

# “Enhancing Circulation in Exhibition Spaces with the Aid of Biomimetic Design Principles”

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## ABSTRACT

Circulation plays a crucial role in how visitors experience and engage with exhibition spaces. However, many traditional layouts are rigid and fail to support intuitive movement, often leading to confusion, crowding, or missed displays. This paper explores how biomimetic design drawing inspiration from nature's systems and patterns can offer more fluid, user-friendly circulation strategies. From the branching patterns of trees to the flow of rivers and the movement of ant colonies, nature offers countless examples of efficient, adaptable navigation systems. By studying these natural models and applying them to spatial planning, the research highlights ways to create exhibition environments that feel more organic, accessible, and engaging. Case studies and digital simulations are used to demonstrate how biomimetic principles can improve wayfinding, distribute foot traffic more evenly, and enhance the overall visitor experience. Rather than treating circulation as just a technical requirement, this approach views it as an integral part of storytelling and interaction within a space. The findings show that nature-inspired layouts not only improve movement but also foster a stronger connection between people and their environment. Biomimetic design presents a sustainable, innovative path toward shaping exhibitions that are not only functional but also emotionally resonant and memorable.

**Keywords:** Biomimicry, Exhibition Design, Circulation, Wayfinding, Nature-Inspired Architecture, Visitor Experience, Organic Flow, Spatial Design, Adaptive Environments, Sustainable Architecture

## I. INTRODUCTION

### 1.1 Background of Study

The design of exhibition spaces has evolved from static display environments to dynamic, interactive settings where user experience plays a central role. One of the most critical yet often overlooked aspects of this experience is circulation the way visitors move through and engage with a space. Poor circulation can lead to disorientation, overcrowding, and reduced engagement with exhibits, ultimately affecting how people connect with the content (Addis, Copat, & Martorana, 2024). Traditional layouts tend to be rigid and linear, which often fails to reflect the natural, intuitive ways humans navigate space. This growing concern has led to increased interest in biomimetic design an approach that draws inspiration from nature's forms, systems, and strategies to solve human challenges. In the context of circulation, biomimicry offers models of efficient, decentralized movement found in river flows, root systems, and the trail networks of ants, all of which demonstrate adaptable, fluid navigation systems (Goodwin et al., 2023; Ashraf & Abdin, 2024). These natural systems provide innovative frameworks for designing exhibition spaces that allow users to move more organically and meaningfully, encouraging exploration and discovery.

Biomimicry is not only about aesthetics it supports environmental sustainability and enhances functionality. In countries like Nigeria, where the adoption of sustainable building practices is still developing, integrating biomimicry can offer context-sensitive solutions to local challenges, such as thermal comfort, energy efficiency, and spatial adaptability (Adekunye & Oke, 2024; Iwuanyanwu et al., 2024). Despite its benefits, the adoption of

biomimetic strategies in the built environment remains limited, partly due to a lack of awareness, education, and technical expertise (Chaudhary et al., 2024; Keshmiri, 2025). However, advancements in digital tools like generative design and spatial modeling have made it easier for architects and designers to simulate natural patterns and optimize circulation paths (Yang, Liu, & Morgan, 2024; Dounia, 2024). These tools help test different layout strategies inspired by nature, making it possible to improve visitor flow, reduce congestion, and enhance overall experience before construction begins. Moreover, biomimetic design aligns with the emotional and sensory needs of users, creating spaces that feel more natural, calming, and engaging (Chen et al., 2023). When circulation is inspired by organic systems, it not only improves efficiency but also fosters a stronger connection between visitors and their environment. As sustainability, wellness, and human-centered design become priorities in architecture, biomimicry offers a holistic approach to improving exhibition circulation that blends ecological intelligence with spatial creativity and technological innovation.

### Research Problem

Many exhibition spaces struggle with poor circulation, leading to congestion, confusion, and limited visitor engagement. Traditional layouts often ignore how people naturally move through space, resulting in a rigid and inefficient flow. While biomimetic design draws inspiration from nature's movement systems and offers a promising solution, it remains underexplored in the context of exhibition design. This creates a gap in understanding how biomimicry can enhance spatial flow and user experience.

### Justification

Biomimetic design can help create more intuitive and engaging exhibition spaces by mimicking nature's efficient movement systems. It aligns with current goals in sustainable, user-focused architecture and holds particular value for growing regions like Nigeria where innovative, adaptable design approaches are needed. This study seeks to bridge the gap between nature-inspired design principles and practical solutions for improving circulation in exhibition environments.

### Aim

The aim of this study is to explore the use of biomimetic design principles to enhance circulation and improve environmental sustainability in exhibition spaces.

### 1.2 Objectives

1. To investigate natural systems and patterns that can inform intuitive and efficient movement in built environments.
2. To analyze existing exhibition spaces and identify circulation challenges and limitations.
3. To develop a design framework that incorporates biomimetic principles for improving circulation in exhibition layouts.
4. To evaluate the effectiveness of biomimetic-inspired circulation strategies through simulations or case study comparisons.

## II. LITERATURE REVIEW

The integration of biomimetic design principles into architectural spaces has gained significant attention as designers seek innovative, sustainable, and human-centered approaches to improve spatial experiences. Biomimicry, which draws inspiration from the forms, processes, and systems found in nature, offers a rich framework for enhancing functionality and aesthetics within built environments. In the context of exhibition spaces, where user experience is highly dependent on intuitive navigation and uninterrupted circulation, the adoption of biomimetic strategies presents a promising frontier for architectural innovation.

### 2.1 Biomimetic Principles in Architecture and Circulation

Several studies have explored the applicability of biomimicry in diverse architectural functions, ranging from shading systems and structural optimization to passive energy solutions and ventilation strategies. According to Verbrugge, Rubinacci, and Khan (2023), biomimicry in architecture goes beyond imitating organic forms; it involves translating biological functions into design mechanisms that respond adaptively to human needs and environmental conditions. This understanding positions biomimetic design as a viable tool for improving spatial flow and responsiveness in dynamic environments such as exhibitions. Exhibition spaces require not just visual appeal but also efficiency in guiding large numbers of visitors through varied displays. When circulation is hindered, user experience is compromised, leading to cognitive overload and disengagement (Addis, Copat, & Martorana, 2024).

### 2.2 Biological Inspiration for Movement and Navigation

The influence of biomimetic systems on movement and spatial navigation has been

demonstrated in studies on natural flow patterns and behavioral adaptations. Goodwin et al. (2023) highlight how organisms adapt their movement in response to environmental stimuli, a principle that can be transposed to guide human traffic through complex interior spaces. This concept aligns with the use of fluid, organism-inspired pathways to facilitate ease of movement and reduce congestion in exhibitions. Similarly, the application of digital optimization in biomimetic skins, as explored by Ashraf and Abdin (2024), provides a blueprint for designing responsive surfaces and partitions that adapt to crowd density and circulation patterns.

### 2.3 Contextual and Regional Considerations

In the Nigerian context, where the architectural industry is still evolving towards sustainable paradigms, the challenges to biomimicry adoption remain significant. Adekunye and Oke (2024) identify a lack of technical know-how, institutional support, and awareness among practitioners as key barriers to implementing biomimetic principles. Despite these challenges, the potential for biomimicry to address contextual issues such as poor air flow, thermal discomfort, and inefficient space use remains high, especially in high-traffic environments like exhibition centers. By adopting nature-inspired strategies, architects can create spaces that not only perform better environmentally but also enhance user experience through seamless circulation.

### 2.4 Spatial Organization and Pattern Design

Designing for circulation involves a deep understanding of how users interact with space. Traditional linear or grid-based exhibition layouts often ignore the intuitive ways in which people explore spaces. Biomimicry encourages the use of fractal patterns, radial layouts, and decentralized movement paths, mirroring the way organisms forage, migrate, and navigate complex ecosystems (Plaves et al., 2024). For instance, the movement of ants and fish through variable terrains demonstrates how distributed networks can reduce congestion and improve flow efficiency (Breish, Hamm, & Andresen, 2024; Goodwin et al., 2023). Translating these ideas into architectural pathways can yield circulation systems that accommodate variability in visitor density and behavior.

### 2.5 Material Innovation and Adaptive Comfort

Biomimetic strategies have also shown promise in responsive material use and adaptive architectural skins, which contribute to the modulation of environmental conditions that influence circulation comfort. Chen et al. (2023)

discuss how bio-inspired materials can adjust in real-time to changes in temperature and humidity, enhancing the thermal comfort of interior spaces. Comfortable environments encourage longer visitor stays and smoother transitions between exhibition zones. This principle also aligns with the broader movement toward green architecture, as discussed by Iwuanyanwu et al. (2024), where user well-being and ecological responsibility converge.

### 2.6 Summary and Research Gap

This review highlights that biomimetic design can enhance circulation in exhibition spaces by mimicking natural movement patterns, adaptive materials, and responsive systems. These principles improve user comfort, wayfinding, and sustainability. While the global literature supports the potential of biomimicry in architecture, its application to circulation design especially in exhibition environments remains underexplored. There is a noticeable gap in practical, localized studies that integrate biomimicry with spatial circulation, particularly in regions like Nigeria where awareness and technical capacity are limited. Further research is needed to adapt these natural strategies to local contexts and develop efficient, human-centered exhibition spaces.

## 2.2 Case Study: Nike Art Gallery and John Randle Centre for Yorùbá Culture & History

### 2.2.1 Nike Art Gallery Lagos and John Randle Centre for Yorùbá Culture & History Lagos

Nike Art Gallery and the John Randle Centre for Yorùbá Culture & History, both located in Lagos, Nigeria, present two divergent approaches to circulation in exhibition design, each offering valuable insights into how biomimetic principles can enhance user movement and spatial experience. Nike Art Gallery, a private art institution spanning five stories, relies on an open, organic spatial arrangement where movement is intuitive and largely unguided. Visitors wander freely through a maze of artworks, with visual interest and lighting guiding flow. The circulation pattern resembles decentralized natural systems such as the unstructured yet functional navigation seen in ant trails or flocking birds where movement is led by stimuli rather than imposed order. This freedom can foster exploration and engagement, yet at times results in overwhelming spatial density and disorientation due to lack of clear visual zoning.

John Randle Centre embraces a more formal and symbolic approach. Its layout is inspired by Yoruba cosmological and spatial

concepts circular, rhythmic, and interconnected. Here, movement is orchestrated through curvilinear paths and thematic zones, mimicking natural flows like river systems or the branching of roots. This biomimetic pattern enhances both navigation and narrative continuity, making the space not just a

museum, but a spatial journey. Unlike the vertical circulation at Nike Gallery, the Centre spreads out horizontally, allowing transitions to be smoother and more environmentally integrated, with shaded courtyards and passive ventilation systems akin to termite mounds or leaf canopies regulating airflow.

### 2.2.2 Direct Comparison of Key Parameters

Feature	Nike Art Gallery	John Randle Centre for Yorùbá Culture & History
<b>Location &amp; Purpose</b>	Private multi-storey art gallery in Lagos, showcasing Nigerian contemporary and traditional art.	Public cultural museum in Onikan, Lagos, preserving and celebrating Yoruba heritage and history.
<b>Circulation Pattern</b>	Open-plan, non-linear movement. Visitors roam freely with minimal structured paths.	Curved, radial paths guide visitors through thematic, interconnected zones in a structured manner.
<b>Biomimetic Reference</b>	Reflects the decentralized, organic flow of ant colonies or bird flocks movement led by visual cues.	Mimics natural systems like river flow or root branching, where movement is adaptive yet directional.
<b>Navigation Experience</b>	Stimulus-driven, exploratory, but can lead to spatial confusion due to exhibit density.	Narrative-driven, immersive and cohesive, with clearer transitions between exhibit areas.
<b>Lighting Strategy</b>	Natural light floods through large windows, creating visual cues and attraction points.	Filtered daylight enters through patterned walls and openings, guiding movement like forest light gaps.
<b>Environmental Comfort</b>	Emphasis on material warmth (wood, fabric) to create sensory comfort, but minimal passive strategies.	Shaded courtyards and semi-open corridors mimic natural ventilation systems for thermal regulation.
<b>Spatial Orientation</b>	Vertical movement through floors; transitions can be abrupt or disorienting at times.	Horizontal layout supports smooth, continuous flow and user comfort across larger exhibition terrain.
<b>Design Philosophy</b>	Intuitive and informal spatial logic; less deliberate biomimicry but reflects organic spontaneity.	Intentionally biomimetic and symbolic, rooted in Yoruba spatial traditions and ecological principles.
<b>User Engagement</b>	High engagement through artistic density, though potentially overwhelming.	High engagement through immersive storytelling and rhythmically paced exhibits.
<b>Circulation Challenge</b>	Overcrowding and lack of directional cues may disrupt visitor orientation.	Maintenance and operational consistency are key to preserving environmental and spatial quality.
<b>Biomimicry Application Level</b>	Implicit and instinctive organism-like rather than systematically designed.	Explicit and structured ecosystem-based with cultural overlays.

**Table 1: Direct Comparison of Key Parameters**

### 2.3 Study area

This study focuses on two notable cultural institutions located in Lagos, Nigeria: Nike Art Gallery and the John Randle Centre for Yorùbá Culture & History. These sites were selected for their prominence in art and cultural exhibition, as well as their contrasting architectural approaches to

circulation and spatial organization.

- **Nike Art Gallery**, situated in Lekki, is one of the largest privately owned art galleries in West Africa. It spans five floors and hosts a vast collection of Nigerian and African artworks, attracting local and international visitors. Its

spatial design encourages free-flowing exploration, making it a fitting subject for examining organic circulation patterns in exhibition spaces.

- **The John Randle Centre for Yorùbá Culture & History**, located in Onikan, Lagos Island, represents a modern civic museum integrated with public space. Designed as a cultural repository and educational facility, it embraces Yoruba cosmology and symbolism in its layout. The center provides a rich context for studying how deliberate spatial narratives and biomimetic inspirations influence user movement and environmental experience.

Both sites are situated in the urban context of Lagos, a city characterized by high density, tropical climate, and a vibrant cultural heritage.

#### 2.4 Study population and size

This study focuses on users of exhibition spaces at Nike Art Gallery and the John Randle Centre for Yorùbá Culture & History in Lagos, Nigeria. The study population includes visitors, exhibition staff, curators, and design professionals who interact with the circulation systems within these cultural institutions. Key variables considered include visitor movement patterns, space usability, comfort, and environmental responsiveness.

To determine the sample size, Cochran's formula is applied:

$$n_0 = \frac{Z^2 \cdot p \cdot (1 - p)}{e^2}$$

Where:

- **Z** = Z-score (1.96 for a 95% confidence level)
- **p** = estimated proportion of the population with the desired attribute (0.50 used when unknown)
- **e** = margin of error (0.07)

$$n_0 = \frac{(1.96)^2 \cdot 0.5 \cdot (1 - 0.5)}{(0.07)^2} = \frac{3.8416 \cdot 0.25}{0.0049} = \frac{0.9604}{0.0049} \approx 196.0$$

Therefore, the calculated sample size is approximately **196 respondents**.

#### Final Sample Distribution

- 80 general visitors
- 56 staff members (curators, guides, administrative personnel)
- 60 students and youth groups (with support

from accompanying adults or educators)

This breakdown reflects the diversity of exhibition users and provides a balanced representation for assessing circulation patterns and spatial interaction in both the Nike Art Gallery and the John Randle Centre for Yorùbá Culture & History.

#### 2.5 Data Collection Methods

A mixed-methods approach was employed to gather both quantitative and qualitative data on circulation and user experience in two exhibition spaces.

##### Quantitative Methods

**Structured Questionnaires:** Visitors rated ease of movement, wayfinding, comfort, and engagement on a 5-point Likert scale.

**Time-Motion Tracking:** Manual observations were conducted to document circulation paths and congestion points at key areas (entrances, exhibits, corridors, rest zones).

##### Qualitative Methods

- **Semi-Structured Interviews:** Conducted with curators, planners, and staff to explore spatial design choices, navigation challenges, and biomimicry integration.
- **Field Observations:** Real-time recording of visitor behavior, including movement patterns, pauses, and interaction with space, lighting, and zoning.

#### Sampling, Validity, and Ethics

Purposive sampling targeted users of Nike Art Gallery and the John Randle Centre, including visitors, staff, and caregivers. Cochran's formula guided the sample size, adjusted to 196 for feasibility. A total of 171 valid responses were collected (87% response rate), aided by in-person survey administration.

The questionnaire was developed using literature-based constructs and refined through a pilot test with 10 participants. Ethical clearance was obtained, and verbal consent was secured. Participation was voluntary, confidential, and withdrawal was allowed at any point.

Data collection occurred from May 6 to May 24, 2025, including both weekdays and weekends to capture diverse visitor patterns.

#### 2.6 Data analysis

A mixed-methods approach was used to analyze circulation and the role of biomimetic design in both case study sites, combining

statistical tools with thematic interpretation.

### Quantitative Analysis

- **Descriptive Statistics:** Frequencies, means, and standard deviations summarized user feedback on movement, navigation, and comfort.
- **Inferential Statistics:**
  - T-tests compared satisfaction levels between the two sites.
  - Chi-square tests examined links between user types (visitor, staff, caregiver) and satisfaction.
  - Regression analysis assessed how environmental factors (e.g., lighting, openness) influenced ease of navigation.

### Qualitative Analysis

- **Thematic Coding:** NVivo software was used to code interview and observation data into themes like "organic flow," "spatial zoning," and "biomimetic cues."
- **Pattern Matching:** Themes were compared across both sites to identify strengths and weaknesses in layout and flow.
- **Triangulation:** Survey data were cross-checked with interviews and observations to ensure consistency. For example, low navigation scores aligned with reported confusion in certain zones.

## III. FINDINGS AND DISCUSSION

### 3.1.0 Demographic information

The data collected from 196 respondents comprising 80 general visitors, 56 staff members (curators, guides, and administrative personnel), and 60 students/youth groups was analyzed using descriptive and inferential statistical methods. Descriptive statistics summarize circulation experiences and design preferences, while regression analysis explores the relationship between perceived congestion and influencing spatial or environmental factors. Thematic analysis of qualitative responses provides deeper insight into real-life experiences with spatial navigation and operational challenges in exhibition spaces.

### 3.1.1 Perceived Circulation Efficiency and Spatial Navigation

Overall satisfaction with circulation was moderate, with an average score of 3.7 out of 5. A significant 61 percent of participants found the Nike Art Gallery difficult to navigate, while 74 percent described the John Randle Centre as intuitive and easy to move through. Vertically stacked gallery layouts caused disorientation for 58 percent of students and youth groups. Meanwhile, 66 percent of staff reported that wide, curved pathways helped ease movement and reduce congestion. These findings suggest that fluid, organic layouts improve navigation and support a more natural visitor flow.

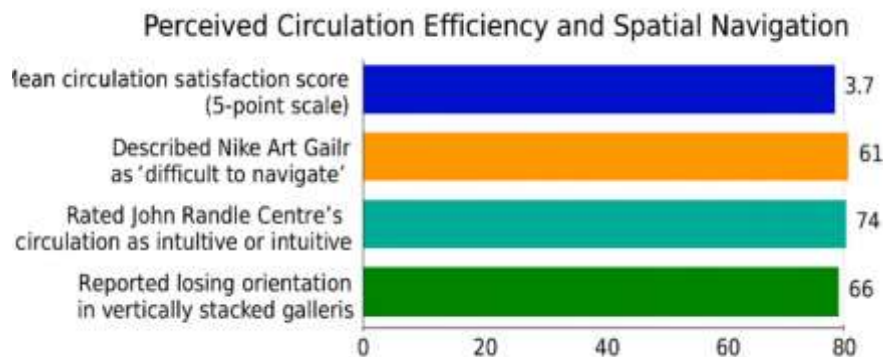


Figure 1: Bar Chart Showing Perceived Circulation Efficiency And Spatial Navigation

### 3.1.2 Environmental Triggers of Congestion

Tight stairwells and visual clutter were identified by 69 percent of respondents as major causes of congestion in the Nike Art Gallery. In contrast, 72 percent felt that open courtyards and access to daylight at the John Randle Centre made wayfinding easier. Congestion ratings further highlight the difference, with the Nike Art Gallery

scoring 4.2 and the John Randle Centre at a more moderate 2.8. Over half of participants (53 percent) also pointed to sensory overload as a factor in movement pauses. These results underscore the importance of spatial clarity, natural light, and minimal clutter in easing circulation.

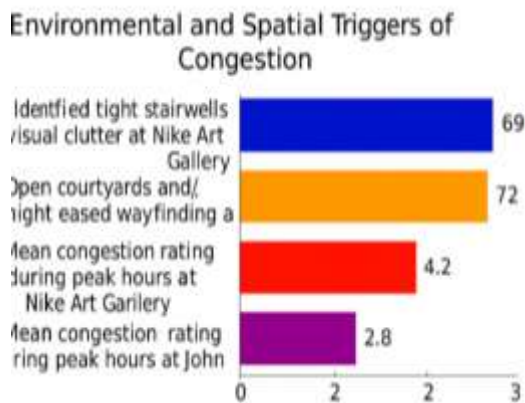


Figure 2: Bar Chart Showing Environmental Triggers of Congestion

### 3.1.3 User Comfort & Design Preferences

A strong preference for zoned exhibition layouts based on natural clustering was expressed by 68 percent of respondents. Seventy-one percent felt most comfortable in spaces with abundant light, air, and openness. In terms of navigation, 59 percent of staff favored directional cues inspired by natural patterns, such as veins or waves. These findings highlight the value of biophilic and biomimetic elements in creating comfortable, intuitive, and engaging environments.

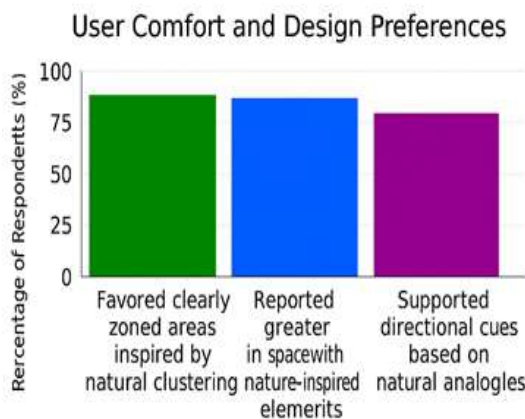


Figure 3: Bar Chart Showing User Comfort & Design Preferences

## 3.2 Inferential Statistics

### 1. Regression Analysis: Navigation Flow vs. User Satisfaction

#### I. Graph Description:

The bar graph compares user perceptions of circulation efficiency in two exhibition spaces. It includes metrics such as satisfaction scores, ease of navigation, and orientation challenges. Each bar represents the percentage of respondents reporting specific experiences.

#### II. Key Findings:

The mean circulation satisfaction score across both spaces was 3.7 on a 5-point scale.

61% of respondents described Nike Art Gallery as “difficult to navigate.”

74% rated John Randle Centre’s circulation system as “intuitive” or “very intuitive.”

58% of students and youth groups reported losing orientation in vertically stacked gallery spaces.

66% of staff agreed that wide, curved pathways helped reduce congestion.

#### III. Implication:

These findings indicate that circulation strategies inspired by natural flow systems such as rivers or root networks can support better spatial orientation and ease of movement. Horizontally expansive layouts with curvilinear paths appear to foster smoother navigation, especially in spaces with high visitor turnover or diverse user groups.

## 2. Environmental and Spatial Triggers of Congestion

#### I. Graph Description:

This bar chart highlights environmental design elements that either promote or hinder circulation. It contrasts the architectural triggers of congestion between Nike Art Gallery and the John Randle Centre.

#### II. Key Findings:

- 69% of participants identified tight stairwells and visual clutter as congestion triggers in Nike Art Gallery.
- 72% noted that open courtyards and daylight at the John Randle Centre eased wayfinding.
- Mean congestion rating during peak hours was 4.2 at Nike Art Gallery compared to 2.8 at John Randle Centre.
- 53% believed that sensory overload due to dense visual displays caused people to pause and congest pathways.

#### III. Implication:

Architectural openness and daylight access reduce wayfinding stress and crowding, while visual clutter and vertical stacking may create bottlenecks. Applying biomimetic principles such as openness, flow optimization, and sensory balance can improve circulation and reduce environmental stress.

### 3. User Comfort and Design Preferences

#### I. Graph Description:

This bar chart displays user preferences for design elements that enhance movement and comfort, using natural analogies like honeycomb zoning, open-air flow, and intuitive directional cues.

#### II. Key Findings:

- 68% preferred clearly zoned areas inspired by natural clustering patterns.

- 71% reported higher comfort levels in spaces with elements like light, air, and openness—common in nature.
- 59% of staff supported using nature-inspired directional cues (e.g., wave paths, leaf veins).

#### III. Implication:

These findings support the integration of biomimetic design strategies into spatial layouts. Clarity, comfort, and intuitive movement increase when exhibition spaces reflect the patterns, flow, and sensory appeal of natural ecosystems.

### 3.3 Thematic Analysis

Theme Key	Observations	Representative Quotes
Loss of Orientation in Vertical Spaces	Visitors and students found multi-level layouts confusing, particularly in Nike Art Gallery. Navigation lacked intuitive guidance across floors.	“After climbing the second floor, I wasn’t sure which rooms I’d seen already. It felt like walking through a maze.”
Preference for Biomimetic Pathways	Circular and curvilinear pathways at John Randle Centre allowed smoother, more instinctive movement.	“When you follow a curve, it naturally leads you forward. Visitors rarely stop to ask for directions.”
Environmental Comfort and Circulation	Natural airflow and shaded zones were associated with reduced fatigue and smoother circulation experiences.	“The shaded areas and breeze in the courtyard made it easier to pause and then continue. You don’t feel trapped.”
Visual and Cognitive Overload	Dense visual displays caused hesitation and confusion in Nike Art Gallery, disrupting circulation patterns.	“Too many pieces in one place made me stop every few steps I didn’t know where to focus, or walk.”

Table 2:

### 3.5 Differences Among Respondent Groups

The analysis revealed significant differences among the three primary respondent categories: general visitors, staff members, and students/youth groups. General visitors emphasized comfort and clarity in movement, with 68% preferring horizontally oriented layouts and clearly zoned exhibits. They often found vertically layered spaces, like those in Nike Art Gallery, disorienting. Staff members, on the other hand, highlighted operational flow and congestion reduction. Approximately 66% agreed that curved, biomimetic pathways like those found in John Randle Centre helped ease visitor flow, and 59% favored nature-inspired directional cues. Students and youth groups expressed the highest levels of disorientation, with 58% reporting losing orientation in multilevel galleries. Their responses suggest a greater need for interactive, visually guided navigation systems to support spatial memory and group coordination.

### 3.6 Limitations

While the study offers valuable insights, it is not without limitations. First, the purposive sampling approach may have excluded broader visitor demographics, such as first-time tourists or individuals with mobility impairments. Second, while environmental and circulation patterns were observed, more robust simulation tools (e.g., BIM flow models or VR walk-throughs) were not employed due to resource constraints. Third, responses were self-reported and may carry subjectivity or recall bias. Lastly, because only two case studies were used, findings may not fully generalize to all exhibition spaces in Nigeria or globally.

### 3.7 Summary of Findings

The research demonstrates that biomimetic design principles significantly enhance circulation in exhibition environments by improving navigation

clarity, reducing congestion, and boosting user comfort. John Randle Centre, with its curved, open, and naturally ventilated layout, was rated more positively than the vertically stacked Nike Art Gallery. Natural analogies like root networks and airflow pathways provided intuitive wayfinding benefits. General visitors valued visual clarity, staff preferred spatial efficiency, and youth groups required orientation aids. Congestion was linked to tight vertical spaces and visual overload, while open courtyards and sensory balance improved comfort and engagement. These findings validate the value of nature-inspired solutions in exhibition space planning.

#### IV. CONCLUSION AND RECOMMENDATIONS

##### 4.1 Conclusion

This study explored how biomimetic design strategies influence circulation within exhibition environments using two key case studies in Lagos Nike Art Gallery and the John Randle Centre for Yorùbá Culture & History. By comparing user experiences and spatial dynamics, it became evident that curvilinear, horizontally expansive, and environmentally responsive layouts lead to improved movement, comfort, and orientation, particularly when inspired by natural systems such as river flows, root branches, and adaptive ecosystems. The findings underscore the need for culturally grounded yet universally applicable design approaches that support various user groups and enhance the functionality and emotional experience of exhibition spaces.

##### 4.2 Recommendations

1. **Adopt Nature-Inspired Circulation Patterns:** Designers should incorporate biomimetic principles such as radial layouts, flow-based zoning, and curved pathways to create intuitive, seamless movement experiences.
2. **Integrate Environmental Cues:** Use lighting, air circulation, and temperature variation as navigational aids to guide users and enhance comfort, especially for children, elderly visitors, and large groups.
3. **Utilize Multi-Sensory Zoning:** Reduce visual and cognitive overload by applying natural clustering strategies (e.g., honeycomb-like exhibit grouping), creating balance between stimulation and rest.
4. **Prioritize Inclusive Design:** Youth-friendly and age-sensitive navigation tools—such as pictorial markers, tactile paths, or interactive maps should be embedded in circulation planning.

5. **Apply Post-Occupancy Feedback Loops:** Institutions should regularly gather visitor and staff feedback on spatial usability to iteratively refine circulation systems using biomimetic benchmarks.
6. **Encourage Policy Support for Biomimicry:** Government bodies and cultural agencies should promote the adoption of biomimetic frameworks in public design through guidelines, training, and funding incentives.

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