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Research On Programs In Architectural Design Thinking

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Abstract: This research paper investigates the integration of user behaviour and time-based program analysis into architectural design pedagogy through a participatory observational framework. Conducted within an academic design studio, architecture students undertook real-time activity mapping across three spatial typologies: a single-family house, a 5BHK bungalow, and a multi-storey girls' orphanage. Spatial overlays and heat maps derived from user movement data highlighted circulation conflicts, multifunctional overlaps, gender-based patterns, and underutilized zones. Through thematic analysis and correlation matrices, the study established the impact of temporal rhythms and user typologies on spatial effectiveness. Findings advocate embedding user-centered, empirical methodologies in architectural education and practice to enhance behavioural responsiveness in design.

Index Terms – architectural programming, design thinking, user behavior, spatial analysis, time-based mapping, participatory design, architectural pedagogy, post occupancy evaluation, human centered design.

I. INTRODUCTION

Architecture, at its core, is the shaping of space in response to human behavior. While form, function, and aesthetics have historically guided architectural design, an equally critical dimension often remains underexplored—the temporal dynamics of spatial use. In residential and institutional settings such as hostels, the ways in which occupants interact with and move through spaces over time can significantly influence spatial efficiency, comfort, and adaptability.

This study seeks to bridge that gap through a pedagogically grounded, user-centric approach. As part of a structured academic exercise, architecture students were tasked with conducting user activity mapping and time-based program analysis. These students collected, visualized, and interpreted data on user behavior by overlaying daily activity sequences on floor plans of a residence and a girls' hostel, allowing for a nuanced spatial-temporal understanding.

The objectives of the study are:

- To enable architecture students to investigate real-time user behaviour through guided activity mapping.
- To analyze how spatial usage varies over different times of the day and identify high-traffic versus underutilized zones.
- To visualize and interpret patterns of interaction, privacy, accessibility, and flow through time-based spatial overlays.
- To critically evaluate the alignment between intended spatial functions and actual user behaviours.

This approach not only introduces students to participatory observation and architectural programming but also simulates a simplified post-occupancy evaluation model. By transforming subjective observations into layered spatial data, the study empowers future architects to design with responsive insight rather than intuition alone.

Ultimately, the research advocates for integrating time-aware programming methods in architectural pedagogy and practice, arguing that such strategies can enhance both design quality and user experience in everyday built environments.

II. LITERATURE REVIEW

Time Frame	Thematic Area	Publications & Authors	Focus / Contribution
1970s	Architectural Programming and Design Thinking	*Problem Seeking: An Architectural Programming Primer* – William Peña, Steven Parshall, Kevin Kelly (1977)	Establishes foundational methods for identifying, analysing, and expressing architectural problems.
	Architectural Programming	*Methods of Architectural Programming* – Henry Sanoff (1977)	Introduces participatory methods and evaluation models to frame design problems collaboratively.
1980s	Architectural Programming and Design Thinking	*Programming the Built Environment* – Wolfgang F.E. Preiser (1985)	Links programming to Environmental-Behavioural Studies and systematizes action-human-goal translation in built environments.
	Architectural Programming	*Values: A Theoretical Foundation for Architectural Programming* – Hershberger, R. (1985)	Focuses on aligning design decisions with articulated values and user-defined goals.
1990s–2000s	Architectural Programming and Design Thinking	*Architectural Programming: Creative Techniques for Design Professionals* – Robert R. Kumlin (1995)	Provides professional techniques and tools for real-world programming integration.
2000s	Architectural Programming and Design Thinking	*Programming for Design: From Theory to Practice* – Edith Cherry (1998/2000)	Connects theoretical insights with practical design workflows.
2006	Design Thinking	*Design Thinking: Understanding How Designers Think and Work* – Nigel Cross (2006)	Offers cognitive insight into how designers process and solve problems.
2009	Design Thinking	*Change by Design* – Tim Brown (2009)	Advocates for a human-centred design thinking process that supports innovation and user empathy.
2006	User Activity Analysis	*Inquiry by Design* – John Zeisel (2006)	Combines behavioural research with architecture to explore how people interact with space.
1994	User Activity Analysis	*How Buildings Learn* – Stewart Brand (1994)	Examines long-term usage and evolution of buildings over time.
1970s–1990s	Participatory Design in Architecture	*Participatory Design: Theory & Techniques* – Henry Sanoff (1990)	Introduces techniques for involving users in architectural planning and programming.
2005	Participatory Design in Architecture	*Architecture and Participation* – Peter Blundell Jones, Doina Petrescu, Jeremy Till (2005)	Explores ethical, social, and collaborative dimensions of participatory architecture.
2015	Participatory Design in Architecture	*Participatory Design Thinking in Architecture & Urban Planning* – John Odhiambo Onyango (2015)	Proposes design thinking as a participatory urban planning method that connects stakeholders at various scales.

Table 1: Chronological Overview of Key Publications and Contributions in Architectural Programming and Design Thinking

A timeline summarizes major thematic areas, authors, publications, and their contributions to architectural programming and design thinking from the 1970s to 2015.

2.1 HISTORICAL FOUNDATIONS OF ARCHITECTURAL PROGRAMMING

The concept of architectural programming emerged in the 1970s as a structured method to bridge user needs with design decisions. *Problem Seeking* by Peña, Parshall, and Kelly (1977) laid the foundation by proposing a five-step process to define spatial problems based on client input, needs assessment, and value-based prioritization. Henry Sanoff (1977) emphasized participatory techniques in architectural programming, introducing user feedback loops as central to defining meaningful spatial solutions.

In the 1980s, Preiser (1985) and Hershberger (1985) expanded the theoretical scope. Preiser linked programming to environmental-behavioral studies, suggesting that programming serves as a mediator between organizational goals and spatial behavior. Hershberger introduced value-based frameworks to assess how individual and societal values influence design outcomes.

2.2 DESIGN THINKING AND PARTICIPATORY APPROACHES

Contemporary architectural programming aligns closely with design thinking models. Nigel Cross (2006) described how designers process problems through iterative, reflective practice, while Tim Brown (2009) emphasized empathy and user-centric ideation in his concept of human-centred design. These perspectives align with the participatory ethos of involving users early and often to generate responsive spatial strategies.

Sanoff (1990), along with Jones, Petrescu, and Till (2005), advocated for participatory design, where users act as co-creators. John Odhiambo Onyango (2015) further contributed to this discourse by proposing participatory design thinking models that combine bottom-up input with top-down planning.

2.3 EVALUATING USER INVOLVEMENT METHODS

Recent research has focused on evaluating how users are involved in the design and evaluation of architectural spaces. Kim et al. (2015) developed a comprehensive framework for comparing user involvement methods in AEC (architecture, engineering, construction) projects. Their model emphasizes direct versus indirect participation, digital simulations, and context-sensitive engagement.

Caixeta et al. (2019) conducted a systematic review of user involvement literature and found that while the concept is widely used, consistent definitions and frameworks remain lacking. They categorized levels of user engagement and called for clearer models tailored to architectural contexts.

Saleh et al. (2020) demonstrated participatory frameworks in practice by engaging students in the redesign of a school playground in Cairo. Their work highlights how creative techniques such as atmospheric collages can elicit emotional and functional input from users, making the design process more inclusive and effective.

2.4 IMPLICATIONS FOR PEDAGOGICAL PRACTICE

Aydin Aktaş et al. (2023) explored architectural programming in higher education, focusing on how students conceptualize and evaluate campus spaces. Their findings reinforce the value of involving students in post-occupancy evaluations and programming tasks, a strategy echoed in this study's methodology.

Collectively, these works establish a strong theoretical and practical foundation for time-based user activity mapping and participatory design. They validate the integration of observational programming methods in architectural education as a means of preparing students for real-world spatial challenges.

3. METHODOLOGY

This study employs a **qualitative and spatial-analytical methodology** grounded in observational data, user mapping, and participatory design exercises. The aim was to analyse the relationship between user activities, spatial layout, and time-based usage patterns in different building typologies. Three case studies were selected: a single-family house, a 5BHK bungalow, and a multi-storey girls' orphanage.

3.1 SCOPE AND CONTEXT OF APPLICATION

The research was carried out within an academic design studio setting as a pedagogical tool. Students actively engaged in both data collection and analysis, gaining exposure to behavioural mapping and user-centric design thinking. The methodology not only served the research objective but also functioned as a framework for experiential learning.

IV. RESULTS

4.1 DATA COLLECTION

Architecture students were involved in observing and recording the movement patterns and activities of building users across different times of the day. These observations were conducted through manual tracking and structured note-taking, which were then graphically translated into movement path diagrams and spatial overlays on floor plans.

The daily routine was divided into distinct time blocks:

Early Morning (5 AM – 8 AM)
Morning (8 AM – 12 PM)
Midday (12 PM – 4 PM)
Evening (4 PM – 7 PM)
Night (7 PM – 10 PM)

This segmentation helped in identifying temporal rhythms and peak activity periods within various spatial zones.

Users were classified into groups based on their roles (e.g., child, mother, visitor, student, warden, and staff). These classifications were used to track activity distribution, overlapping space use, and role-based circulation.

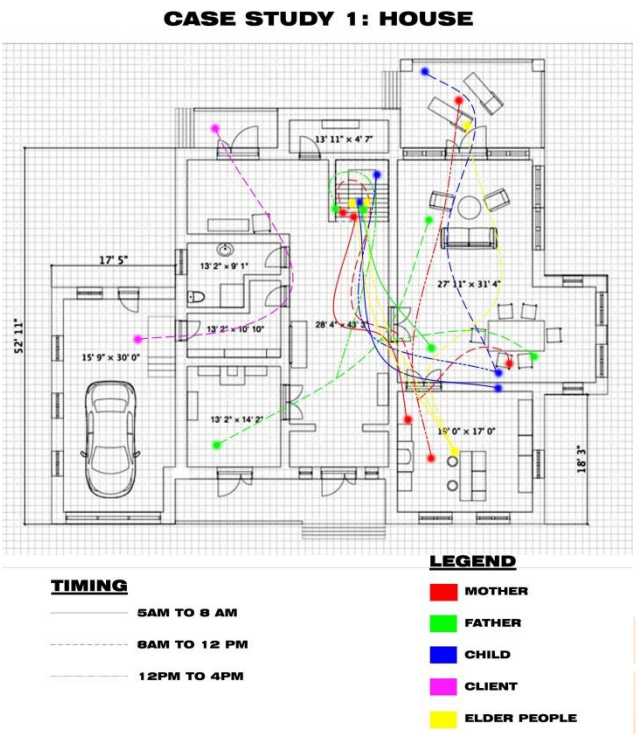

Figure 1: User Movement Path Overlay – Case Study 1 (Single-Family House)
Visual representation of user circulation patterns based on time-segmented observation.

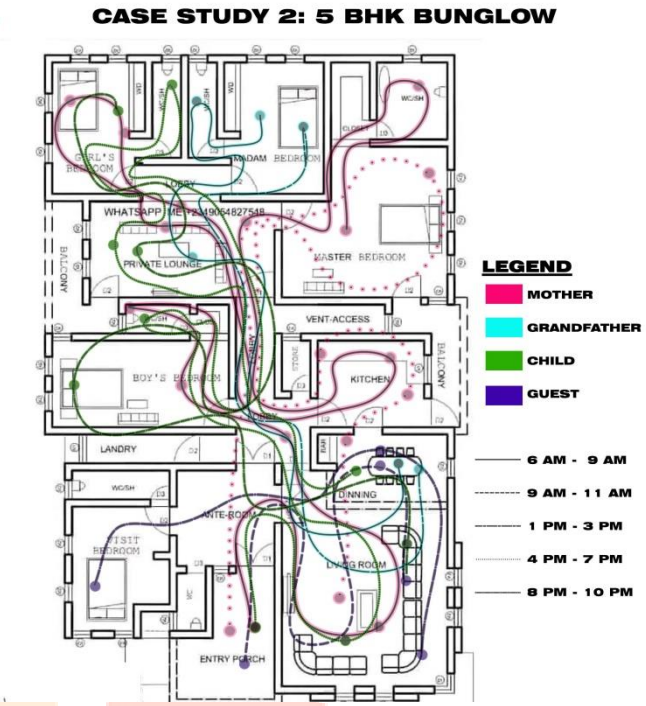

Figure 2: User Movement Path Overlay – Case Study 2 (5BHK Bungalow)
Shows time-based user flow and high-activity zones within a larger residential layout.

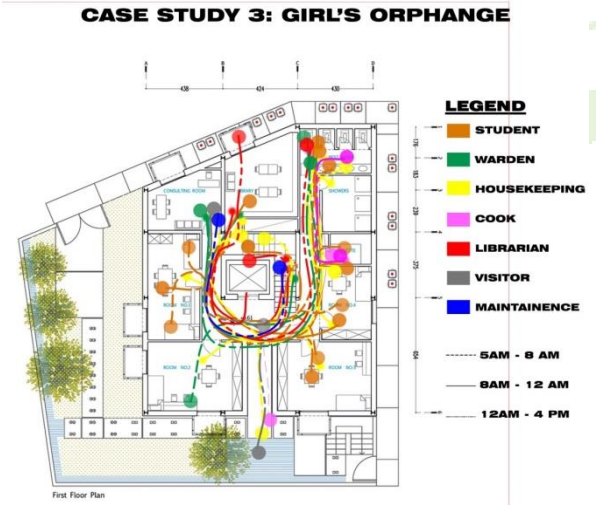

Figure 3: User Movement Path Overlay – Case Study 3, First Floor (Girls' Orphanage)
Highlights ground-level circulation including service and student movement overlap.

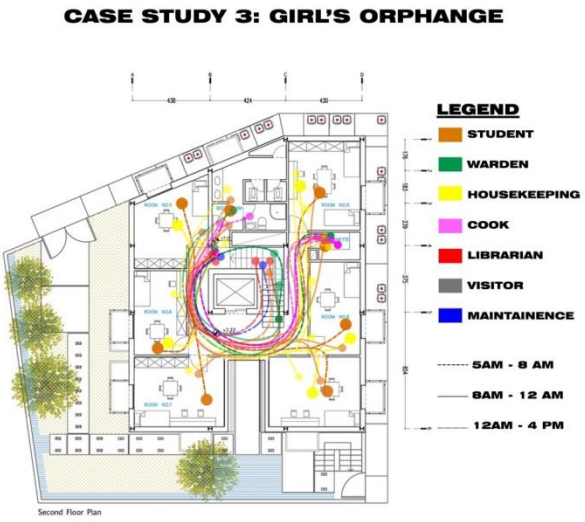

Figure 4: User Movement Path Overlay – Case Study 3, Second Floor (Girls' Orphanage)
Visualizes vertical movement and time-sensitive activity among students and staff.

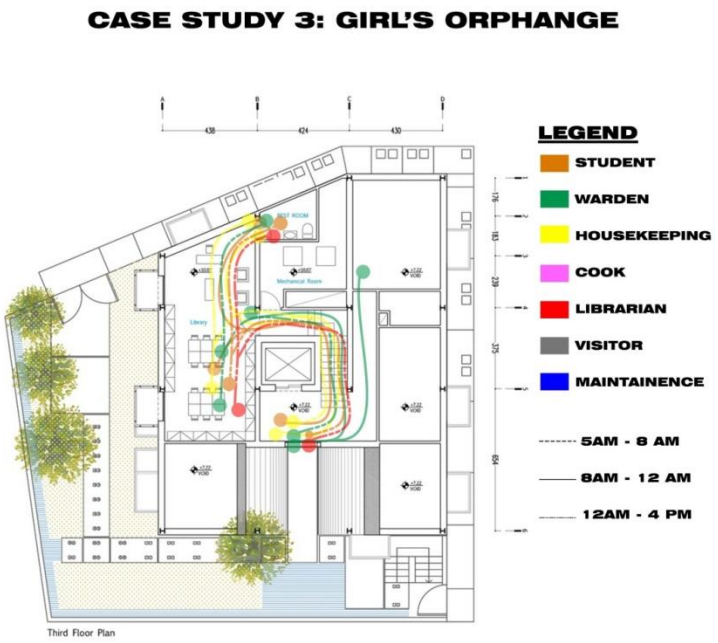

Figure 5: User Movement Path Overlay – Case Study 3, Third Floor (Girls' Orphanage)
Depicts reduced activity concentration and specialized spatial usage.

4.2 Spatial analysis results

This section presents the key findings from the three case studies—House (CS1), 5BHK Bungalow (CS2), and Girls' Orphanage (CS3)—based on user activity mapping, time-segmented analysis, thematic interpretation, spatial overlays, and correlation matrices.

4.2.1 Thematic Analysis

Raw observational data were coded into recurring themes such as circulation conflict, multifunctional overlap, user disengagement, and spatial hierarchy. These themes provided qualitative insight into user experience and behavior.

4.2.1.1 Thematic Analysis of Case study-1(a single-family house)

Raw Observation	Initial Code	Theme	Location (Space/Time)	Remarks
Aged people move between dining, bedroom, and hall frequently	Elderly Circulation	Age-Specific Movement Pattern	Hall / Bedroom / Dining – All day	Zoning must support ease of access
Multiple activities overlap in hall (client meetings, eating, resting)	Activity Overlap	Multi-Functional Conflict	Hall – 8 AM to 12 PM	Public-private zoning is blurred
Morning congestion due to simultaneous cooking, cleaning, and bathing	Routine Congestion	Temporal Conflict Zone	Kitchen / Bathroom – 5 AM to 8 AM	Needs staggered functional allocation
Children often shift from hall to bedroom and outdoors	Child Mobility	Dynamic Movement	Hall → Bedroom / Outdoors – Morning & Evening	Reflects flexibility and freedom
Father and mother use dining and kitchen most often	Core Activity Use	Gendered Spatial Pattern	Kitchen / Dining – 8 AM to 2 PM	Reinforces centrality of these spaces

Table 2: Thematic Analysis Summary – Case Study 1 (Single-Family House)
Illustrates coded themes derived from user activity mapping and time-based spatial behaviour.

This analysis captures key spatial and temporal patterns within a residential setting based on user activity mapping. Frequent movement between dining, bedroom, and hall reflects the need for accessible and

connected spaces. Zoning should support ease of access for elderly users. Overlapping activities in the hall (8 AM–12 PM) indicate blurred public-private boundaries. Better zoning or flexible furniture layouts are needed. Simultaneous use of kitchen and bathroom (5–8 AM) creates temporal conflicts. Staggered routines or additional facilities could alleviate this. Children move freely between spaces, showing dynamic use. Design should allow flexible, adaptable zones for varied activities. Parents predominantly use the kitchen and dining (8 AM–2 PM), highlighting traditional gendered patterns. Inclusive spatial planning can address such norms.

4.2.1.2 Thematic Analysis of Case study-2 (5BHK bungalow)

Raw Observation	**Initial Code**	**Theme**	**Location (Space/Time)**	**Remarks**
Grandfather wakes early, uses entry porch, dining, and bedroom	Early Routine – Elderly	Temporal Zoning – Seniors	Entry Porch / Dining / Bedroom – 6–9 AM	Elder-friendly access and seating
Child circulates between bedroom, dining, living room, and lounge	High Activity Mobility	Dynamic Circulation	Private Lounge / Living / Dining – Evening	Spaces support child flexibility
Guest stays in visit room but uses living and dining zones	Visitor Integration	Guest–Family Overlap	Visitor Bedroom → Living / Dining – 7–10 PM	Public zone zoning works well
Mother transitions frequently between kitchen, dining, and bedrooms	Functional Core Use	Service-Oriented Flow	Kitchen / Bedroom / Living – 9 AM to 3 PM	Flow shows typical multitasking routes
Living and dining room host all family together in evenings	Peak Occupancy	Communal Convergence	Living + Dining – 6–9 PM	Requires larger shared volume, acoustic comfort

Table 3: Thematic Analysis Summary – Case Study 2 (5BHK Bungalow)
Highlights recurring patterns and spatial insights from mapped observations.

Seniors use entry porch, dining, and bedroom in the early morning (6–9 AM), requiring accessible, elder-friendly spaces. Evening mobility between lounge, living, and dining areas suggests need for adaptable, child-friendly layouts. Guests shift between private and shared zones (7–10 PM), benefiting from well-zoned public areas. Mothers follow multitasking routes (9 AM–3 PM) through kitchen, dining, and bedroom, indicating a need for efficient layout. Peak family presence in living and dining areas (6–9 PM) calls for spacious, acoustically comfortable environments.

4.2.1.3 Thematic Analysis of Case study-3 (a multi-storey girls' orphanage.)

Raw Observation	Initial Code	Theme	Location (Space/Time)	Remarks
Heavy overlap of student and housekeeping staff movement in corridor	Path overlap	Circulation Conflict	Corridor – 5–8 AM	Unsafe/chaotic transition zone
Students avoid terrace space	Avoided Zone	User Disengagement	Terrace – All day	Underused potential common area
Visitors and librarian overlap in library	Shared Zone Clash	Functional Ambiguity	Library – 8 AM–12 PM	Reconsider scheduling or zoning
Central staircase is used by every user group	High Central Use	Vertical Circulation Hotspot	Staircase – all time blocks	May require safety/design upgrade
No janitor room access in shared areas	Infrastructure Gap	Lack of Support Spaces	Near restrooms – All day	Spatial inadequacy
Prayer room is occasionally used by warden for admin work	Space Reuse	Non-Programmed Use	Prayer Room – Afternoon	Overlaps affect intended spiritual function
Mechanical room accessed frequently by maintenance staff	Back-of-House Activity	Support Zone Priority	Mechanical Room – 8 AM–4 PM	Design ensures minimal user conflict
Library is quiet and less visited during midday	Quiet Zone – Low Traffic	Underutilized Resource	Library – 12 PM–3 PM	May require programming/activity push
Students occasionally come up to the library without staff	Unscheduled Use	Autonomous Access	Library – Post 3 PM	Shows independent user behavior

Table 4: Thematic Analysis Summary – Case Study 3 (Girls' Orphanage)
Shows key findings regarding user movement, functional conflicts, and spatial underutilization in institutional settings.

The analysis reveals key spatial and temporal challenges in institutional settings. Circulation conflicts, especially in corridors and staircases, highlight the need for safer and more organized movement flows. Underused areas like terraces and midday libraries point to untapped spatial potential. Overlapping functions, such as admin work in prayer rooms or mixed use of library zones, suggest a lack of programming clarity. Gaps in support infrastructure and autonomous student behavior further emphasize the need for zoning upgrades, activity scheduling, and spatial flexibility. Collectively, these insights call for improved user-centric planning and adaptive space management.

3.2.1.4 Comparative Analysis of three Case studies.

Recurring patterns in spatial use were categorized into six primary themes:

Theme	Description	Case Evidence
Circulation Conflict	Overlapping user paths cause spatial friction	CS3 corridors (5–8 AM); CS1 central hallway
Multifunctional Overlap	Same space used for conflicting activities	CS1 Hall: client meetings, resting, dining (8 AM–12 PM)
Temporal Congestion	High density during routine transitions	CS2 Kitchen & Dining (6–9 AM); CS3 Staircases
Underutilized Zones	Spaces avoided or rarely accessed	CS3 Terrace (All day); CS1 bedrooms (Afternoon)
Non-Programmed Usage	Informal space repurposing	CS3 Prayer Room used for admin by warden
Gendered Circulation	Movement patterns influenced by gender roles	CS1 and CS2 Kitchen use by mothers (8 AM–2 PM)

Table 5: Comparative Thematic Matrix of All Three Case Studies
Categorizes spatial challenges and behavior patterns across residential and institutional typologies.

This analysis identifies key spatial challenges across case studies. Circulation conflicts arise from overlapping user paths, particularly in corridors and staircases. Spaces often face multifunctional overlap, leading to blurred zoning, as seen in CS1's hall. Peak hour congestion highlights the need for temporal scheduling, especially in kitchens and stairwells. Underused zones like terraces and bedrooms point to design or access issues, while informal repurposing of spaces suggests gaps in programming. Gendered usage patterns reflect social roles influencing spatial behavior, indicating a need for inclusive planning.

4.2.2 Time-Series Analysis

Activity trends were studied across different time blocks to understand the temporal distribution of movement and zone usage. This helped visualize spatial congestion, underutilization, and routine-based zoning.

Case Study	Time Block	User Categories	Key Spatial Zones (High Activity)	Observations/Patterns
House (CS1)	**5 AM – 8 AM**	Mother, Father, Child, Elder	Kitchen, Restroom, Central Hallway	Morning prep and grooming; kitchen is active; path overlaps in central zone
	8 AM – 12 PM	Client visits, Elder People	Living Room, Kitchen	Guests overlap with family circulation; common zones are densest
	12 PM – 4 PM	Elder, Mother	Kitchen, Hallway	Kitchen remains in use; elder moves toward rest areas
5BHK Bungalow (CS2)	**6 AM – 9 AM**	Mother, Child, Grandfather	Kitchen, Bedroom to Dining Paths	Morning meal prep; children move from private to communal areas
	9 AM – 11 AM	Mother, Guest	Living Room, Dining	Guest interaction begins; shared spaces activated

	1 PM – 3 PM	Grandfather, Child	Private Lounge, Bedrooms	Quiet/rest period; reduced kitchen activity
	4 PM – 7 PM	All Users	Living Room, Entry, Dining	Family convergence; major overlap in circulation
	8 PM – 10 PM	Children, Mother	Bedrooms, Private Lounge	Return to private areas; end-of-day routine
Orphanage – 1st Floor (CS3)	**5 AM – 8 AM**	Cook, Housekeeping, Students	Kitchen, Bathrooms, Stairs	Meal prep and hygiene; early congestion in core zones
	8 AM – 12 PM	Warden, Students, Visitor	Library, Consultation Room, Entry	Visitors arrive; admin and education spaces used
	12 PM – 4 PM	Housekeeping, Maintenance	Staircases, Storage, Staff rooms	Facility upkeep and zone transitions
Orphanage – 2nd Floor	**5 AM – 8 AM**	Students, Warden	Washrooms, Dorms, Stairs	High movement; vertical transit to ground floor
	8 AM – 12 PM	Cook, Warden	Corridor, Stairwell	Staff movement supporting breakfast and shift
	12 PM – 4 PM	Students	Dorms, Common Room	Quiet/rest hours; limited corridor traffic
Orphanage – 3rd Floor	**5 AM – 8 AM**	Housekeeping, Cook	Library, Mechanical, Prayer Room	Setup and cleaning of specialized spaces
	8 AM – 12 PM	Students	Library, Prayer Room	Study and group time; spiritual activities
	12 PM – 4 PM	Warden, Students	Library, Staircase	Movement back to dorms; limited activity

Table 6: Time-Series Activity Distribution – Case Studies 1, 2, and 3

Documents temporal shifts in activity zones across various user types and building programs.

Each typology exhibited a distinctive temporal rhythm:

CS1 (House): Kitchen and hall remain active throughout the day; early morning and evening routines are congested. The living room, dining area, and the central hallway/staircase appear to be high-traffic zones for multiple individuals across different time periods, which is typical for common family spaces.The kitchen is also a focal point for movement, especially during morning and midday.

CS2 (Bungalow): Clear public-private transition; communal zones peak during evening hours (6–9 PM). The "KITCHEN" and "DINNING" areas are high-traffic zones for all family members, especially during meal times. The "LIVING ROOM" serves as a significant communal space, particularly in the evenings,

where family members and guests converge for relaxation and interaction. The daily rhythm of the household, with peaks of activity in common areas during morning, lunch, and evening hours.

CS3 (Orphanage): Vertical movement peaks in early morning and noon; library underutilized post-afternoon. The vertical circulation (stairwell) is crucial for linking these specialized functions to the main residential areas on the second floor and communal areas on the first.

4.2.3 Correlation Matrix

Numerical scores were assigned to spatial characteristics such as user path frequency, flexibility, circulation efficiency, privacy zoning, and user-centeredness. Using these variables, correlation matrices were generated to explore relationships and identify spatial alignment or conflict.

CASE STUDY-1(HOUSE)					
CO-RELATION MATRIX	User Paths	Flexibility	Circulation	Privacy Zoning	User-Centeredness
User Paths	1	0.05	0.98	-0.98	0.08
Flexibility	0.05	1	0.22	-0.097	0.96
Circulation	0.98	0.22	1	-0.96	0.22
Privacy Zoning	-0.98	-0.097	-0.96	1	-0.16
User-Centeredness	0.08	0.96	0.22	-0.16	1

CASE STUDY-2(BUNGLOW)					
CO-RELATION MATRIX	User Paths	Flexibility	Circulation	Privacy Zoning	User-Centeredness
User Paths	1	0.73	0.58	-0.58	0.91
Flexibility	0.73	1	0	0	0.70
Circulation	0.58	0	1	-1	0.30
Privacy Zoning	-0.58	0	-1	1	-0.30
User-Centeredness	0.91	0.70	0.30	-0.30	1

CASE STUDY-3 (GIRL'S ORPHANAGE)					
CO-RELATION MATRIX	User Paths	Flexibility	Circulation	Privacy Zoning	User-Centeredness
User Paths	1	-0.34	0.85	-0.85	-0.7
Flexibility	-0.34	1	0.09	-0.09	0.85
Circulation	0.85	0.090	1	-1	-0.42
Privacy Zoning	-0.85	-0.090	-1	1	0.42
User-Centeredness	-0.7	0.85	-0.42	0.42	1

Each case exhibited different spatial relationships. The matrix below illustrates correlation strength between key spatial-performance variables:

Case	High Positive Correlation	High Negative Correlation
CS1	Circulation & User Paths (0.98)	Privacy Zoning & Circulation (-0.96)

CS2	User Paths & User-Centeredness (0.91)	Privacy Zoning & Circulation (-1.0)
CS3	Flexibility & User-Centeredness (0.85)	User Paths & Privacy Zoning (-0.85)

Table 7: Correlation Matrices for Spatial Parameters Across Case Studies
Presents relationships among user paths, flexibility, circulation efficiency, privacy zoning, and user-centeredness.

4.2.4 Spatial Overlay and Heat map Mapping

Heat maps are visual representations that use color gradients to indicate the intensity or frequency of activity within a defined space. In architectural analysis, they are particularly effective in illustrating spatial usage patterns, movement density, and the relationship between user behavior and built environments.

In this research, heat maps were generated by overlaying manually tracked user movement data onto floor plans of three case studies: a **single-family house**, a **5BHK bungalow**, and a **multi-storey girls' orphanage**. These visualizations captured the spatial distribution of activities across different time segments of the day—early morning, morning, midday, evening, and night.

The color-coded maps enabled the identification of:

- **High-traffic zones** (indicated by warmer colors like red/orange),
- **Underutilized areas** (represented by cooler tones like blue),
- **Circulation bottlenecks**, and
- **Functional overlaps or spatial conflicts**.

User movement paths were overlaid onto floor plans to generate heat maps indicating high-traffic and low-use zones. These diagrams were instrumental in identifying functional bottlenecks and programmatic gaps.

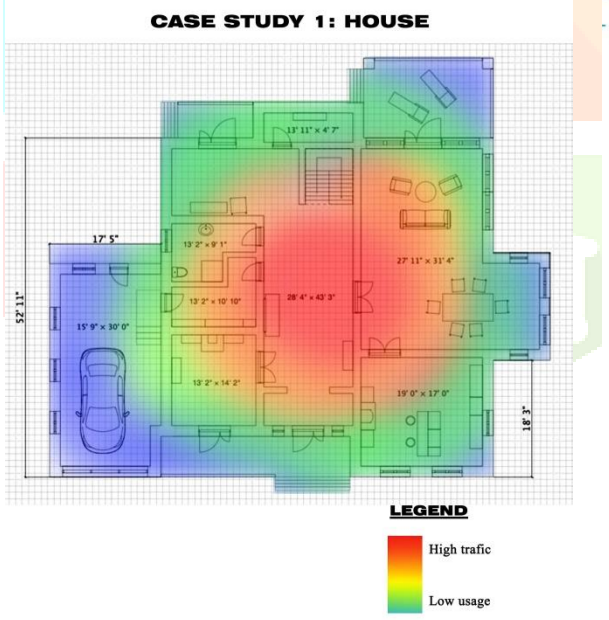

Figure 6: Spatial Heat Map – Case Study 1 (Single-Family House)
Color-coded intensity map illustrating usage density and underutilized zones.

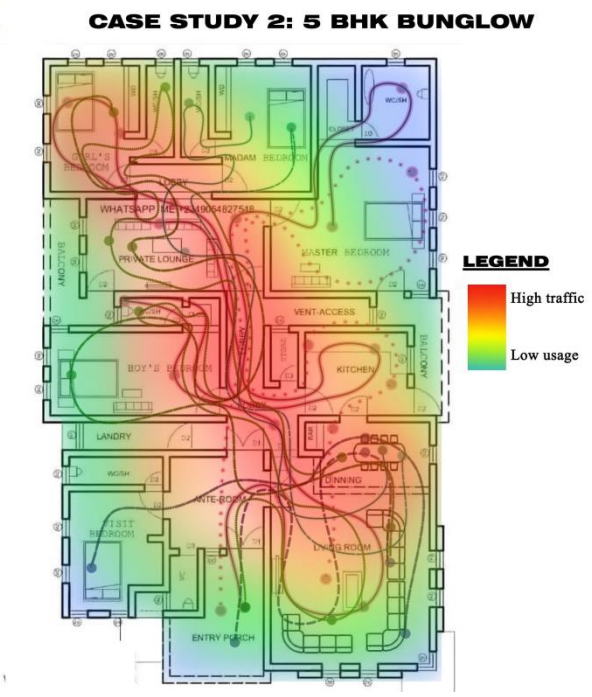

Figure 7: Spatial Heat Map – Case Study 2 (5BHK Bungalow)
Indicates circulation hotspots and spatial overlaps across public-private transitions.

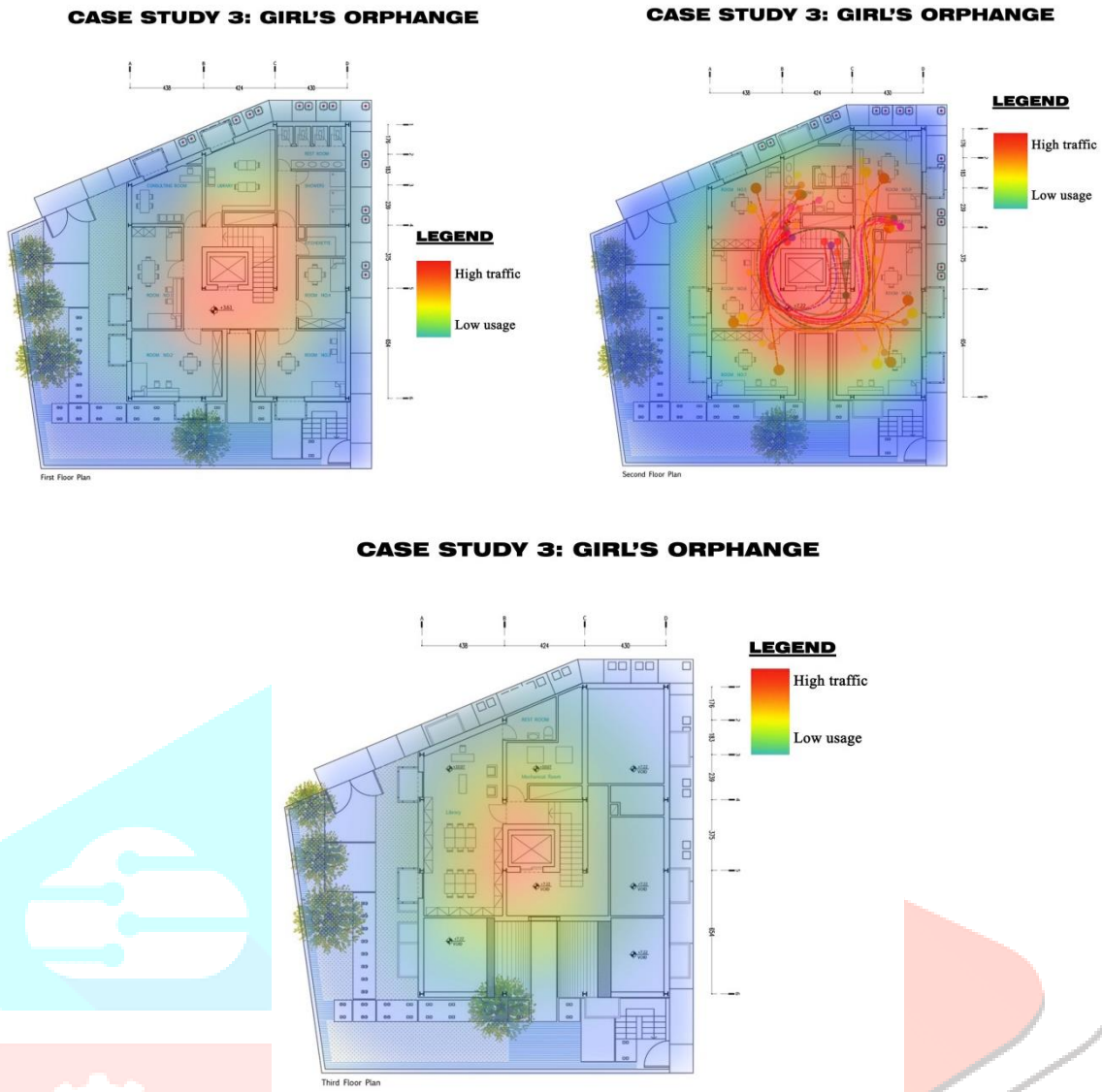

Figure 8: Spatial Heat Map – Case Study 3 (Girls' Orphanage)
Highlights vertical movement peaks, shared facility usage, and underused potential zones.

The heat map analysis across the selected case studies—comprising a single-family house, a 5BHK bungalow, and a multi-storied girls' orphanage—demonstrates a significant correlation between spatial configuration and user movement patterns. These visualizations, derived from user-programmed activity tracking and spatial overlays, provide a data-informed foundation for re-evaluating residential design from a human-centered perspective.

In Case Study 1 (House), the highest concentration of foot traffic is observed in the central circulation spine that connects the living, dining, and bedroom areas. This affirms the spatial logic of transitional zones acting as connective tissues within compact residential layouts. The peripheral areas, such as bedrooms and garage spaces, exhibit lower usage intensity, supporting their designated roles as private or utilitarian zones. From a design thinking standpoint, this highlights the importance of optimizing central shared spaces to enhance functional efficiency and comfort.

Case Study 2 (5BHK Bungalow**)** reveals a more complex pattern of movement, with high-traffic zones concentrated around the vertical and horizontal circulation axes that unify multiple bedrooms, the kitchen, and social areas. The integration of private lounges and multiple access points emphasizes a layered approach to privacy and interaction. This suggests that in larger residences, the clarity of spatial hierarchy and transition is essential for intuitive navigation and user well-being. The visual traces further reinforce how user needs evolve across age groups and daily routines—supporting the need for adaptable and inclusive design strategies.

In the Girls' Orphanage (Case Study 3), distributed across three floors, the analysis reveals a strong dependence on the central courtyard and circulation corridors. The first and second floors show peak activity along the inner perimeter, particularly around shared utilities such as the kitchenette, showers, and library. The central courtyard not only functions as a physical connector but also as a social integrator—validating its role as a vital architectural and experiential core. On the third floor, movement is less intense, indicating limited use or specialized activity, such as study or mechanical functions. This stratification of activity levels across vertical spatial tiers illustrates the effectiveness of stacking communal and private functions thoughtfully in institutional housing.

V. Discussion

The results illuminate how temporal behaviors and user typologies shape spatial dynamics in residential and institutional settings.

Key discussions include:

- Across all three cases, there were instances where architectural intent conflicted with user behavior. For example, CS3's terrace and library remain unused due to poor accessibility and scheduling, despite being designed as communal assets. This reflects a disconnect between spatial provision and programmatic timing**.**
- Movement patterns were significantly influenced by user identity—children displayed exploratory circulation, mothers had service-oriented routes, while elders preferred zone stability. This reinforces the need for role-sensitive zoning, particularly in multi-generational or multi-user facilities.
- Correlation matrices showed an inverse relationship between privacy zoning and spatial flexibility, especially in CS1 and CS2. Open-plan configurations allowed dynamic use but compromised on privacy, highlighting a trade-off that must be balanced during programming.
- Students engaged in the mapping and analysis developed a deeper understanding of how architecture interfaces with human behavior. This validates participatory and observational programming as effective design-thinking tools in education (Aydin Aktaş et al., 2023; Sanoff, 1990).

VI. CONCLUSION

This research demonstrates the effectiveness of integrating time-based user activity mapping into architectural programming education. Key conclusions include:

- **Design Thinking Benefit:** User-centric observational strategies foster empathy, understanding, and critical spatial analysis in students, aligning with human-centered design principles (Brown, 2009; Cross, 2006).
- **Behavioural Insights:** Spatial data over time reveals congestion zones, underutilized assets, and behavioral conflicts, enabling proactive design interventions.
- **Pedagogical Value:** The academic studio setting provided an effective framework for experiential learning, transforming students into researchers and reflective designers.
- **Future Directions:** Scaling this methodology with digital sensors or post-occupancy data can further validate behavioural trends and influence real-world design decisions.

Ultimately, the study advocates for embedding behavioral-programmatic alignment as a core pillar of architectural pedagogy and practice.

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