reviews highlighted the layout, while many users reported unpleasant conditions such as poor hygiene and lack of seating. The Wrocław example, on the other hand, was found to be clean and tidy by almost all users, receiving a more positive assessment than the Berlin example. Regarding "Aesthetic Value", both examples were positively evaluated. For both stations, users perceived the modern design and visual appeal. "Security" emerged as a persistently complained-about issue, particularly at Berlin Südkreuz. Numerous users reported discomfort due to a lack of security personnel and the presence of intoxicated individuals. "Additional Functions", such as shopping and dining areas, were positively received at both stations. However, while the Wrocław example was positively viewed for its connection to a large mall, the Berlin example received positive feedback for having more additional functions directly within the station itself. "Impact on Urban Identity" was evident in perceptions of neglect and maintenance. Users criticized the Berlin example, describing the environment as dirty and poorly managed. In the Wroclaw example, one user compared it to Warsaw, the capital of Poland, highlighting the better Wroclaw terminal. These opinions demonstrate that transportation hubs play a symbolic role in shaping a city's image, both positively and negatively.

CONCLUSION

This study examines the user experience of transportation interiors through a comparative analysis of Berlin Südkreuz Station and Wrocław Central Bus Terminal, identifying common user themes. Adopting a phenomenological approach and analyzing Google Maps comments as user-generated data, the study identified recurring themes among users: Accessibility and wayfinding, Spatial comfort and hygiene, Aesthetic value,

Safety, Additional functions, and Impact on urban identity. These findings highlight that transportation interiors are not merely infrastructural nodes, but more layered cultural and social environments that shape daily practices and perceptions.

The analysis of the sample stations revealed that "accessibility and wayfinding" are among the most influential factors affecting user satisfaction. According to user comments, functional failures such as malfunctioning elevators or inadequate wayfinding significantly reduce perceived accessibility, while consistent wayfinding strategies, multilingual wayfinding, and digital information systems improve spatial readability and independence. Similarly, qualified, and adequate lighting design, sensory atmosphere, and safety measures stand out as critical determinants of user perception, affecting both the psychological well-being and safety of passengers. "Spatial comfort and hygiene" are equally important. Cleanliness, spatial arrangement, ergonomic design, and overall environmental quality directly influence the perception of transportation-functional spaces. In terms of aesthetics, contemporary design approaches in these spaces strengthen the identity and character of transportation hubs, contributing to users' sense of place. The frequently recurring security issues in the Berlin example highlight the importance of the psychological dimension of user experience, demonstrating the necessity of considering security perception in spatial user experience. Users (P6, P9, P10, P11, P20) reported harassment, lack of visible security staff, and the presence of drunk individuals. Additional functions, such as retail and dining services, enriches the stations' role as social and cultural spaces beyond their transit function. Another substantial outcome concerns the role of transportation hubs in contributing to urban identity. Berlin Südkreuz station was frequently described by users as unsafe and dirty. A large, overgrown area of bushes in its vicinity, which has become a massive landfill, was criticized. This image has the potential to influence the perception of Berlin for first-time visitors. Wrocław Central Station, on the other hand, was generally rated as better in terms of safety and cleanliness compared to Berlin Südkreuz Station. In one review, Wrocław was compared to Warsaw, the capital of Poland. The user (P16) emphasized that the Wrocław bus station was better than Warsaw's. This demonstrates that station design has a positive impact on the perception of urban identity. In this respect, the function of stations is not limited to facilitating mobility; they also function as symbolic gateways, shaping visitors' first impressions of the city. Furthermore, the integration of additional functions such as public art, retail, and spontaneous events within transportation-related interiors, as in the case of Berlin, shows that transportation hubs can go beyond their transportation function, improving user experience and becoming integral components of urban identity.

The study results demonstrate that transportation interiors, particularly waiting and circulation areas, play a decisive role in shaping spatial user experience through the interaction of physical and sensory design elements. This finding is consistent with the literature highlighting the multidimensional and multilayered aspects of user experience, encompassing perception, emotion, and social interaction beyond mere functionality (Norman, 2010; Erap et al., 2021: 341). A comparative analysis of the Berlin Südkreuz and Wrocław Central Bus Terminals revealed that accessibility and wayfinding remain key determinants directly influencing user experience. As Lynch (1964: 101) and Passini (1984: 163) point out, environmental cues such as signage, landmarks, and spatial differentiation reduce cognitive load and facilitate spatial wayfinding. In the Wrocław example, color-coded floor directional signs and multilingual information boards increased readability, while in Berlin, the use of color coding as a tool in directional units and color-coded parametric shapes on the ceiling created recognizable directional signs. These results, based on both user feedback and on-site observations, support Wei et al. (2025: 22), who emphasize the importance of consistent visual systems for wayfinding in complex public transport environments.

The study also found that "hygiene", "safety", and "additional functions" shaped user perceptions and reactions. Negative perceptions associated with inadequate care or antisocial behavior corroborate Evans' (2009: 372) assertion that passengers' sense of safety is closely linked to the physical and social order of spaces. Conversely, the integration of commercial functions, social amenities, and even spontaneous cultural events demonstrates how transportation hubs can transform into hybrid cultural environments, aligning with Carter et al.'s (2007: 756) view that place identity emerges from multi-layered social practices. It is noted that, beyond providing user comfort and basic spatial functions, transportation spaces contribute to the construction of urban identity. As Tunç (2007: 104) observed in the Istanbul metro, positive user experiences within transportation interiors positively influence the overall perception of the city. Similarly, in this study,

additional facilities or adverse environmental conditions at Berlin Südkreuz Station and the integration of the Wrocław Bus Terminal into a commercial complex have shaped the urban image by serving as symbolic gateways for both local and international users. In conclusion, this study confirms that designing transportation hubs not only as infrastructural nodes but also as experience-oriented spaces where physical accessibility, sensory quality, and social interaction intersect can improve spatial user experience.

This study is expected to contribute to filling a gap in the literature where studies on transportation interiors are relatively limited. The study's findings aim to provide a framework for future design strategies by emphasizing the necessity of user-centered, inclusive, and holistic approaches. Investments in accessibility, clarity of wayfinding, lighting comfort, safety, and additional functions are not merely technical requirements but critical factors shaping user satisfaction, perception of safety, and the urban identity of cities. The study points to the necessity of adopting user-centered and holistic design approaches in transportation interiors. By focusing on user experience in future transportation hubs, psychological well-being can be improved.

Author's Contribution

The author contributed 100% to the study.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

This study is based solely on open-source data obtained from Google Maps reviews. No personal information was collected, stored, or disclosed, and all analyses were conducted in compliance with ethical research standards.

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Research Article

Spatial representations of ecological vandalism in dystopian science fiction cinema

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Abstract
This study examines the relationship between ecological vandalism and spatial representation in dystopian science fiction cinema. Adopting a qualitative research design, the study utilizes Seymour Chatman's narrative analysis framework. The film universe of the study comprises dystopian science fiction works that thematically address the spatial consequences of ecological disasters. From this universe, three films were selected using purposeful sampling based on specific theoretical and content-related criteria. The selected films are: *A Boy and His Dog* (1975), *Waterworld* (1995), and *Snowpiercer* (2013). The analysis indicates that ecological vandalism transforms space into fragmented, mobile, or enclosed structures, and these transformations shape the cinematic narrative through atmosphere, plot structure, and symbolic representations. This study reveals cinema's spatial representation of ecological crises, contributing to ecocritical film studies and offering new insights into the intersection of environment, narrative, and visual culture.

Keywords: Dystopian science fiction, Ecological vandalism, Spatial representation, Cinematic space, Film studies

Extended Abstract

Introduction: The global environmental crisis fundamentally challenges understandings of space as both natural systems and designed environments. Anthropogenic ecological devastation generates pervasive uncertainty regarding human settlement, positioning cinema as a crucial medium for navigating complex scenarios. Science fiction is particularly significant, as it builds speculative worlds that reflect environmental fears while reconstructing spatial representation. Dystopian narratives specifically portray the spatial realities of post-disaster survival, yet academic discourse often overlooks how environmental catastrophes actively reshape cinematic settings. A lack of research exists concerning how anthropogenic destruction, or ecological vandalism, influences the spatial design and visual representation of filmic worlds. Consequently, investigating how environmental collapse operates as a fundamental structural and aesthetic component, rather than a passive background, is essential.

Purpose and scope: This study aims to examine the relationship between ecological vandalism and spatial representation in dystopian science fiction cinema. In this context, it seeks to contribute to interdisciplinary fields such as film studies, architecture, and environmental humanities by offering spatial readings of ecological collapse as portrayed in dystopian visions of the future. In accordance with the research problem and objectives, this study is guided by two principal research questions. These questions aim to explore the relationship between ecological vandalism and spatial representation in dystopian science fiction films, specifically investigating how ecological vandalism transforms space (RQ1) and how the resulting spatial transformations affect the cinematic narrative (RQ2). Through a critical analysis of how ecological destruction is represented in dystopian science fiction cinema, the study reveals the ways in which environmental catastrophes reshape cinematic spatial constructs and narrative structures. By focusing on the interplay between ecological collapse and spatial representation, the research offers both a theoretical and methodological contribution to two key areas: ecocritical approaches to cinema and spatial narrative analysis. The study further

contributes to scholarly discourse by linking environmental awareness with spatial storytelling, thereby offering valuable insights for enriching interdisciplinary academic conversations.

Method: This study adopts a qualitative research design, employing narrative analysis to address the research questions. The analytical framework is based on Seymour Chatman's theory of narrative structure, which distinguishes between story, referring to the underlying plot and spatial context, and discourse, encompassing the manner in which these elements are presented to the audience. The cinematic universe is defined as dystopian science fiction films centered on spatial survival following a global anthropogenic ecological catastrophe. From this universe, three films were selected using purposeful sampling based on four objective criteria: thematic variation (desertification, marinization, glaciation), temporal distribution (the 1970s, 1990s, and 2010s), narrative structure restricted to standalone universes, and significant cultural or commercial prominence. Consequently, the sample comprises *A Boy and His Dog* (1975), *Waterworld* (1995), and *Snowpiercer* (2013). Data collection involved multiple viewing techniques and purposive screenshot capture to compile scene-based observation notes on spatial hierarchy, mise-en-scène, and spatio-temporal organization. The analysis was conducted at the story level, focusing on spatial functions and transformations, and at the discourse level, examining atmosphere construction and cinematographic choices to provide a layered interpretation of ecological space.

Findings and conclusion: Findings demonstrate that ecological vandalism fundamentally reshapes cinematic environments and serves as the central impetus for dystopian narratives. Addressing the first research question, the application of Chatman's dual framework reveals distinct spatial impacts across the narrative levels. At the story level, which governs physical settings and plot mechanics, ecological vandalism acts as a force of morphogenesis. It eliminates familiar architectures to generate fragmented, mobile, or enclosed survival structures. In *A Boy and His Dog*, desertification resulting from nuclear warfare produces a fragmented spatial structure where scorched, functionless surface zones coexist with authoritarian, synthetic underground societies. Conversely, *Waterworld* illustrates a fluid spatial environment where marinization triggered by climate neglect generates mobile settlements across a boundless ocean. In *Snowpiercer*, glaciation caused by radical climate engineering confines human existence to a hermetically sealed, linear ecosystem. Simultaneously, at the discourse level, which dictates visual presentation and atmosphere, these transformed environments evoke a dystopian sublime. The vast, unforgiving expanses of deserts and oceans are cinematographically constructed to embed a profound atmospheric dread directly into the narrative. Regarding the second research question, the analysis demonstrates how these spatial shifts dictate the cinematic narrative across both dimensions. Within the story dimension, the severe material constraints of ruined spaces actively shape character agency, motivations, and survival strategies. Conversely, within the discourse dimension, these environments function as symbolic arenas that align with necrofuturological dread, operating as cinematic manifestations of anticipatory collapse. For instance, the train in *Snowpiercer* functions visually and thematically as a necrofuture, acting simultaneously as a refuge and a mobile tomb. In conclusion, ecological vandalism redefines cinematic space physically, ontologically, functionally, and symbolically. Space shifts from a passive backdrop to an active agent that embodies collapse, shapes character agency, and drives the narrative dynamics. This study reinforces the bridge between environmental awareness and spatial storytelling, contributing to ecocritical film studies and spatial narrative analysis. Future research should explore the affective dimensions of ruined spaces and the intersectionality of ecological consequences with social justice issues, including gender, class, and race.

Keywords: Dystopian science fiction, Ecological vandalism, Spatial representation, Cinematic space, Film studies

INTRODUCTION

The global environmental crisis is fundamentally challenging our understanding of space, both as a natural system and a designed environment. The tangible impacts of Anthropogenic ecological devastation, from accelerated climate change to severe biodiversity loss, have generated a pervasive atmosphere of uncertainty about the future of human settlement. Recent scholarship increasingly characterizes this era as the "Anthropocene," a geological epoch where human actions have become a primary force of ecological destruction, a phenomenon that cinema is uniquely positioned to reflect and critique (Paszkiewicz, 2021: 2; Pop, 2020: 227). This collective anxiety provides fertile ground for artistic exploration, with cinema serving as a crucial "eco-critical" medium for navigating these complex scenarios (Şen, 2018: 32). The ecocritical approach systematically examines how cultural products construct and critique the relationship between humanity and the physical environment. Through this analytical lens, an ecological catastrophe is evaluated not merely as a natural accident but as the direct consequence of systemic human intervention. Consequently, the concept of ecological vandalism is situated within this framework as a deliberate and destructive spatial violation. This theoretical connection establishes how environmental ruin is visually and narratively spatialized

in cinema. Within this context, the science fiction genre is particularly significant, as it directly confronts these existential threats by building speculative worlds that not only reflect our environmental fears but also actively reconstruct the very meaning and representation of space itself.

Cinema functions as a narrative medium that simultaneously depicts and reinterprets social, environmental, and technological shifts, providing a vital discursive arena through its focus on moments of crisis. Within this framework, dystopian science fiction cinema brings to life the spatial realities of post-disaster survival, offering accounts of resource depletion, societal breakdown, and marginalized ways of living. Dystopian narratives frequently rely on a scenography of urban ruins and fragmented spaces to depict the consequences of systemic collapse (Gandy, 2024: 11; Walter, 2019: 133). These stories are generally set in speculative worlds marked by profound ecological decay. Within these films, decaying megacities and deserted infrastructures serve as physical symbols of both political authority and environmental apathy (Kılıçarslan, 2007: 53; Farstad, 2021: 69). Despite this visual prominence, existing research tends to treat environmental catastrophes simply as narrative triggers. This perspective overlooks how such disasters do much more than drive the story forward; they actively reshape the cinematic environment and function as integral narrative components (Tan, 2020: 301). There remains a significant lack of research regarding how anthropogenic environmental destruction, or ecological vandalism, influences the architectural design and visual representation of these filmic worlds. This oversight indicates a clear necessity for investigating how environmental collapse operates as a fundamental structural and aesthetic component rather than acting merely as a passive background in dystopian cinema.

This study aims to examine the relationship between ecological vandalism and spatial representation in dystopian science fiction cinema. In this context, it seeks to contribute to interdisciplinary fields such as film studies, architecture, and environmental humanities by offering spatial readings of ecological collapse as portrayed in dystopian visions of the future. In accordance with the research problem and objectives, this study is guided by two principal research questions (RQ1 and RQ2). These questions aim to explore the relationship between ecological vandalism and spatial representation in dystopian science fiction films, with a particular focus on how environmental destruction shapes spatial configurations and how these spatial dynamics influence cinematic narrative structures.

RQ1: How does ecological vandalism transform space?

RQ2: How do the spatial transformations caused by ecological vandalism affect cinematic narrative?

This study examines how ecological destruction is represented in dystopian science fiction cinema, aiming to reveal the ways in which environmental catastrophes reshape cinematic spatial constructs and narrative structures. By focusing on the interplay between ecological collapse and spatial representation, the research offers both a theoretical and methodological contribution to two key areas: ecocritical approaches to cinema and spatial narrative analysis. The study further contributes to scholarly discourse by linking environmental awareness with spatial storytelling, thereby offering valuable insights for enriching interdisciplinary academic conversations.

THEORETICAL FRAMEWORK

This study is grounded in a multidisciplinary theoretical framework that brings together environmental philosophy, spatial theory, narrative theory, and genre studies. This framework enables a comprehensive understanding of how ecological destruction is constructed, visualized, and spatially articulated within dystopian science fiction cinema. The first component of this framework addresses the concept of ecological vandalism within the broader discourse of the Anthropocene and critiques of capital-driven environmental degradation. Subsequently, dystopian science fiction is positioned as a narrative strategy through which ecological anxiety and sociopolitical critique are mediated. Spatial theory is employed to demonstrate that cinematic space does not function as a passive setting but rather as a narrative and ideological construct shaped through visual and structural codes. Finally, recurring spatial motifs, symbolic environments, and aesthetic conventions are examined as critical tools that render ecological collapse both visible and meaningful. Together, these theoretical components constitute a conceptual basis for analyzing how cinematic space in dystopian narratives functions as both a representational medium and a carrier of ecological discourse.

Ecological Vandalism and the Anthropocene Debates

The environmental crisis, one of the defining issues of the twenty-first century, is increasingly understood as a direct consequence of human activity. Within this context, ecological vandalism must be understood as a conceptual act that transcends simple environmental destruction or accidental disaster. Unlike natural catastrophes, vandalism implies a degree of intentionality, systemic neglect, or a calculated violation of the inherent value and integrity of a space. This conceptualization aligns with the legal and ethical frameworks of ecocide, where environmental ruin is recognized as a profound crime against the collective habitability of the planet (Higgins et al., 2013: 261). When such systemic neglect and spatial violations are aggregated to a global level, they fundamentally alter the Earth's biophysical systems. It is precisely to articulate this unprecedented, planetary scale of humanity's impact that the concept of the Anthropocene emerged, framing it as a geological force shaping the planet's ecosystems (Chakrabarty, 2009: 209).

While this geological framing captures the scale of the crisis, defining environmental collapse solely in such broad term risks obscuring the specific ideological structures that legitimize spatial ruin. Consequently, to understand the tension between vandalism and other modes of destruction, one must consider the post-political condition, where systemic environmental degradation is often framed as an inevitable byproduct of progress rather than a deliberate act of spatial violation (Swyngedouw, 2013: 10-11). Deepening this political critique, scholars argue that these impacts stem not merely from individual consumption habits, but from the interventionist logic of the global capitalist system. Building on this, Moore (2016) coins the term Capitalocene to argue that the logic of capital accumulation is the primary driver of ecological ruin. From this perspective, the persistent consumption of fossil fuels can be viewed as a form of global vandalism perpetrated by fossil capital against the shared atmospheric space (Malm, 2016: 9). Collectively, these perspectives reframe ecological vandalism not as arbitrary or inevitable harm, but as a calculated and systemic form of destruction aligned with specific ideological and economic interests.

The nature of this calculated destruction becomes particularly clear through the lens of ethical neglect and the violation of spatial integrity. This aligns with the theory of slow violence, which describes a spatialized devastation that is often invisible, delayed, and dispersed across time and space (Nixon, 2011: 2). Such violence is frequently the result of systemic neglect, where the deliberate withdrawal of care or maintenance functions as a tool of environmental degradation, effectively producing toxic geographies that are rendered invisible or out of sight (Davies, 2019: 418). For instance, the cinematic portrayal of an Earth entirely buried under corporate waste in *WALL-E* (Stanton, 2008) serves as a stark visual manifestation of Moore's Capitalocene and the slow violence of unchecked consumption. Despite such cinematic representations, the inherent difficulty of visualizing such dispersed and delayed ruin highlights a broader epistemological challenge: how to comprehend ecological catastrophes that exceed the boundaries of human perception. Addressing this exact problem of imperceptibility, Morton (2013: 1), with his concept of Hyperobjects, posits that vastly distributed phenomena like climate change or radioactive contamination are entities transcending time and space, beyond the grasp of direct individual perception. This framework serves as a conceptual tool for grasping era-defining catastrophes that overwhelm the limited scope of individual or societal consciousness. Morton's perspective implies that aesthetic codes for representing such destruction in cinema can, and perhaps must, be constructed within a post-human framework.

Furthermore, eco-feminist theorists such as Plumwood (2002: 10) highlight that ecological devastation is intrinsically linked not only to economic systems but also to anthropocentric and patriarchal modes of thought. Plumwood's analysis deepens the ideological dimension of ecological vandalism by connecting environmental domination to social hierarchies. Thus, cinematic representations can be seen not merely as depictions of disaster, but as critical examinations that expose the underlying epistemological frameworks that drive it. The aforementioned theoretical approaches establish that the spatial representations forming the focus of this study are not reducible to technical considerations alone. Instead, they are revealed as complex, layered constructs, deeply intertwined with historical discourses, ideological codes, and prevailing levels of ecological consciousness. Through this framework, the theoretical logic underpinning cinematic spatial constructions becomes more legible, enabling a critical and analytical evaluation of how environmental ruin is integrated into the narrative.

Dystopia, Science Fiction, and Ecological Themes in Cinema

Dystopia and science fiction function not merely as speculations about the future but as critical reflections of contemporary socio-political structures, environmental threats, and ideological conflicts. With the growing visibility of the climate crisis, dystopian science fiction films centered on ecological catastrophe are increasingly recognized as intersecting with the emerging subgenre of climate fiction. Rather than replacing the science fiction category, this thematic framework expands it by producing narratives specifically focused on scenarios of environmental collapse (Heise, 2008). Examples such as *Soylent Green* (Fleischer, 1973) and *Interstellar* (Nolan, 2014) clearly illustrate this intersection, in which traditional science fiction tropes are actively used to examine severe ecological anxieties. These narratives, by framing the rupture in the human-nature relationship both aesthetically and structurally, prompt the audience to interrogate their own connection to the contemporary world.

Suvin's (1979) concept of cognitive estrangement posits that science fiction prompts a critical re-evaluation of existing social reality by confronting the audience with an unfamiliar world. Jameson (2005), in turn, reads dystopian narratives as symptomatic of a late capitalist structure that actively forecloses the possibility of imagining a collective future. These genres not only transform the temporal and spatial dimensions of narrative but also ideologically reconstruct the relationship between nature, environment, and humanity (Buell, 2001; Garrard, 2012).

Dystopian science fiction cinema, particularly in its depiction of post-catastrophe worlds and new spatial arrangements, employs space not merely as a functional area, but as a narrative plane bearing the ideological and emotional imprints of the crisis. The genre's potential, in this context, is directly linked to its capacity for processing both individual and collective ecological traumas. Building on this connection to trauma, ecological vandalism within dystopian cinema operates not merely as a background setting but as a primary narrative driver. Kaplan (2015: 33) conceptualizes this dynamic through the notion of pre-traumatic stress syndrome, arguing that dystopian films compel audiences to foresee the traumatic consequences of ongoing ecological neglect. This anticipatory dread is vividly illustrated in films like *The Day After Tomorrow* (Emmerich, 2004), where the rapid onset of a catastrophic ice age spatializes the immediate trauma of climate change, serving as a cautionary projection of environmental apathy. By visualizing the outcomes of such vandalism, dystopian narratives construct a traumatic structure that generates anticipatory fear and forces characters into profound ethical dilemmas, thereby directly shaping the plot trajectory. Furthermore, Brereton (2019: 157) highlights the environmental affordances of cinema, noting that such films forge deep emotional connections regarding ecological loss. In these narratives, ecological vandalism amplifies the tragic depth of the story, serving as the central catalyst that triggers character motivations centered around mourning and survival. Therefore, dystopian cinema acts as a critical bridge between ecological vandalism and spatial narrative, providing the necessary context for examining how environmental collapse guides character experience.

This theoretical background demonstrates that the spatial representations central to this study are not mere aesthetic preferences. Rather, they reveal a multi-layered construct in which dystopian cinema actively reconstructs the human-nature relationship, merges environmental anxieties with political narratives, and allows space to serve as a primary vehicle for ecological discourse.

The Use and Representation of Space in Cinema

Apart from being recognized as a powerhouse of mass media and art, cinema, whose etymological roots trace back to the Lumière Brothers' Cinématographe, functions as an essential medium for the production and reimagining of architectural forms (Türkmen, 2024: 110). Both architecture and cinema are characterized by shared visual and narrative properties, with each discipline acting as a mirror to the social configurations of its respective era. For instance, the deliberate architectural contrast utilized to communicate socio-economic inequalities in *Parasite* (Bong, 2019), the brutalist vertical hierarchy reflecting systemic collapse in *High-Rise* (Wheatley, 2016), and the alienating, hyper-modernist environments conveying social detachment in *Playtime* (Tati, 1967) collectively exemplify how physical spatial design is employed to visually articulate these social structures. However, the most vital point of convergence between these two fields is the concept of space. While architectural practice is centered on the design of tangible environments and human interaction, the

cinematic medium utilizes fictional space to build atmospheric depth and support the storytelling (Kılıçaslan & Türkmen, 2024: 201).

In this light, cinematic space should be viewed not as a passive setting but as an intricate, layered construct where narrative themes and character arcs find their significance. These spatial complexities have long drawn the interest of various scholars. For instance, Chatman (1978) divided the narrative structure into the two fundamental components of story and discourse, arguing that the arrangement of space within a film is deeply functional rather than purely aesthetic. Such a theoretical lens is crucial for grasping the specific ways that cinema organizes the dimensions of time and space.

Building on such structural approaches to narrative, Lefebvre's (1991) theory of the production of space posits that space is not merely a perceived reality but a construct produced through social relations, ideologies, and cultural codes. Soja (1996) extends this approach, proposing with his concept of thirdspace a multi-layered spatial ontology that encompasses both experiential and imagined spaces. These perspectives reveal how cinematic spaces are ideologically shaped, both in terms of their physical design and their narrative significance (Bruno, 2002; Stam, 2000). Classic examples such as the vertical class stratification visualized through the towering skyscrapers and subterranean factories in *Metropolis* (Lang, 1927), or the neon-lit, decaying urban sprawl of *Blade Runner* (Scott, 1982), demonstrate how cinematic environments actively produce and reflect socio-economic hierarchies rather than merely hosting the narrative.

This theoretical perspective, which frames space as an ideological vehicle in cinematic narrative, holds particular importance in narratives depicting environmental devastation. Indeed, the spaces in such dystopian films are not merely locations where events unfold, but are themselves narrative elements that bear the remnants of catastrophe, simultaneously containing both past and future. To theoretically ground how ecological vandalism actively transforms this cinematic environment, it is crucial to examine the shift from functional space to critical landscape. Stefanopoulou (2021: 39) conceptualizes this transformation through rhetorical environmentality, suggesting that ecological crisis strips the cinematic space of its traditional functionality. Through the lens of ecological vandalism, the space is reconfigured into an ecocritical rhetorical device; the ruined landscape itself becomes the primary mode of critique. This physical transformation is deeply intertwined with the collapse of social structures. Podgajna (2016: 53) analyzes this dynamic through the fragmentation of socio-political indicators, demonstrating how ecological collapse vandalizes and dismantles intellectual and bureaucratic architectures. Consequently, the hierarchical order of space is violently disrupted, reducing the built environment to a "waste land" that physically mirrors systemic decay.

Furthermore, the impact of this vandalism extends beyond the physical setting into the very structure of the film. Bobaru (2025: 140) introduces the notion of formal ecology, arguing that the cinematic narrative and form operate as an ecology in their own right. Within this framework, ecological vandalism actively dictates the cinematic form, influencing spatial perception and visual composition to displace the anthropocentric focus and create a post-human spatial reality.

This theoretical background demonstrates that space in cinema is not confined to a purely functional role. Rather, it is constructed as a medium of representation within the narrative, one that contains layers such as historical memory, ideological structures, and environmental trauma. By integrating these spatial and narrative theories, the study establishes a cohesive analytical lens. This framework provides a systematic approach to investigating how ecological vandalism alters the physical morphology of the built environment and how these resulting spatial configurations generate new layers of cinematic meaning, thereby offering profound theoretical depth to the subsequent spatial analysis.

METHOD

The present study employed a qualitative research design to address the research questions, using narrative analysis. The analytical framework adopted in this study was structured based on Seymour Chatman's (1978) seminal theory of narrative structure. According to Chatman (1978: 19), a narrative consists of two fundamental components: story (histoire) and discourse (discours). The story represents the substantive content of the narrative, specifically the "what", encompassing the chronological chain of events (actions and

happenings) and the "existents," which include the characters and the specific physical settings or environments where the action occurs (Meunier, 2022: 252; Pier, 2003: 73). In the context of this study, the story dimension dictates the functional realities and morphological conditions of the ecologically devastated built environment. Conversely, the discourse represents the expressive plane of the narrative, specifically the "how", defining the specific cinematic mechanisms through which this content is communicated to the viewer (Webb & Mallon, 2007: 370). For spatial analysis, the discourse dimension involves stylistic and structural choices, including framing, camera angles, and visual composition, which collectively construct the atmosphere and shape the emotional reception of the space (Wolf, 2011: 6). This dual framework provides a comprehensive theoretical mechanism for analyzing both the physical transformation of space within the fictional world and the ideological meanings generated by its visual presentation.

The cinematic universe of this study is defined as dystopian science fiction films centered on spatial survival following a global anthropogenic ecological catastrophe. From this universe, three films were selected using purposeful sampling based on four objective criteria: thematic variation (desertification, marinization, glaciation), temporal distribution (the 1970s, 1990s, and 2010s), narrative structure (standalone universes rather than extensive franchises like the Mad Max series), and significant cultural or commercial prominence (e.g., global box office success, massive production scales, and prestigious recognitions such as Hugo or Academy Award nominations). Consequently, the final sample comprises *A Boy and His Dog* (Jones, 1975), selected for its cult status and Hugo Award; *Waterworld* (Reynolds, 1995), noted for its massive production scale and Academy Award nomination; and *Snowpiercer* (Bong, 2013), distinguished by its global box office success. This structured approach ensures distinct and culturally impactful spatial representations for the comparative analysis.

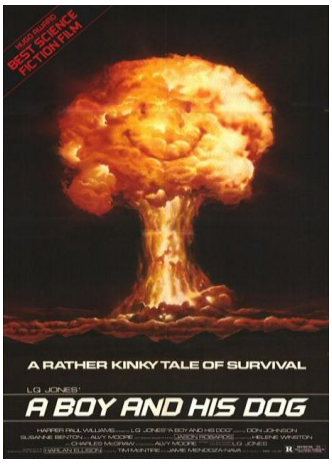
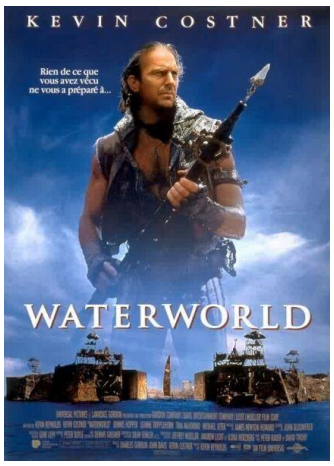
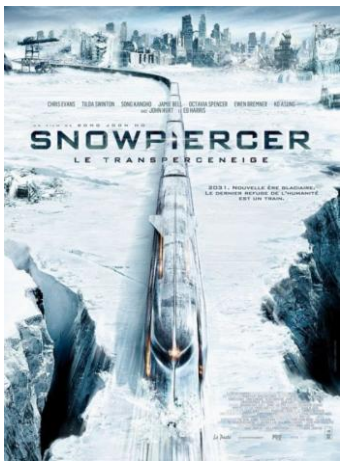
The selected films were analyzed using a multiple viewing technique, focusing on scenes that directly or indirectly reflect spatial representations. Each film was examined in terms of the function of space, its transformational dynamics, and its role in atmosphere construction. Accordingly, scene-based observation notes were compiled, documenting key visual and narrative elements such as spatial hierarchy, mise-en-scène, and spatio-temporal organization. To support the visual analysis, a purposive screenshot capture method was applied, deliberately selecting frames that explicitly demonstrate the spatial and architectural consequences of the ecological catastrophes, which were then archived as a visual dataset. This approach allowed for a more precise and reproducible interpretation of spatial structures. Furthermore, a range of secondary materials, such as scholarly articles, interviews, and production notes, were reviewed to add a layer of contextual richness to the overall evaluation.

The analysis was conducted using Seymour Chatman's (1978) dual-layered narrative structure theory, which distinguishes between the dimensions of story and discourse. At the story level, the analysis focused on the function of space within the plot, modes of spatial transformation, and the reconstruction of the built environment. At the discourse level, meaning-making processes were examined through the visual representation of space, atmosphere construction, and cinematographic choices. This analytical approach enabled a layered interpretation of spatial representation, addressing not only narrative content but also formal and aesthetic devices that shape the audience's perception of ecological space.

SYNOPSIS OF SELECTED FILMS

This section offers brief synopses of the three dystopian science fiction films selected as the sample of this study, with the aim of establishing conceptual clarity and narrative context for the subsequent analysis. These synopses highlight the central ecological disaster, the narrative structure, and the spatial settings of each film, which are essential to understanding how ecological collapse is spatialized and represented through cinematic storytelling. The chosen cinematic works represent varied ecological catastrophes, including desertification, marinization, and glaciation, which are examined through the lens of different historical periods and creative directorial visions. The promotional posters included in Table 1 reflect each film's thematic and spatial atmosphere, emphasizing their ecological focus and narrative form. These visuals function as paratexts that support spatial storytelling through symbolic and compositional cues.

Table 1. Promotional posters of the selected films

A Boy and His Dog	*Waterworld*	*Snowpiercer*
		

A Boy and His Dog is one of the early examples of post-apocalyptic dystopian cinema, set in the year 2024 after a nuclear war has rendered most of the Earth's surface uninhabitable. The film presents a fragmented spatial structure in which chaotic and violent surface zones coexist with authoritarian underground societies. Desertification is portrayed not merely as a visual backdrop but as a narrative condition that disrupts social organization and survival dynamics. By examining the vertical spatial dichotomy that exists between the scorched land above and the synthetic organization below, the film investigates the specific ways in which ecological devastation redefines inhabited spaces and various mechanisms of control (Winters, 2024).

Waterworld is set in a distant future in which global warming has melted the polar ice caps, submerging all landmasses. In this ocean-covered world, human settlements are organized as floating structures, and the narrative revolves around conflicts shaped by resource scarcity and territorial uncertainty. The film constructs a fluid spatial environment in which marinization redefines the concepts of habitability, mobility, and spatial belonging. This aquatic dystopia portrays the erosion of terrestrial stability both physically and socially, representing ecological crisis as a force that dissolves established norms (Tatna, 2023).

Snowpiercer takes place in a world overtaken by a new ice age, triggered by the failure of a climate engineering intervention. The remnants of humanity survive aboard a constantly moving train that circles the Earth, strictly divided along class lines. Glaciation functions as both a spatial setting and a narrative catalyst, forcing civilization into a closed, linear ecosystem. The interior of the train is organized as a microcosm in which each carriage represents a distinct socio-spatial zone. The film critiques ecological destruction not merely as an environmental issue but also as a condition deeply entangled with spatialized inequality (Lee & Manicastri, 2018).

FINDINGS AND DISCUSSION

The narrative architectures of the three selected dystopian science fiction films are visually illustrated through scenes categorized into three spatial dimensions: Environment, Exterior, and Interior. These categories enable a detailed analysis of how ecological collapse is not only thematically foregrounded but also spatially articulated within the cinematic narrative. The selected scenes demonstrate how environmental devastation reshapes the functionality, aesthetics, and socio-political layers of space. In each film, these spatial dimensions directly influence characters' mobility, sense of spatial belonging, and survival strategies.

The selected scenes from *A Boy and His Dog* portray a fragmented spatial structure shaped by a post-nuclear apocalypse. The environmental scenes illustrate a scorched and barren terrain characterized by cracked earth and desolate landscapes, which serve to visually articulate the far-reaching aftermath of ecological catastrophe. The Exterior scenes focus on transitional zones such as makeshift shelters and ruined infrastructure, which function as threshold spaces of vulnerability and survival. In contrast, the Interior scenes highlight underground

or enclosed environments where remnants of organized society or scavenged living quarters persist. These spaces embody mechanisms of control, repression, and adaptation within a world fractured by ecological and moral collapse (Table 2).

Table 2. Spatial structure of *A Boy and His Dog*

Environment			
	[00:02:01]	[00:06:45]	[00:06:49]
Exterior			
	[00:52:34]	[00:07:33]	[00:14:46]
Interior			
	[00:36:43]	[00:09:00]	[00:25:43]

According to the findings obtained through the narrative analysis, *A Boy and His Dog* presents a dystopian spatial condition shaped by desertification resulting from nuclear warfare and uncontrolled resource exploitation. The scorched land and fragmented built environment render space functionless, disordered, and insecure. At the story level, characters inhabit both underground shelters and fragile surface structures, reflecting a layered spatial transformation in the aftermath of ecological collapse. The interplay between these two environments, defined by the contrast between the paradoxically secure yet subjugating underground and the precarious, defenseless surface, fundamentally configures the spatial trajectory of the narrative. From a narratological perspective, this vertical spatial divide functions as the primary structural catalyst for the plot. The continuous physical necessity to navigate between these opposing zones structurally dictates the narrative progression. Consequently, this spatial friction generates the core narrative conflict, directly shaping the thematic development of survival versus subjugation. At the discourse level, the visual juxtaposition of vast, unregulated barren landscapes with enclosed, claustrophobic interiors enhances the film's atmospheric emphasis on threat, solitude, and spatial uncertainty. The construction of an "existential space" within this subterranean society internalizes the external ecological trauma, utilizing the artificiality of the mise en scene as a psychological refuge (Pallasmaa, 2001). This contrast reinforces the notion that ecological devastation not only alters the physical landscape but also produces psychological and social conditions of alienation and instability, ultimately turning space into a site of existential conflict (Table 3).

Table 3. Narrative analysis of *A Boy and His Dog*

Ecological Vandalism	**Ecological Catastrophe**
Nuclear warfare and uncontrolled resource consumption	Desertification (Loss of land's biological productivity)
Story Level (Content)	**Discourse Level (Expression)**
Parched, deteriorated lands and subterranean shelters construct a spatial framework that conveys the collapse of civilization, the fragmentation of order, and the necessity of survival.	The vast, ungoverned depiction of scorched terrain, paired with the enclosed and repressive design of underground interiors, reinforces an atmosphere of isolation and existential threat.

The selected frames from *Waterworld* represent a liquid dystopia in which the Earth has been submerged due to polar ice melt triggered by global warming. The Environment scenes foreground the boundless ocean, symbolizing the erasure of terrestrial reference points and the overwhelming scale of planetary collapse. Within the exterior sequences, the visualization of boat surfaces, floating settlements, and eroding maritime ruins provides

a spatial interface that negotiates the relationship between humanity and the inundated world, thereby organizing the structures of both communal engagement and social friction. The Interior scenes capture confined and multifunctional spaces that range from makeshift domestic zones to mechanical compartments. These scenes emphasize the tension between degradation and resilience, illustrating how mobility and adaptability redefine habitation under extreme ecological conditions (Table 4).

Table 4. Spatial structure of *Waterworld*

Environment	 [00:01:23]	 [00:15:40]	 [00:10:02]
Exterior	 [00:08:10]	 [00:05:12]	 [01:48:34]
Interior	 [00:02:51]	 [01:46:15]	 [00:20:15]

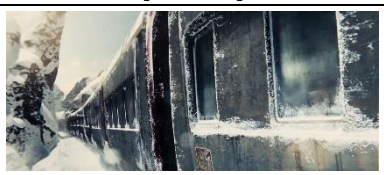
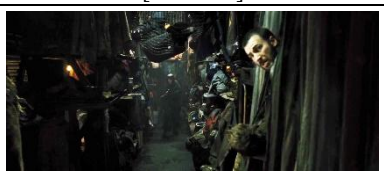
In *Waterworld*, the ecological collapse triggered by global warming and climate-neglectful policies manifests as marinization, resulting in the complete submergence of land. This spatial condition renders the world directionless, fragile, and transient. At the story level, the characters navigate life aboard floating structures, constantly moving across an expansive ocean in search of solid ground. This ceaseless condition of movement defines the characters' existential reality and situates the central narrative friction within a spatial framework, wherein land emerges as an objective that holds both material and allegorical significance. Rather than serving as a passive backdrop, this fluid spatial condition operates as the central mechanism propelling the story. The absolute absence of terrestrial stability structurally dictates the narrative progression. Thus, the spatial void itself produces the underlying narrative tension, ultimately driving the thematic development of adaptation within a directionless world. At the discourse level, the repeated visual portrayal of endless water surfaces constructs an atmosphere dominated by uncertainty, isolation, and disorientation. The juxtaposition of improvised marine settlements against an infinite, placeless backdrop reinforces a sense of vulnerability and existential instability. From the perspective of forensic architecture, these scavenged structures act as material "witnesses" to the planetary collapse, providing formal evidence of the systemic neglect that led to the Earth's submersion (Weizman, 2012). Such a "salvage aesthetic" illustrates what Cairns and Jacobs (2014) describe as the "perverse" life of architecture, where ecological vandalism has accelerated the death of built forms. In this context, space is not merely a setting but a shifting and unstable force that actively shapes the narrative's thematic core and the characters' psychological condition (Table 5).

Table 5. Narrative analysis of *Waterworld*

Ecological Vandalism Global warming and climate-neglectful policies	**Ecological Catastrophe** Marinization (Submergence of landmasses under water)
Story Level (Content)	**Discourse Level (Expression)**
A world submerged in water and scattered with floating settlements spatially frames the plot's core conflict, where the search for land becomes the narrative's central axis of tension and survival.	The repetitive portrayal of endless water surfaces heightens spatial uncertainty, while makeshift structures evoke vulnerability and helplessness, reinforcing the fragility of this aquatic dystopia.

The analysis of these visual stills from *Snowpiercer* maps out a spatialized narrative set within a hermetically sealed ecosystem, specifically a high-speed train that traverses a glaciated world following a catastrophic failure in climate engineering. The Environment scenes depict an uninhabitable, glaciated exterior visible only through the train's windows, emphasizing the inaccessibility and hostility of the outside world. The Exterior scenes focus on the train's outer shell and transitional technical areas, symbolizing the impermeable divide between interior survival and exterior extinction. The Interior scenes guide the viewer through the train's class-stratified compartments, ranging from labor-intensive sectors to leisure zones and centers of power. This linear spatial journey critically engages with issues of hierarchy, control, and systemic inequality within a post-ecological order (Table 6).

Table 6. Spatial structure of *Snowpiercer*

Environment			
	[01:55:28]	[00:35:52]	[01:16:46]
Exterior			
	[00:43:15]	[01:16:59]	[00:35:58]
Interior			
	[00:12:50]	[01:18:48]	[01:16:10]

In *Snowpiercer*, glaciation caused by radical climate engineering renders the external world entirely uninhabitable, positioning the train as the only viable closed system for human survival. This extreme condition transforms space into a confined, regulated, and highly hierarchical structure. At the story level, the train's continuous movement traps the narrative within a narrow physical environment, embedding the idea that life can persist only within a controlled and linear system. Spatial restriction becomes a narrative constraint that defines both action and survival. At the discourse level, the train's class-divided compartments are emphasized through corridors, thresholds, and visually repetitive spatial transitions. These design elements reinforce themes of oppression, tension, and structural inequality. The cinematic use of enclosed, sequential interiors accentuates the spatial manifestation of social order, turning the train itself into a metaphor for systemic control and ecological desperation. This linear ecosystem exemplifies the use of infrastructure as a political instrument of control, where access to vital resources is strictly dictated by the technical fabric of the space (Gandy, 2014). In this narrative, space becomes a mechanism of both survival and subjugation (Table 7).

Table 7. Narrative analysis of *Snowpiercer*

Ecological Vandalism	**Ecological Catastrophe**
Radical intervention through climate engineering	Glaciation (Encapsulation of land beneath ice layers)
Story Level (Content)	**Discourse Level (Expression)**
The frozen world and the spatial design of the train render continued human existence possible only within a confined route, making the narrative progression highly dependent on spatial constraints.	The train's limited, class-divided structure, reinforced by narrow framings and repetitive corridors, foregrounds an atmosphere of oppression, tension, and social segregation throughout the film.

The outcomes of this analysis demonstrate that the spatial and narrative configurations of the three investigated films, *A Boy and His Dog*, *Waterworld*, and *Snowpiercer*, reveal how diverse modes of ecological vandalism fundamentally reshape cinematic environments. These findings suggest that human-driven environmental

degradation acts as the central impetus for dystopian narratives. Each film centers on a specific ecological crisis, consisting of desertification, marinization, and glaciation, which collectively serve as the foundation for the plot. Ultimately, these disasters transcend mere physical alteration of the landscape, as they radically reconstruct the operational boundaries, functional dynamics, and overall atmosphere of the narrative space.

The first research question (RQ1: How does ecological vandalism transform space?) is answered through the finding that ecological vandalism transforms space into fragmented, mobile, or enclosed structures. These spatial shifts represent a radical morphogenesis, directly paralleling Bulu and Kavut (2021), as familiar architectural forms are violently eliminated to prompt the emergence of new spatial structures adapted to harsh environmental conditions. In *A Boy and His Dog*, the desertification caused by nuclear war produces a fragmented spatial morphology between the surface and the uncanny underground shelters. In *Waterworld*, the marinization resulting from climate negligence generates makeshift atolls and constantly shifting, fluid, floating settlements. In *Snowpiercer*, glaciation confines life to a self-contained, strictly hierarchical system within the train, isolated from the outside world. Furthermore, the spatialization of these catastrophes directly visualizes Morton's (2013) concept of hyperobjects within the cinematic narrative. The radioactive wasteland, the boundless marinization, and the planetary glaciation are not merely localized disasters; they represent vastly distributed ecological phenomena that transcend traditional temporal boundaries. By transforming these imperceptible hyperobjects into tangible cinematic spaces, the films force the narrative to navigate an overwhelming, era-defining crisis, effectively grounding abstract environmental philosophy in physical spatial design.

The impact of these transformed spaces is closely related to Brereton's (2005) concept of ecological sublime moments. However, rather than utopian sublimity, the studied films offer a dystopian sublime. The endless, unforgiving vastness of the desert in *A Boy and His Dog*, the uncanny, boundless expanse of the ocean in *Waterworld*, and the freezing silence of an ice-covered world in *Snowpiercer* evoke awe while embedding a profound atmospheric and thematic tension directly into the cinematic discourse. Cubitt (2005) investigates how ecological anxieties are mediated through popular media, and within the analyzed films, this mediation is profoundly spatial. Space becomes the primary site and medium for expressing critiques about the consequences of ecological vandalism, acting as a powerful visual mediation of concerns like nuclear warfare, uncontrolled climate change, and failed geoengineering.

The second research question (RQ2: How do the spatial transformations caused by ecological vandalism affect cinematic narrative?) is answered through the finding that these spatial transformations shape cinematic narrative through atmosphere, plot structure, and symbolic representation. These findings strongly align with Ivakhiv's (2013) assertion that cinematic environments function as active ecologies intertwining the material, the social, and the perceptual. Within the selected films, the material devastation of the landscape directly dictates social hierarchies and generates a profound perceptual atmosphere that limits character agency. Transformed spaces in these films, specifically the claustrophobic and hierarchical wagons of *Snowpiercer*, the boundless and ever-threatening ocean of *Waterworld*, and the bleak and violent wasteland of *A Boy and His Dog*, generate an atmosphere that dictates character experiences, motivations, and constraints. The narrative largely unfolds through struggles for survival, meaning, and escape in these challenging and resource-scarce environments. The works of Willoquet-Maricondi (2010) and Parham (2015) emphasize the potential of film to convey ecological values, and this potential is realized in dystopian science fiction, particularly through spatial representations. The transformed spaces shape narrative development, ensuring that water and rare land become vital symbols in *Waterworld*, or the train in *Snowpiercer* becomes a metaphor for class injustice. Space itself becomes a symbolic narrative arena where ecological collapse and its consequences are structurally embodied.

Canavan (2021) explores how science fiction produced in the Anthropocene era reflects the tension between utopian possibilities and a pessimism termed necrofuturological dread. According to Canavan, this dread is embodied in necrofutures, which function as anticipatory premeditations of a coming collapse. From this perspective, the spatial transformations in the three films analyzed, encompassing desertification, marinization, and glaciation, serve as cinematic manifestations of this necrofuturological dread. For instance, the train in *Snowpiercer* simultaneously serves as a refuge and a mobile tomb, thereby reflecting the paradoxical tension between survival and apocalypse that characterizes the cultural products of the Anthropocene. In summary,

the findings of this research demonstrate how ecological vandalism in dystopian science fiction films transforms space not only physically, but also functionally, atmospherically, and symbolically, whereby these shifts become a central dynamic of the cinematic narrative. Space shifts from a passive backdrop to an active narrative element that embodies ecological collapse, shapes character agency, and conveys the thematic concerns of the film.

CONCLUSION

This study fundamentally aimed to investigate the intricate relationship between ecological vandalism and spatial representation in dystopian science fiction cinema and to elucidate how this relationship shapes the cinematic narrative. A core objective was to understand how human-induced environmental destruction, transcending its role as a mere theme or backdrop, actively transforms the spatial fabric of films and how these transformations become embedded at the heart of narrative dynamics.

The significance of this research lies in its theoretical and methodological contributions to interdisciplinary fields such as ecocritical film studies and spatial narrative analysis. By conducting a detailed analysis of the transformative effects of ecological vandalism on cinematic space and the narrative functions of these spaces (through the examples of *A Boy and His Dog*, *Waterworld*, and *Snowpiercer*), this study has reinforced the bridge between environmental awareness and spatial storytelling. Consequently, it has deepened our understanding of how cinema imagines and critiques ecological crises and potential futures. The research has demonstrated that space, far from being a passive stage, becomes an active agent that embodies ecological collapse and its societal repercussions, generating meaning and driving the narrative.

Beyond the specific data detailed in the findings, a key interpretation emerging from this study is that ecological vandalism redefines cinematic space not only physically but also ontologically. The transformation of space into fragmented, mobile, or enclosed structures reflects deeper existential conditions such as instability, rootlessness, forced adaptation, and often, heightened social control or anomie. Disasters like desertification, marinization, or glaciation disrupt the fundamental relationships characters have with their world; space ceases to be a secure haven or a familiar environment, instead becoming an arena of constant struggle, negotiation, and survival. This, in turn, profoundly affects not only the plot of the cinematic narrative but also the psychology, motivations, and moral choices of the characters. Thus, ecologically devastated space exists in a dialectical relationship with the narrative, functioning as both its cause and consequence.

The limitations of this study offer significant opportunities for future research. The current focus on visual structure and spatial representation could be expanded by integrating diverse methodologies (e.g., reception studies, ethnographic analyses) or alternative theoretical lenses (such as psychoanalytic, post-colonial, or ecocritical readings) to explore audience reception and socio-cultural contexts. Expanding the sample beyond three films to include non-Western dystopian cinema could reveal cultural variations in the spatial representation of ecological vandalism. Furthermore, accessing primary sources like director commentaries or production design notes would offer deeper insights into spatial design intentions. Building on these expansions, future research could explore the affective dimensions of transformed spaces, examining how uncanny or claustrophobic environments influence the audience's emotional reception of ecological messages. Furthermore, to expand upon the "discourse" dimension of Chatman's narrative theory utilized in this study, incorporating the formal and conceptual analysis framework proposed by Ryan and Lenos (2012) into subsequent research would provide a robust methodological tool for systematically decoding the cinematographic organization of these spaces. Investigating spatial representations of resistance and ecological restoration would provide a vital counter-perspective. While dystopian narratives depict collapse, further studies could explore how they also visualize alternative community forms or spatial practices that defy devastation.

Moreover, the intersectionality of the spatial consequences of ecological vandalism with other social justice issues, including gender, class, and race, awaits further investigation. The spatial reflections of class stratification, prominent in *Snowpiercer*, could serve as a starting point for analyzing how different social inequalities intertwine with ecological crises and manifest spatially in other dystopian films. Finally, an

analysis of the soundscapes of these devastated spaces could move beyond visual representation to offer new horizons in understanding the atmosphere and narrative impact of environmental collapse. Such multi-layered and interdisciplinary approaches will aid in a more comprehensive understanding of the complex and vital relationship cinema establishes with the ecological crisis, one of the most pressing issues of our time.

Author's Contribution

The author contributed 100% to the study.

Competing Interests

There is no potential conflict of interest.

Ethics Committee Declaration

Ethics committee approval is not required for this study.

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Figure References

Table 1: Jones, L. Q. (Director). (1975). *A Boy and His Dog* [Film]. LQ/JAF Productions; Reynolds, K. (Director). (1995). *Waterworld* [Film]. Universal Pictures; Bong, J. (Director). (2013). *Snowpiercer* [Film]. CJ Entertainment.

Table 2: Jones, L. Q. (Director). (1975). *A Boy and His Dog* [Film]. LQ/JAF Productions.

Table 4: Reynolds, K. (Director). (1995). *Waterworld* [Film]. Universal Pictures.

Table 6: Bong, J. (Director). (2013). *Snowpiercer* [Film]. CJ Entertainment.

Author's Biography

Anday Türkmen received his PhD from Mimar Sinan Fine Arts University in 2023, with a dissertation focusing on basic design education and spatial ability. His research interests encompass interior architecture pedagogy, creativity, and spatial skills. Recently, his work has focused on the intersection of architecture and cinema, hostile architecture, and the morphological typology of architectural interventions. He also serves as an assistant editor for Modular Journal. Currently, he is an Assistant Professor at Istanbul Gedik University, Department of Interior Architecture and Environmental Design.

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